A system of dental surgery / by Sir John Tomes.

Contributors

Tomes, John, 1815-1895.
Tomes, Charles S. Sir, 1846-1928.

Publication/Creation

London : Churchill, 1887.

Persistent URL

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A SYSTEM

OF

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OF

DENTAL SURGERY

BY

SIR JOHN TOMES, F.R.S.

CORRESPONDING MEMBER OF THE PHILADELPHIA ACADEMY OF NATURAL SCIENCES;
LATE DENTAL SURGEON TO THE MIDDLESEX AND DENTAL HOSPITALS

THIRD EDITION

REVISED AND ENLARGED

BY

CHARLES S. TOMES, M.A., F.R.S.

LATE LECTURER ON DENTAL ANATOMY AND PHYSIOLOGY
TO THE DENTAL HOSPITAL OF LONDON

WITH 292 ILLUSTRATIONS

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PREFACE

TO THE THIRD EDITION.

In revising this work for its third edition, it has been necessary to make a good many alterations, but it has been my endeavour to carefully preserve the original character of my father's book, whether in making additions or omissions.

The whole section relating to the structure of the dental tissues has been omitted, and that relating to the growth and development of the jaws has been curtailed; this latter, though anatomical rather than surgical in its character, appears necessary for the right understanding and treatment of irregularities. It has not seemed to me to be desirable to devote much space to the description of the mechanical details of the operation of filling teeth; these things certainly cannot be learnt from descriptions, however detailed, and I have therefore embodied in the text little more than a few general principles of procedure.

And inasmuch as fashion in instruments changes rapidly, and no two operators affect precisely the same

forms, but few instruments have been figured; of these a good many are woodcuts which have been kindly lent by Messrs. Ash from their illustrated catalogue.

I have also to express my obligations to Mr. C. Heath, from whose "Injuries and Diseases of the Jaws" several woodcuts have been borrowed, and also to Mr. Bland Sutton, whose "Principles of Pathology" has been laid under contribution.

It has been my endeavour to acknowledge the sources whence information has been drawn; but in my anxiety not to overburden the text of a student's manual with many references, it is very possible that in some, perhaps in many, instances I may have failed to do so.

CHARLES S. TOMES.

37, Cavendish Square,
March, 1887.

PREFACE

TO THE FIRST EDITION.

In the following pages an attempt has been made to produce within the limits of a manual a strictly practical work on Dental Surgery. In order to fulfil this object, it became necessary to enter upon the structure and development of the teeth and jaws in a limited degree only, and to leave untouched any historical account of the writings of those who have from time to time contributed to our knowledge in this branch of surgery. The diseases of the teeth, and of the parts subservient to them, together with the coincident maladies, have been treated of, so far as may be, in the natural order of their occurrence, and the structure and development of the tissues involved have been to some extent described before entering upon the diseases to which they are respectively liable.

In a work devoted to the description of practical details, the modes of procedure in the treatment of diseases, whether by operations or otherwise, must necessarily be those practised by the Author. The methods adopted by others are known only through published descriptions, the mere reprint of which would be but a work of supererogation. On this account, together with the want of space, the quotations from other writers have been but limited. I must, however, express my obligation to many of those who have written

upon dental surgery; and I cannot leave unmentioned the names of Mr. Bell, Mr. Spence Bate, Mr. Samuel Cartwright, Mr. Chapin Harris, and Mr. Arthur. Reference is not unfrequently made to a series of lectures published in 1848. Many subjects but imperfectly touched upon in these pages are more fully treated in that work, and many specimens are there figured which illustrate subjects discussed in this volume.

The demands of an active practice leave but little leisure for writing, and that little has been seriously interrupted by engagements consequent upon the gradual organization which the dental profession has recently undergone. From these, and from causes less controllable, the present work has passed very slowly through the press, many of the earlier sheets having been in print upwards of eighteen months.

To Mr. Bagg I am greatly indebted for the highly artistic illustrations which he has produced from specimens in my own collection, and from others which have been liberally contributed by my professional friends.

JOHN TOMES.

37, Cavendish Square,
February 28, 1859.

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A

SYSTEM OF DENTAL SURGERY.

TEETHING.

The term *teething* might be employed to express the development of the teeth from the commencement to the completion of the formative action; but custom has limited its use to the expression of a single phase of the process—that is to the eruption or cutting of the temporary teeth. Although this, nearly the last in a series of developmental actions, may be regarded in many respects as the most interesting, and is the one which the medical practitioner is usually required to watch, yet if observation were restricted to the eruption of the teeth without instituting an inquiry into the preceding conditions, our knowledge of the subject would be very imperfect. It is desirable, therefore, to describe the conditions of the teeth and jaws at the time of birth, and to trace the changes onwards until the temporary teeth have arrived at maturity.

At the time when my father undertook the first edition of this work, the museums in which an extended series of young skulls would be likely to be found were visited, but without success. So far as could be learned, no such series existed. It therefore became necessary to make a collection, taking care that the age of each specimen should, if possible, be ascertained. This was done, and the preparations comprised in the collection were sufficiently

numerous to allow of deductions being made from the characters they present. Indeed, little or no literature bearing upon the subject, with the exception of John Hunter's writings, was to be found, and it hence appeared necessary to embody in the earlier chapters of the book not only the conclusions arrived at respecting the growth and development of the jaws and teeth, but also to a great extent the details of the data upon which they were based. But now that the deductions drawn from the large, and at that time unique, collection of young skulls of known ages have obtained general acceptance, and that other works treating of special dental anatomy are in existence, it does not seem necessary to enter into such full detail, so that the old chapter upon teething is somewhat abridged in this edition.

If two perfectly healthy children, whose ages are similar, be selected for examination, we shall rarely find that they present precisely similar conditions as regards the rate of teething; yet there will probably be no great disparity in the conditions of the two. Each will pass through the same phases, although, until the process of dentition is completed, one may be a few weeks, or even months, in advance of the other.

There is, however, another source of fallacy to be guarded against. The specimens obtained are necessarily taken from individuals who have been the subjects of disease; and supposing the fatal illness to have been of long standing, the jaws may have been modified. That such has occurred to some members of the series is sufficiently obvious, but the diseased action appears to have influenced the growth of the jaws themselves, rather than the rate of development of the teeth. And it is a remarkable fact that there is more fixity about the teeth than about the jaw bones under the influence of inherited or pathological variations; thus in short-muzzled dogs the teeth do not diminish in size proportionately with the shortening of the face, so that they come to be crowded, and the same thing is every day observed in

the human subject. Hence, even these specimens may serve to confirm the results obtained from an examination of healthy jaws so far as the teeth are concerned.

Those minor differences in size and form which constitute individuality, by which we are enabled to distinguish one person from another, though in all essential characters they are precisely similar, must be borne in mind when investigations of this character are undertaken.

It would perhaps be difficult to find a more interesting subject for investigation, than the progressive changes in form and of relative proportion between the various parts of the jaws during infancy, which occur as necessary consequences of a mode of growth which is so subservient to the development and arrangement of the teeth.

The fact that the development of the hard tissues of a tooth is preceded by the formation of soft tissues, or tooth-pulp, of equal size and form to the future tooth, must at all times be kept in view. Not that the entire pulp assumes the dimensions of a perfected tooth before its conversion into the hard tissue commences, but that each part of the gradually developing tooth is first formed in pulp tissue of its full size, and then calcifies. For example, the cusps of the molars and the edges of the front teeth first assume their full dimensions in the form of pulp, and then calcify; the process of gradual development and subsequent calcification proceeding until the teeth are perfected. In dentine, which forms the great bulk of each tooth, we have no such thing as outward growth; no addition to the external surface of the formed tissue ever takes place, excepting by the superposition of the enamel, and of the cementum, which respectively coat the crown and the root of the tooth; but these add comparatively little to the size of the organ. Hence it follows that both the forms and dimensions of the crowns of the teeth are unalterably fixed long before the jaws are sufficiently enlarged to admit of their ultimate and normal arrangement.

If the maxillæ of a nine months' fœtus be examined, it will be found that the union of the two halves both of the

upper and lower jaws is effected by the interposition of fibro-cartilage, which allows a certain amount of motion between the parts thus connected. The alveolar margins are deeply indented with large open crypts, more or less perfectly formed. The depth of these bony cells is only sufficient to contain the developing teeth and tooth-pulps, the former rising to the level of the alveolar margins of the jaws. At this period the crypts or alveoli are not arranged in a perfectly uniform line, neither are they all equally complete. The septa, which divide into a series of cells that which at an earlier age was but a continuous groove, are less perfect at the back than at the front part of the mouth. The alveoli of the central incisors both of the upper and lower jaws are a little larger within than at the orifice, and this difference is made still greater by a depression upon the lingual wall of each for the reception of the pulp of the corresponding permanent tooth. By the arrangement of the divisions, the alveoli of the central incisors are rendered broader in front than behind, and the relative dimensions of the sockets of the lateral teeth are reversed, as shown in Figures 1 and 2. The crypts of the canine teeth are placed a little anterior to those of the laterals, and nearly in a line with the central incisor sockets, giving to the jaws a somewhat flattened anterior surface. In these alveoli we have at present no depression provided for the pulps of the permanent teeth.

The sockets for the first temporary molars are placed in the median line of the alveolar ridge; have a somewhat square form, with the outer margins inverted; and, in the lower maxilla, are marked on their floors by a slight groove, in which the inferior dental nerve and artery lie The very close approximation of the nerve to the developing teeth, may, perhaps, serve in some measure to explain the liability of children to reflex nervous disturbances dependent on the teeth. The nerve and artery enter this alveolus on either side through an aperture in the base of the septum, which divides imperfectly the first from the second tem-

porary molar, and pass out to the external surface of the

FIG. 1. (1)

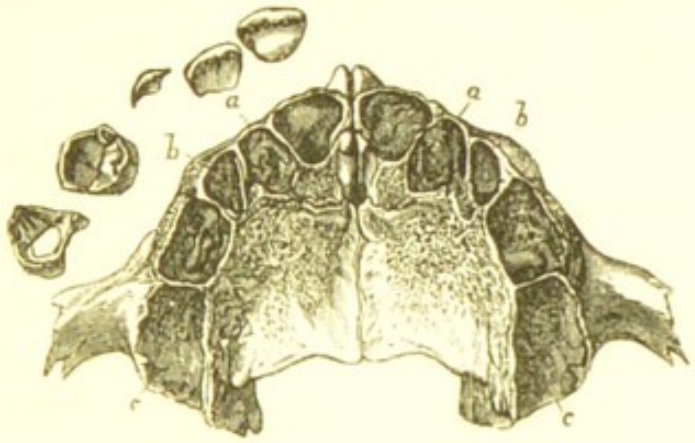
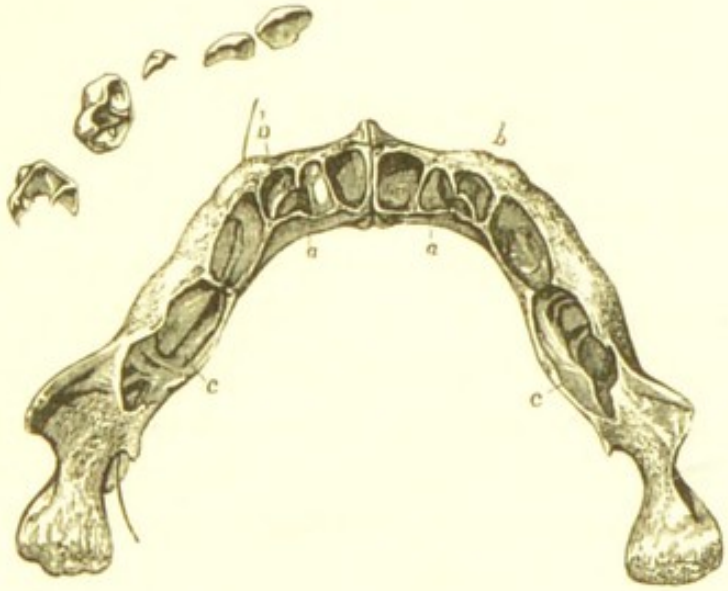


FIG. 2. (2)



jaw through an orifice in the septum dividing the canine from the former tooth.

(1) The upper jaw of a nine-months' fœtus deprived of the soft parts, showing the relative positions and dimensions of the alveoli, the partly developed teeth having been removed from the sockets on the right side of the jaw. *a*, the socket of the lateral incisor; *b*, that of the canine; *c*, the alveolus of the second temporary molar, the posterior wall at this age being absent. This and the subsequent figures are two-thirds life-size.

(2) The lower jaw of a nine-months' fœtus, showing the condition of the alveoli. *a*, the sockets of the lateral incisors; *b*, those of the canine teeth; *c*, the alveoli of the second temporary and first permanent molars. A bristle is placed in the inferior dental canal.

Behind the alveoli for the first temporary molars we have a large open socket, which, in the upper maxilla, has but a very imperfect posterior wall. Projecting inwards from the free edge of the outer and inner alveolar walls, we may observe small spicula, the rudiments of septa which are destined to divide the cavity into two distinct sockets, and thus separate the pulps of the second temporary and first permanent molar teeth, both of which at present occupy one large alveolus. The division usually takes place a little earlier in the lower than the upper jaw. The groove which marks the passage of the nerve and artery in the floor of the socket of the first temporary molar, can be traced through the alveoli of the two posterior teeth, back to the inferior dental foramen, which is situated midway between the angle of the jaw and the edge of the inner wall of the alveolus of the first permanent molar, a little below the floor of the posterior part of the last alveolus.

At this period the articular process of the lower jaw is scarcely raised above the level of the alveolar edge, while the angle is projected downwards a little below the general level of the inferior margin of the jaw. The coronoid process rises at an angle of forty-five degrees from the alveolar edge, its ascent commencing at the anterior boundary of the socket of the first permanent molar. In the upper jaw the zygomatic process proceeds outwards from the anterior margin of the large open socket of the second temporary molar.

It is necessary to notice, with some degree of accuracy, the relative position of these points, as in tracing the growth of the jaws, changes occur which can be recognised only by a knowledge of the preceding conditions.

The temporary teeth at nine months are partly formed. The central incisors are calcified through the greater length of the crown; but the lateral teeth are less advanced. The terminal points only of the canines are calcified, while the masticating surfaces of the first temporary molars are completed, excepting the enamel, which at this stage has not

attained more than half its thickness, a condition common also to the more anterior teeth. The second temporary molar is represented by calcified cusps, which are united in a circle, the central part of the crown being as yet uncalcified. The conditions are shown in Figs. 1 and 2. If examined in the recent condition, it will be seen that in the front teeth calcification has advanced nearly to the base of the tooth pulp,

FIG. 3. (1).

FIG. 4. (2)

which ends in a broad flat surface; while in the canines and molars the pulp extends a short distance below the terminal line of calcification.

At the age of *two months* but little change from the fœtal characters has taken place in the upper jaw. The maxilla

(1) The upper jaw of a nine-months' fœtus, the soft parts having been removed, showing the outer surface of the alveolar processes. *a*, the depressed portion corresponding to the position of the lateral incisor.

(2) The lower jaw of a nine-months' fœtus, showing the relative size and position of the several parts of the bone at this age.

is, however, generally a little larger, and the sockets slightly deeper and more prominent at the anterior free margins, than at the time of birth, the relative position of the teeth

FIG. 5. (1)

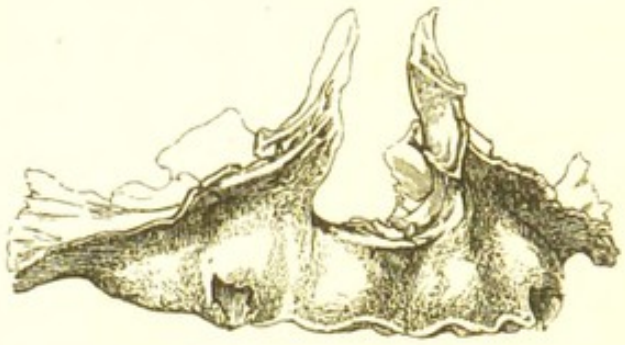
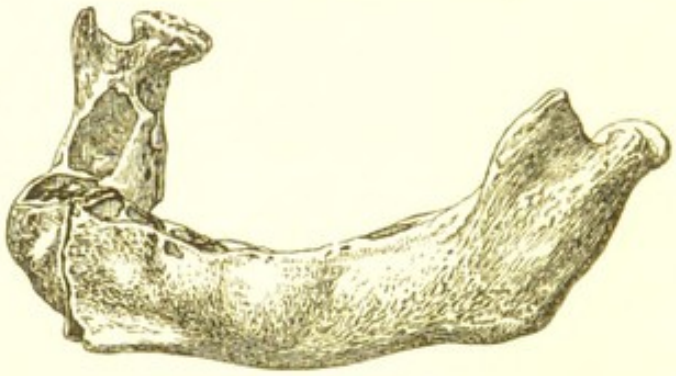


FIG. 6. (2)



being unchanged. In the lower jaw the differences are much more strongly marked. In addition to a general increase of size, growth has advanced rapidly in the ramus, and the angle has become less obtuse. The articular process rises above the general level of the alveolar ridge, an indication that during the early weeks of infancy growth is more active in the ascending ramus than in any other part of the lower jaw. At the point of junction of the two halves.

(1) The upper jaw of a male two months old, showing the general increase of size as compared with the fœtal jaw, and the increased depth of the alveolar processes.

(2) The lower jaw of a male two months old, showing the increased size as compared with the fœtal jaw given in Fig. 4, and the changes in the relative position of the body and ascending ramus during the two months succeeding birth.

increase in the depth of the jaw may be observed. This has been in great part effected by additions to the free edge of the alveoli, which have been extended anteriorly into a somewhat larger curve. But in addition to growth

FIG. 7. (1)

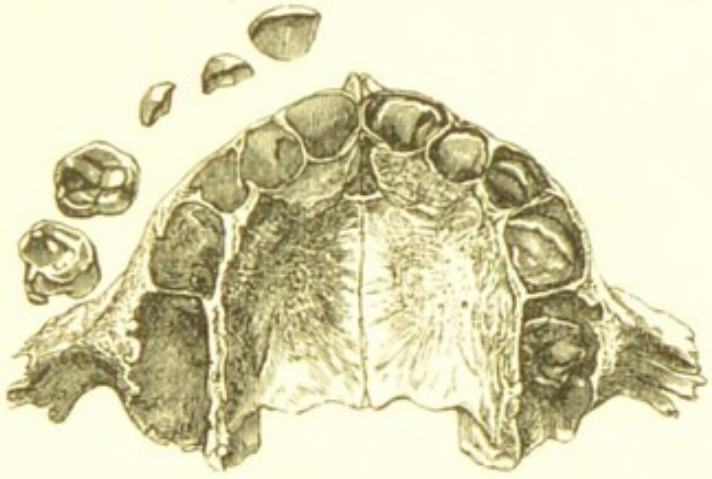


FIG. 8. (2)

in the positions mentioned, development has gone on from the opposed surfaces of the two halves, encroaching upon

(1) The upper jaw of a male two months old, showing the condition of alveoli and forming teeth at that age.

(2) The lower jaw of a male two months old, showing the condition of the alveoli and teeth at that period.

the fibro-cellular tissue which connects them. The structural character of this development will be subsequently considered. Similar changes occur in the suture connecting the two halves of the upper jaw. Growth proceeds in the line of junction of the two halves, and indeed at each of those points where the bone is at present connected only by soft tissue to the adjoining bones. Increase of bone in the median line would necessarily lead to separation of the central incisors; this is, however, prevented by the teeth on either side inclining towards the centre, and the sockets partake in a similar change of direction, the free edges being closely approximated, while the deeper parts become separated from each other.

At the age of *two months*, the teeth are more advanced in development than at the time of birth, but the change is not so strongly marked in them as in the maxillæ. The crypt of the pulp of the first permanent molar is yet without a posterior wall in the upper jaw; and in the lower jaw, the septum dividing this from the socket of the second temporary molar is incomplete.

When the *third month* has been attained, the maxillæ show a deepening of the alveoli, and a contraction of their open mouths, so that the developing teeth do not fall out from a macerated specimen.

The figures illustrating the condition peculiar to this age are singular in the absence of lateral incisors in the lower jaw, and in the want of a crypt for the first permanent molar on one side of the upper jaw. In other respects they present the characters common to jaws of similar age.

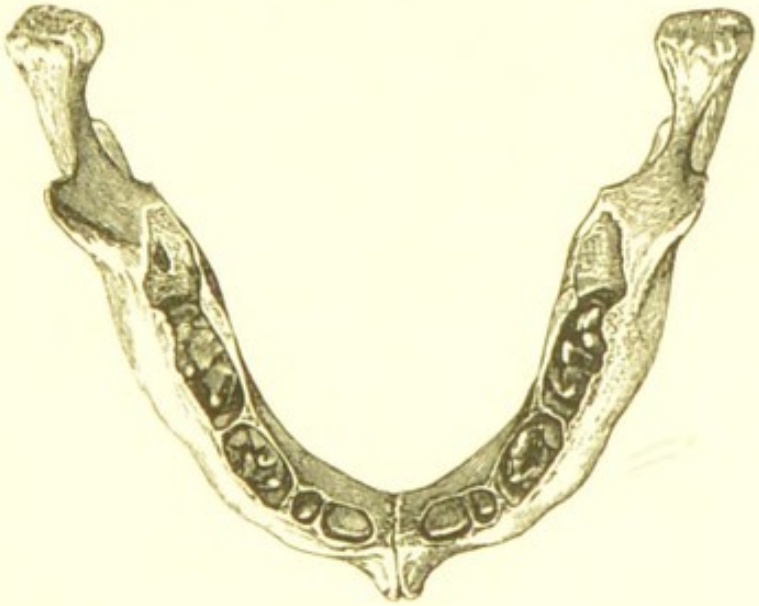
The inversion of the edges of the alveoli, and consequent narrowing of the apertures described as pertaining to the jaws of three months old, is less pronounced at six months, although as yet the teeth lie below the free edges of the sockets. The increased size of the alveolar orifices must be regarded as the first of those changes which precede the eruption of the teeth.

The relative position of the teeth is but little changed;

the canines of the upper jaw are even more out of the regular line than formerly, being placed at this period

Fig. 9. (1)

Fig. 10. (2)



almost external to the lateral teeth, thereby producing great prominence in the jaw at these points.

At the age of *eight months*, at the front part of the mouth, the alveoli, which have hitherto developed more rapidly

(1) The upper jaw of a male three months old, showing the advanced condition of the alveoli, and the inversion of the edges of each socket, together with completion of the posterior wall of the sockets which contain the second temporary molar and the pulp of the first permanent molar.

(2) The lower jaw of a male three months old, showing the inversion of alveolar edges, and consequent contraction of the apertures. The lateral incisors are wanting.

than those situated further back, now become the seat of absorption: while the more posterior ones assume a greater activity of growth. The central incisors of the upper jaw, although they do not descend below the general level of the alveolar ridge, are exposed on their anterior surfaces by the absorption of great part of the outer wall of the sockets, at the same time that the teeth have moved bodily a little forward. The outer edges of the central teeth are in front of the lateral teeth, the latter being still placed in a line internal to the canines, so that if the teeth were cut in their present positions, the arrangement would be extremely irregular. This fact, which applies equally to the permanent dentition, should be steadily kept in mind when estimating the degree of irregularity in newly cut teeth.

The sockets of the upper molar teeth, which formerly extended up to the floor of the orbit, are now separated from it by the antrum, which at this time is represented by a deep depression, extending under the orbit in its inner two-thirds.

In the lower jaw the changes from the earlier conditions are more striking. The two halves, which in the upper are still separable, are in the inferior maxilla becoming united, and no longer part under maceration. The symphysis and mental prominence are strongly marked, the bone behind the front teeth is thickened, and turned outwards at the alveolar margin, giving a curved surface, the convexity being directed towards the tongue,—a form altogether different from that of the corresponding part in the mature fœtus, when the posterior surface of the symphysis is straight. It was shown that in the fœtal jaw the point of the inferior border corresponding to the position of the first and second temporary molars descends to a lower level than the parts anterior or posterior to it. In the nine-months' jaw, the relative depths of the three parts indicated are changed, the middle portion now being the highest. The removal of the anterior wall of the alveoli of the central incisors, and partly also of that of the

lateral teeth, has been effected in the lower as in the upper jaw.

Taking the jaw figured as a fair standard of the conditions peculiar to this age, it will be seen, on comparison

FIG. 11. (1)

FIG. 12. (2)

with the preceding figures, that the bone has undergone great change, not only in size but also in form, and that the changes in form are more remarkable in some parts of the jaw than in others.

(1) The upper jaw of a male nine months old, showing absorption of the anterior walls of the sockets of the central incisors preparatory to the escape of the crowns of the teeth from their alveoli.

(2) The lower jaw of a male nine months old, showing absorption of the outer walls of the socket of the incisors preparatory to the eruption of those teeth. Two-thirds life-size.

In order to institute a comparison of the relative changes which mark the growth of a bone, it is necessary to find some fixed points from which to take measurements; this, however, is no easy matter, seeing that processes for the attachment of muscles or foramina change their position from time to time. To illustrate what is meant by this change of position, suppose that a process for the attachment of a muscle is situated at a point one-third of the way down a long bone of a fœtus. Now if the bone grow equally at its two ends by deposition in its epiphyses, eventually the process (if it remained still) would come to be very nearly in the middle of the bone, for that approximation towards one end which made a great difference in a small fœtal bone would make only an inappreciable difference in an adult bone six or seven times the length of the former. But as a matter of fact such is not the case: a process situated at a point distant from one end of a long bone by one-third of its length preserves that proportionate distance, no matter how much the bone may grow; obviously this can only come about by the process shifting its position,[1] and gliding as it were along the surface of the bone. Now if the jaw-bone were in all respects comparable to a long bone, this fact would offer an insuperable objection to the choice of any muscular process or foramen as a point of measurement. Fortunately, however, for our present purpose, the lower jaw-bone stands in quite a different position to that of a long bone: if we draw a horizontal line through the level of the upper pair of spinæ mentales in an adult jaw we shall about equally divide it; but the life history of that part which lies above the line and that which lies below it is widely different. The lower portion is the jaw that supports muscles of deglutition, of mastication, and the like structures essential to the well-being of the animal, and is progressively developed from the earliest time of ossification until it has attained its full size without intermission;

(1) G. N. Humphry, in Trans. Med. Chirurgical Society, vol. xiv.

not so however the portion of bone above our imaginary line. This is subservient to one purpose only ; that of supporting the teeth when perfected, that of protecting them whilst developing. And so far from being itself gradually elaborated and developed without a check, it was built up around the calcifying temporary teeth, and then in part removed to allow of their eruption : built up again around their fangs, and yet once more absorbed to give exit to the permanent teeth : then developed afresh around the roots of the permanent set of the teeth, so that in the socket of the permanent teeth probably not one fragment of the original alveolar portion of the jaw remains. And when the teeth are shed for the last time the alveolar portion of the jaw is again removed. Relatively, then, to the changeable alveolar portion we may regard the body of the ramus as fixed and immutable, and we shall not be led into any error of consequence by taking muscular processes or foramina as points of measurement from which to estimate the relative proportions of these two portions of the horizontal ramus at various ages.

The foramen mentale is particularly suitable as a point from which to take relative dimensions, as its position may be practically assumed as fixed, and as undergoing little or no change after birth. In the full-grown fœtus it is situated at the point corresponding to the septum which divides the sockets of the temporary canine and first temporary molar, and on a plane with the bottom of the alveoli. In the adult jaw, the foramen is in close proximity with the extremity of the root of the first bicuspid—that is, on a level with the bottom of the socket of the tooth which succeeds the first temporary molar. Now, assuming that these positions remain unchanged during growth, while other parts undergo alterations, we have a point from which the relative amount of increase of different parts, and of the same part at different ages, can be estimated. If the terminal portion of the inferior dental canal be examined in the fœtus its orifice will be found to be in the

direct line of its course, opening forwards, but in an adult jaw it will be found to look outwards, upwards, and backwards, so that its position is slightly posterior to that which it would have assumed had it remained in the line of the canal. This change in position is due to a great increase in the thickness of the bone due to deposition on its outer surface, and to that tendency to a preservation of its original position relatively to the length of the jaw already alluded to (page 14). But inasmuch as the growth of the jaw differs in many important particulars from that of the long bones, the foramen does not fully preserve its original position relatively to the two ends of the bone, but in the adult is proportionally farther from the ascending ramus than in the fœtal jaw.

An examination of a series of jaws serves to show that almost the whole change which is effected in the position of the foramen is completed within the first few months after birth; after this time no marked change takes place, it having then become opposite to the middle of the socket of the first temporary molar, and remaining in the adult opposite to the root of the first bicuspid.

On the inner surface of the jaw the tubercles for the attachment of the genio-hyo-glossus and genio-hyoideus undergo but little change during the growth of the jaw. In the fœtus they are placed opposite to and a little below the base of the sockets of the central incisors; the two upper tubercles being even at this early age well marked. In the adult subject the position, as regards the central incisors, is the same, excepting in those cases in which the alveolar process is developed in an unusual degree, in which case the extremities of the roots of the teeth occupy a higher level than the spinæ mentales. The upper of the two pair of processes are at all ages nearly at the same level as the mental foramina, though where the latter have a distinctly upward direction, as is sometimes the case in the adult, they rise to a somewhat higher level.

If, on the inner surface of the jaw, the distance across from

the junction of the septa between the sockets of the first and second temporary molars and the inner plate of the alveoli of either side be measured in the full-grown fœtus, and in jaws up to the age of nine months, when osseous union between the two halves usually commences, this measurement being made on a level with the attachment of the genio-hyo-glossus muscle, it will be found, that although the jaws have with age greatly increased in size, yet the distance between these points has not materially increased. Again: if a line be stretched across from the above points, and measurements be made from the centre of the line to the upper of the two pairs of spinæ mentales, it will also be found that the distance has not increased with the ageing of the subject. But if the measurement be made from the centre of the line to the anterior alveolar plate, it will be seen that the distance between these two points gradually increases with the age of the subject, and that the front teeth contemporaneously assume a more forward position. The stationary condition of the inner, while the outer alveolar plate and teeth are moved forward, allows the former to increase in thickness, and afford receptacles for the pulps of the anterior permanent teeth.

Three years after the publication of the preceding statements in the first edition of this work, Dr. Humphry read a paper before the Cambridge Philosophical Society, in which an identical conclusion was arrived at as to the growth of the jaw by inferences from a series of experiments performed by inserting wires into the jaws of growing animals.

The following diagram may serve to render this point clearer; in it a jaw from a nine-months' fœtus is placed over an adult jaw, the limits of which are marked by dotted lines.

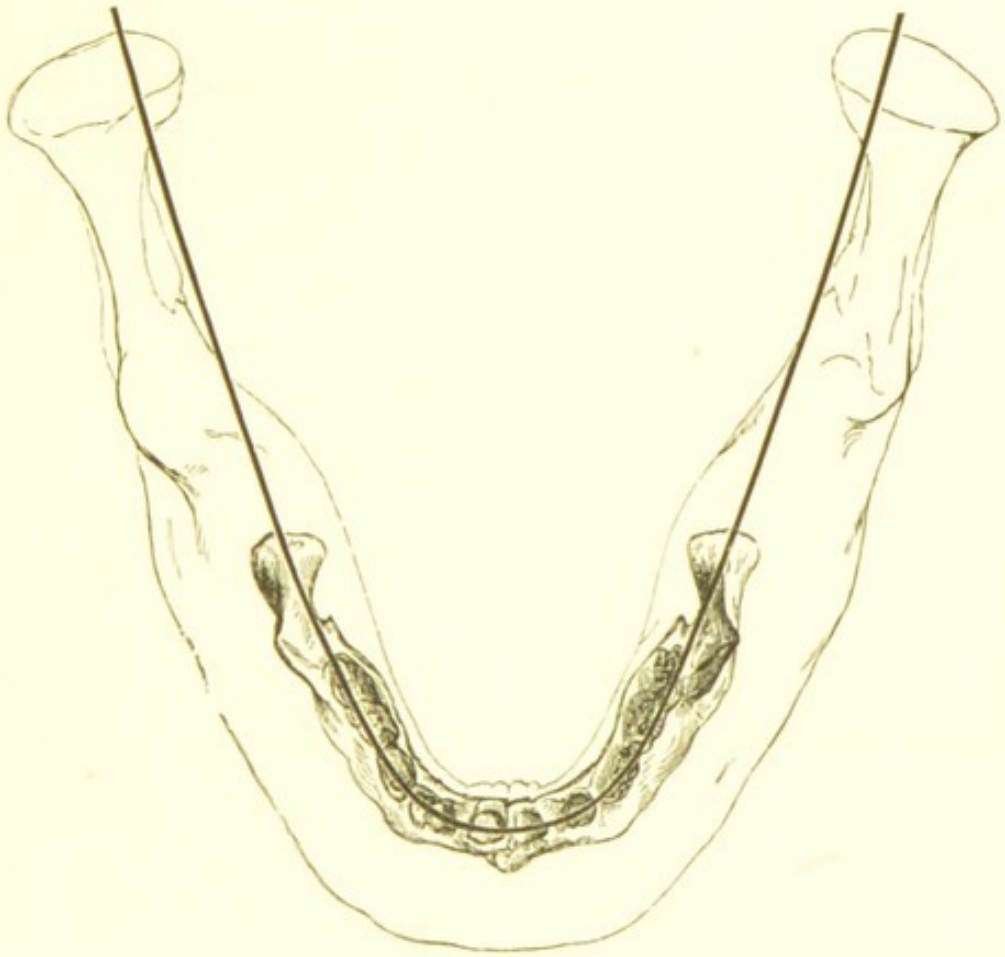
It will be seen that the arch of the jaw in the fœtus is as wide and as large as in the adult; the difference between them in this part being simply due to additions to its thickness to a slight extent on the inside, but very much more on the outside of the jaw. It will also be seen that the

increase in size in the adult jaw is gained exclusively by its prolongation backwards, and not by anything like interstitial growth. As expressed by Dr. Humphry, "Although the bones of the alveolar arch are lengthened, and the arch is rendered more elliptical, it is not widened. The widening of the jaw, in correspondence with the increasing width of the base of the skull, takes place behind the alveolar arch in the ascending portion, and is effected by the progression of absorption on the inner and addition to the outer surface of this part." But without the aid of this modelling process, the mere prolongation backwards of the horns would give a considerable increase in width.

The growth of the anterior part of the jaw by addition of bone previous to union at the symphysis, may be computed by relative measurements of the fœtal and nine-months' jaws. An increase of distance between the symphysis and mental foramen, amounting to the eighth of an inch in favour of the older jaw, is shown. This increase will be found to correspond in amount with the greater thickness in the antero-posterior direction near the symphysis. If a line be drawn the eighth of an inch in front of the symphysis of the fœtal jaw, and the distance from the mental foramen to that point of the line corresponding to the symphysis be taken, it will be found to agree with the measurement of the nine-months' jaw between the points already described. The foregoing facts show sufficiently clearly that the growth of the anterior parts of the lower jaw is produced by addition of bone to the anterior surface, rather than by any material increase by the development of bone in the fibro-cellular tissue which, up to this period, unites the two halves. Development in the latter position appears to have its period of activity limited to intra-uterine life. After birth, the process of growth in this direction is all but suspended until the period arrives for the osseous union of the two halves of jaw, when the action is resumed, the fibro-cellular tissue is replaced by bone, and all further increase at this point is then at an end. Still keeping the

mental foramen as the point from which to make the computations of relative growth in different directions, it will be found, by examining the series of jaws, that additions have been made to the lower border of the jaws, but that

Fig. 13.



there has been relatively a much greater activity shown in the alveoli, which at the age of nine months have acquired their maximum height in the front part of the jaw. The length of the jaw posterior to the mental foramen has steadily increased with the increasing age of the subject, the direction of the growth being indicated by a series of minute vascular grooves which mark the bone at and near the angle of the jaw. Between these grooves the bone rises into minute ridges, many of which are continued to the posterior border of the ramus, and there terminate in short

slender spicula, giving to the border a rough surface, which, although well marked in many dry specimens, is much more strongly pronounced before the bone is allowed to dry, and the partly-calcified spicula to become contracted by the loss of moisture. If these grooves are traced through a series of specimens of progressive ages, commencing with the fœtal jaw, it will be seen that those about the coronoid process indicate the course in which that part has advanced; a line which, it will subsequently be shown, is permanently marked in the adult jaw by the external oblique line. Then, again, a similar line of grooves indicates the course which has been taken by the articular process in its progressive growth upwards and backwards. Indeed, this line is also indicated by the surface being slightly raised, there being a distinct rounded eminence along the outer surface of the jaw, ending in the condyle, which becomes less marked in the adult. Below, and a little posterior to this line, we have the angle of the jaw, the increase in which has been already noted.

M. Kölliker has shown that the articular cartilage is of unusual thickness for cartilage so placed; and that, in addition to the usual functions of articular cartilage, it is here subservient to the purposes of development, its office in one respect being similar to the cartilage which in childhood is placed between the epiphysis and shaft of a long bone. It is not proposed to enter upon the subject of osseous development, until the changes of form and increase of size of the maxillæ have been traced from birth to manhood. But the discovery first recorded by M. Kölliker has been mentioned, in order to show that in whatever direction the jaw has increased, the increase has been produced by additions to the external surface. There are no indications of interstitial growth within and throughout the whole substance of the bone. It is not unusual to find increased size of a bone described as expansion, but the term is not applicable. We may have great increase in the size of the medullary cavity and of the circumference of a long bone,

as seen in diseased limbs; but in such cases the enlargement of the cavity is produced by progressive absorption of its parietes, and the enlargement of the outer dimensions by development of bone upon the surface.

The conditions of the alveoli coincident with the progressive development of the teeth, do not appear to have attracted that amount of attention which the subject deserves; and the stage in which the wall or walls of the sockets are partially absorbed preparatory to the passage of the teeth through the gums, although an important and necessary action for the liberation of the crown of the tooth from the socket, seems, so far as I know, to have escaped observation altogether.

If the teeth of the specimen which has been under consideration be removed from their sockets and examined separately, it will be seen that the crowns of the central incisors are perfected so far as their exteriors are concerned, and that the production of the necks of the teeth has commenced. The enamel of these teeth presents the character which marks the completion of its development—namely, the smooth and polished surface which succeeds to the dull, opaque, and almost chalk-like character maintained so long as the tissue is incomplete. The lateral incisors present similar appearances, excepting that the neck is less pronounced than in the central teeth. The canines at present are placed deep in the sockets, the crowns being incomplete, contrasting strongly with the teeth immediately behind them. These, the first temporary molars, have the crowns nearly completed, the masticatory surfaces being on a level with the alveolar margin. The latter parts have already been slightly reduced by absorption, and the outer apertures of the sockets have been thereby enlarged. The second temporary and the first permanent molars, although considerably advanced as compared with those of the six-months' subject, are still considerably below the level of the alveolar margins, the outer of which is turned very much inwards, and hence the openings of the sockets

are contracted, an arrangement calculated to afford protection to the developing teeth.

Passing from the nine to the *twelve months'* subject, further

Fig. 14. (1)

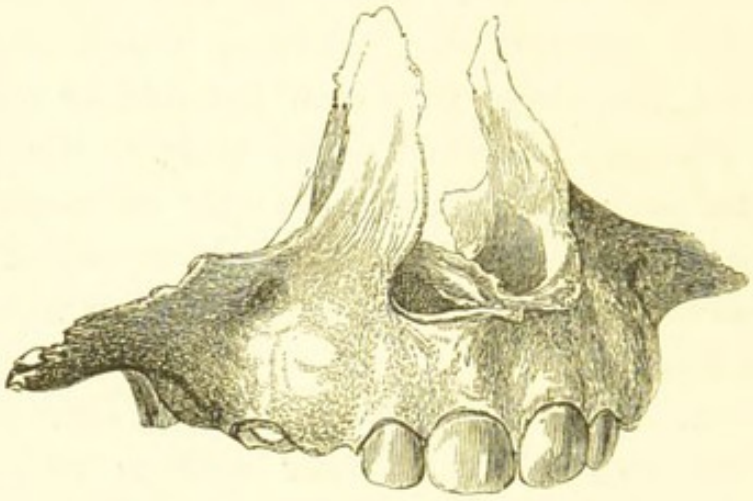
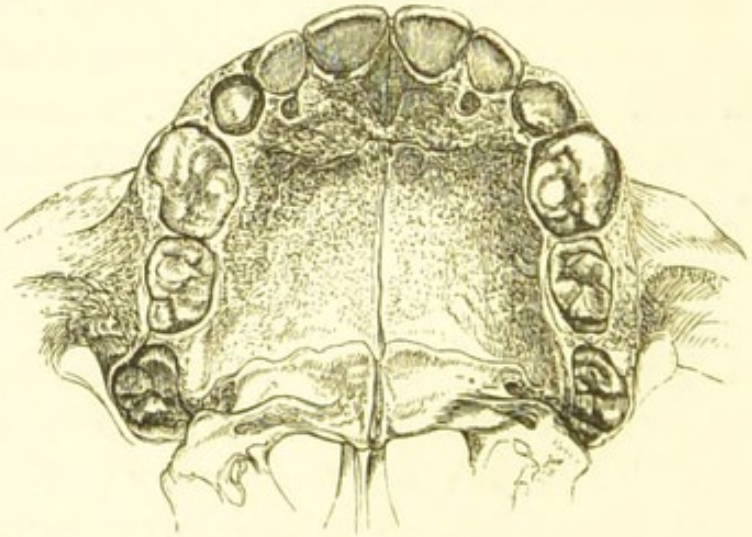


Fig. 15. (2)



changes in the dental apparatus will be observed, indicating that during the intervening three months the process of teething, as the term is commonly understood, has fairly

(1) Upper jaw of a male thirteen months old, showing the incisors, with the crowns escaped from the alveoli, and the emargination of the socket of the first temporary molar.

(2) The palatal surface and the alveolar margins of the same specimen.

set in, and at the latter age is in full activity. It was stated that the anterior wall of the alveoli of the central incisors in the nine-months' jaw had been diminished by

Fig. 16. (1)

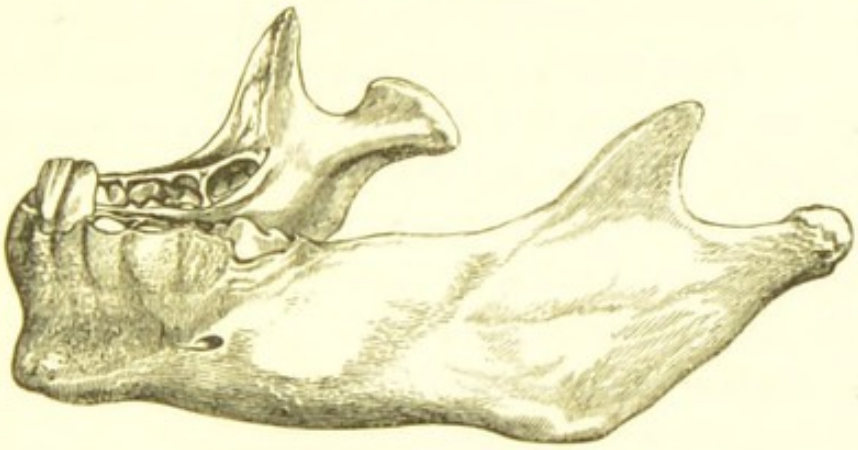
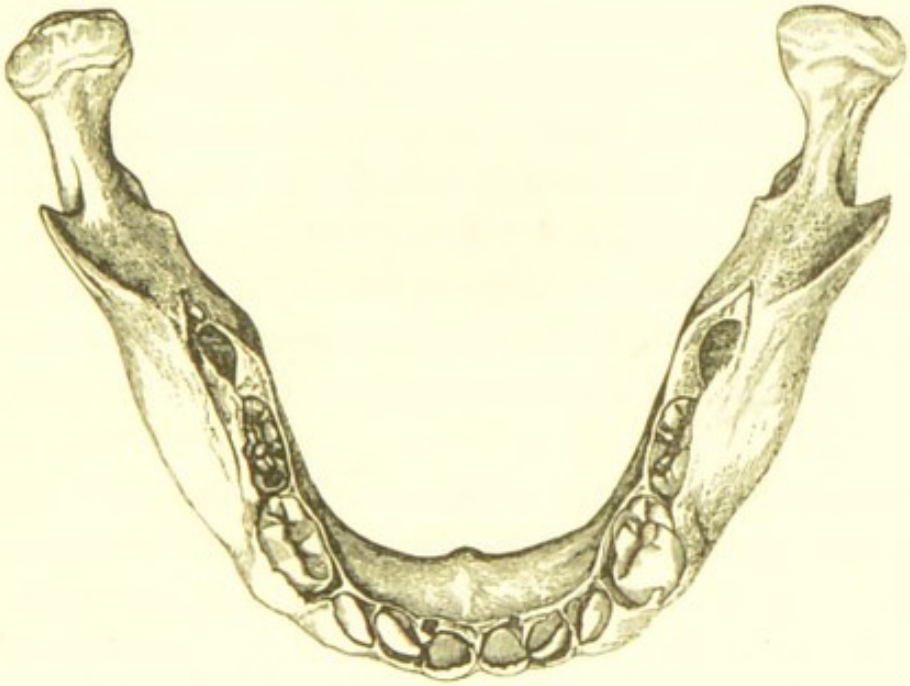


Fig. 17. (1)



absorption, exposing to view the crowns of the teeth, although these organs did not rise above the general level of the alveolar ridge. At the age of twelve months the crowns of

(1) The condition of the lower jaw and teeth of a thirteen-months' male subject. In this example, the first temporary molars of the upper do not appear more advanced than the corresponding teeth of the lower jaw—a condition which is rather unusual.

these teeth have escaped from the sockets to the extent of half their length, the whole of the enamel on the anterior surface being visible. They are placed against the anterior wall, and are separated by a considerable interval from the posterior wall of the alveoli. The latter process at this age descends below the level of the anterior wall of the sockets, at the same time that an increase of thickness of the bone at this part is allowed by the forward movement of the incisor teeth. The crypts of the permanent teeth become enlarged, occupying the space which has been gained. The apertures leading to the permanent incisors are now situated near the alveolar margin, but at present open upon the inclined surface which forms the posterior wall of the enlarged sockets of the temporary teeth.

The lateral incisors have escaped from their alveoli to the extent of two-thirds of their crowns. The canine prominences on the anterior surface of the jaw, which during the earlier months of life form so strong a feature, are now becoming lost; not, however, by their own subsidence, but by the advancing forwards of the alveoli of the neighbouring teeth. The first temporary molars at this age have passed through the apertures of the sockets, and the emargination of the external plate is gradually becoming lost, the process of development having succeeded to that of absorption of the socket.

If the maxillæ of an *eighteen-months'* child are compared with those of twelve or thirteen months, the relations of growth between the teeth and sockets may be seen. The emargination of the sockets of the central incisors, and consequent enlargement of the alveolar apertures necessary for the evolution of the crowns of these teeth, having been accomplished, and the crowns having passed through, absorption is suspended, and the several alveoli becoming contracted, apply themselves to the teeth, development at the margins keeping pace with the growth of the roots of the teeth. The socket of an incisor, so long as the crown is below the alveolar margin, is larger at its base

than at its more external boundary; but no sooner does the crown leave the socket, than the relative dimensions reverse themselves. The base contracts, by the development of new bone, to the dimensions of the root. The level of the socket is not, however, at present changed. If the comparison of the two subjects be continued, it will be seen that although the length of the ascending rami has considerably increased in the older jaw, yet that the angle formed by the two portions remains pretty much the same.

Forty Months.—If we now pass to maxillæ from a subject forty months old, it will be seen that the whole of the temporary teeth have taken their normal position in the jaws, and appear complete; but if the roots are examined, the inaccuracy of this conclusion will be discovered. The incisors are the only teeth in which the fangs are completely formed. The canines are destitute of about one-third, the first temporary molars of a fifth, and the second temporary molars of at least one-half, of their normal length.

At this period a change takes place in the form of the jaw, and it may be regarded as the second epoch, at which this bone shows a more rapid rate of development. It was stated that within two months subsequent to birth, the angle of the lower maxilla became less obtuse; and in tracing the same point in jaws of progressive ages, it may be seen that but little further change takes place in respect to the angle until the subject arrives at the third year. But at this age a manifest alteration may be observed. If a line be drawn along the alveolar margin, and across the ascending ramus, it will be seen that the angle formed by this line and the latter part is between fifty and sixty degrees; and that the articular and coronoid processes rise high above the alveolar line. It is important to observe how the angle has been diminished, as the recognition of this process of change will to a considerable extent elucidate the manner in which the adult form is reduced to that assumed by the jaw in advanced age. At the time of birth, the sockets are not deeper than the partially

formed crowns of the teeth. The development of the sockets and of the teeth proceeds together, but the rate of growth is somewhat greater in the bone than in the teeth; so that the walls of the crypts rise above the contained teeth, and eventually arch over and protect them. When the crowns of the teeth are completed, the inverted edges of the sockets are absorbed, and reduced in height until they are lower than the teeth. The crowns of the latter gradually pass through the widened apertures of their respective sockets. When the portions of the teeth which are invested with enamel have passed the edges of the bone, development of the latter is resumed, and keeps pace with the increasing length of the teeth. Now, if attention be directed to the mental foramen at the several ages which have been noticed, it will be seen that from first to last this aperture is in close connection with the terminal portion of the first temporary molar; indicating that the gradually increased depth of the jaw has been obtained by additions to the alveolar edge of the bone. If equal additions had been made to all parts, the relations between the body and the rami would have been maintained. But growth elsewhere is relatively slow, hence the angle formed by the two divisions of the jaws has become changed contemporaneously with rapid growth of the alveolar margin. The rami have been gradually elongated. Their rate of growth is not, however, subject to sudden acceleration, as in the case of the alveolar border; a condition which is compensated by the protrusion of the several teeth taking place at different periods in different parts of the jaws. If, for instance, the whole of the temporary teeth were cut at the same time, and the growth of the alveoli were equal throughout the whole line, the elongation of the rami must assume a sudden activity, otherwise the front part of the mouth could not be closed. With deficient length of the rami, the molar teeth alone would come in contact,—an abnormal condition not very rare in the adult, and to which I shall subsequently advert. In

the child, however, the eruption of the front teeth, and the subsequent rapid development of their alveoli, produce depression of the chin when the mouth is closed; at the same time the upper and lower gums, situated behind the front teeth, no longer come in close contact. The rami steadily increase in length, and after a time the back teeth appear through the gums, and occupy the space which has been gained, first by the separation occasioned by the prior development at the front part of the mouth, and afterwards by the lengthening of the rami.

By the uninterrupted but comparatively slow elongation of the rami, and the rapid but successive growth of the front and back parts of the jaws, a relation of parts is brought about by which the whole series of teeth are allowed to be brought in contact simultaneously. If it were necessary to find a reason why the rami should not be subject to irregular rates of growth, similar to, and in accordance with, such as are seen to occur in the alveolar portions of the jaws, a sufficient reason might be found in the fact that bone which is developed in temporary cartilage under ordinary circumstances, increases steadily, and that the articular processes of the lower maxilla are increased in length by development in cartilage situated beneath the surface of the articular cartilage; the development in this situation offering no exception to what appears to be a general law in relation to the development of bone in temporary cartilage. On the other hand, bone may be formed with comparative rapidity upon a free surface of pre-existing bone.

The more acute angle formed by the alveolar margin and the ascending rami in the jaw of the forty-months' subject, as compared with younger subjects, has been already mentioned. But if the line formed by the lower border of the body of the jaw be examined in relation to that bounding the posterior portions of the rami, it will be found that the angles formed are more obtuse, hence preserving at these points a greater similarity to the younger jaws; and the condition is maintained so long as the jaw continues to increase in length.

The deep portion of the articular cartilage is to the articular portion of the jaw as regards growth, what the cartilage interposed between the epiphysis and apophysis is to a long bone. If, therefore, the lines last referred to were rectangular, as is the case in some finely-developed adult jaws, we might have a further increase in the length of the rami, and in the depth of the jaws; but it would be difficult to see how the length could be increased in the horizontal portion.

At the age under consideration, the first permanent molar in the lower maxilla lies internal to the anterior portion of the base of the coronoid process; that is, supposing the jaw to be viewed from the outer side. The opening of the socket is contracted, of oval form, and directed upwards and inwards. Posterior to this opening we have the depression for the reception of the pulp of the second permanent molar, which at present lies upon the upper surface of the hinder part of the process of bone covering the first molar, a slight groove passing from the new to the older socket. In the upper maxilla we find a similar condition as regards the first permanent molar. The walls of the socket are strong; the aperture is small, and in a line with the alveolar margin, being directed downwards instead of downwards and backwards, as in the younger examples. On the posterior surface of the tuberosity a slight depression may be observed, connected, as in the lower jaw, by a shallow groove with the socket of the first molar. In this depression we have the earliest indication of a crypt for the reception of the pulp of the second permanent molar of the upper jaw.

In jaws from a specimen aged four years, the incisor teeth are the only ones which are really perfected. The roots of the others are slightly deficient in length, and are hollow at their extremities. Four or five additional months would probably have served for their completion. At the commencement of the sixth year the temporary teeth are all fully formed, a condition which is most likely attained six months prior to this period; but there are not specimens of determined ages ranging between the fourth and fifth year

suitable for the elucidation of the point. Seeing, however, that at the termination of the fourth year the development of the first set of teeth is not completed, and that at the commencement of the sixth year these teeth are perfectly formed, it may be assumed that at four and a half years of age the primary dentition is completed.

Much of course depends upon the health and vigour of the child, and upon consideration of race ; thus an Eskimo child of a year old was found to have sixteen teeth, and the sister aged twenty-five months had the milk dentition complete.

Having traced the progress of the temporary teeth from the time of birth up to the period of their completion, and the contemporaneous conditions of the jaws, the further changes in form of the jaws will be resumed in connexion with the development and eruption of the permanent teeth.

In describing the different parts of individual teeth which may or may not hold the normal position, there is some little difficulty in writing intelligibly without first defining the precise meaning of the terms used. The teeth being placed in an ellipse, the terms *anterior* and *posterior*, if applied indifferently in describing the surface of an incisor and a molar tooth, would fail to indicate corresponding parts in the two teeth, and the confusion would be still greater when the teeth are altogether out of the usual position. In order to avoid this difficulty, arbitrary terms must be adopted and used without reference to the actual situation of any individual tooth, even supposing it be misplaced. Thus, the surface which normally is directed towards the lips or cheeks will be described as the *labial* or *buccal*, and that directed towards the tongue as the *lingual*, surface. The surface which lies against a neighbouring tooth, and would, were the dental arches straightened out, look towards the middle line, will be termed the *mesial* surface ; while that which is directed outwards in the front, and backwards in the molar teeth, will be called the *distal* surface.

Irregularity in the position of the temporary teeth is seen in children whose jaws have not acquired the size necessary for the normal arrangement. The defect is usually confined to the incisors, and may be limited to slight crowding and a consequent want of uniformity of position in several contiguous teeth. In three children, members of a large family, one of the central incisors of the lower jaw is in each turned, so that the mesial side of the tooth stands in the position which should be occupied by the anterior or labial surface. The dentition in other respects is regular, both in these and in the brothers and sisters, although the jaws in each child are unusually small. A transverse section of a permanent central incisor of the lower jaw, when taken immediately below the enamel, gives an elongated oval, the long axis of which corresponds in direction with the median line of the mouth. Hence the turning of such a tooth in the jaw would only crowd to a greater degree the contiguous teeth. But the roots of the temporary lower incisors are cylindrical, so that these teeth, when turned in the manner described, give greater room for those near them than would have been obtained had the normal position been preserved. Hence this deviation from the usual arrangement must be regarded as a means taken by nature to accommodate the want of concordance between the size of the teeth and the size of the jaws.

Irregularity in the number of the temporary teeth.—As regards the number, a child may have either more or less than the twenty. Instances are cited in which the jaws have been entirely edentulous, as in some of the families of hairy persons, and the author has been informed that a girl, about fifteen years old, was then, and had been from the time of her birth, entirely edentulous, and that the lower part of the face preserved the appearance usually presented by a child prior to the eruption of the teeth. Such cases, however, must be extremely rare. A diminution in the ordinary number of temporary teeth is, however, not so uncommon. Thus there are figured two instances in

which the lateral incisors are absent—one in which they are wanting in the lower (Fig. 10), the other in which they are absent in the upper, jaw (a view of which will be found in a subsequent figure). These cases of deficiency in the number of the first teeth possess but little practical interest, and, in a physiological point of view, we can do nothing more than recognise the bare fact. We are as little able to account for the absence of a temporary tooth usually present, as to determine why twenty, rather than a smaller or greater number, constitute the normal series.

The presence of teeth in excess of the usual number demands more attention, as we may in certain cases be called upon to determine whether or not they should be allowed to remain. Cases arise in which there are five incisors in the lower jaw, uniformly arranged, and with no peculiarity in the form of either; so similar indeed, that it is difficult to determine which should be regarded as the supernumerary tooth. In the series, there is an upper jaw, the age of which is probably five years, having two supernumerary teeth. They are placed behind the central incisors, near the median line of the jaw; have conical crowns and roots, the latter being a little short of completion. Indications are present of their having passed through the gum, or rather the palate, for they are situated posterior to that part which is usually designated gum. The circumstance that the other temporary teeth are fully formed, while these are not quite completed, might lead to the question, whether they should not be reckoned as supernumeraries of the permanent teeth; but examination of the latter shows that the enamel of the most forward of them is at present incomplete, and that the formation of the roots has not commenced. Hence it is fair to conclude, that the palatal teeth are supernumeraries of the first set of teeth. In this case it is quite possible that articulation was to some extent interfered with, and if so, their immediate removal would have been desirable, as was the case in a child, aged five years, who was brought, having a supernumerary tooth similar in character

and in position to those last described. The tooth was removed in consequence of a difficulty in articulation, which arose contemporaneously with its appearance in the palate.

Another case came under treatment, in which the central and lateral incisors were united, and to these a third tooth was attached; this, the supernumerary, was united through the greater part of its length to the lateral. When the time arrived for the eruption of the permanent central incisor, the removal of the three became necessary. It was then seen that the root of the central incisor had been absorbed, but that the corresponding parts of the other two teeth retained their full dimensions. I have seen other instances of an unusual number of temporary teeth, but the excess has always been in the incisors themselves, or in their neighbourhood. Similar examples are recorded by many writers on the subject of dental surgery.

FIG. 18. (1)

The temporary appear much more exempt from individual deformity than the permanent teeth. I have but one example. In this a strongly-pronounced conical cusp arises from the posterior surface of a central incisor.

Geminated teeth.—Another deviation from the ordinary course of development remains for consideration, which, like the preceding instances of departures from the usual laws, cannot be considered in connection with those conditions which are attributable to disease. The pulps for the development of the individual teeth are not only distinct from each other, but are contained each one in its own crypt. Occasionally, however, the alveolar septum is absent, and

(1) Temporary teeth. The central and lateral incisors, left side of the upper jaw, together with a supernumerary tooth, united. The root of the central had been absorbed, and the permanent tooth was ready to pass out of its socket; hence the removal of the united teeth was necessitated. The patient, a female, was eight years of age. The other teeth were free from peculiarities.

two become laterally united, and the teeth produced from the adherent pulps form one mass, distinguishable from one another only by the presence of a more or less distinctly pronounced groove which marks the line of confluence. Sometimes the crowns of the teeth are more or less distinct, the roots only being united ; while in others the crowns are united, and the roots are to some extent separated. At the points of union the dentine is common to the two teeth, the cementum or the enamel, as the case may be, forming a common investment. This condition was known to M. Desirabode, who says, "The union of the crown is a real fusion of the two teeth in which the ivory substances are common to each other."(1).

The central and lateral incisors, or the lateral incisors and canines, appear to be the only teeth of the temporary set

Fig. 19. (2)

Fig. 20. (3)

subject to gemination. The accompanying figures illustrate the appearances presented by united teeth. (Figs. 19 and 20.)

(1) American Journal of Dental Science, 1847.

(2) Shows the front view of the lateral incisor and canine from the left side of the under jaw, united throughout their entire length, but with the line of junction well marked. The age at which they were removed was seven years. The corresponding teeth on the opposite side of the jaw were similarly united.

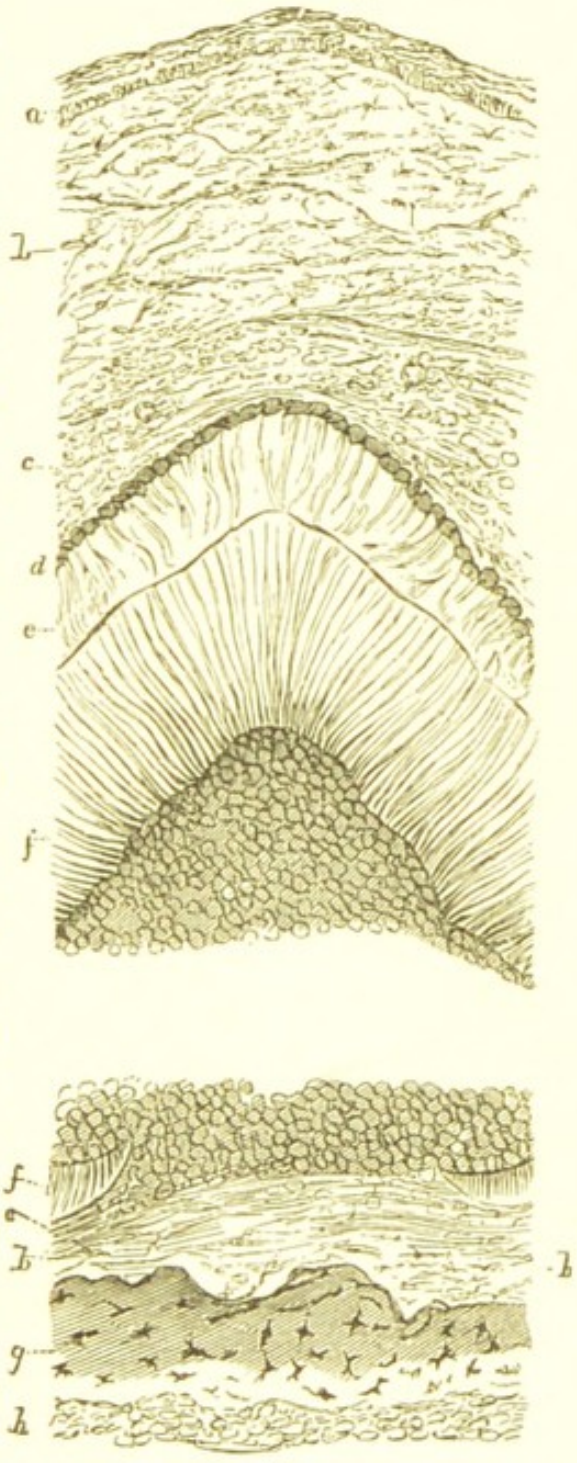
(3) Shows the representation of the lateral incisor and canine from the left side of the lower jaw of a patient aged nine years. In this example the line of junction is less distinctly marked than in the preceding illustration, and is altogether wanting near the base of the enamel.

This abnormality is not very uncommon; and Mr. Brookhouse, of Manchester, met with two good examples of geminated teeth, in which the laterals and centrals were joined laterally throughout their length, and had a pulp cavity common to the two teeth. This was the more apparent in consequence of their removal (necessitated by caries) prior to the completion of their roots, so that an opportunity for a complete examination was given. A transverse section through one of the specimens, made immediately below the termination of the enamel, exhibits the common pulp cavity constricted at the point corresponding to the line of junction, and dilated at either extremity.

The eruption or cutting of temporary teeth.—If we decalcify the lower jaw of a nine months' fœtus, and make a section through the gum and jaw, passing through one of the developing teeth, the tissues will be exposed in the following order:—First, we have a thick layer of epithelium, the cells of which are flattened, but gradually increase in thicknes the further they are removed from the surface, and eventually terminate in a series of slightly elongated cells, the stratum Malpighi. Below the epithelium comes a thick layer of stellate areolar tissue, the meshes of which are comparatively large and open. In the meshes of the areolar tissue a few free cells may be found, but they are not abundant. Blood-vessels traverse this texture in considerable numbers. Near the lower boundary they become more abundant, are of larger size, and the tissue itself becomes more condensed. The fibres are placed nearer each other, and assume collectively the form of an ill-defined fibrous membrane, which dips down within the socket in the form of a sac—the sac or outer investment of the developing tooth. Still proceeding from above downwards, after passing through the upper part of the sac we come to the "enamel organ," then to the dentine and the dentinal pulp, which at its base merges into the lower portion of the sac, without any definite line of separation or structural distinction between the two. Below this, again, we have a little loose areolar tissue which

connects, although but feebly, the sac with the bony socket. Then comes the bone, which forms the base of the socket on its one surface, and the lower border of the jaw on its other; succeeded by the periosteum, which on its osteal surface is in great part formed of nucleated cells, the bulk of the membrane being made up of fibrous tissue, tending in character rather towards the stellate areolar tissue, than to the fibrous tissue of older subjects.

FIG. 21. (1)



After the crown of a tooth has been formed, before it can be cut, the aperture of the socket must be enlarged, and the coat of the sac immediately above the crown of the tooth removed, together with the superimposed fibro-areolar tissue and epithelial layer. These parts—which stand in the way of the eruption of a tooth—may, however, be removed in such strict accordance with the rate of growth and outward progress of the tooth—growth and waste may be so nicely

(1) Showing the relative position of the tissues exposed in a vertical section through the lower jaw of a nine months' fœtus. *a*, series of elongated cells, forming the base of the epithelial layer; *b*, stellate areolar tissue; *c*, condensed tissue, forming dental sac, on the inner surface of which is the enamel pulp; *d*, the enamel organ; *e*, the enamel; *f*, the dentine, with the dentinal pulp; *g*, the bone forming the lower border of the jaw; *h*, the periosteum.

balanced—that the subject of these changes suffers no inconvenience. In some children tooth after tooth appears without any premonitory symptoms. The period of teething comes and goes, attracting attention only when a new tooth is discovered. Instances of teething such as the foregoing are comparatively rare, and can only occur in children who are and have been in all respects perfectly healthy, which involves a series of conditions which our artificial state of living does not tend to bring about, even if it can allow.

Residence in crowded cities, even in members of the middle classes, seldom fails to produce some amount of injurious influence upon childhood; and among the working classes, insufficient or improper food greatly tends to increase the evil which the want of a good atmosphere has been sufficient to create. Even among the agricultural population we often find great crowding in the individual dwellings, a scarcity of animal food, and, by way of making the matter worse, a perfect indifference to the condition of the precincts of the cottages. A stagnant pond or a filthy ditch, into which is thrown the refuse from the house—one or other, or both, are found in most of our rural villages, within a few yards of the labourer's house. The almost universal presence, in one form or another, of these disturbing causes, is attended with a loss of that balance of the various functions of the body which constitutes perfect health. Hence we find that but few children pass through the period of teething without suffering. In some cases the attendant ailment is slight and unimportant; in others, maladies arise which endanger life. The management of children during the eruption of the temporary teeth is seldom entrusted to those who confine their practice to dental surgery, and therefore their knowledge of the coincident disorders necessarily becomes limited, a condition which has arisen within the last seventy or eighty years. Many of the earlier writers upon dental surgery were evidently consulted in cases where disease was supposed, correctly or otherwise, to arise from obstruction to the eruption of the temporary teeth.

Dentition as a cause of local and constitutional disturbance.—In estimating the amount of influence dentition may have in the production of disease, those changes in the teeth, and in the parts connected with them, which are described in the foregone pages, must be kept in the mind; but not those only. There are other parts in the alimentary tract which in the healthy subject undergo concordant changes. Dr. West, in his valuable work "On Diseases of Infancy and Childhood," has brought together many of the facts which bear upon this subject; in his words:

"The shape of the human stomach in the first month of existence approaches that which it retains through life in the carnivora, in whom the process of digestion is more simple than in any other mammalia. It is long, but little curved, growing narrower toward either end, where it passes into the œsophagus on the one hand, and into the intestine on the other. Its small curvature is but little arched, and approaches nearly to a straight line; the large curvature is but slightly developed, and runs almost parallel with the other,—characteristics which are all found in the stomach of carnivorous animals. Compare with this the form of the stomach in the adult. It is altogether more rounded: the œsophagus no longer enters at its left extremity, but nearly midway between that point and the pylorus. The pylorus itself is drawn back towards the cardia, and the two orifices are thus brought near to each other: hence the small curvature is very short; the great curvature of considerable extent, forming not merely the whole under part of the circumference of the stomach, but likewise bounding the whole of that pouch which is situated beyond its cardiac orifice. Besides this, too, the transition from the pylorus to the intestine is gradual in the child, while in the adult the demarcation between stomach and intestine is well marked. The result of all this is, that in the adult, who is an omnivorous animal, the stomach presents a form not unlike that which it has in some of the rodents—as the rat and the rabbit; and that the food, in the course of diges-

tion, undergoes somewhat of a rotatory motion, not the simple onward movement which is communicated to it in the stomach of the carnivora. The stomach of the adult, then, is framed to act upon substances which may require some time for their digestion, while that of the infant is ill suited to retain matters long within it, and its small size unfits it for receiving much at once. If, therefore, the food given to an infant be such as can be digested with facility, it soon passes out of the stomach, and the infant speedily seeks for more. Nor are these arrangements, calculated for the rapid digestion of easily assimilated food, confined to the stomach of the infant, but the form and proportions of the intestines correspond thereto: the small intestine is relatively shorter than in the adult; the large intestine of smaller calibre; the cæcum less developed; whilst the peristaltic action of the bowels is more rapid than in later life; excrementitious matters are quickly expelled, and the healthy infant passes three or four evacuations in the twenty-four hours."

Thus it is shown that while the organs of mastication are coming forward for use, the alimentary canal is at the same time assuming a form suitable for the digestion of substances that require to be masticated before they are passed into the stomach. And it may be assumed if the normal relations existing between the dental and digestive apparatus, as regards their respective rates of development, be disturbed, that the child will become predisposed to disease.

The tables of mortality, under the head of death from teething, give over four per cent. of the whole number of deaths under the age of twelve months, and over seven per cent. between the latter age and three years. In these cases death is not, presumably, supposed to arise directly from disordered dentition, but from disease produced by teething. But before full credence is given to facts advanced in these returns, it should be shown that the disordered dentition is not itself a secondary affection, or that its cause was in-

capable of producing the fatal disease. There is a lack of records of careful post-mortem examinations of the teeth and jaws, in cases of death attributed to abnormal dentition. It should be shown, in individual cases the symptoms of which had been watched, in what particular the process of teething differed from the normal course—whether the crowns of the teeth being ready for eruption, the margins of the alveoli had not been sufficiently dilated by absorption of the bone to allow of their passage towards the surface of the gums, or whether the gums only impeded the eruption of the teeth; and moreover, that in the presence of other unnatural conditions, the dental was the primary affection—that it was, in truth, the first link in the chain of disordered actions. There can be but little doubt that difficult dentition has been overrated as a cause of fatal disease occurring during the period of its presence. This has been strongly felt by Dr. West, who says:

"The error which has been committed with reference to this matter, not merely by the vulgar but by members of our own profession also, consists, not in overrating the hazards of the time when changes so important are being accomplished, but in regarding only one of the manifestations—though that, indeed, is the most striking one—of the many important ends which nature is then labouring to bring about. A child in perfect health usually cuts its teeth at a certain time and in a certain order, just as a girl at a certain age presents the various signs of approaching puberty, and at length begins to menstruate. In her case we do not fix our attention solely on the menstrual flux; nor, if it fail to appear, do we have recourse to the empirical employment of emmenagogue medicines. We examine into the cause of its absence; try to ascertain whether it depends on the state of the health in general, or of the uterine system in particular, and regulate accordingly our attempts at cure. The epoch of dentition is to be looked at just in the same way as that in which we regard the epoch of puberty. Constitutional disturbance is more common,

and serious disease more frequent, at those times than at others; but their causes lie deeper than the tooth which irritates the gum that it has not yet pierced in the one case, or than the womb which has not yielded the due discharge of blood in the other. You might produce hæmorrhage from the uterine vessels in the latter instance, or might cut through the gum which enclosed the teeth in the former, with no other effect than that of aggravating the condition of your patient."

Yet the phrase, "Bel enfant jusqu'aux dents" gives expression to a belief very widely spread, and unfortunately too well grounded, that this is the period at which many a child becomes sickly, and perhaps never again recovers strength.

Dr. Copland gives the following definition of *Difficult Dentition*:—"Slow or retarded evolution of the teeth, with signs of local irritation and constitutional disturbance, often with disorder manifested especially in the digestive organs and nervous system, occurring chiefly in weak or over-fed children." In describing the local symptoms we must again borrow from Dr. West:

"Though a perfectly natural process, dentition is yet almost always attended with some degree of suffering. Many of us, no doubt, can remember feeling much pain when we cut our wisdom-teeth, and children probably experience the same kind of annoyance. This, however, is not always the case; for sometimes we discover that an infant has cut a tooth, who had yet shown no sign of discomfort, nor any indication that dentition was commencing, with the exception of an increased flow of saliva. More frequently, indeed, the mouth becomes hot, and the gums look tumid, tense, and shining, while the exact position of each tooth is marked, for some time before its appearance, by the prominence of the gum; or the eruption of the teeth is preceded or accompanied by somewhat different conditions of the mouth, in which there are much heat, and intense redness of the mucous membrane, an extremely

copious flow of thin saliva, and a disposition to the formation of small aphthous ulcerations on the tongue, at the outer surface of the alveolæ, or at the duplicature of the lip, though the gums themselves may not be particularly swollen or painful. Either of these states is usually attended with some degree of febrile disturbance, and apparently with considerable suffering to the infant, who is constantly fretful and peevish, or cries out occasionally as if in pain. A third morbid condition of the mouth is sometimes seen, which is usually ushered in or attended by very considerable fever and disorder of the chylopoietic viscera. The gums then become extremely hot and swollen, and unusually tender, especially over some tooth or other in particular, and in that situation we find the gum swollen up into a kind of little tumour. Small unhealthy ulcerations, with a sloughy appearance, often form upon the summit of the gum, and especially around any tooth which has partly pierced through it. To this affection, which is often very painful, and often difficult of cure, the name of *Odontitis Infantum* has been applied by some Continental writers."

One of the most common diseases incident to this period is diarrhœa, attacks of which will come on as each group of teeth comes to the surface, and pass away in the intervals: sometimes, however, from the long continuance of the diarrhœa, the child will pass into the condition of marasmus.

Many of these symptoms, according to Dr. Copland, frequently precede the appearance of the teeth by several weeks, but do not always maintain a uniform severity. Indeed, they may altogether subside and reappear before the teeth are cut. In such cases, the old nurses tell you that the teeth were breeding in the first attack, and in the second cutting the gums. A more probable explanation is, that in the one case they were passing through the alveolar opening—in the other, making their way through the gums. It has been pointed out by Trousseau[1] that teething is not a

(1) Clinical Lectures, Trousseau, vol. iv. (Sydenham Society Edition).

continuous process which, once begun, is carried on without interruption till its completion, but that it takes place in well-marked stages. The teeth are cut in groups, and when one group of teeth is fairly erupted there is a period of rest till it is time for the next group to appear. It will of course be understood by every one who is familiarised with the numerous irregularities arising in dentition, that this definite serial order will in some instances be departed from, though the statement is none the less very generally true.

At an age varying from six to nine months the lower central incisors appear, their eruption being rapid, and being completed in from three to ten days; then comes a period of rest of two or three months, at the end of which the four upper incisors come down into place. Then again after the lapse of some months the lower lateral incisors and the four first molars are cut, their eruption being followed by a considerable lapse of time, amounting often to four or five months, when the four canines commence to come through. The eruption of the canine teeth covers a very long period, taking perhaps two or three months for its completion, and it is during the eruption of these teeth (according to Trousseau) that a child suffers most severely, though a different opinion has been expressed by Dr. West,[1] who considers that the four first molars cause the greatest amount of constitutional disturbance during their progress from the alveoli. The greater time taken by the canine teeth, and the severer symptoms occasioned by them, are accounted for by Trousseau, by the fact that they are the only members of the temporary series which come into place between two other previously erupted teeth, so that they are likely to meet with greater resistance in their transit. But he appears to have in some degree misapprehended the conditions under which the eruption of teeth takes places when he mentions their length of root as

(1) On some Nervous Disorders of Childhood, by Charles West, M.D.

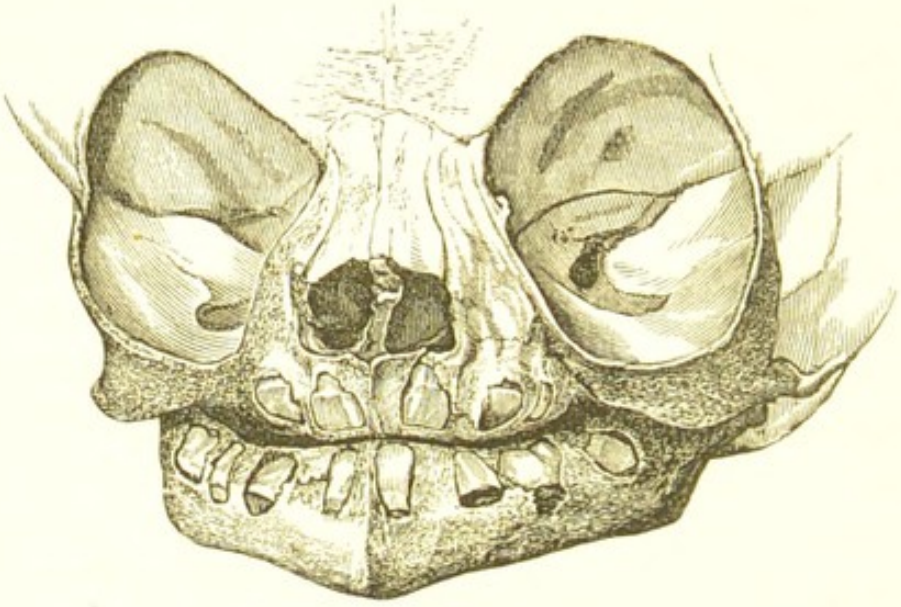
being another difficulty in the way of their easy transit; for the root is not fully formed until the crown is well advanced in its movement towards its final position.

Tubercle does not appear to interfere with the progress of dentition, but rickets does so in a very great degree; in fact great delay in the appearance of the teeth would always lead to a suspicion of the existence of rickets.

Among the collection of infantile maxillæ which has been made, there are several specimens of local disorder which may be noticed at this point of the inquiry. In one example, taken from a subject nearly nine months old, the teeth present no obvious peculiarity either as regards structure or forwardness. The jaws are, however, small, and the bone is unusually porous, the alveoli being at many points imperfect, leaving the forming teeth partly exposed on their anterior surfaces. In a second specimen, twenty-one months old, a similar condition of the maxillæ exists. The incisors and first temporary molars have been erupted, and appear tolerably well developed. Nothing is known of the history of these cases, but surely the unusual condition of the bone of the alveolar processes must have been attended with local indications of disorder. In a third specimen we have the enlarged cranium peculiar to chronic hydrocephalus, accompanied with an absence of the outer alveolar plate, so that the teeth are exposed over the whole of their anterior surfaces. The bone does not exhibit any unusual porosity, the defect being in quantity only,—a peculiarity which is extended to the whole of the bones of the face. (Fig. 22.) In a patient who presented similar conditions, the anterior surfaces of the teeth could be felt through the gums. The child was under the treatment of Dr. West, who tells me that he has observed in cases of this kind dentition is seldom attended with local irritation or any increase of the pre-existing constitutional disturbance. If this be a constant condition, it goes some way towards showing that the local irritation so commonly observed is consequent upon the obstruction offered to the eruption of

the teeth by the margins of the sockets, rather than to that afforded by the gums. Further observation is required

FIG. 22. (1)



before the question can be set at rest. Indeed, this remark may be applied to the whole subject. Some practitioners attribute almost every ailment of infancy to dentition, without, however, attempting to explain how so much mischief is produced, contenting themselves with the general statement, without telling us in what particulars the series of changes which accompany the eruption of the teeth were defective. Other medical men entertain the opinions so clearly set forth by Dr. West.

In addition to the various characters presented by the gums which have been already noticed, there is a condition which is more rare. The gum over the coming tooth is enlarged, but the enlargement is circumscribed, has a blue or purple colour, and yields to pressure. If an incision be made into it, a small quantity of transparent fluid will escape, and we shall find the tooth at the

(1) View of the facial portion of skull of child who had suffered from hydrocephalus, showing the developing temporary teeth, and the defective anterior walls of the sockets.

bottom of the emptied cyst. In these cases, the enlargement apparent on the surface of the gum was obviously produced by the secretion of fluid between the surface of the enamel and the superjacent soft tissue. But it is not certain whether the lining of the cyst was composed of the fibrous tissue which forms the base of the enamel-pulp, or of the stellate areolar tissue which lies external to the latter. There appears to be no connection kept up between the enamel and the tooth-sac when once the former is completed, and it is not improbable that a slight amount of fluid may be present as a normal condition. The inconvenience experienced by the patients appeared to be very slight, and the occurrence of effusion in the sac would merit little attention, but that it offers a probable explanation as to the source of another disease which sometimes arises in connection with the evolution of teeth—a subject which will be considered in a future page.

Hunter, after stating that the teeth, in their advance towards the surface of the gum, exert pressure upon the superimposed parts, thereby causing inflammation and ulceration, goes on to say, "that ulceration which takes place in dentition is one of the species which seldom or never produces suppuration; however,in some few cases I have found the gums ulcerated, and the body of the tooth surrounded with matter; but I believe this seldom happens till the tooth is near cutting the skin of the gums." The condition here described is probably subsequent to the infiltration of serous fluid within the capsule investing the enamel.

The most common result of difficult dentition is a general febrile condition. Hunter says:

"The fever is sometimes slight, and sometimes violent. It is very remarkable both for its sudden rise and declension: so that in the first hour of this illness, the child shall be perfectly cool; in the second, flushed and burning hot; and in a third, temperate again."

Disorders of the nervous system frequently arise at this epoch, varying in intensity from slight muscular twitching

to violent convulsions. The following case occurred in the family of a medical man :—A child, playing round the dining-room table, suddenly fell down in a state of insensibility. The father at the time was absent, and a neighbouring practitioner was called in, who, on examining the mouth, found that the gum was raised, and in a state of tension over a temporary molar. An incision was made down to the tooth, the child immediately recovered its sensibility, and in a few hours was perfectly well. Now, as no medicine was given, and as the insensibility was continued until the gum was divided, it would be too much to assume that the operation and the recovery had no further relation than mere coincidence, especially when it is remembered that the majority of those engaged in extensive general practice could furnish cases similar to the one cited above. On the other hand, we may have convulsions when teeth are about to be cut, and the gums may be lanced with no apparent advantage, the disease running its course towards recovery or death, uninfluenced by the dental operation.[1]

Instances of epileptiform convulsions dependent on the eruption of the temporary teeth are far from uncommon ; and in some few cases where partially erupted temporary teeth have appeared to be sources of irritation, medical men,[2] all other remedies having failed, have in several instances extracted them, with the effect of at once relieving the convulsions. Hunter, whose work on the teeth cannot be too often referred to by those engaged in the practice of dental surgery, or in the treatment of disorders coincident with an abnormal state of the dental apparatus, states: "The partial or local consequential symptoms are the most varied and complicated ; for the appearance they put on is in some

(1) Two equally striking cases of convulsions with considerable pyrexia at once relieved by lancing tumid reddened gums, were communicated by Mr. Stevenson Smith to the Edinburgh Obstetrical Society, and are quoted in the Dental Cosmos, vol. xii., p. 209.

(2) Portal, Observations sur l'Epilepsie, p. 333, and Dental Cosmos, vol. xii., p. 211, in which latter case the patient was in a state of collapse.

degree determined by the nature of the parts they affect; wherefore they imitate various diseases of the human body. These symptoms we shall describe in the order of their most frequent occurrence: diarrhœa, costiveness, loss of appetite; eruptions on the skin, especially on the face and scalp; cough, shortness of breath, with a kind of convulsed respiration, similar to that observed in hooping-cough; spasms of particular parts, either by intervals or continued; an increased secretion of urine, and sometimes a diminution of that secretion; a discharge of matter from the penis, with a difficulty and pain in making water, imitating exactly a violent gonorrhœa."

A case is given in which this disturbance of the urinary organs was invariably coincident with cutting of teeth, the one as it were keeping time with the other. Hunter's own words are: "It was observed at last, that they (the urinary symptoms) returned only upon his cutting a new tooth; this happens so often, regularly, and constantly, that there was no reason to doubt but that it was owing to that cause."

Here, then, we have, on the highest authority, a long list of the many ailments that *may* be consequent upon disordered dentition; and it is for the practitioner to distinguish in individual cases, whether the disease present during the time of teething is consequent upon some derangement of this process, or upon an abnormal condition of some other organ or organs, of which the dental difficulty is but itself a symptom. In forming this distinction, the state of the jaws must be the principal guide. If, in the presence of symptoms which might arise from teeth, we find that teeth are not pressing forward towards the surface of the gums, and that the latter maintain their normal appearance, it will be useless to have recourse to the gum lancet; yet, even in this case, the disorder may be due to, or much influenced by, the teeth. They may be confined by the sockets, a difficulty beyond the reach of mere division of the gum. It is not easy to see how wounding the superjacent soft tissues should promote absorption of the osseous margins of the sockets; yet there

are those who, on all occasions, have recourse to this practice.

There are, however, cases in which this simple operation will at once either mitigate or entirely remove most alarming symptoms; but in such we shall find the gum prominent, and in a state of tension over the advancing tooth. Under these conditions the gum should be divided down to the surface of the tooth, and not at a point only, but across the whole breadth or length of the crown; in fact, the imprisoned organ should be entirely set free.

Then, again, there are cases in which the gums may be lanced with advantage, for the sake of local depletion, without reference to the liberation of the teeth. When we find the part inflamed and painful, this measure may be adopted, but the indiscriminate adoption of this treatment in all cases when the gums are turgid and inflamed will occasionally lead to mischievous results. In children who are enfeebled, either from disease or residence in a bad atmosphere, ulceration of the wounded parts may follow as a consequence of the operation, or in some instances severe hæmorrhage, which has been known to prove fatal.

Trousseau expresses a strong opinion adverse to scarification of the gum, which is, nevertheless, undoubtedly of great service in some cases, and it will be long before the practice is abandoned, if indeed it ever will be.

For a detailed account of the symptoms and treatment of those diseases which may be occasioned or aggravated by abnormal dentition, the reader must be referred to works treating upon the diseases of infancy and childhood. These are subjects which seldom come under the notice of the dental surgeon; but he, having his attention constantly directed to the organs of mastication in all their varied conditions, should be able to point out any deviation from the normal state of the teeth and jaws with greater precision than those whose practice ranges over a wider field. The conditions necessary to the acquisition of this special knowledge pre-

clude the possibility of his gaining an amount of practical information upon the general subject of disease sufficient to place him upon an equality with those who devote themselves to the study of the diseases of infancy and childhood.

Relations of the temporary to the developing permanent teeth at the period when the former are fully formed.—If we select for examination perfectly well-formed jaws from a subject in which the first permanent molars have not appeared through the gums, but in which the temporary teeth are all perfect, we shall find that each member of the latter set has become slightly separated from its fellow,—a condition indicating that the growth of the jaws has been in all respects normal, and consequently that a good and well-arranged set of permanent teeth may reasonably be expected.

The crowns of the permanent incisors, both of the upper and lower jaws, are perfected, excepting perhaps at that part where the enamel terminates. There the dull and chalk-like appearance which that tissue presents when the development is progressing, may be observed. The canines are still less advanced, while the crowns of the first bicuspids have not attained to more than two-thirds, and those of the second bicuspid to not more than a third, of their ultimate lengths. The crowns of the first permanent molars are, as respects their external surface, fully developed; and the septa of dentine which extend across the base of the pulps marking out the several roots yet to be developed are fully pronounced. The second permanent molars are at present represented by about two-thirds of their crowns, and invested with a thin layer of partially developed enamel. The positions of the pulps of the wisdom-teeth are but faintly indicated by slight depressions in the bone posterior to the sockets which contain the forming second molars. These marks may, however, at this period, be altogether wanting.

The position of the temporary teeth in the jaws differs

from that of the permanent set in being perfectly vertical. The crowns do not occupy a more forward position in the dental circle than their respective roots; the crown of each tooth is directly over or under (as the case may be) its own root, the latter standing immediately in front of one or other of the successional teeth.

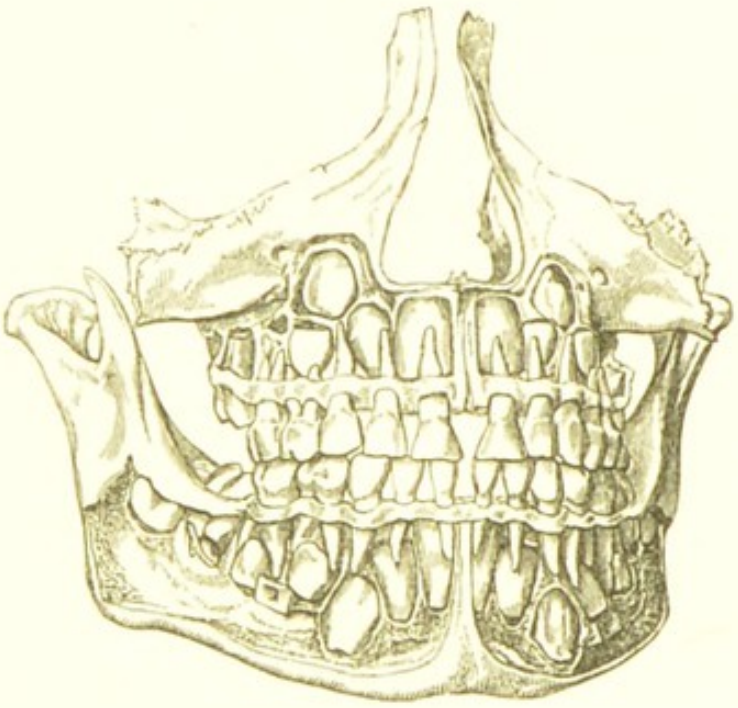
On removal of the bone from the anterior surface of the maxilla, it will be seen that the permanent central incisors are placed nearly parallel with each other, the cutting edges in the upper teeth being inclined a little forwards, while the parts corresponding to the base of the crowns of the two teeth respectively are placed immediately below the floor of the nose, from which cavity they are separated by a thin layer of bone only. The teeth at this stage of growth completely fill the cells or crypts. The corresponding lower teeth hold a similar position in the lower jaw, but have a strictly vertical position, and show a slight advance in development as compared with the upper centrals.

The lateral incisors of the upper jaw have a slightly oblique direction, the cutting edges being more forward than the base of the crowns, which are nearly on a level with the corresponding parts of the central teeth. The labial surface of each is often slightly turned, so that the mesial surface which lies against the central incisor is directed outwards, while the mesial angle of the tooth stands in front of, and a little over the contiguous portion of the central incisor. The point at which the one tooth overlaps the other, corresponds to the position of the root of the temporary lateral incisor. That side of the lateral which in the perfected teeth lies against the canine, here rests against the cell which contains the first bicuspid; while the developing canine is at this period above the latter tooth. In the lower jaw the lateral incisors are placed less regularly, holding a position slightly more backward than the centrals. The tooth on either side is turned from the median line, and lies obliquely over the canine, to the extent of about half of that tooth. They do not, how-

ever, as in the upper jaw, come in contact with the cells that contain the first bicuspids.

The permanent canine teeth at this stage of dentition are situated above the line of the other teeth in the upper, and below it in the inferior maxilla. Those of the upper jaw are directed slightly forwards and outwards, while in the lower jaw these teeth have a direction upwards and a little

FIG. 23. (1)



inwards. The bicuspids are placed in cells situated between the roots of the temporary molars.

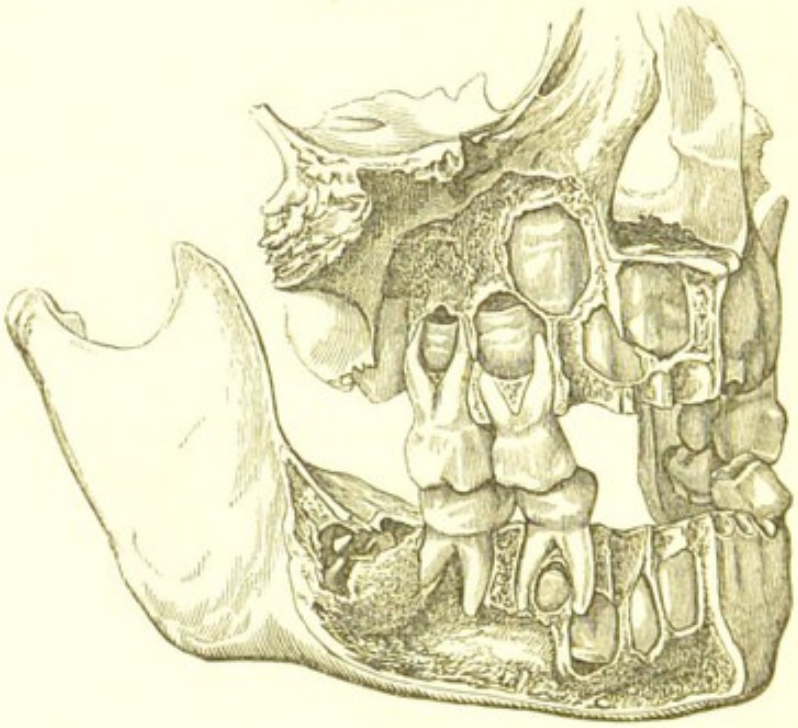
In the specimen which has been chosen for description, and from which the illustration is taken, we have perfectly well grown jaws, showing very completely the relations in position of the first to the second set of teeth, and the relative position of the several members of the latter to each other. It is very desirable that the practitioner should be well acquainted with the conditions which

(1) Shows the relations of the temporary and permanent teeth at the period when the former are perfectly formed, in an example of well-formed maxillæ.

this, in common with many other similar specimens, presents. We see in it all the early conditions necessary to the development of a perfectly regular set of teeth fulfilled.

In another specimen (Fig. 24), the arrangement is equally normal, but differs in one respect from that which has been described. In this case the mesial sides of the upper lateral incisors are placed behind the distal sides of the central teeth. The degree of overlapping is perhaps rather in

FIG. 24. (1)



excess of what may be regarded as a perfect arrangement, and the lateral have descended nearer to the alveolar margin than the central incisors; but still the specimen will serve for illustrating the relative position of the several teeth alluded to, at the same time that it exhibits an irregularity in the position of the right lateral incisor in the lower jaw. This tooth has its mesial edge turned outwards towards the lips, and there is a diminished size of the anterior

(1) Showing the relative position of the two sets of teeth, with the upper lateral incisors descending lower than the central teeth, and the right lower lateral with its mesial edge turned outwards.

part of the jaw, as compared with many other jaws of similar age.

Attention may again be directed to the fact that the temporary teeth are placed vertically in the jaws, and that if their successors were similarly implanted, there would not be room in the upper jaw for the canine teeth. But the upper incisors in the place of a vertical have an oblique direction forwards and outwards towards the lips, while the vertical line is at this age followed by the bicuspids. Now, if we produce an imaginary line through the axes of the upper incisors in their present state, to the extent of perfected teeth, it will be seen that the difference in the direction of the line of growth between the incisors and the bicuspids will lead to a separation between these teeth sufficient to admit the canine into the dental line. In order that this result shall be attained, it is necessary that the relative rate of growth between the several teeth shall remain undisturbed. If, for instance, the canine advances too rapidly upon the lateral incisor, and makes its appearance through the gum before the lateral tooth has advanced sufficiently forwards and outwards, both teeth will be displaced: the lateral will be forced within the proper line and the canine will occupy a place external to it.

Many children, however, either from hereditary tendency or from ill-health and consequent defective growth in the jaws, have the permanent teeth during their development placed irregularly. Attention has already been directed to the fact that the size of the crowns of the teeth is determined at an early age, and is not capable of subsequent alteration. It would appear, however, that a want of proper relation in respect of size between the teeth and the jaws may become a permanent hereditary character, quite apart from the influences of health and disease. In certain families we may see large teeth associated with small jaws, the want of the requisite size in the latter parts necessitating the removal of two or more of the permanent teeth before the regular arrangement of the remaining ones can be assumed

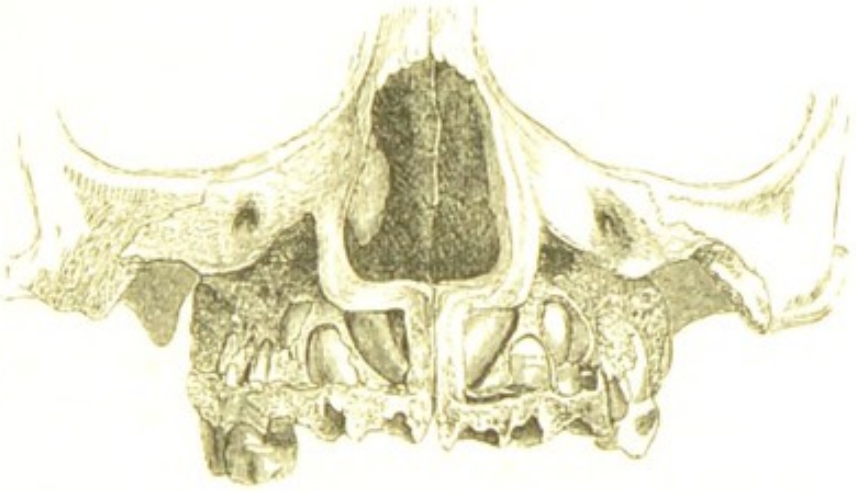
—and this without any indication either of want of constitutional vigour, or of predisposition to disease. It is, in fact, a peculiarity transmitted from parent to child, and must be regarded rather as an hereditary characteristic, than as an abnormal condition resulting from an arrest in the development of the maxillæ, capable of amendment if the patient be subjected to treatment during the period of childhood. It is very necessary that this part of dental surgery should receive far more consideration in an anatomical and physiological point of view than it has hitherto done. In the absence of precise knowledge upon the subject, there is room for great disparity of opinion as regards treatment, leaving a wide and very productive field for the cultivation of the charlatan, who sees in every case of irregular disposition of the teeth an opportunity for mechanical interference, in some cases securing to himself a large fee for doing by means of mechanism that which nature would have effected, had the opportunity been allowed; and in other cases submitting the patient to a long course of treatment, which entails no useful result.

In the subsequent pages a few examples of irregularity during the developmental period altogether prior to the eruption of the teeth are given, as instructive studies.

Irregularity in the position of the permanent, during the existence of the temporary teeth.—The first example selected for description in illustration of irregularity in the position of the permanent teeth, will be that of a child who died when a little over the age of four years. The temporary teeth in the front part of the mouth are crowded, the mesial edges of the lateral incisors of the upper jaw being directed forward, from insufficient space for a more regular position of these teeth. The permanent central incisors, although uniform as regards each other, hold an unusual position. The mesial edges are turned forward, and the cutting edges of the teeth, from the obliquity of the crowns, are directed towards the mesial line. The upper lateral incisors lie in front of the distal edges of the central teeth, and the canines

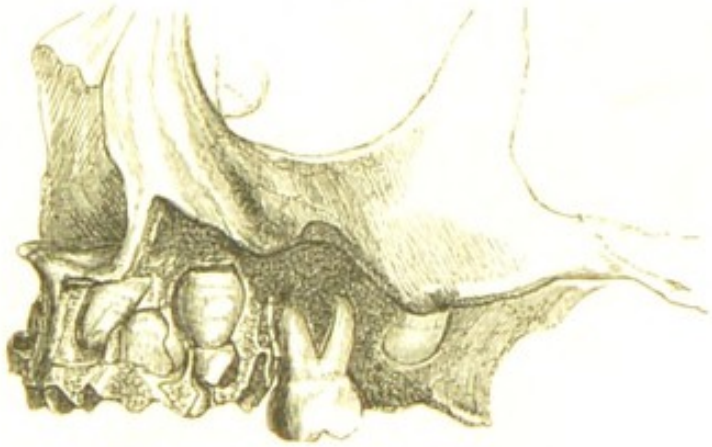
are placed immediately over the roots of the first temporary molars, and consequently immediately over the developing cusps of the first bicuspids. We have in this case a deranged

FIG. 25. (1)



position which, until the teeth have passed through the gums, cannot be materially changed. The development of

FIG. 26. (2)



the teeth has been continued while the jaws have been comparatively stationary. The oblique and twisted posi-

(1) Showing the permanent central incisors, with their mesial sides directed forwards and outwards, while the distal edges lie behind the mesial sides of the laterals.

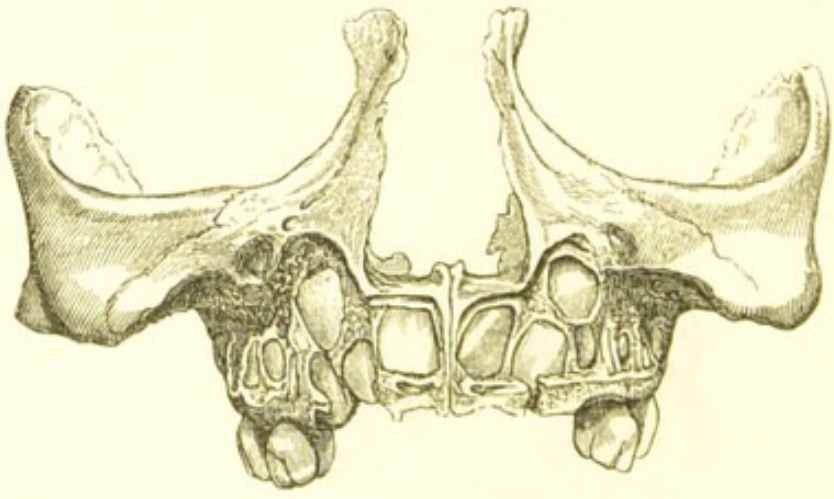
(2) Side view of the same specimen, showing the relative positions of the central and lateral incisors, the canine and the first bicuspids, the latter tooth being interrupted in its development by the canine.

tion of the central incisors will be maintained until they are acted upon by the antagonistic teeth of the lower jaw; and the first bicuspids, which have been encroached upon and retarded in growth by the canines, will be crooked and misshaped, at the same time that they will be forced into an irregular position in common with the impinging canines, leading probably to one or other of the permanent forms of displacement of the later teeth, considered in a future page. In this case, the teeth in the lower jaws are subject to but slight irregularity.

In another specimen, from a subject who died at the age of four years and thirty-six days, the lateral incisors of the upper jaw are placed behind the centrals, the latter teeth and canines being separated only by the common wall of their respective crypts.

In a third specimen, the mesial surface of the left upper

FIG. 27. (1)



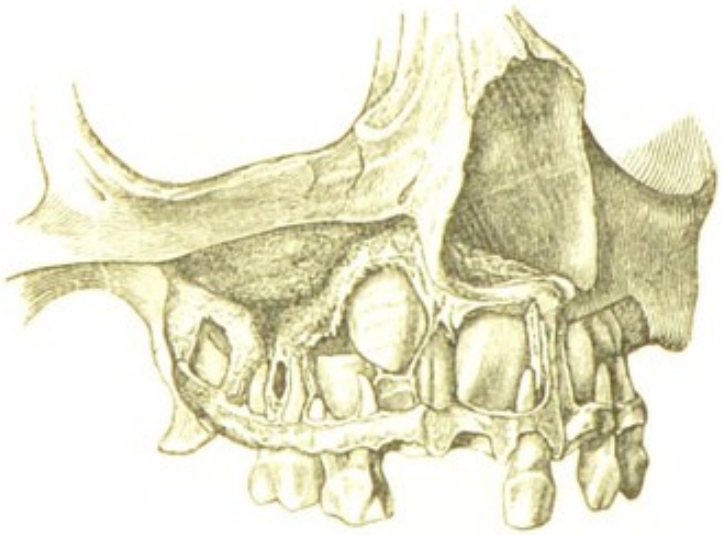
central is turned outwards, while the corresponding part of the fellow tooth is turned inwards. The mesial side of the left lateral incisor lies in front of the distal side of the central, and on the opposite side of the jaw the mesial side of

(1) Shows malposition of the incisors. The left central has its mesial edge turned outwards, with the lateral lying in front of the distal edge. The right central incisor has its distal side everted, with the lateral placed behind.

the lateral is placed behind the distal side of its contiguous central tooth. The canine and bicuspid teeth hold the normal position.

In a fourth specimen we have an arrangement of teeth which may not unfrequently be seen in the adult. The deviation from the natural form is but slight, yet gives a very characteristic appearance to the mouth, and one which indicates a want of activity in the growth of the jaw during

FIG. 28. (1)



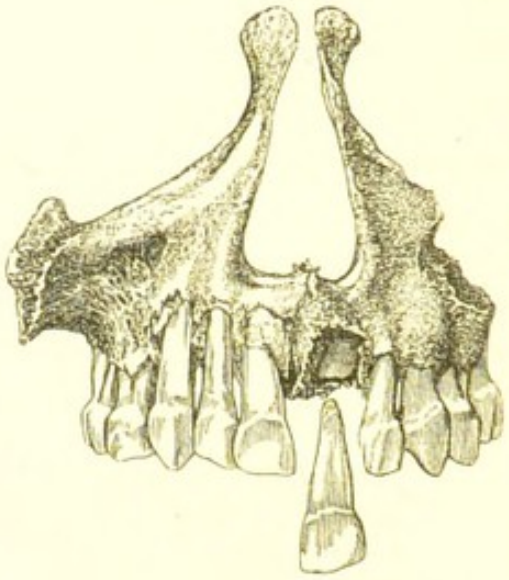
childhood. In this the mesial sides of the upper centrals are slightly everted, while the crown of each tooth, regarded in its length, slants outwards from the median line. Usually, the upper and smaller parts are separated by a wider interval than the lower portions of the crown; in this case the mesial surfaces are parallel throughout the whole length of the crowns. Hence the eversion.

Hitherto, the relations of the teeth to each other and to the jaws, have been considered in cases where the maxillæ present the normal structural appearance, as distinguished from cases in which there are obvious marks of a diseased condition of the bone. In the specimen from which the two

(1) Shows the centrals symmetrically arranged, but with the mesial side of each tooth turned slightly outwards.

succeeding figures are taken, the bone is defective both in the quantity and in the quality of the tissue. The temporary teeth are almost devoid of sockets, while the developing permanent teeth—in the absence of sufficient bone to admit of the existence of normally-formed crypts—are covered at certain points by soft parts only. The subject—a male—from which the maxillæ were taken, died exhausted by

FIG. 29. (1)



strumous abscesses when he was said to be six years old. Both in the upper and lower jaws, the incisors and canines are almost without sockets, and the molars have but imperfect ones. The general dimensions of the jaws, even supposing the age to be overstated to the extent of eighteen months, are a third below the normal size. This has led to the malposition of the permanent teeth. The central incisors of the upper jaws are of the usual size and shape, although the enamel is at certain points defective.

The canines lie with their mesial surfaces in contact with the distal sides of the central teeth, leaving no space whatever for the lateral incisors. These are placed within the

(1) Front view of the upper jaw of a male subject who died at the age of six years, showing a defective condition of the outer alveolar plate and an imperfect implantation of the temporary teeth.

dental arch, behind the temporary canines (Fig. 30), lodged in very imperfect crypts, and placed at right angles to their proper position, the cutting edge of each tooth being directed outwards instead of downwards. The first permanent molars have their crowns nearly perfected, and are placed with the masticating surfaces directed obliquely backwards, the base of the crown running over the fangs of the second temporary molar, and encroaching upon the space which should be occupied by the second bicuspids.

The second permanent molar, the cusps of which are calcified and united the one to the other, is altogether without an osseous receptacle.

In this specimen we have a remarkably good example of

FIG. 30. (1)

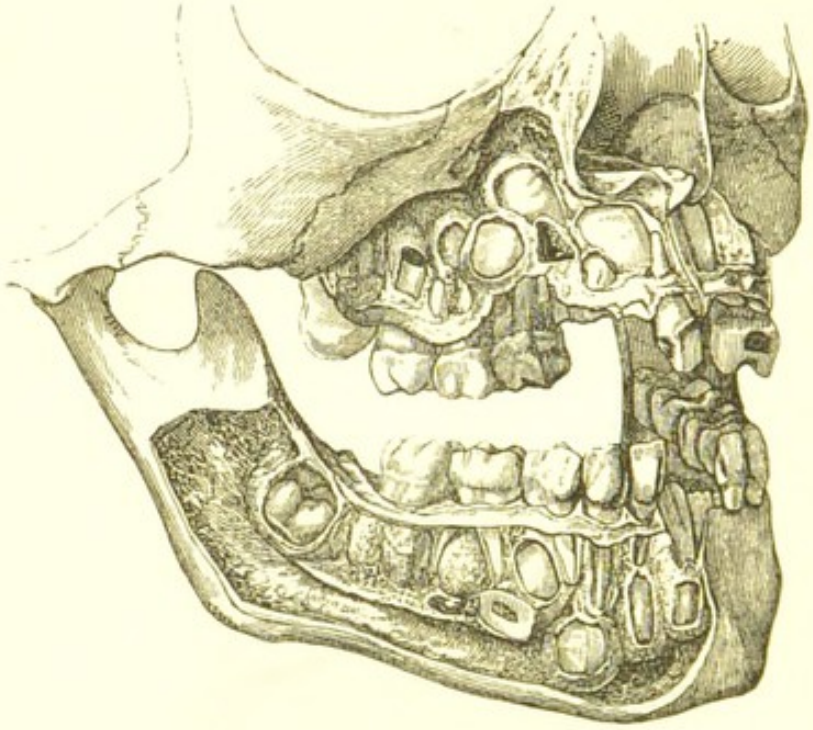
the effects produced from the development of the maxillæ having been suspended, while that of the permanent teeth was continued. We here see the great amount of displacement that may arise from the presence of long-standing constitutional disease.

Local disease in the temporary may also affect the perma-

(1) Palatal view of the specimen illustrated in the last figure, showing an abnormal condition of the bone and the exposure of the permanent canines.

nent teeth; but the effect will be limited to those in the immediate neighbourhood of the disease. Caries, and consequent alveolar abscess, arising in a temporary tooth, sometimes produces injurious effects upon, and even displacement of the succeeding tooth; and this is, I think, a more frequent consequence when the disease is situated in the first or second temporary molars, than when the front

FIG. 31. (1)



teeth are affected. In a preparation figured to illustrate the effects of dead teeth, it may be seen that the developing first bicuspid of the upper jaw has been driven outwards by the mischief arising from the presence of a dead temporary molar.

In addition to the causes already enumerated, mechanical injury of the maxillæ or of the temporary teeth, may be

(1) The upper and lower jaws at the age when the permanent incisors are about to appear through the gums, showing the relative position of the two sets of teeth. The left lateral incisor of the upper jaw is imperfectly developed, and placed external to the central tooth; and the first bicuspid of the same side has been forced outwards by disease, and subsequent death, of the preceding temporary molar.

cited as producing displacement of the permanent teeth while lodged within the dental crypts.

Among mechanical causes, the extraction of temporary teeth may be placed. We have most of us seen examples where removal of the second temporary molar has been accompanied by that of the partly-formed second bicuspid; an accident which has arisen either from the unusual convergence of the roots of the temporary, or from the absorption of the walls of the crypt of the permanent, tooth. The latter condition is not, I think, extremely rare in those cases where alveolar abscess is consequent upon disease in the temporary molar. A certain degree of inflammatory action of the soft parts in the immediate vicinity of bone leads to more or less absorption of the latter, and at the same time the former become glued together by effused lymph. Supposing these conditions to prevail, it will not be difficult to conceive how, in attempting the extraction of one, both teeth may be removed.

Taking the phases of dentition in the order of their occurrence, the next point which presents itself for consideration is the absorption of the roots of the temporary teeth.

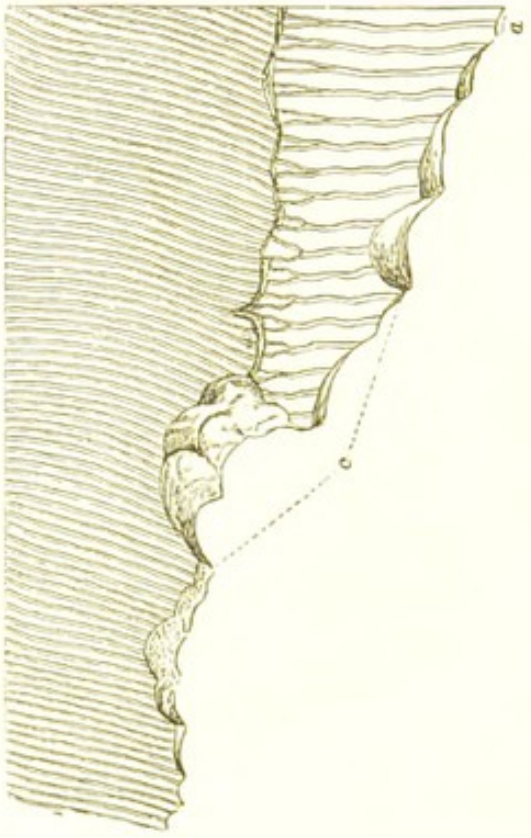
Shedding of the temporary teeth.—No sooner is the temporary set of teeth fully formed, than a process is set up for the removal of some of its members. Within twelve or eighteen months of the completion of the roots of the second molars and canines, the roots of the incisors are attacked by absorption.

The destruction may commence on any part of the root, or at several spots simultaneously. Particle after particle is by degrees carried away, until nothing but the crown of the tooth is left, and even this is often so much hollowed out, that little save the enamel remains, and sometimes not all of that.

Although among a number of temporary teeth we may find that absorption has commenced at several and distant points, and not uncommonly on the labial surface of the

root; yet, in the majority of cases, that part which lies nearest to the growing tooth will be the first to show indications of wasting, and upon which the process will be the most active. The opposed surfaces of the roots of the lower temporary molars, embracing bicuspids, are acted upon, while the outer surfaces usually escape. The lingual surface of the root of a front tooth is commonly attacked, the process commencing at or near the extremity; but the

FIG. 32. (1)



proximity of the permanent tooth is not by any means the point necessary. I have examined many specimens, in which a portion of the labial surface midway between the neck and the point of the root has been carried away.

As was for the first time described in the first edition

(1) A section from a temporary tooth, in which the dentine (*a*) and the enamel (*b*) have been removed by absorption, leaving the festooned outline (*c*).

of this book, the cementum is first attacked, then the dentine disappears, and the enamel at those points where the dentine has been entirely removed suffers from the same action. But whichever of the three tissues is attacked, we see the same characteristic surface as that shown by bone when undergoing a similar action—namely, a surface full of deep indentations, as though they had been made by a sharp

Fig. 33. (1)

piercing instrument, having a semicircular extremity. These minute holes or depressions proceed in various directions, several advancing from contrary points towards the same spot, not unfrequently isolated pieces of dentine. If a section be taken through the substance of a tooth, so as to cut the wasting part at a right angle, we shall find the surface acted upon to have an irregular festooned outline, so characteristic in appearance that when once seen it cannot fail to be again recognised.

Closely applied to this surface a cellular mass will be found, which is but slightly adherent, the wasting and growing surfaces readily parting, unless the two are held together by the irregularities on the surface of the former. It will sometimes happen that the cellular mass penetrates

(1) Shows the compound cells which form the surface of the absorbent papilla.

into the dentine through a small opening, and there dilates, in which case its withdrawal becomes impeded. This condition is now and then found in sections prepared for examination, and affords a favourable opportunity for examining the two tissues *in situ*. Indeed, we may find a few cells adherent to the surface of the dentine where less deep burrowing has occurred. By the aid of the microscope, the structure of this peculiar organ can be determined. The surface is made up of peculiar multiform cells, each one being composed of several smaller cells, the number varying from two or three to as many as fourteen or fifteen. The form is variable, but egg-shaped or spherical figures are found to prevail, although some few deviate from these forms, and offer a very strong resemblance to those cells described by M. Kölliker as myeloid cells.

The relation the more superficial of these cells bear to the wasting surface of the dental tissues is peculiarly interesting. It has been already stated that the surface of the papilla is closely applied to the wasting surface of the tooth ; and in favourable specimens it may be shown that the individual indentations correspond to, and are occupied by, these large cells. On several occasions I have obtained specimens in which the two retained their natural positions. Each semicircular indentation in the dentine was occupied by a compound cell. Very possibly in other cases several cells may take the place of a single cell. Below the surface the papilla is made up of ordinary nucleated cells and free nuclei, similar to those contained in the superficial compound cells ; while at and near the base, the tissue assumes the characteristics of developing fibrous tissue.

If a tooth which has lost its root be carefully removed, we shall find remaining in its place the growing papilla, corresponding exactly in size and form to the surface from which it has been separated ; and this separation may often be effected with so little injury, that no blood appears upon its surface after the operation, although the organ is highly

vascular and readily torn (1). The superficial extent of the papilla will be equal to that part of the tooth undergoing waste, but the extent, as regards depth, is slight; for, as the root of the tooth disappears, the socket is contracted by the deposition of bone, which forms at the base of the absorbent organ as rapidly as the cellular surface encroaches upon the tooth. The cases in which we find an exception to this condition are those in which the permanent has advanced close to the fangs of the temporary tooth, when the crypt containing the one communicates with the socket of the other, indicating that the rate of growth of the permanent, has been equal to, if not greater than, the absorption of the deciduous organ. But even in these cases we may occasionally observe some part in which the contraction of the socket has been coincident with the absorption of the occupant fang.

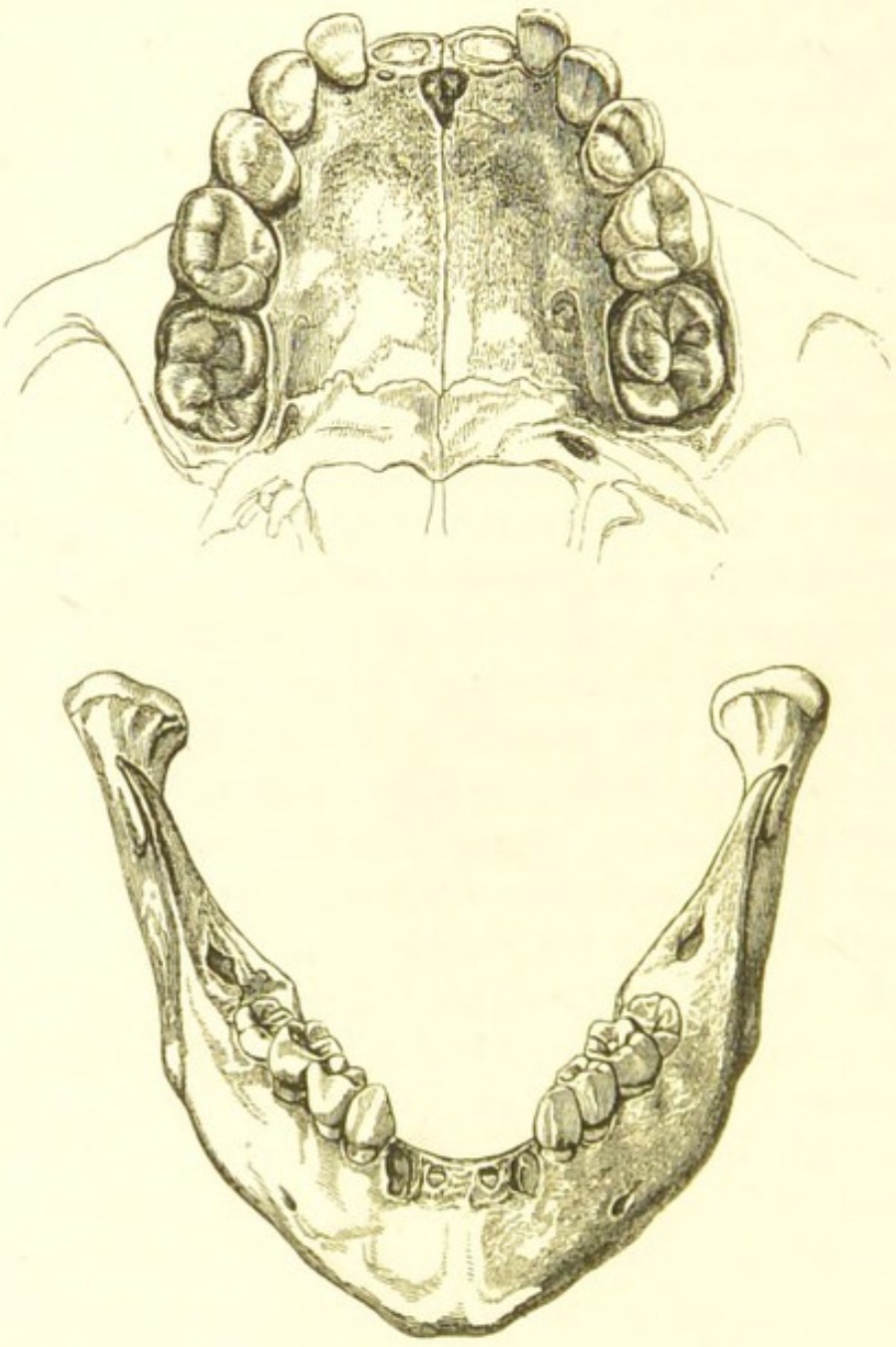
The idea that mere pressure of the one tooth against the other has anything to do with the absorption of the first set must be absolutely rejected; as is proved, if it needed any further proof, by the existence of the shallow but perfect sockets which are formed when the temporary teeth are shed before their successors are ready to appear. This, however, must be a very common condition, as there are many specimens illustrating the point.

The fact was not overlooked, I think, by Hunter, although his description is not very clear. He states, at page 99 in his "Natural History of the Teeth:"—"The new *alveoli* rise with the new teeth, and the old *alveoli* decay in proportion as the old teeth decay; and when the first set falls out, the succeeding teeth are so far from having destroyed by their pressure the parts against which they might be supposed to push, that they are still enclosed and covered by a complete bony socket. From this we see that the change is not produced by a mechanical pressure, but by a particular process in the animal economy."

(1) Laforgue and Bourdet recognised the presence of the absorbent organ, but supposed it exhaled a fluid capable of dissolving the roots of the temporary tooth.

Many cogent reasons for rejecting the idea that pressure has to do with it are to be found elsewhere ("Dental

Fig. 34. (1)



Anatomy," C. S. Tomes, p. 195), but another condition may be adduced, tending also against that opinion,—namely, that

(1) The upper and lower jaw of a female subject, six years and five months old, showing the layer of bone which forms the bottom of the socket of the temporary incisors after the roots have been absorbed.

temporary teeth occasionally maintain their place to the exclusion of the permanent ones, which are then kept within the substance of the jaw, or appear in some unusual position.

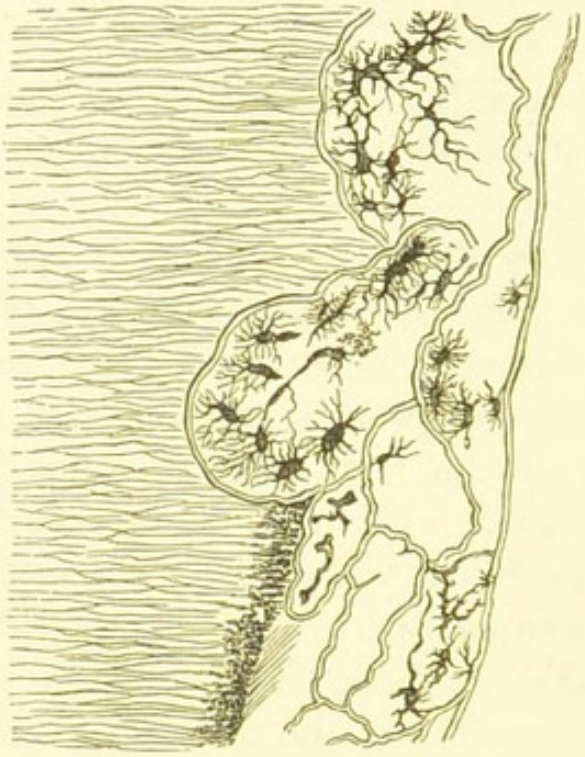
The relations as regards time between the absorption and shedding of temporary teeth and the appearance of the succeeding permanent teeth, are by no means constant. In some cases the temporary teeth are thrown off two years before the corresponding permanent ones come through the gums. In others, again, the new will replace the old ones in as many weeks or even days.

Before the laws which regulate the absorption of the fangs of teeth can be fully recognised, a more perfect knowledge of the condition attending the process must be acquired. When the process of absorption has once commenced, it appears to have been assumed that the action would be continued, with more or less rapidity, until the tooth falls out. Such, however, is not constantly the case. Not only is the action of absorption suspended, but one of development takes its place. We find the excavated surface of the dentine, cementum, and enamel covered with cementum, the latter following all the irregularities of the former tissues, and closely united to them. (Fig. 35.) In cases where this development is going on, or in which the new tissue is retained, the teeth offer considerable resistance when their removal is attempted. In those instances where the first teeth have remained, and tend to the displacement of the second set, this deposit of cementum will be found to exist in considerable quantity.

The development of bone upon the surface which had formerly been the seat of absorption, by no means indicates that the tooth will not again be subject to destructive action. On the contrary, specimens show that the bone deposited under the above circumstances may itself become the subject of absorption, that this process may be again suspended and development be renewed, that the absorption may again take the place of development; in

fact, that wasting and reparation may alternate until, by the preponderance of the former, the tooth is shed. In sections of teeth showing this peculiar condition of development, we may find upon the growing bone numerous osteo-

FIG. 35. (1)



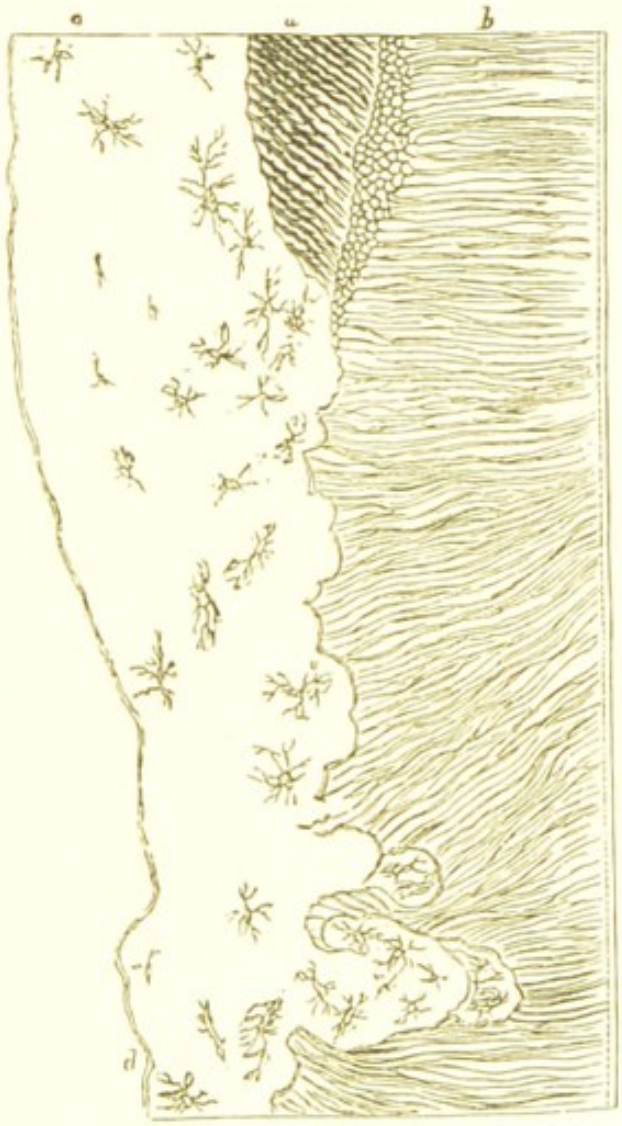
blasts. A bone lacuna, situated within a semi-circular indentation in the dentine, gives the appearance of a lacunal cell, and a lacuna similarly situated in the cementum (a circumstance of common occurrence), has possibly been supposed by Mr. J. Salter to be what has been described in the paper before referred to as a lacunal cell (2).

(1) A section from the fang of a tooth in which the dentine (*a*) has been removed, together with the cementum (*c*), and again made good by the deposition of cementum. The appearance presented at the junction of the dentine and cementum, where absorption has not encroached upon the tissues at that point, is shown at (*b*). The curved irregular line in the cementum indicate the extent of absorption at various periods, and the boundaries of the tissue which has replaced the lost parts.

(2) Transactions of the Pathological Society, vol. vi., p. 169.

The part of a tooth which has the greatest power of resisting absorption is that in immediate contact with the pulp. We find examples in which a thin shell of dentine encircles that organ, while that around it has been in great part taken

Fig. 36. (1)



away. This is, however, eventually removed, and the pulp itself changes its character, and becomes an absorbent organ, or makes way for that which is. In a fortunate selection we

(1) A section from a temporary tooth, the fangs of which have been absorbed, and the crown hollowed out; the enamel having been partly removed, and both tissues coated over with new cementum. *a*, the dentine; *b*, the enamel; *c*, the cementum; *d*, the junction of the absorbed surface of the enamel and new cementum.

may find sections showing in one part dentine which has been but recently formed; in another part, absorption in active progress; and in a third, the deposition of bone on the surface of the wasted dentine. In no instance, however, is dentine deposited upon the surface of that which has been diminished by absorption.

It would appear that the dentinal pulp, although its function may be changed into that of absorption, or its place be taken by an absorbent organ, and this, again, changed to one for the development of bone, is incapable of resuming under any recognised circumstances its primary function of dentinal development. In other words, that a portion of dentine when removed by absorption, cannot be replaced; while in bone, or cementum, the renewal of a lost portion is of frequent occurrence.

It will be seen that the foregoing facts bear upon the opinions advanced by Messrs. Tomes and De Morgan in the paper on the structure and development of bone, before cited; that we have indications in teeth, as in bone, of alternations of removal and of deposition of tissue. In the young subject, the development of bone tissue is in excess of absorption, allowing the bones to increase in size; in middle life the two powers, under ordinary circumstances, balance each other, and the bones preserve their adult dimensions; while in old age the absorbent action appears to preponderate. Conditions pretty nearly parallel occur in the dental tissues after the temporary tooth has been fully formed; portions of cementum are removed, and with them, in some cases, a little dentine; the lost parts are replaced by cementum, more or less, but the absorption being in excess of the development, the tissues disappear, and the tooth is shed. After the formation of the permanent teeth we have occasional alternations of the two actions; but they are balanced, and neither increase nor diminution in size is observed. But as age comes on, it often happens that absorption is in excess, the roots diminish in size, the teeth become loose, and fall out.

The normal shedding of one or more of the temporary teeth is, however, sometimes subject to interruption. The absorption of the roots is suspended, and the tooth holds its place, while its successor is matured within the jaw in some unusual position, or is altogether wanting. It is not uncommon to find the temporary incisors firmly implanted, with the permanent teeth appearing through the gum behind them. In instances of this kind it is difficult to determine whether or not the permanent teeth were developed in a perfectly normal position, and their position subsequently changed by the persistence of the milk teeth consequent on the arrest of absorption, or whether the relative position of the two sets has been from the first irregular; but original malposition of the developing permanent organs is the more probable. Many instances in which the second temporary molars have been retained until the middle period of life has passed, have come under notice. The second bicuspid has been wanting, and the temporary tooth has retained its original position.

The influence of the first and second sets of teeth upon each other at the time of replacement is so constant, and so varied in character, that it becomes impossible to treat fully of all that relates to the disappearance of the one, prior to entering upon the relations of the other. It will therefore be convenient to revert to several points connected with the shedding of the temporary (and especially those relating to treatment), in connection with the eruption and arrangement of the permanent teeth.

The observations at present at our disposal are not sufficiently numerous and varied to admit of the deduction of any general law, as regards the power by which absorption of one tissue by another is effected. But I think they point strongly to the idea, that a cell structure in an active state of development, is capable of appropriating or removing out of its way a matured tissue, however fully it is calcified.

The eruption of the permanent teeth.—Attention has already been directed to the changes in the condition of the alveolar processes antecedent to the eruption of the temporary teeth. Very similar conditions prevail when the permanent organs are about to make their appearance through the gums. It has been shown that absorption of the alveolar margin of the sockets of the first teeth is not necessarily coincident with the removal of their roots, but that the opposite condition very commonly obtains; that absorption of the dental tissues may be accompanied by development of osseous structure. When, however, the permanent tooth is ready to emerge from its bony cell, absorption is again set up, and in this case the bone which lies over the crown of the growing tooth is attacked. The coronal portion of the crypt is enlarged, and the outer alveolar plate emarginated in the manner which we have seen precedes the evolution of the temporary tooth. The aperture becomes enlarged until the crown of the tooth can readily pass through. The comparatively large size of the crown as compared with the neck or the root of a tooth, necessitates a breadth of socket, during the period both of development and of evolution, far greater than is required for the implantation of the fully-emerged organ. Hence a tooth at this stage of its progress can be readily moved from side to side by moderate pressure, and very slight mechanical obstruction will turn it either into or out of its normal position. The presence even of a small portion of the root of a temporary tooth will be sufficient to change the direction; and on the other hand, the action of the tongue on the lips will suffice to bring back the out-growing organ into its natural position, if the impediment be removed during the period of active eruption. The condition to which I have alluded is shown in the enlarged alveolar apertures of the first permanent molar teeth in Fig. 34, and will be seen in connection with other permanent teeth forming the subject of subsequent illustrations.

The provision for a tooth to take its proper place, displayed in the greatly widened socket at the period of erup-

tion, would however be insufficient if the whole of the front teeth advanced towards their ultimate position simultaneously. It has been shown that the crowns, while within the jaws, are necessarily placed in an uneven line, and this irregularity would become permanent if all were to make their appearance through the gums at the same time. But, although the jaws at the age of five or six years do not afford sufficient space for the uniform arrangement of the crowns of the developing teeth, yet there would be ample room for the roots of these teeth to be placed in an even line. It has been stated that the crowns of the forming teeth are inclined slightly outwards, and that the growth of the alveolar arch is principally confined to the free edges and the outer surface. Bone is added externally, while it is being removed from the inner surface of each crypt to allow space for the increasing tooth, at the same time that the tooth is moved bodily forward. If adult specimens in which the teeth and jaws are well formed, be examined, it will be found that growth in the direction indicated has been continued until the parts have arrived at maturity. In the adult the crowns of the front teeth are placed in advance of the base of the nose ; in the child they are in a line vertical to it : and if we measure the ellipse formed by the anterior surface of the upper jaw in a horizontal plane at this level, extending on either side as far as the second bicuspids, and then apply the measure to the corresponding part in an adult, or in an edentulous old person, we shall find the result in each case very nearly similar. In tracing the permanent teeth as they are respectively protruded and take their position in the dental arch, it is desirable to bear the foregoing points in mind. In certain cases we shall find mischief arises from want of growth in the facial bones at the earlier periods of life, but in many instances the deviations from the normal position of the teeth and alveoli are independent of insufficient size of the bodies of the maxillæ; or in other words, cases in which the basal bone has attained its usual extent, while

the teeth are irregularly placed in an irregularly-formed arch.

It is necessary to draw a distinction between the bodies of the maxillæ and the alveolar processes, as it will subsequently be shown that in cases of irregular dentition, the irregularity may depend upon a want of accordance between the general dimensions of the jaws and the determined size of the teeth; or the mal-arrangement may depend solely upon imperfect development, in respect to position, of the teeth and the alveoli.

In describing the evolution of the teeth individually, and the coincident conditions, the chronological order in which they usually appear will be followed.

The first permanent molar of the upper not uncommonly precedes by a few weeks the corresponding tooth of the lower jaw; but I do not know that, in respect to priority, any great uniformity prevails. The conditions presented by these teeth at the age of *six years and five months*, are shown in Fig. 34. In the upper jaw, the bone which lay over and protected the tooth at an earlier age, is entirely removed, not only from the coronal surface, but also to a great extent from the labial side of the crypt; and this has taken place prior to the tooth being raised above the general level of the alveolar margin. It is now, however, in a condition for rapid development of the fangs, and two or three months would have served to bring it to the surface of the gums. On removing one of the teeth from the upper jaw, the roots, although very short and imperfect, are seen to have their respective positions defined, the neck of the tooth being perfected. The enamel has attained its maximum amount, and is deficient only in density. At the age under consideration, the first molars occupy the posterior part of the alveolar arch, the second molar in the upper being confined to the back part of the tuberosity, and in the lower jaw to an excavation in the base of the coronoid process.

In a specimen obtained from a female subject aged *seven*

years, the first molars have gained the level of the temporary teeth, although the fangs are at present very short and truncated ; each fang has its own well-defined socket, the depth of which is equal to the length of the developing root. If a tooth be extracted before decomposition has commenced, it will be found that the formative pulp is contained within the large and open cavity of the fang, projecting only in a very slight degree from the extremity. It looks as though it had been cut off on a level with the end of the root, so abrupt and flat is the termination of the soft tissue. Were it otherwise, pressure upon the masticating surface of the tooth would produce compression of the pulp, as the socket has not yet contracted to the dimensions of the tooth, and the septa of bone which eventually rise between the roots, are not sufficiently developed to take the pressure, and thus relieve the roots from being driven against the bottom of the socket.

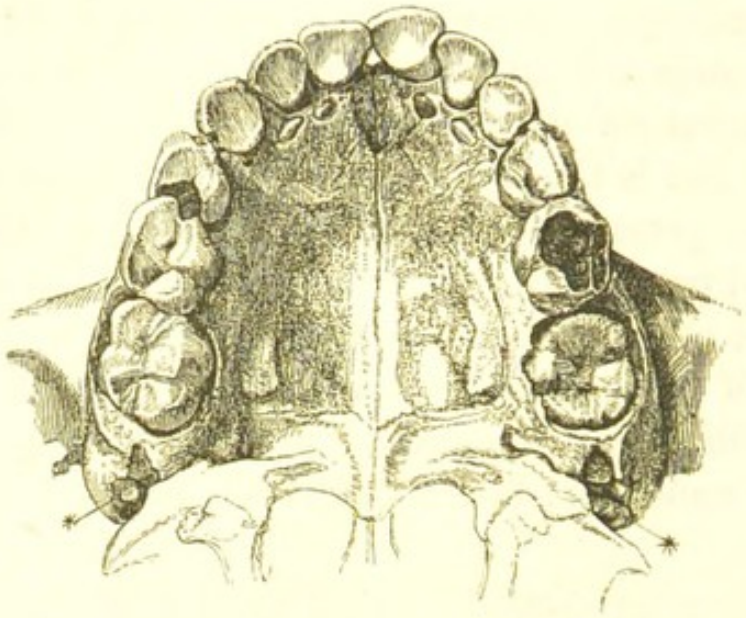
In the accompanying figure (Fig. 37), the molar of the right is in advance of the corresponding tooth of the opposite side of the jaw. On the one side the tooth had appeared through the gum, on the other the surface of the mucous membrane had not been pierced. The position of the second molar is indicated by the asterisk. In the specimen previously described, the first molars occupied the terminal portion of the alveolar arch ; in the present case a small amount of space posterior to them is gained, and the second molars, which were placed at the back part of the tuberosity and directed backwards, are now descending into the dental line, and are directed obliquely downwards and backwards.

In the specimens which have been described, the new teeth have their implanted portions of the full depth of the sockets, the bottoms of which reach in the upper jaw to the floor of the antrum, and in the lower maxilla to the inferior dental canal. This leaves no room for growth in the direction of the deeper parts. The increasing length of each tooth must therefore be accompanied

by an increased depth of socket produced by addition of bone to the free margin of the alveolus.

The development proceeds rapidly until the opposing

Fig. 37. (1)



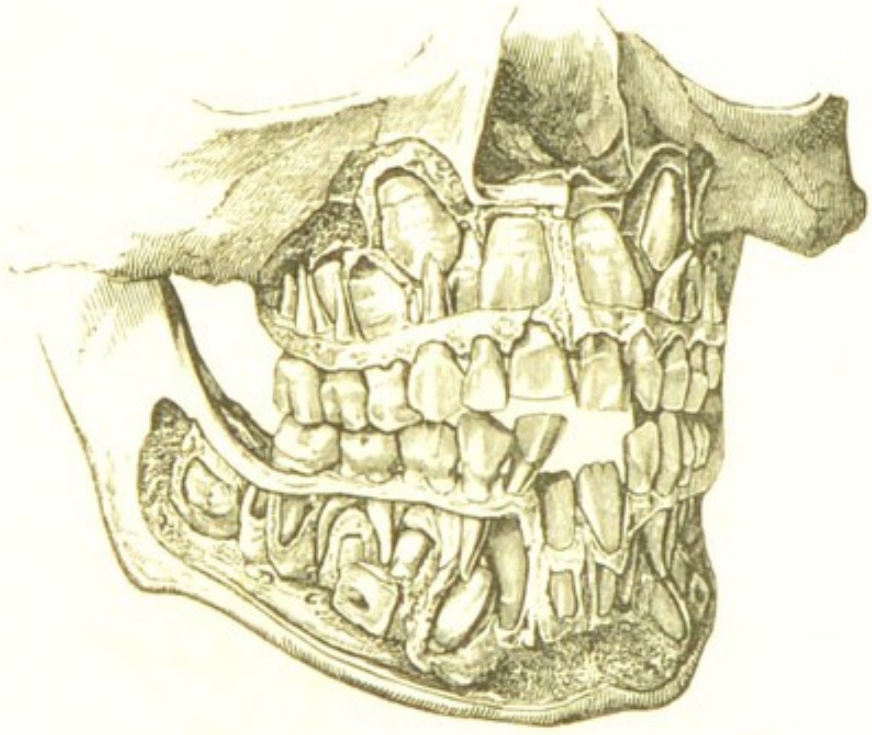
teeth come in contact, when the antagonism becomes adjusted, a process which is rendered easy by the comparatively loose implantation of the teeth.

The teeth which usually succeed the first permanent molars in the order of emergence, are the central incisors of the lower jaw. After the temporary central incisors have been shed, absorption of the corresponding edges of the alveoli commences, and commonly carries away the outer plate to a considerable depth. The condition is shown in Fig. 38; in this case the whole of the bone which lay in front of the crowns of the new teeth has been absorbed. In other instances the waste may be rather more limited, but in all cases the depth of the jaw becomes diminished at the

(1) Showing the condition of the alveolus of the first permanent molar at the time the tooth is advancing to the surface of the gum. The tooth on the right side is a little in advance of that on the left side of the mouth. * The crypt of the second permanent molar.

points corresponding to the teeth, which are about to advance from their osseous crypts to the surface of the gums. The posterior alveolar plate, although diminished in height, usually suffers in a much less degree than the outer surface of the jaw, and consequently offers a less broken outline

FIG. 38. (1)



than that shown in the last figure. If the specimen under consideration be compared with an adult jaw from which the outer alveolar plate has been removed, it will be seen that the open bases of the two advancing incisors hold the position which the ends of the roots of the fully formed corresponding teeth occupy.

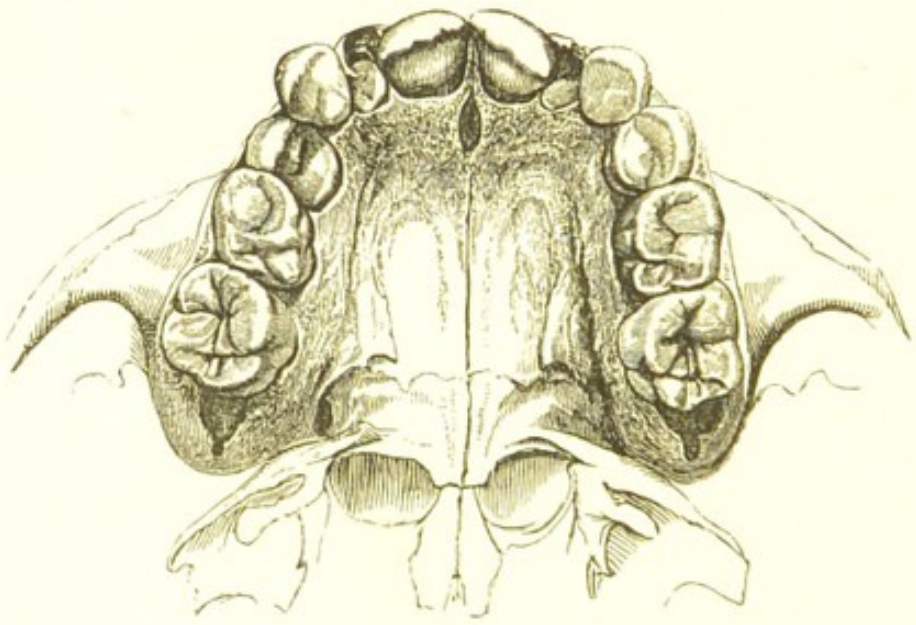
The conditions which have been described as pertaining to the eruption of the lower central incisors, will be found

(1) Shows the relative position of the two sets of teeth, and the absorption of the anterior plate of the alveoli of the lower central incisors antecedent to their emergence. In the upper jaw the roots of the temporary incisor have been removed, and absorption of the edge of the alveolus of the left central incisor has commenced. It will be seen that the depth of the alveoli at this point is equal to the length of the developing teeth.

to accompany the evolution of the upper central teeth; the amount of bone removed by absorption varying with the position and size of the teeth. It is, however, by no means easy to obtain specimens of the age required to illustrate the changes attendant upon the eruption of the permanent teeth. The dealers do not appear to regard them as saleable, and they can be acquired from other sources only at uncertain intervals.

The subject (a female) from which the following figure has been taken, died at the age of seven years and eight months. The central incisors have emerged from the

FIG. 39. (1)



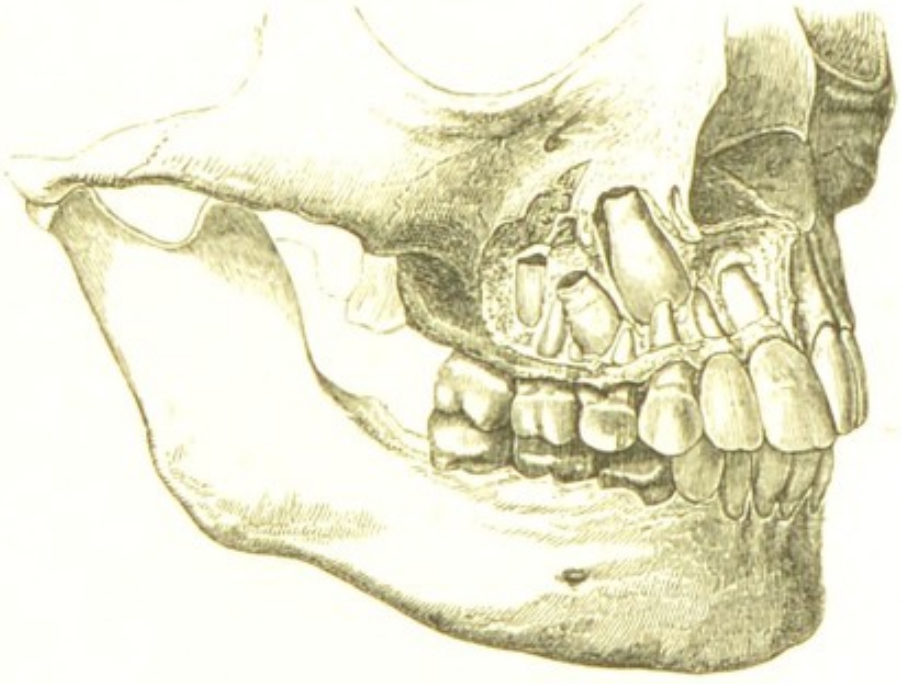
alveoli to the extent of about two-thirds of the length of their crowns, the right being a little in advance of its fellow tooth. The respective alveolar apertures are greatly enlarged, allowing the teeth to be moved either outwards or inwards.

In this instance, the jaw is rather contracted in size, and

(1) Upper jaw of a female subject seven years and eight months old, showing the central incisors taking their place in the alveolar arch. The right tooth is well placed, but the left is a little turned on its axis. The alveolus of each is larger than the contained tooth, affording space for the teeth to assume a normal position.

the new teeth, in the absence of the temporary laterals, have their distal sides situated but a short distance from the canines, leaving insufficient space for the permanent lateral teeth, supposing the present position of the centrals to be maintained. But the provision afforded for adjustment by the enlarged sockets, will allow the crowns of the teeth to take a more forward position, which, as they descend obliquely outwards, will be still further increased until the teeth have attained their full length. And thus the

FIG. 40. (1)



space, at present too limited for the normal arrangement of the neighbouring teeth, will eventually become sufficiently extended.

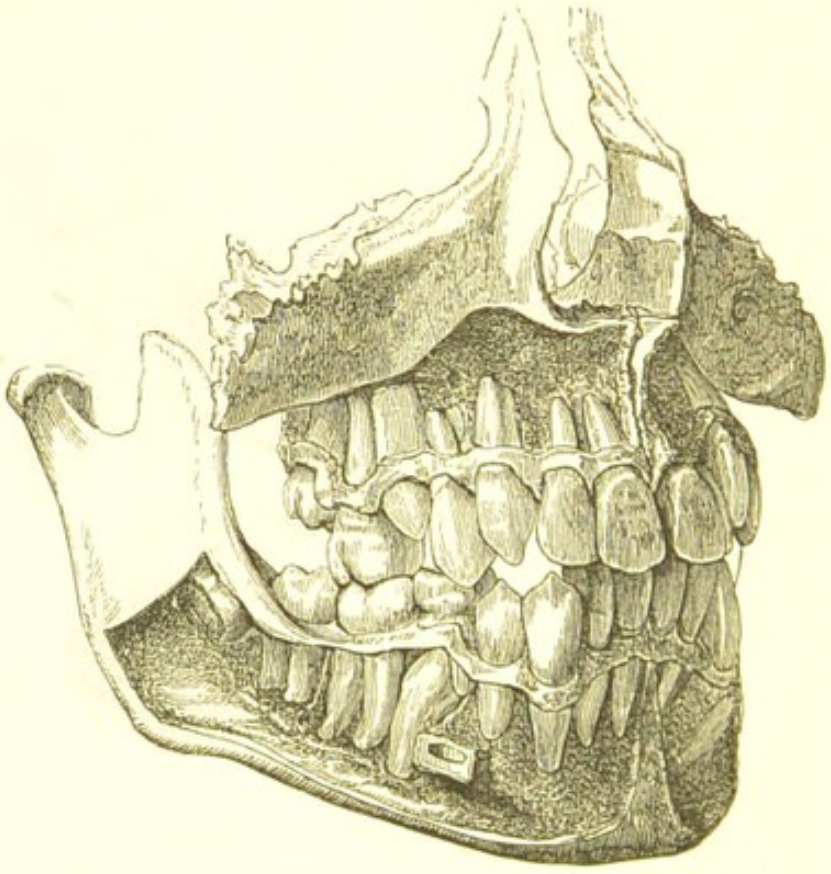
The phenomena which have been described as attending the eruption of the central incisor, are repeated when the lateral teeth are protruded. These are, however, subject to an influence as regards their position, from which the central incisors are exempt. The canines are at this period far

(1) Showing the permanent central and lateral incisors in their normal position in the dental arch, with the canine and bicuspids within the jaw.

advanced in development, and their large, rounded, mesial sides not unfrequently interfere with the direction of the roots of the lateral teeth, and thus tend to turn the crowns of the teeth out of their natural position—an evil which is usually remedied by the further descent of the canines towards the alveolar margin. The normal position of the incisors after falling into line, is shown in Fig. 40.

Taking what may be regarded as the normal order of

FIG. 41. (1)



eruption, the first bicuspids will succeed the lateral incisors. If Fig. 38 be examined, it may be seen that the convex distal side of the crown of the upper canine lies upon the mesial side of the neck of the first bicuspid, and necessitates the flattened or grooved surface which characterises that part of the tooth, while the distal side of the tooth is simi-

(1) Showing the conditions of the permanent teeth after the eruption of the canines; in the upper jaw, the second bicuspid.

larly influenced (although in a less degree) by the second bicuspid.

After the first bicuspid has taken its position, the canines are the next to appear in the line of the erupted teeth. The appearances presented by the teeth in a favourable specimen are shown in Fig. 41.

After the canines, the second bicuspids appear through the gums, and make up the full complement of those which have been preceded by temporary teeth. The preceding may be looked upon as the natural order in which the first permanent molars, and the teeth anterior to them, appear; but this order is frequently subverted, and in very many cases without entailing any evil consequences. It will, however, be convenient to consider all the deviations from that which is regarded as the normal order under one general heading, after the evolution of the second permanent molar has been considered, and after the changes in the form and size of the jaws coincident with the eruption of the permanent teeth have been traced.

Between the age of twelve and thirteen years, the second permanent molars advance towards the surface of the gums, accompanied by alveolar changes similar to those which have been described in connection with the emergence of other teeth. At this time the crypts for the third molars hold the positions which those for the second molars held when the first molars emerged from their bony cells, and occupied the terminal portion of the alveolar tract.

If the mouth be examined immediately after the eruption of the second molars, the dental arches will appear fully occupied. In the lower jaw, a tooth on either side will be placed close to the base of the coronoid processes, and in the upper maxilla at the extremities of the alveolar portion of the bone. But by the time the patient has reached the *sixteenth or twentieth year*, the jaws will have lengthened posteriorly, and to an extent sufficient for four new teeth to take their respective positions in the dental arches. Under favourable circumstances, the development and eruption of

the wisdom teeth is but a repetition of those progressive changes which have already been described in respect to the first and second molars, and therefore need not be dwelt upon. No doubt these teeth are seldom cut without greater inconvenience to the patient than the anterior molars, and the period of emergence, too, is less defined; but we have hitherto considered the eruption of the permanent teeth when the process has been perfectly normal, the deviations from which have yet to be considered.

The periods of eruption of the permanent teeth have in the foregoing pages been traced from preparations. But the subject has been examined statistically.

In 1837, Sir Edwin Saunders published a monograph, entitled, "The Teeth a Test of Age." About this time, the miseries entailed by employing young children in factories were, not for the first time, forced upon the attention of the Legislature. The necessity of restricting the hours of labour and of establishing laws for defining the period at which children should be allowed to enter upon factory labour, was admitted. But a difficulty arose as to the principles upon which this period should be fixed. It was contended by some that a certain state of physical development should be taken as the standard, while others thought that the age would form a better criterion of the capabilities of enduring labour without injury. The statements of parents as respects the ages of their children could not be depended upon; hence it became necessary that some means should be found whereby the age of a child could be determined independently of the representations of interested parties. With this view, Sir E. Saunders entered upon an inquiry respecting the relations of the eruption of the permanent teeth to the age of the individual. He visited many of the large metropolitan schools, and selected for examination those children who had reached the ninth and the thirteenth year, and published the results in a series of tables, of which the following are characteristic examples:

	INCISORS.		CUSPID.	BICUSPID.		MOLARS.	
	Cent.	Lat.		Ant.	Post.	Ant.	Post.
Of 457 boys of nine years of age—							
20 had	4	4	...	...	...	4	...
77 had	4	3	...	...	...	4	...
91 had	4	2	...	...	...	4	...
5 had	4	1	...	...	...	4	...
34 had	4	...	...	...	...	4	...
20 had	3	3	...	...	...	4	..
10 had	3	...	...	...	...	4	...
Of 227 boys of thirteen years of age—							
104 had	4	4	4	4	4	4	4
57 had	4	4	3	4	4	4	3
29 had	4	4	3	4	3	4	2
33 had	4	4	3	4	2	4	1
4 had	4	4	2	4	1	4	...

Sir E. Saunders sums up the results of his investigations in the following words :

"Thus, then, it appears that of 708 children of nine years of age, 389 would have been pronounced, on an application of this test, to be near the completion of the ninth year; that is, they presented the full development for that age. But on the principle already stated, that of reckoning the fourth tooth as present when the three are fully developed, a still larger majority would be obtained, and instead of 389, the proportion would be as follows: of 708 children, no less a number than 530 will be fully nine years of age. What, then, are the deviations in the remaining 178? They are the following :—126 would be pronounced eight years and six months, and the remaining 52 eight years of age, so that the extreme deviations are only twelve months, and these only in the inconsiderable proportion (when compared with the results obtained by other criteria) of 52 in 708.

"Again, of 338 children under thirteen years of age, no less than 294 might have been pronounced with confidence

to be of that age. The remaining 44 would have been considered as follows: 36 in their thirteenth and eight near the completion of their twelfth year."

It must not be forgotten that the periods of eruption of the teeth may be modified by conditions of general health; just as the first commencement of teething is retarded by rickets, so will the further continuation of the process be interfered with by malnutrition, and a child being long behind time in the cutting of the permanent teeth is usually an indication of want of vigour, just as is inadequate height or inadequate weight. And the converse would perhaps hold good to some extent, for there is evidence derived from lower animals to the effect that the teeth may, as it were, be forced.

Thus, at one of the Royal Agricultural Society's shows, a pen of pigs were disqualified on the ground that their teeth showed them to be older than the age under which they were entered. But the owner, anxious to vindicate his own good faith, brought conclusive proof that they were not, but that they had been highly fed and cared for, and that this had had the result of hurrying on the change of the teeth.

A similar fact has been noticed with regard to cattle.

Mr. S. Cartwright has published a Table which embraces a much more extended period, and gives results obtained from 3074 cases. After describing the order and the periods of eruption of the permanent teeth, he makes the following remark:

"These periods I find form a moderately fair average. I have particularised them for the sake of affording you some idea of the times of replacement of the various classes of teeth; but exceptions are so frequent, that it is not possible to give with accuracy the exact time for their change. These tables will show you the times of appearance of the teeth in the given number of cases—upwards of 3000—which I have collected and which have come under my notice."

The following is a reprint from his fourth lecture, published in the "British Journal of Dental Science," May, 1857:—

3074 cases.

	Upper incisors.	Lower incisors.	Upper canines.	Lower canines.	Upper anterior bicuspids.	Lower anterior bicuspids.	Upper posterior bicuspids.	Lower posterior bicuspids.	Upper anterior molars.	Lower anterior molars.	Upper posterior molars.	Lower posterior molars.
Between the 5th and 6th birthdays: Out of 170 children	5	17	..	..	..	..	1	..	34	48	..	..
6th and 7th: Out of 340 children	52	207	..	..	3	1	2	4	182	199	..	..
7th and 8th: Out of 496 children	180	407	..	..	19	7	3	5	472	479	..	..
8th and 9th: Out of 530 children	459	524	8	7	85	38	16	12	524	524	..	..
9th and 10th: Out of 454 children	435	451	20	40	143	60	51	32	453	453	6	11
10th and 11th: Out of 322 children	318	321	48	98	199	104	110	69	322	322	18	26
11th and 12th: Out of 303 children	303	303	112	166	231	167	166	123	303	303	51	79
12th and 13th: Out of 203 children	203	203	136	159	175	149	144	102	203	203	103	118
13th and 14th: Out of 140 children	140	140	115	120	133	116	122	93	140	140	100	113
14th and 15th: Out of 86 children	86	86	79	83	86	86	79	77	86	86	78	79
15th and 16th: Out of 30 children	30	30	29	30	30	29	30	28	30	30	30	29

Before we enter upon the subject of irregularities in the development of the permanent teeth, and the various disturbing causes, it will be advantageous to give some further

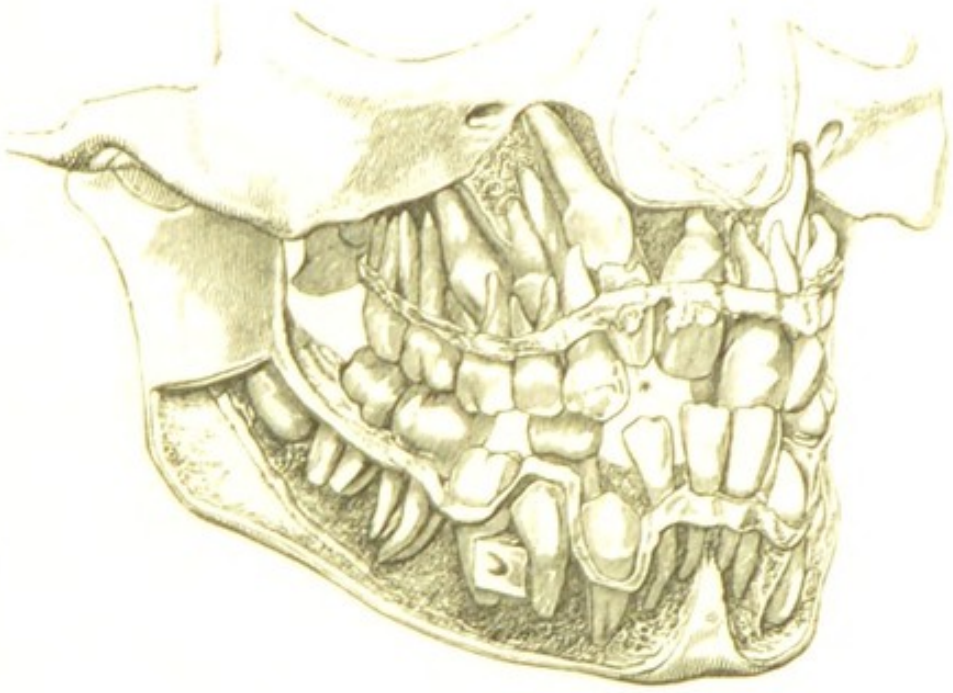
attention to the conditions under which the alveolar processes are formed, and to the laws which regulate the growth of the jaws.

Development of the alveolar processes in connection with second dentition.—In the earlier pages, it was stated that the alveolar processes are formed after the dental papillæ are developed, and that at the time of birth they have risen up to the level of the developing teeth. Within two or three months they arch over and nearly enclose the teeth, thereby evincing a more rapid rate of growth than the teeth themselves. When the teeth are ready for eruption, the anterior wall of each alveolus is absorbed to the extent of about half its whole depth. The teeth emerge, and the alveolar processes again commence to grow; but not as in the former cases, more rapidly than the teeth. They now keep pace with the teeth. At the time the development of the several teeth is commenced, the papillæ are placed at their ultimate depth in the jaws. They do not grow into, but up from the maxillæ, and the alveoli grow with them. At the period of eruption the lower end of the truncated and unfinished root reaches to the bottom of the socket, the position of which, as regards depth, is not changed with the gradual lengthening of the root of the tooth. After emergence, the depth of the alveolus is equal to the length of the root of the inclosed tooth, the subsequent growth of the root at its base being equalled by the development of the alveolus at its free edge.

When the permanent teeth are ready to emerge, the process of absorption is again called into requisition, and the labial wall of each alveolus is, in the anterior part of the jaws, removed, the loss of bone being extended to a point corresponding to the neck of the emerging tooth. This condition is shown in Figs. 31 and 38; but the accompanying illustrations exhibit in a remarkable manner the dependency of alveolar on dental development. The dentition is in many respects irregular; but the point to which I would draw attention is the extremely broken line de-

scribed by the alveolar margin, both in the upper and lower jaws. It may be seen that the terminal edge of each socket corresponds with the neck of the contained tooth, however irregularly the latter may be placed with respect to its fellows, exception of course being made to

FIG. 42. (1)

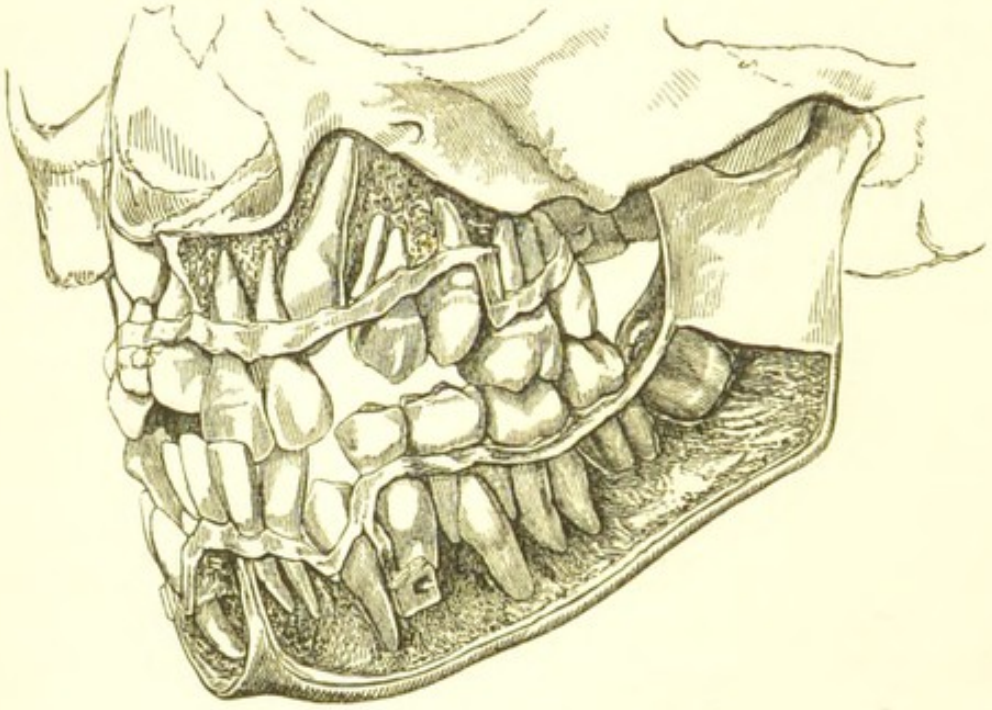


those teeth which have not yet passed through the gum. On the right side of the lower jaw, the first temporary molar is retained; and on the left, the second temporary molar is present. In each case the tooth and its alveolus are raised to a higher level than is usually attained by the temporary teeth, and higher than the adjoining first per-

(1) The upper and lower jaws of a subject about fourteen years of age; showing the relations of the alveolar processes to the teeth. In the upper jaw the temporary canine and the first and second molars are retained. *A supernumerary tooth has taken the place of the permanent lateral incisor, the lateral being forced backward towards the palate. The central incisor has been obstructed in its descent, and the root consequently curved. The permanent canine is far advanced in its development, but its descent is obstructed by the supernumerary tooth and the lateral incisor. In the lower jaw the first temporary molar has been retained, and raised to a higher level than usual, and with it the alveolus.

manent molars and their sockets. This elevating process has no doubt been effected after the tooth itself had been matured, and shows in a remarkable manner the relation of alveolar development to the changes of position in the teeth. It is not uncommon to find temporary molars

FIG. 43. (1)



present, even in patients of advanced age. I occasionally see a gentleman, over fifty years of age, in whose lower jaw the second temporary molars have been retained. They range with the adjoining teeth, and perform their part in mastication. The teeth generally are of the usual size, and the jaw and alveolar processes maintain the usual depth. In this case the temporary teeth and their alveoli must, at the period of second dentition, have been raised to

(1) View of the left side of the specimen figured No. 42. In the upper jaw, the irregular line described by the alveolar margin is shown in connection with the permanent teeth. In the lower jaw, the first and second temporary molars are retained, and both the teeth and their alveoli are raised above the level of the permanent teeth and their sockets. Both this and the preceding figure illustrate irregularities in the position of the permanent teeth, and will be referred to in connection with the subject of irregularity

the level of the adjoining parts of the dental arch. Other instances present themselves in which the persistent temporary teeth do not gain the general level. The cause is, however, usually very apparent: the contiguous teeth hang over, and as it were hold down the depressed tooth; and here again the socket corresponds to the level of the neck of the tooth. There is no disposition on the part of the bone at this point to grow up to the general line of the alveolar processes, independently of the tooth to which it gives implantation. In the one case we have a tooth raised above, and in the other held down to, the normal height of a temporary tooth; and in each the alveolar development has strictly conformed to the position of the tooth.

The appreciation of the foregoing conditions will be found of great practical value in respect to the treatment of irregularities in the position of the permanent teeth. Diseased action in the structures may, however, modify the relations of the one part to the other. I have seen a case in which the alveolar processes were enormously thickened, and so raised that the teeth lay in grooves; and instances are not very uncommon in which development of the osseous tissue is arrested. But the results of normal action only have as yet been considered. The consequences entailed by disease upon the permanent teeth and their sockets, will be treated in a future page.

Growth of the maxillæ during second dentition.—In pursuing this inquiry, the natural variation in absolute size and in the minor details of form, which the jaws, in common with other parts of the body, present in different individuals, must be kept in view. It will be desirable, therefore, in repeating these observations, to select for examination specimens which present the average condition of the parts.

On comparing the jaws of a child in whom the first permanent molars are advancing towards the surface, with the maxillæ in which the wisdom teeth have taken their ultimate

position, we are at once struck with the great difference in size, not only of the teeth, but of the jaws themselves; and it seems at first sight very difficult to explain how the younger can assume the characters of the older specimen, without having recourse to the undefined idea of general expansion by interstitial growth throughout the whole substance of the bones.

It has been shown how the alveolar portions grow up, are partly removed, and again grow up; how they are from time to time moulded to the required forms; and it will not be difficult to point out how the other parts of the jaw are, by the progress of developmental changes, gradually advanced towards the adult form.

At a preceding page (page 17) mention was made of certain points as convenient for the purposes of measurement, as being liable to little alteration during the growth of the maxillæ, the tubercles for the attachment of the genio-hyo-glossus and the mental foramen being selected as the most suitable for the purpose. When rightly interpreted, measurements taken from these two points give identical results; but before proceeding further it will be well to explain that at first sight measurements taken from the mental foramen will give misleading results, owing to an abrupt change in the direction of the canal at its anterior extremity. If the outer surface of the bone be removed so as to expose the whole length of the inferior dental canal in a series of specimens of different ages, the manner in which the mental foramen has become raised will be apparent. In the nine months' subject the orifice is on a level with the course of the canal and looks forwards: now the portion of the canal already formed does not undergo any further change, but as the thickness of the bone is augmented by deposition on its outer surface the canal comes to lie at a greater depth within the bone.

The necessary addition to the length of the canal before it can reach the surface does not, as might perhaps have

been expected, take place in direct continuation of its previous course; but, in obedience to a law already alluded to (page 14), gives to the added portion of canal an upward and backward direction.

This fresh addition to the canal therefore forms within the thickness of the jaw an angle with that previously existing, and this angle corresponds in position with the opening or mental foramen in the fœtal jaw. If then we rasp off the surface till we reach this angle, and take our measurements from it instead of from the external opening, we shall have an unchanging point, and the results of our inquiry will be consistent with those attained when the tubercles were chosen as the fixed points. In old age nature performs this operation for us, and removes the bone till this angle is nearly, or quite, reached—hence the foramen is brought down nearer to the lower border of the jaw. But with the exception of additions to either end during the period of growth and consequent alterations of the aperture, there is not the smallest reason to suppose that the position of the canal is in any way changed at any period of development.

In the former editions of this work certain actual measurements of a particular series of jaws were given; but as I have found that students have experienced some little difficulty in grasping the meaning of the passage when placed before them in this form, it has seemed preferable to embody the results of these investigations in the accompanying diagrams.

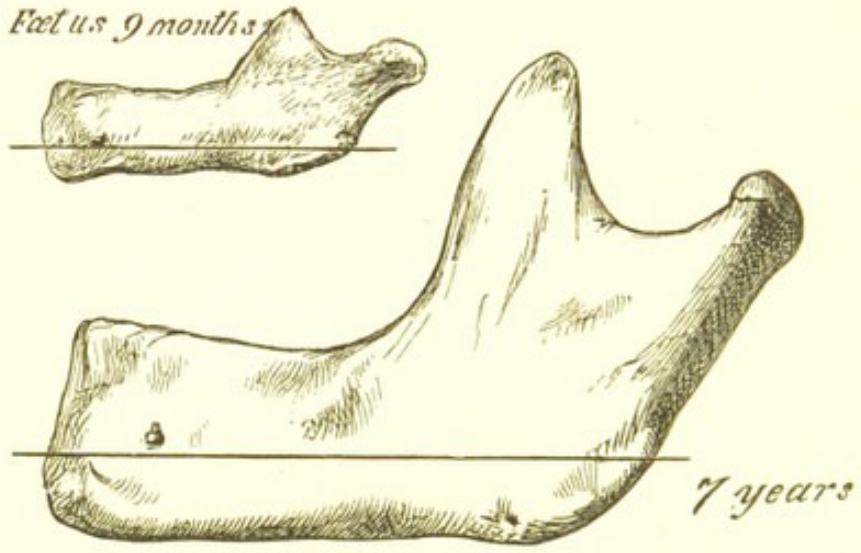
As some variations, due to individual peculiarities, such as greater or less development of the chin, exist between different specimens, these diagrams are drawn up according to average dimensions taken from a considerable number of jaws, and are drawn to scale.

The horizontal line represents the level of the anterior portion of the inferior dental canal in the fœtus, and the corresponding portion in the adult jaw, which may be taken as separating the alveolar portion, strictly subservient to

the lodgment of the teeth, from the basal portion which subserves other purposes.

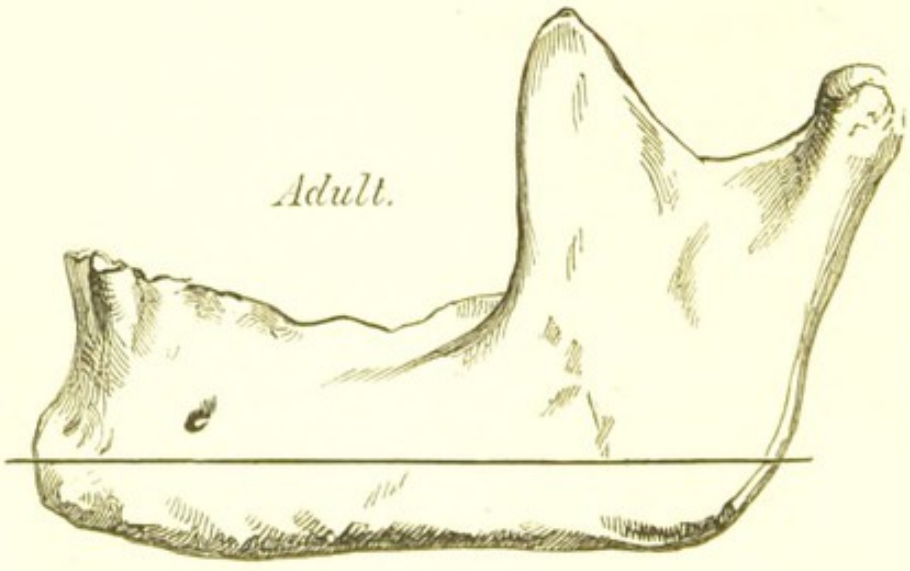
On comparing the jaw of the nine months' fœtus with

FIGS. 44 AND 45.



that of a seven years' child it is seen that that portion which lies below the line has more than doubled in its depth; but

FIG. 46.



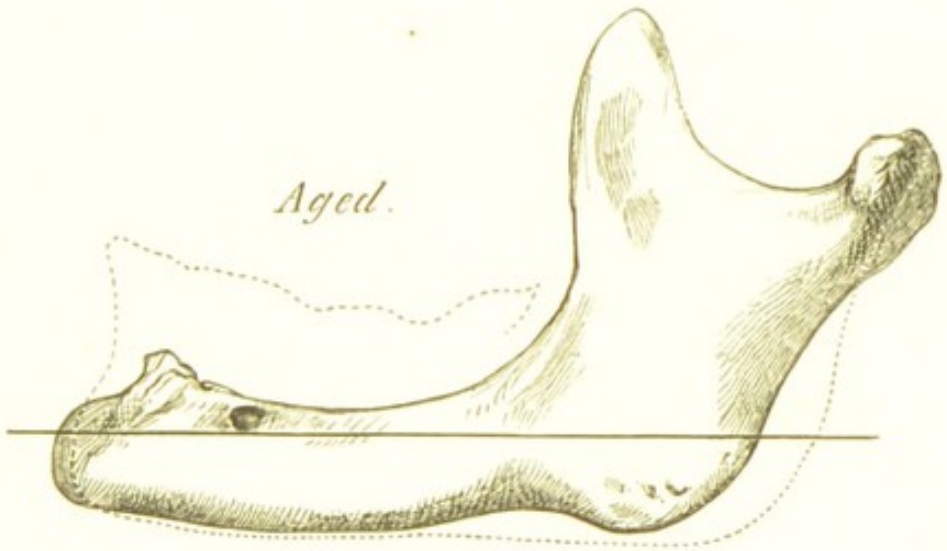
on looking at the adult and the aged jaw it is apparent that this portion of the bone has attained its full development in

depth, or very nearly so, at the age of seven years, and that it remains comparatively unchanged after that time until the death of the individual.

Looking, however, at the alveolar portion above the horizontal line, it is apparent that it does not attain to its full development till after the permanent teeth are in place, and that so soon as the teeth are lost, it disappears, so that in the aged jaw here figured it is almost absent.

Such measurements prove very conclusively the difference between the basal and alveolar portions of the jaw, and

FIG. 47.



bring prominently forward the entire dependence of the latter on the teeth, a point which cannot be too strongly insisted on, as it has practical bearings, to be alluded to in a future page.

In the nine months' subject, when the anterior teeth are about to be cut, the inferior dental canal is nearly straight from end to end, its whole length corresponding to that portion which in the adult lies under the bicuspids and first permanent molar, and forms scarcely more than one-third of its entire length. The straightness of this portion is permanently preserved in all the specimens I have examined. The

middle third is slightly curved upwards, and the posterior portion is still more curved, and if prolonged, would pass through or immediately in front of the articular process. The course of this posterior third traverses the ascending ramus of the adult jaw rather obliquely, and in the great majority of cases corresponds with the direction of the condyle rather than that of the ramus. These points have been entered upon with some degree of minuteness, in consequence of their affording evidence as to the manner in which the jaw becomes lengthened to so great an extent by additions at its posterior portions.

In tracing the growth of the jaw backwards, we may take the inferior dental canal as marking pretty accurately the line of growth followed by the condyle, and the external oblique line as that which has been followed by the base of the coronoid process. For the sake of facilitating description, it may be assumed that the backward growth takes place at three points—in the sub-articular cartilage of the condyle, in the periosteum investing the coronoid process, and in that investing the angle.

The condyle stands with its long axis directed nearly transversely across the ramus, the one extremity lying nearly on a plane with the outer surface of the bone, while the other overhangs to a considerable extent the inner surface of the ramus. Now, if we take a thin vertical section, suitable for microscopic examination, from a perfectly fresh young jaw, it will be seen that new bone is developing in the temporary sub-articular cartilage—not, however, in the linear manner usual in the temporary cartilage of long bones, but by the extension of ossification among small groups of cells. As the action extends throughout the articular extremity, the bone so produced would, if permanently retained, assume the form of a broad process, marking the course through which growth proceeded. On the outer surface we frequently can discern a slight ridge, extending a short distance from the head of the bone; but if the prominence were preserved on the inner surface, the

inferior dental artery and nerve would be turned from their course towards the canal. Hence the hard tissue, although produced, is at this point speedily removed, and in the place of a ridge extending from the articular process downwards, we have a concavity immediately below the articulation, and along it the vessels and nerves pass before entering the bone. A section taken from this part will show that the newly-formed bone has been removed by absorption.

The progressive growth of the coronoid process is effected in the usual manner of sub-periosteal development—that is, by the ossification of cells and connective blastema; and here, again, the modelling process effected by the supervention of absorption is called into requisition. If all the bone which is developed were retained, we should have the ascending ramus extending forward over half the alveolar margin. If a transverse section be taken from the base of the ramus of a growing jaw, it will be found that indications of absorption are presented at the anterior edge; and at the point corresponding to the posterior border of the jaw, evidences of osseous development are present. The fact, that the enlargement of the jaw takes place by backward growth almost exclusively, has been already alluded to (page 19); in this respect also Dr. Humphrey's experiments are confirmatory of the inference here drawn.

The correctness of the above views, as to the development of the jaw, has received a somewhat unexpected confirmation from two examples of arrested development of the one ramus of the jaw whilst the other has attained its normal size. The first of these two specimens (1) was brought before the Pathological Society by Mr. Edward Canton; it occurred in a girl of generally stunted growth, in whom the whole left side of the face was flattened, and the external

(1) Figured and described in Pathological Society's Transactions, vol. xii., 1861, p. 238.

ear was almost absent. At the post-mortem examination the zygomatic and auditory processes were found to be altogether absent, while the glenoid cavity was represented by a perfectly smooth surface.

As is seen in the figure, on the left side of the jaw the ascending ramus is a very short, narrow process terminating in two points, which may perhaps represent the coronoid and condyloid processes. But there is nothing to be seen at all like a condyle at the summit of this process, and therefore,

FIG. 48. (1)

there being no articular surface, there can be no articular cartilage.

But it has just been pointed out that the backward and upward elongation of the jaw takes place in great part by ossification in this articular cartilage, just as a long bone grows by ossification progressing in its epiphyses. Hence the absence of the condyle accounts perfectly for the arrest in the development of this portion of the jaw; it will however be noticed that the vertical development of the horizontal ramus, which is entirely correlative with that of the teeth, has not suffered in a like degree: the teeth have been developed, and consequently the alveolar portion of the jaw has attained to something approaching its normal depth and width. The length of this aborted side of the jaw does not exceed that attained by that of a child aged two years and a half.

(1) Mr. Canton's specimen of stunted lower jaw.

The great elevation of the incisor teeth is simply the consequence of imperfect antagonism, an explanation rendered the more certain by their serrated edges, which have obviously not come into contact with the upper teeth.

On the inner surface of the stunted process, at a level corresponding to that of the crown of the second molar tooth, is the Inferior Dental Foramen, which is much smaller than that of the right side. The mental foramen is entirely absent, the nerves and vessels having been apparently wholly used up in the substance of the bone.

The second specimen, which is in the museum of the Odontological Society, (1) presents somewhat similar characters; of its history nothing whatever is known, but it appears to be the jaw of quite an aged person, and the alveolar portions of the jaw having been for the most part absorbed after the loss of the teeth, the fact of the entire dependence of the growth of this region of the jaw on the presence of the teeth is not so strongly exemplified as was the case in the last mentioned specimen. But that the aborted body has at one time been of a depth apparently disproportionate to its backward elongation, is probable from the presence along its upper surface of the sharp ridge which is usually left after absorption of alveoli, consequent on the loss of the teeth. In the spinous process which terminates this stunted ramus, no separate representatives of coronoid and condyloid processes can be traced: it is a simple spine, which from its relation with the external oblique ridge would correspond more nearly with the coronoid than with the condyloid process, and presents on its inner surface a prominence apparently giving attachment to ligaments or muscles. There is not a trace of an inferior dental canal, and consequently no mental foramen; but whether this absence of its proper vascular supply is to be regarded as a cause or an effect of the stunted growth is an almost insoluble problem. The tubercles for the attachment

(1) Transactions Odontological Society, March, 1872.

of the genio-hyoid and genio-hyo-glossus, which probably marked the median line of the body, do not correspond with the position of the mental prominence on the outside of the jaw, which latter has partaken in the asymmetrical development of face which must have existed, and is considerably displaced to the right.

A case of arrested development of both sides of the jaw, not shared in an equal degree by the alveolar borders, is related by Professor Humphery. (1) The chin was in a plane two inches behind the edge of the upper alveolar edge, but the alveolar border of the lower jaw took a wider sweep than the body of the bone, which it consequently overlapped. The teeth were as large as in a well-formed jaw, so that they were forced to spread out in a fan-like manner.

The manner in which additions are made to the posterior border of the jaw has been described in connection with the growth of the jaws of very young subjects. During the period of youth the process is continued, and as the subject approaches manhood, the angle becomes fully pronounced. At the same time, the mental prominence and the points for the insertion of muscles attain their permanent characters. In each case the increased size is produced by sub-periosteal development upon the pre-existing bone. The development of the jaw may, in some respects, be compared to modelling. Portions of new tissue are laid upon that already formed, and reduced to the fitting size and shape, and again renewed at such points as the attainment of the ultimate form of the part may require.

Still, even during manhood, the maintenance of the form of the jaw is dependent to a great extent upon the teeth. When the organs of mastication are lost, the whole of the alveolar processes are by degrees removed, the process of absorption being arrested only at those points where muscles are inserted; neither is the waste limited to the alveolar margin. Both the outer and inner surfaces of the bone are

(1) Medico-Chirurgical Review, vol. xxvii., 1862.

reduced, and even the interior becomes more porous than during the period when the teeth were present. The spinæ mentales, however, retain nearly their full size, although the angle of the jaw about which the masseter muscle is inserted, suffers considerable loss—not however until that muscle is thrown partly out of use by the loss of the teeth, and consequently of the capability of mastication. If two jaws be taken, the one full of teeth, the other from an old edentulous subject, and in each the dental canal be exposed throughout its length, we may then, by the use of a file, taking the canal as our guide in removing the bone, reduce the younger to the form of the older jaw, showing that absorption alone is competent to effect the whole change. In the one case we have a jaw for the implantation of teeth, and for the insertion of powerful muscles for bringing the teeth into effective use, in addition to affording attachment for muscles connected with the organs of speech and deglutition; and in the other, the jaw is subservient only to the latter purposes.

We have hitherto spoken of the lower jaw, which, from its slight connection with the other bones of the face, can be studied in its progressive changes of form and size more readily than the superior maxilla. But if crania of various ages, extending from seven to twenty-one years, be carefully examined, the difference presented by the upper jaw at the several periods, and the manner in which these differences have been produced, may be recognised. Mr. Hilton, in his monograph on the development of certain portions of the cranium, makes the following statement:

"The sphenoid bone forms the centre around which all the other bones, both of the cranium and face, are developed. It is truly and literally indeed a wedge, as its name implies; and thus impacted or wedged in amongst all the other cranial and facial bones, its progressive development spreading its different processes out in all directions, plays a most important part; not only in determining the adult configuration of the skull, but in adopting the final conformation

of the organs of the face to the increasing perfection of their associated functions. The mouth, nose, orbits, and pharynx, are all more or less directly influenced, and contemporaneously rendered more perfect in form by the complete development of this bone.

"The primary idea, or primary intention of the development of the sphenoid, seems chiefly with reference to the masticatory function; but in the changes that it produces in the direction of the cranial and facial bones, it may not inaptly be compared to the scaphoid bones of the carpus and tarsus; for in its growth and final development it effects for the cranium and face precisely the same object that these bones effect for the hand and foot.

"Like these bones, then, the growth and completion of the sphenoid, in spreading out the cranium, and in enlarging the cavities of the organs belonging to the face, supplies the deficiency of the muscular tension which in other parts of the body has so large a share in determining the final or perfect forms of the bones." (1)

Of the different parts of the sphenoid bone, those which undergo the greatest change during the period under consideration, as regards size, and which are also the most directly connected with the present inquiry, are the pterygoid plates. These parts increase to the extent of one-third of their ultimate length between the age of seven and twenty-one years. In a specimen of seven years, the anterior surface of the pterygoid process is separated from the first permanent molar by a distance scarcely exceeding a quarter of an inch, and the nascent second molar lies in the tuberosity, in great part external to the sphenoidal processes. The space, at present so inconsiderable, has, before the adult form is acquired, to be increased fully two-thirds, accompanied by an increased length of the pterygoid plates, the general direction of which remains unchanged. The general principles which have been pointed out as pertain-

(1) Notes on some of the Developmental and Functional Relations of certain Bones of the Cranium. Selected by F. W. Pavy, M.D., from Lectures on Anatomy by John Hilton, F.R.S. 1855.

ing to the development of the lower jaw, may be applied to those facial bones which are connected with the masticatory apparatus. The tuberosity is to the upper what the base of the coronoid process is to the lower jaw. From this point the alveolar line is lengthened. In the specimen last mentioned, the second molar is buried high up in the tuberosity. Soon after the expiration of the twelfth year, the distance between the pterygoid process and the first molar will have increased sufficiently to allow the second molar to take its place in the dental line, and by the expiration of the twentieth year the third molar is usually found in its normal position. Up to this period, the facial bones are connected to each other and to the bones of the cranium by sutures only; and in the soft tissue within these, development of bone takes place.

The maxillary bones, while their processes are increased in length, are moved bodily forward, the rate of growth keeping pace with the increase at the tuberosity. Coincidently with development, the modelling of certain parts by superficial absorption is carried on. By this process, the anterior surface of the lower border of the malar process is removed, and thus thrown backward. In the seven years' specimen it lies immediately above the anterior third of the first molar; at twenty-one it holds a similar position with respect to the second molar, thus showing a recedence equal to the width of one tooth.

As respects the changes of form and position which the glenoid cavity undergoes during growth, but little need be said. Here we have articular cartilage, beneath which the required amount of bone is slowly developed in the same manner as the subarticular cartilage of the lower jaw.

Mr. Shaw some years ago pointed out that the cranial portion of the skull differs but little in dimensions even if the comparison be made between giants and persons of ordinary stature, whereas the face and all the bones which enter into its formation differ much, and this is very marked in the lower jaws. This is apt to give to the faces of such

overgrown people a coarse animal aspect; the orbits also are pretty constant, and the adjustment of the varying sized face to the unvarying orbits and cranium is largely effected by the size of the frontal and maxillary sinuses. (Med. Chirurg. Transac. vol. xxvi., 1848.)

Irregularities of the Teeth.—The number, form, period of eruption and arrangement of the teeth may, any or all of them, be abnormal; and these abnormalities again may be accidental in the individual or they may be inherited.

Thus the late Dr. McQuillen (1) gave some striking examples of the transmission of characters apparently trifling from parents to children. In one family the upper lateral incisors bit inside their corresponding lower teeth in the father, and in three out of four of his children; the fourth child had not cut these teeth at the date of the observation. In another family the father, son, and grandson alike never had any lateral incisors in the upper jaw; a second son had them exceedingly dwarfed, and some of the latter's children had them so stunted as to make them unsightly, so that they were extracted for the purpose of inserting artificial substitutes. In a later number of the same journal a family in whom no permanent teeth at all are found, is mentioned as being well known to many American dentists.

Within the author's own experience no less than three families have been met with in which the same teeth are generally absent, or, if present, are stunted in greater or less degree.

Mr. Weiss has recorded the transmission of the peculiarity of well defined additional lingual cusps in the upper molar from a father to six of his children.

An instance of the congenital absence of bicuspid teeth is given by Mr. Heath (2), and in my own practice I have lately met with an example of the absence of the left upper lateral incisor in three sisters; on the right side these teeth are present.

(1) Dental Cosmos, vol. xii., p. 75.
(2) Injuries and Diseases of the Jaws, p. 185.

Numerous other examples might be collected, but the foregoing will sufficiently serve to illustrate that strong tendency to hereditary transmission of peculiarities which is found to exist, and to suffice to cause dental irregularities.

Correlations of growth are found to exist between parts of the organism, which, so far as we know at present, have little or nothing to do with one another; but in other examples of this concomitant variation some homological relation can be traced between the varying organs. Such is the case with hair and teeth, which in their origin are closely similar, and which only become strongly differentiated in their after development.

And it has been remarked by Mr. Darwin that those orders of Mammalia which are most aberrant in their dermal coverings, namely, the Cetacea and Edentata, are also remarkable for deficiency or redundancy in the number of their teeth.

For example, the hairless, naked Turkish dog is extremely deficient in its teeth, often having none except one molar on each side, and perhaps one or two imperfect incisors (1); and the same fact has been observed in a hairless terrier. Inherited baldness has been found associated with inherited deficiency of the teeth, and it is stated by Mr. Sedgwick (2) that in rare cases where the hair has been renewed in old age this has usually been accompanied by a renewal of the teeth.

Mr. Craufurd, as quoted by Mr. Darwin, states that at the Burmese Court there was a man covered with straight silky hair, which on the spine and shoulders was as much as five inches in length. He had no molar teeth, and the incisors were very small; his daughter inherited the peculiarity of a hairy skin, her face, even including the nose, being covered with silky hair, and, like her father, she had neither molar nor bicuspid teeth.

(1) Darwin, Animals and Plants under Domestication, vol. i., p. 31.
(2) British and Foreign Medico-Chirurg. Review, April, 1863.

These hairy persons did not present any marked peculiarity at birth, save that there was a little hair about the ears, whence it spread all over the body ; and it is a significant fact that there was nothing abnormal in their milk dentition. In the case of Julia Pastrana, rendered famous by the exhibition of her stuffed skin after her death, the forehead and the chin were densely covered with hair, and there were said to have been so many supernumerary teeth in the mouth that the appearance of a double row of teeth in each jaw was presented.

Models have, however, been presented to the Odontological Society by Mr. Hepburn, the authenticity of which appears to be beyond question, and these do not exhibit the number of teeth attributed to her, but it would appear that she was affected with a form of general hypertrophy of the gums and teeth described at a later page ; so that while the old statements about her call for correction, she is none the less interesting to the student of dental irregularities, for she exemplified in a marked manner that hypertrophy of one set of cutaneous appendages goes hand in hand with hypertrophy of the others.

The hairy child lately exhibited at the Aquarium presents no abnormality in her teeth, although the contrary has been asserted.

Some few years ago a Russian peasant was exhibited in London whose face was so hairy that it resembled that of a Skye terrier, and the hair was so long and abundant that it had to be cut in order to enable him to see. His son was also hairy.

The father had no teeth up to the age of seventeen, then he had four teeth in the lower jaw but none in the upper ; whilst the child has the four lower incisors, but no signs of any others. It is remarkable that, on an examination of the mouths made by Mr. Oakley Coles and myself, when models were taken, it was found that the man, though stoutly and even powerfully built, had jaws no

larger than those of the child; this tallies remarkably with what has been inferred on other grounds as to the dependence of the growth of the jaws upon the existence of the teeth.

This man bore no particular resemblance to his mother, his brother, or his sister—his father was unknown, the man having been born during the absence of the reputed father, who was a soldier.

Mr. Moon (1) gives two striking family histories. The mother had normal teeth, the father (who was dead) was said to have had only two incisors, and those pointed; there were four children, of whom one (male) had normal teeth; a female, aged ten, did not strongly resemble the others, and had teeth only slightly abnormal; another, aged eleven, had all the incisors and canines small, sharply pointed, and hooked at the points, her hair was scanty and inclined to fall out, and her eyes were defective; another, aged fifteen, had her upper incisors, canines, and premolars mere sharp, curved cones; her hair was scanty and fair.

Another family presented a boy who had no toe nor finger nails at birth; his hair was absent for a year, and at the age of nine he had scanty light hair, no eyebrows, and very scanty eyelashes. He had four temporary canines, two permanent upper incisors, which were recurved and pointed, and only two molars (the upper temporary).

The sister, aged eight, had conical lower incisors, and only one upper incisor yet erupted, which was normal. Three others had hair and teeth normal.

The mother of these children had no upper lateral incisors, never had first lower molars, second bicuspids, or third molars; the father was in all respects normal.

The association of certain forms of maxillary deformity with other defects, such as congenital idiocy, may perhaps be explained on the principle of correlation of growth, but it will be more convenient to defer the discussion of this

branch of the subject until the special irregularities alluded to are described.

Dental irregularities in some few instances are referable to the action of the law of "correlation of growth;" in all the instances with which I am acquainted this law has operated in producing either deficiency or redundancy in the number of the teeth, rather than in causing the assumption of abnormal forms or position.

Thirty-two being the number in a normal series of permanent teeth, any deviation, whether it be in an excess or in a diminution of that number, will constitute an irregularity. In other words, there may be irregularity from too many or too few teeth. Each of these forms of departure from the normal series is far from rare; but of the two forms it is perhaps more common to find that in which the teeth are in excess, one or two supernumerary teeth, as they are termed, being present. The connection which seems to exist between the hair and teeth in respect of abnormal development has already been noticed, as was also the fact that such abnormalities are often inherited. At all events we will first consider that condition in which the teeth exceed the proper number.

Supernumerary teeth may spring up during the second dentition in any part of the alveolar arch, and the forms of such teeth may either resemble those of special members of the normal series, or they may deviate from each of the recognised forms, and assume a somewhat irregular conical shape, sufficiently characteristic in itself to be at once recognised as that of a supernumerary tooth (1).

Several cases, occurring either in the first or the second dentition, have come under my own observation, in which five equally well-formed incisors occupied the lower jaw.

(1) Seeing that supernumerary teeth assume two distinct forms, the one being regular, the other irregular, it might, perhaps, be advantageous when speaking of those which in no respect differ from members of the normal series, to use the term supplemental, reserving supernumerary for the irregular-shaped teeth.

In neither case was it possible to determine from an examination of the crowns of the teeth which was the supplemental tooth. A third lateral incisor in the upper jaw, undistinguishable from the normal tooth, we have seen in one case only. Instances of a third canine or of a fifth bicuspid, and also of supplemental molar teeth (the form of the additional tooth being perfectly normal), have been seen even in lower races of mankind, and in a gorilla, though they are rare. But examples in which an ill-shaped tooth without determined form is found placed between the front teeth, or behind them, or even holding the place to the exclusion of the normal member of the set, are met with by all who are engaged in practice. The number is commonly limited to one, or at most two, supernumerary teeth symmetrically arranged; but I have seen a case in which there were four supernumerary teeth, forming a group with the upper incisors and canines. The front part of the mouth looked to be studded over with teeth, without any attempt at a definite arrangement. Indeed, there was some little difficulty in recognising the normal members of the series; for while the supernumerary teeth to some extent resembled normal front teeth, the latter were ill-formed, and approached the former in character. As cases like the foregoing occur from time to time, in which the recognition of the supernumerary tooth or teeth is attended with difficulty, it becomes necessary that we should, if possible, establish the special characters which are peculiar to supernumerary teeth, as distinguished from faulty-shaped normal members of the series. In the absence of such knowledge, we may allow a supernumerary tooth to remain and exclude the normal tooth from its place, as shown in Figure 107; or we may be induced to remove a badly-shaped tooth under the impression that it is not a member of the series.

Yet, where the discrimination depends upon very nice shades of difference, the necessary knowledge, even if it is possessed by the author, can scarcely be conveyed in a written description. Mr. J. Parkinson has placed his col-

lection of supernumerary teeth at my disposal. These, with a considerable number collected by myself, form a series sufficiently large to justify the observer in regarding any peculiarity of form which prevails throughout the collection as a special characteristic of supernumerary teeth. After removing from the series those which are not distinguishable from normal forms, we have remaining, teeth the crowns of which exhibit the following characters :—The lingual and labial surfaces are not distinguished by any difference of form. The enamel terminates on the neck of

FIG. 49. (1)

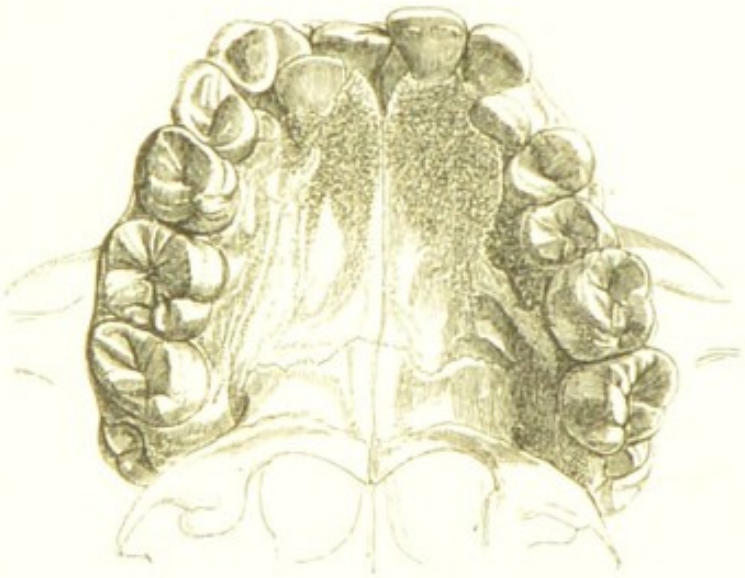
the tooth in an even line, differing in this respect from the terminal line in ordinary teeth. The crown of the tooth will, in the majority of cases, present a simple cone with a sharp apex ; in other instances, the point will be replaced by an irregularly depressed surface, corresponding in character to the masticating surface of a bicuspid or molar. More rarely the conical or cylindrical form is lost, and in its place we have a more or less flattened crown, the grinding surface being marked longitudinally with a deep fissure. Several examples have come under my observation, in which the crown has been divided in three or four plates, meeting at a common centre in such a manner as to produce a cross. It would, however, be hopeless to attempt to describe more than the general characters of supernumerary teeth, inasmuch as the minor differences of form are infinitely varied ; no two are precisely similar.

(1) Shows the front view of a specimen in which a supernumerary tooth external to the front teeth occupies the space between the lateral incisor and canine teeth.

The roots of supernumerary teeth are almost invariably single. The crown not uncommonly presents a certain amount of complexity, and approaches to the form of a molar tooth, but I do not remember to have seen a single specimen of a strictly speaking supernumerary tooth, in which the root was divided.

The history of supernumerary teeth has not attracted that degree of attention at the hands of practitioners which the subject deserves. There are several points the investigation

FIG. 50. [1]



of which would be attended with advantage. Thus we find that supernumerary teeth, for the most part, are matured and make their appearance before the permanent teeth situated in the same part of the mouth.

In the case figured at page 217, the position of the central incisor is preoccupied. In Fig. 50, a supernumerary tooth holds the place of the lateral incisor, which, with the central, is held back from taking the normal position. In

(1) A palatal view of the specimens shown in Figs. 42 and 43. The supernumerary tooth is situated between the canine and the central incisor of the right side.

the specimen from Sir E. Saunders' collection, two supernumerary teeth (Fig. 52) occupy the place of the central incisors. One of the excluded teeth has come through above the alveolar line.

Again, in Fig. 51 there are two supernumerary teeth, and one of these has to a certain extent interfered with the position of the central incisor. Now, in each of these instances the abnormal have preceded the normal teeth, and occasioned the malposition of the latter. But it may happen that a

FIG. 51. (1)

supernumerary tooth appears in the place and at the time of a normal tooth, the latter having been retarded in its development by the presence of the former. In one case a central incisor of the upper jaw was cut at the usual time, and by the side of it a supernumerary. The latter was at once removed, under the strong belief that the absent central tooth would after a time make its appearance. The expectation was realised, but three years elapsed first. The neighbourhood of the incisors must be regarded as the most common position for supernumerary teeth to take, and the upper is more frequently favoured than the lower jaw. An extraordinary case of supernumerary teeth has been

(1) Shows the appearances presented by a cast taken from a mouth in which two supernumerary teeth appeared behind the incisors, one resembling to some extent an incisor, the other altogether irregular in shape.

put upon record by Professor Cope, in which the dental formula was—

$$\text{i.}\ \frac{5}{4}\ \text{c.}\ \frac{1}{2}\ \text{pm.}\ \frac{3}{0}\ \text{m.}\ \frac{3}{3}\ \frac{3}{4}.$$

The first two molars were furnished with accessory lobes, thereby further showing the tendency to redundancy of parts. A brother of the patient had—

$$\text{i.}\ \frac{4}{4}\ \text{c.}\ \frac{1}{1}\ \text{pm.}\ \frac{2}{1}\ \text{m.}\ \frac{3}{3},$$

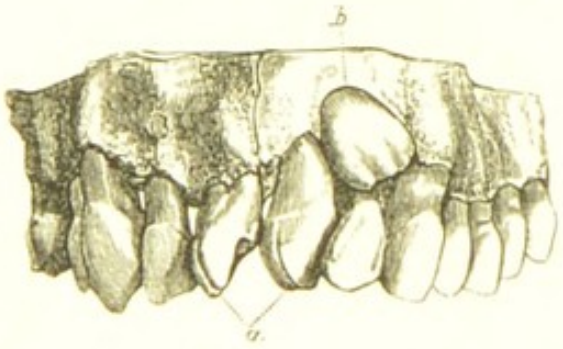
and a sister—

$$\text{i.}\ \frac{3}{3}\ \text{c.}\ \frac{1}{1}\ \text{pm.}\ \frac{2}{1}\ \frac{2}{2}\ \text{m.}\ \frac{3}{3},$$

a grandmother having $\text{i.}\ \frac{5}{4}$.

Instances, however, are not wanting in which the additional teeth appear among the molar division of the series. In a

FIG. 52. (1)



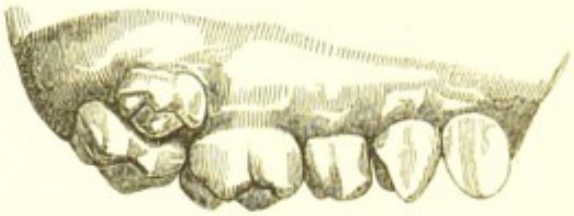
patient of my own, a diminutive tooth, resembling a small and badly-formed wisdom-tooth, appeared on each side of the mouth external to the first and second permanent molars of the upper jaw. The age of the patient and the appearance of the teeth themselves led to the supposition

(1) Shows the front view of a specimen in which two supernumerary teeth (*a*) hold the place of the central incisors, while the left central (*b*) has appeared above the alveolar line. I am indebted to Sir E. Saunders for the use of this specimen.

that they were the representatives of the wisdom-teeth. Within two or three years the eruption of the true wisdom teeth in the usual position showed that the supposition was incorrect.

Instances have, however, occurred in which an additional

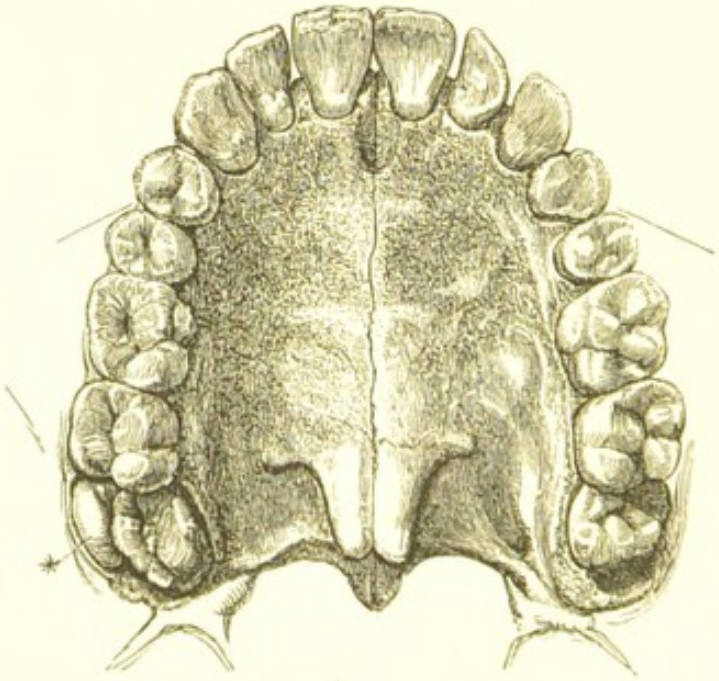
Fig. 53. (1)



molar tooth has appeared undistinguishable as regards form from a normal member of the series, and a similar occurrence has been remarked in respect to the bicuspids.

The following illustration is taken from a specimen in

Fig. 54. (2)



which a wisdom-tooth and a supernumerary occupy the

(1) Shows a supernumerary tooth placed externally to the first and second permanent molars of the upper jaw.

(2) A palatal view of an upper jaw in which a supernumerary tooth occupies the external portion of the socket of the right wisdom-tooth.

same socket. Although in this case the hard palate is thickened in a peculiar manner, and terminates in four processes, yet the jaw is well formed as respects the dental arch, and the teeth are both well developed and well arranged. In this instance, the form of the jaw can have nothing to do with the development of the additional tooth. Indeed, I do not know that any connection between good or bad development of the jaw, and the occurrence of supernumerary teeth, can be traced. Still, my own personal observations would, perhaps, justify me in stating that supernumerary teeth are more frequently found in perfect than in imperfectly developed jaws.

FIG. 55. (1)

The relations of supernumerary to the temporary teeth during the development of the former are not, in the absence of actual observations, readily understood. Now, where we have supernumerary teeth in the front part of the mouth taking precedence slightly, in respect to time, of the permanent teeth, a question is suggested as to the relations at an early period of the formation of the latter to the temporary teeth, and to the supernumerary, which it remains for future anatomists to determine. It has been suggested that the frequent occurrence of supernumeraries in the incisive region is due to atavism. Thus Mr. Wilson (Brit. Dent. Assoc. Journal, March, 1885) points out that in the typical Mammalian dentition there are six incisors, whilst man has only four, and suggests that supernumeraries are merely the reappearance of these suppressed teeth, and this idea is shared by Dr. Edwards of Madrid (Brit. Dent. Assoc. Journal, Dec. 1885).

A few instances have been, however, put on record in which supernumerary teeth in the milk dentition have been followed by supernumeraries in the same position in the permanent dentition. Mr. A. Woodhouse has also met

(1) Supernumerary tooth from between the second and third molars of the lower jaw.

with cases of supernumerary wisdom-teeth (Trans. Odont. Soc., 1876).

A single phrase will suffice to describe the treatment of cases in which supernumerary teeth make their appearance. They should be extracted as soon as their character is clearly established.

Instances may, however, occasionally present themselves to the practitioner, in which a supernumerary tooth may be retained with advantage; but these will, for the most part, be confined to those cases in which, from neglect, the whole of the teeth have been allowed to remain until all chance of the normal tooth coming into its proper position on the removal of the intruder is lost.

In the case shown in Fig. 107, the central incisor would have probably occupied the usual place, had the supernumerary tooth been removed on its first appearance through the gum; but had its extraction been performed after the completion both of itself and of the displaced central tooth, no advantage would have been gained by the operation. The position of the central incisor having been unalterably determined, the space left by the extraction of the intruder would have remained unoccupied.

Under the head of irregularity in the number of the permanent teeth, those cases in which the *dental series is more or less defective* yet remain to be considered.

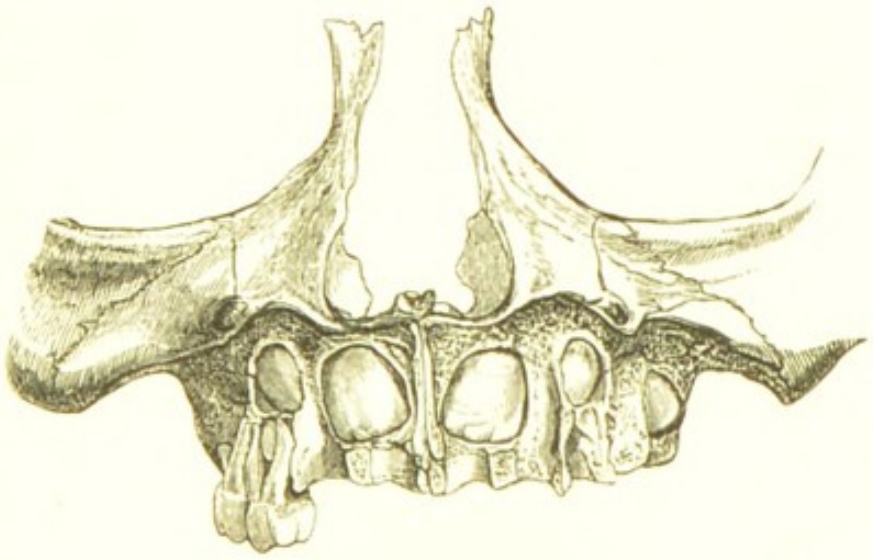
Instances have been cited of a total absence of the permanent teeth (1). One or two such cases have been described to me by gentlemen who have examined the subjects for themselves. In my own practice, however, I have failed to meet with an individual who from the first was perfectly destitute of permanent teeth. The nearest approach to the edentate condition which has in any way come under my own observation, is exhibited in two casts taken by Mr.

(1) In the Museum of the Odontological Society are several models of cases in which the teeth were deficient, and allusion has already been made to the subject in discussing the origin of various abnormalities (page 103).

Harrison from a patient under his treatment. One molar occupied each side of the upper and lower jaws. These four molar teeth, with four incisors (two in each jaw), were all the permanent teeth.

According to the statements of the patient and of her friends, the temporary teeth presented no peculiarities either as regards their number or the manner or the time of their shedding. A temporary canine tooth was retained in the

FIG. 56. (1)



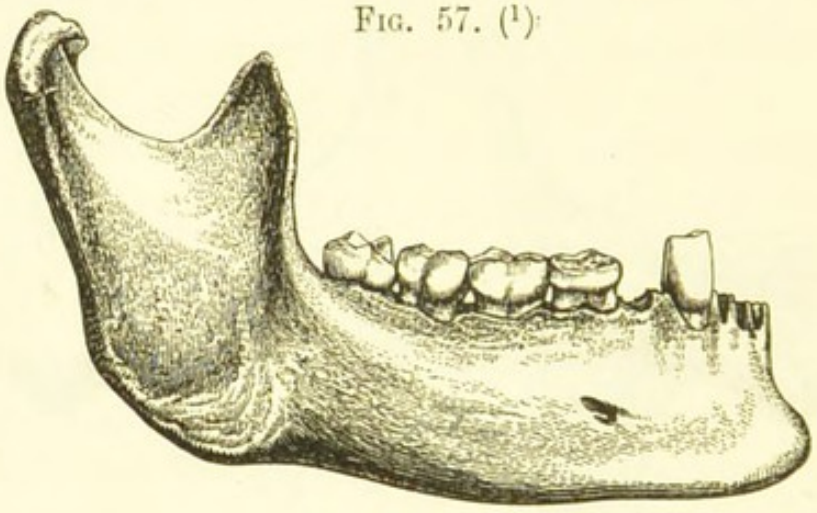
upper and lower jaw; the other members of the deciduous set dropped out at the usual time, but, with the exception of the four central incisors, their successors were wanting. A case has been already described, in which there was an almost total absence of the temporary series, yet permanent teeth not only made their appearance at the usual time, but took their place with great regularity as respects arrangement. Now, although these two instances may be looked upon as very rare and exceptional ones, yet they prove that

(1) Front view of an upper jaw of a young subject. The temporary alveoli show that the temporary lateral incisors were wanting, and the absence of permanent lateral teeth is also shown.

temporary do not necessarily precede permanent teeth, and that temporary are not necessarily followed by permanent teeth. With these facts before us, we are not able to turn to the condition of the temporary teeth for explanation of any diminution in the permanent series, with much hope of success.

Although any great diminution in the number of the permanent series is rarely seen, the absence of one or two members of the set is far from uncommon; several

FIG. 57. (1)



instances have already been given, and they might be multiplied greatly. Although it is usual for abnormalities, whether consisting in an excess or a deficiency of number, to affect both sides of the mouth, yet this symmetry is not always met with. I have two patients (sisters) in whom the right upper lateral incisors are absent; the left laterals are small, but otherwise well formed.

I believe when one description of tooth only is wanting, it will generally be found that the lateral incisor is the missing member. Perhaps we should except from this rule the wisdom-teeth. They, however, are so extremely irregular in all respects, as compared with the other teeth, that we are

(1) Shows a well-developed adult jaw, in which the second temporary molar is persistent, no second bicuspid having been developed.

seldom in a position to declare them absent, although they may not have appeared above the surface of the gums. But if the third molars are less frequently absent than the lateral incisors they stand next in the order of absentees. The second bicuspid is sometimes absent, and its place supplied, as in the preceding illustration, by the second temporary molar.

From a strictly practical point of view, these cases of deficiency in the number of the second set of teeth have but little interest. By those, however, who pursue dental surgery as a liberal profession, they will not be passed over with indifference, although our present knowledge of the subject will not enable us to recognise the cause which has produced the defect.

It is, however, of great practical importance that we should be fully aware that Nature sometimes fails to produce those permanent teeth which are preceded by temporary teeth, and that in such cases the latter will, if allowed to remain, serve the purposes of mastication and articulation up to the middle period of life, and in some instances even later.

Irregularity in the forms of the permanent teeth.—It is not proposed at this place to enter into a minute description of those slight deviations from what may be regarded as the typical form of any member of the dental series, but the allotted space will be occupied in considering the more strongly marked cases of departure from the usual characters.

Teeth, though individually well shaped, may be so much above or below the ordinary size that they become disfiguring to the possessor. The two accompanying illustrations (Figs. 58 and 59) are taken life-size from two sets of teeth, composed of teeth of extreme dimensions.

In these examples, the peculiarity has been common to all the members of the respective sets of teeth ; but we shall sometimes find in the same mouth teeth excessively large

associated with teeth excessively small. For example, the

FIG. 58. (1)

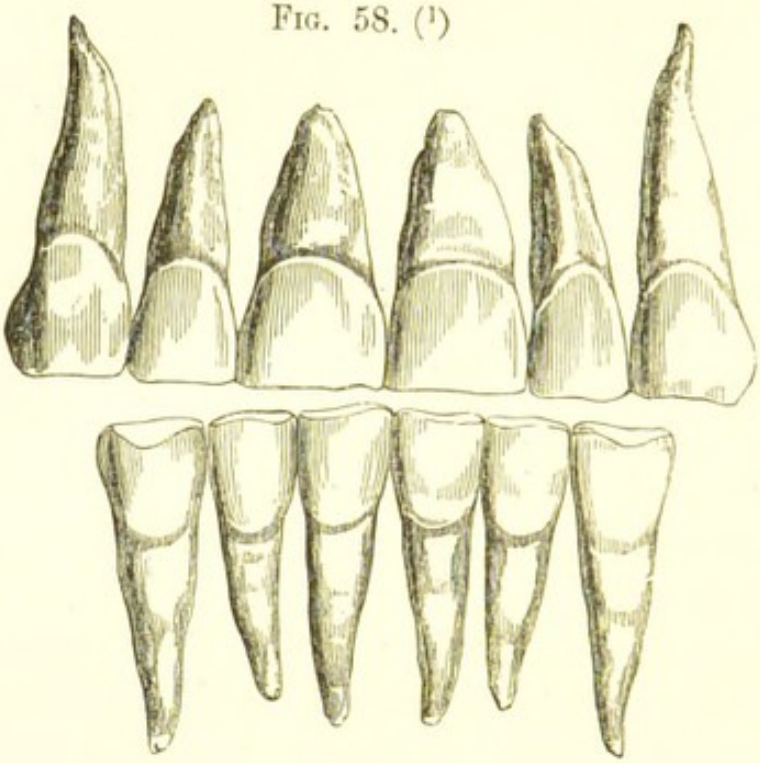
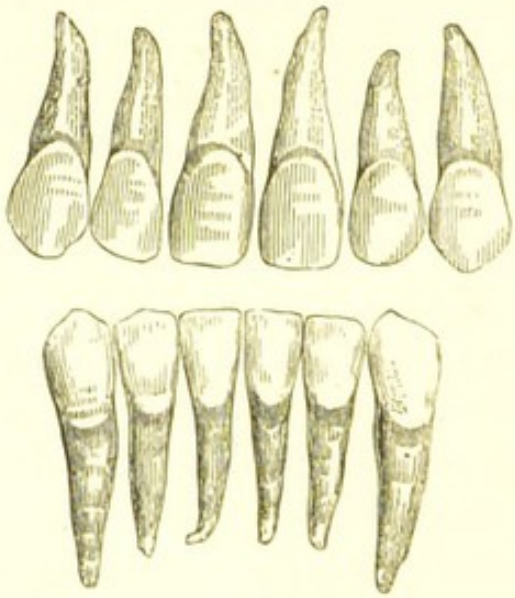


FIG. 59. (2)



central incisors may greatly exceed the average size, while

(1) A front view, life-size, of an unusually large set of front teeth, of the upper and lower jaws.

(2) A front view, life-size, of an extremely small set of permanent front teeth from the upper and lower jaws.

the lateral teeth are represented by small cones only. Then, again, the corresponding teeth of the same jaw may differ in size and form. The one may be large and well formed, the other small and imperfectly developed.

The very large wisdom-tooth which forms the subject of

FIG. 60. (1)

this figure, illustrates the point just mentioned. The tooth is double the usual size, and is the only member of the set which exhibits any peculiarity either as to dimensions or form.

Irregularity in form is, however, sometimes connected with diminution of size; one tooth may be unusually small and ill shaped, while the other members of the set are well developed. A case came under treatment about four years since, in which one of the upper central teeth was

FIG. 61. (2)

FIG. 62. (3)

irregular in shape, and about one-fourth of the size of the corresponding tooth (Fig. 61). From some cause, the diminutive incisor occasioned a good deal of irritation in the

(1) Shows, life-size, an unusually large wisdom-tooth from the lower jaw.
(2) Deformed and stunted central incisor of the upper jaw.
(3) Bicuspid of the upper jaw, with the root imperfectly developed.

gum; this, with the unsightly character of the tooth itself, led to its being extracted. The teeth adjoining the vacated space were, by means of ligatures, gradually brought towards each other, and eventually so far reduced the interval, that the absence of the faulty central was not missed.

The irregularity as regards size will sometimes be limited to the root of a tooth. In the example from which the preceding illustration was taken, the crown has attained the usual size; the enamel, however, exhibits indications of defective organisation, and the root is most imperfectly developed. The tooth was removed within two years of its appearance, in consequence of the irritation it excited in the surrounding gum (Fig. 62). It can scarcely be supposed that any constitutional condition would cause the production of one defective tooth, and leave uninfluenced other teeth developing at the same time. A strictly local cause may be looked for with much greater chance of success. The prolonged existence of gum-boil in connection with a temporary tooth may produce the result, or the encroachment of a neighbouring tooth upon the formative pulp may lead to the formation of a dwarfed and misshapen tooth (Fig. 26).

Slight deviations from the usual forms of the crowns of the permanent teeth need not be described, but it is necessary that attention should be drawn to the fact that *supplemental cusps* are sometimes found arising from the necks of teeth, and presenting all the appearances of distinct supernumerary teeth. A practitioner has been known to seize upon such a cusp, believing it, I presume, to be a supernumerary tooth, and drag out, not only the cusp, but the incisor from which it arose.

The case from which the following illustration (Fig. 63) is taken occurred in my own practice. A large nodule or cusp projected from the neck of the tooth. It was perfectly covered by the gum, so that its presence could not be suspected, until, in passing the forceps up

towards the neck of the tooth, some unusual obstruction was felt.

Supplemental cusps only have been spoken of, but we sometimes see a tolerably perfect little tooth growing out,

Fig. 63. (1)

Fig. 64. (2)

as it were, from the side of another tooth. In Fig. 64 a small tooth is shown connected with the distal side of the second or third lower molar below the termination of the enamel.

In the Museum of the Odontological Society are many specimens of molar teeth with nodules projecting from their sides, and there is one in which a minute but well-formed supplemental tooth projects at a right angle.

Under the head of irregularities in the forms of teeth, several physical peculiarities have yet to be considered, for describing which it is difficult to find a more fitting place.

Those deviations from the normal number and arrangement of the roots of teeth which influence dental operations, will be treated of in connection with the operations themselves. But as the discussion of the subject of irregularities of form generally would include such as are manifested in the roots, as well as those which occur in the crowns of the teeth, the matter cannot be altogether passed over at this place.

(1) A permanent tooth, with a large nodule of enamel attached to the neck below the point covered by the edge of the gum.

(2) A lower molar, with a small tooth projecting from its side.

The incisors may have their roots crooked or bent, or even twisted in a spiral form, but they are rarely bifid. In one case, a lateral incisor of the upper jaw had a cusp rising up from the base of the crown on its lingual surface, and a small supplemental root held a corresponding position as respects the root of the tooth.

In the upper canine teeth, two or three specimens only have fallen under my notice which have exhibited a tendency to a division of the one large and strong root into two, an actual division being confined to the immediate vicinity of the apex. In the lower teeth bifid roots are more common.

The bicuspid teeth, unlike the front teeth, are very liable to irregularity in the arrangement of the roots. Normally they have but one root, which is laterally compressed in upper teeth, and in the lower teeth also it is to some extent compressed laterally, yet in a much less degree than in the corresponding teeth of the upper jaw. Very commonly, however, we shall find that the flattened single root of the first bicuspid of the upper is replaced by two, and sometimes even by three, well-formed fangs, holding the same relative position as the roots of the upper molar teeth.

Indications of a division into three fangs in the upper, and into two in the lower bicuspids, may often be seen, even where they are not actually separated; and the teeth on the opposite sides of the mouth usually preserve an exact symmetry in this respect.

The differentiation between molar and premolar (bicuspid) teeth, which in some animals, as, for instance, in the horse, can hardly be said to exist, is not carried to any very great extent in man; and it is interesting to note that in the anthropomorphous apes the bicuspids have three roots in the upper, and two in the lower jaw as a normal condition.

Whether or not we are disposed to accept such facts as the occurrence of three-fanged bicuspids as indications of reversion to an ancestral type, there can be no doubt that the

explanation of the occurrence of this abnormality in the fangs of the bicuspids is to be found by a reference to the teachings of comparative anatomy.

The bicuspids of the lower jaw, although their roots may be bent, but seldom terminate by two roots.

Among the molar teeth, the first permanent molars will

FIG. 65. (1)

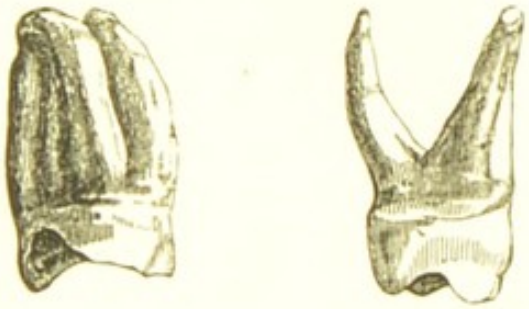


FIG. 66. (2)

be found to be the most constant, and the third the least constant, in the number, shape, and position of their roots. Three may be regarded as the typical number of the roots of the upper molar, and two as that of the lower molar teeth. Now, although we find occasional exceptions to these rules in the first permanent molars, they are very unusual. In the two teeth from the upper jaw which are figured, the three roots are, by the confluence of two, reduced to two in number; and I have seen one or two cases in which the two roots of a first permanent lower molar were united so as to form one conical mass.

On the other hand, in the place of a diminished, we may have irregularity from an increased number of roots. The lower molar may have three, or even four, roots, and the corresponding upper teeth four in the place of three roots. But, as was before stated, these departures from the normal

(1) Shows two first permanent molars of the upper jaw. In the tooth to the right the two labial roots are united and reduced to one, and in the left-hand figure the posterior labial and the palatal roots are united so as to form one broad and flattened root.

(2) Shows, life-size, a wisdom-tooth from the upper jaw.

number and arrangement of the roots are very uncommon in the first permanent molars.

In the second permanent molar, however, they are by no means rare, and in the wisdom-teeth the typical form is very seldom produced.

No rule can be laid down for the form and number of the roots of the dentes sapientiæ, so variable and inconstant are the forms assumed by these teeth. In one case the tooth is terminated by a single conical root; in another, the one is replaced by five, or even six, small roots. The accompanying figure is taken from a wisdom-tooth of the upper jaw, the single sharply pointed fang of which occasioned pain whenever the crown was pressed upon. This, which is life size, may be compared with the figure of a wisdom-tooth given in a previous page (119), in illustration of the sizes between which the third molar may range.

The accompanying figure (Fig. 67), which is borrowed by the permission of the Council of the Odontological Society, represents a tooth the fang of which is expanded out at its apex into a cup-shaped disk, on the margins of which are several foramina by which the nerves and vessels gained access to the pulp. The tooth is more fully described in the Transactions of the Society (1).

There appears to be good foundation for the statement that the upper wisdom-teeth in the lowest savage races have their three fangs distinct (2), although, on looking over a large number of skulls in various museums, I have found exceptions to this rule.

The great variability in the size and shape of the wisdom-tooth in civilised races, its occasional absence, and the irregularity of the period at which it is erupted, may, when contrasted with its large size and regular form in the lowest

(1) Transactions of the Odontological Society, new series, vol. iii., p. 200, 1871.

(2) Owen. Anatomy of Vertebrates, vol. iii., p. 320.

savage races, be taken as an indication that the wisdom-tooth is slowly disappearing, and that there is a strong probability that in future generations it will be normally absent. Moreover, comparative anatomy lends a certain

FIG. 67.

FIG. 68. (1)

support to this conjecture, inasmuch as in the anthropomorphous apes, where it is a proportionately larger tooth, it is erupted at an earlier period, coming into place before the canine tooth. On this matter Professor Huxley (2) says: "In the Gibbons, the permanent canine emerges contemporaneously with, or before, the last molar; but in the other anthropomorpha the last permanent canine is cut, ordinarily, only after the appearance of the last molar."

In connection with irregularities in the number and form of the roots of the teeth, the unusual deviations in the size may be mentioned. The corresponding teeth will vary slightly in almost every instance where a comparison can be made; but in a few cases the departure from the normal length will be greatly in excess of what may be regarded as the average standard. Mr. J. Parkinson gave me a pair of canine teeth which had attained the length of one inch and three-eighths, the roots alone measuring one inch. Excessive length in the root of a tooth cannot be productive of

(1) Showing a central incisor of the upper jaw, the root of which is deficient in size.

(2) Huxley. Anatomy of Vertebrate Animals, p. 486.

injury to the tooth itself; but the opposite condition, excessive shortness in the root, is often connected with the early loss of the tooth. Instances are sometimes found in which, although the crown of a tooth has acquired the usual size, the root is extremely short and weak; consequently the implantation is deficient in that strength and even firmness which is necessary to insure the durability of the organ.

In another place, under the head of *Dilaceration* (1), I have described a condition of tooth resulting from displacement of the calcified portion of a tooth from the tissues which were instrumental in its production, the development being continued after the normal position of the calcified part had been lost. Supposing, for example, the crown of an incisor when partly formed be moved from its position upon the pulp, and turned outwards or inwards, or to either side, and there to remain in a state of rest, the development of the tooth may then be continued with the displacement of one-half of the crown permanently preserved.

In some cases the amount of distortion will be slight, in others so great and so disfiguring that the tooth is necessarily sacrificed. I have seen specimens in which the crown of an incisor has been placed at a right angle with the root.

A good example of dilaceration as a result of injury occurred in the practice of Mr. Tuck, of Truro. The temporary central had been knocked out at the age of two and a half years; the dilacerated successor was cut at the age of eleven and a half years; nearly half the crown had been calcified prior to the injury, and this is of course perfect, even in the enamel formation; but in the displaced portion the enamel is very imperfect in front, but tolerably perfect at the back.

The instances of dilaceration which have fallen within

(1) Lectures on Dental Physiology and Surgery.

my own notice have been limited to incisors and bicuspid teeth. There is no reason why the molar teeth should not be subject to the deformity equally with the front teeth, excepting that the situation in the mouth of the former renders them less liable to accidental disturbance than the front teeth.

To the naked eye the displacement of the crown is sufficiently apparent, but the coincident derangement of the

FIG. 69. (1)

tissues can be seen only by the aid of the microscope. If, however, we take a thin section from a tooth the crown of which has been moved on its pulp during the period of calcification, we shall find the dentinal tubes greatly bent or disturbed in their course at the point of injury. The relations of the enamel, the dentine, and of the cementum, are also interfered with at a corresponding point.

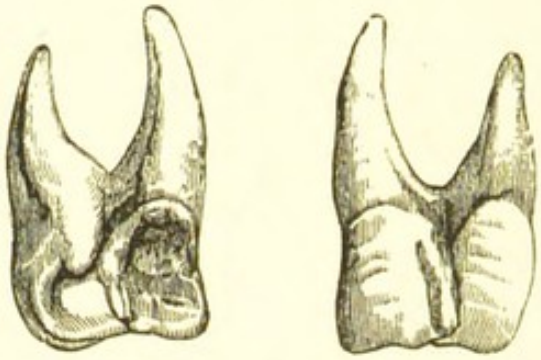
There is one other deviation from the normal condition which, as it affects the forms of individual teeth, must be included under the present heading—viz., *the union or gemination of contiguous teeth.* This subject was entered upon in connection with the temporary teeth (page 32),

(1) Shows three instances of dilaceration. The figure to the left is taken from an upper bicuspid, the crown of which had been moved on the pulp. The centre figure is that of a central incisor removed from a boy in consequence of the cutting edge of the tooth being directed towards the tongue. The boy had received a blow upon the mouth. The right-hand figure shows the appearance presented by a section of an incisor similarly deformed to the preceding example, although the development has yet to be completed.

but in respect to the permanent teeth it has yet to be considered.

When two teeth are permanently united, the union must have been effected through the medium of their respective pulps prior to the development of the teeth themselves; or the connection must have resulted from diseased action in-

FIG. 70. (1)



volving teeth placed in close apposition. Cases of this latter class, being the result of exostosis, will be considered in connection with that disease. In the specimen which forms the subject of the following figure, the pulps of the central incisors must not only have come in contact, but have been pressed upon each other with sufficient force to cause the left to have become to a slight extent imbedded in the right tooth-pulp. The development of the united crowns having been perfected, each tooth had its root separately produced.

In a very interesting specimen, for the use of which I am indebted to Mr. Styers, of Nottingham, the central and lateral incisors were united throughout their whole length. The line of confluence, though sufficiently marked for recognition, was not deeply cut, consequently the four teeth at a short distance looked like two extremely large but symmetrical central incisors.

Union of the lateral incisor and canine is now and then

(1) Shows a view of the lingual and of the labial surfaces of two permanent central incisors of the upper jaw, the crowns of which are united.

met with. The accompanying figure (Fig. 72) is taken from a specimen in which both the crowns and roots of the lateral incisor and canine are united. The appearance produced by this large tooth was objected to on the part of the parents, who induced a dentist to make an artificial division by means of a file. The operation resulted in

FIG. 71. (1)

FIG. 72. (2)

opening the pulp-cavity, and consequently in the death of the united teeth. Extensive alveolar abscess followed, for the relief of which the teeth were removed nine days after the operation of filing. In this example, although the union was perfect, and effected by the dentine of each tooth being, at the point of junction, common to the two, yet the position and size of each tooth was defined by a depression running the whole length of the teeth, and, corresponding to the depressed line on the surface, is a contraction in the pulp-cavity which is common to the two teeth. In examining connate teeth, it will sometimes be found that a supernumerary has become united to a normal member of the dental series. Two cases have fallen within my own observation, in each of which a lateral incisor was united to an equally well-developed supplemental lateral. In one example, the

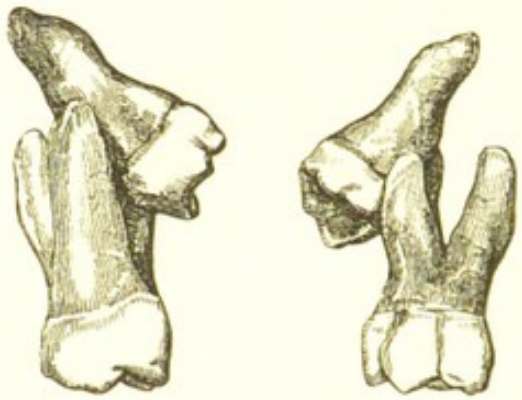
(1) Shows the permanent central and lateral incisors of the upper jaw, united throughout the whole length of the teeth. From a specimen lent to the author by Mr. Styers.

(2) The permanent lateral incisor and canine from the right side of the upper jaw, united.

teeth had been removed from the upper, in the other the teeth remained in the lower, jaw of a patient. In a third case, each central incisor of the upper jaw had joined to its median side a supernumerary tooth, equal to about one-half of its own breadth, thus producing by the union two front teeth individually one-third larger than the normal size.

Union between a canine and a bicuspid, or between the two bicuspids, or between a bicuspid and first molar, except-

FIG. 73. (1)



ing as the result of diseased action set up long after the development of the teeth has been completed, is of very rare occurrence.

The molar teeth are not, however, equally exempt from gemination. Many specimens have been preserved showing permanent union between the second and third molars. In the example figured, the third molar passes obliquely between the palatine and posterior labial roots of the second molar, and is united to each of them.

In another specimen, placed at my disposal by Mr. Harrison, the second and third upper molars are united at several points, without the ordinary position in the jaw of either tooth being materially altered. The masticating surface

(1) Shows the second and third molars united. The right figure represents the two teeth from the labial aspect; the left, from the lingual or palatal aspect.

of the wisdom tooth is upon a higher level than that of the second molar; but the difference is not greater than is often seen to exist between the corresponding teeth in the mouths of patients.

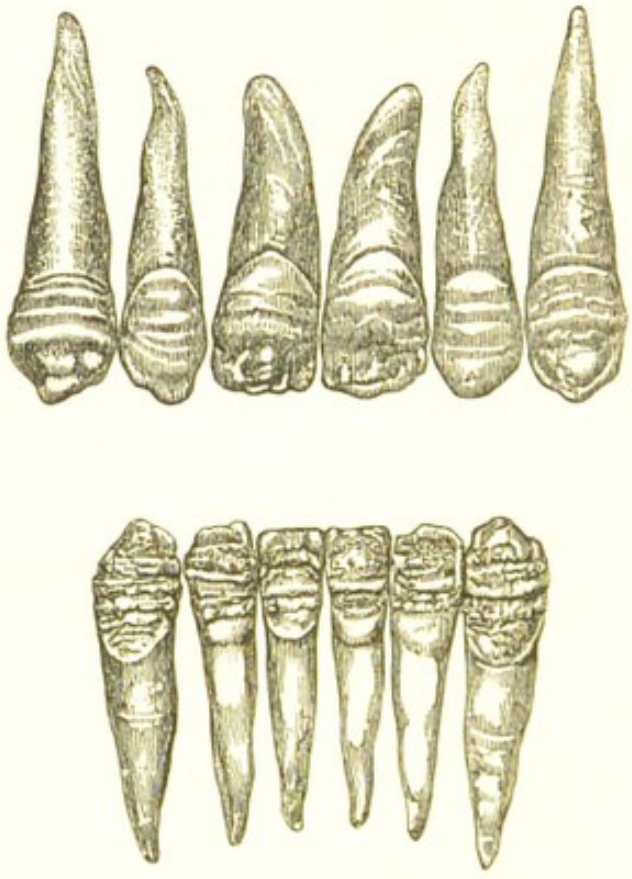
In examining a series of connate permanent teeth, it will be found that where the crowns are involved, the union is effected by a continuity both of the dentine and of the enamel, the connecting portions of the tissues being common to the two teeth, and by dentine and cementum, or by cementum only, where the union is limited to the roots.

In the one case, both the dentinal and enamel pulps were united, and thus produced a geminated tooth; in the other case, the union must have been effected long after the crowns of the teeth were developed, and at the time the roots were forming. In cases of union occurring under the latter circumstances, the medium of connection may be limited to the cementum, much in the same manner as we see the contiguous roots of a tooth bound together by the interposition of cementum. Those examples in which, by the large development of cementum consequent upon disease, two contiguous teeth become united, must not be classed with such as may be regarded as cases of congenital union. The cementum may be the uniting medium in either case; but in the one the cementum will not exceed the normal amount, in the other it will exist in excess, and constitute a disease.

Perhaps we shall not find a more fitting place for considering those deviations from the normal forms of the teeth which are consequent upon interrupted development of the dental tissues. The crowns of the affected teeth, instead of presenting the beautiful smooth and glossy surface characteristic of finely developed enamel, are disfigured by the presence of an irregularly grooved or pitted surface, accompanied by a considerable diminution in size. The incisors are commonly very thin and compressed, while the canines and the cusps of the molars are terminated by sharp points.

By the aid of the microscope we may learn that the tissues are not only deficient in quantity, but that they are defective also in quality. Neither the enamel nor dentine is perfectly developed: the elements of the former are imperfectly combined, hence the tissue is porous, yellow, opaque, and very fragile; and in the latter, the dentinal tubes are wanting in that uniformity of size and arrangement which they exhibit in well-developed teeth.

FIG. 74. (1)



The condition of system which operates so unfavourably upon the developing teeth frequently passes off before they are completed; consequently those parts of the teeth which are formed after the health has improved assume the normal appearances. It is very common to find teeth which show most distinctly that they have been produced under two

(1) Showing the front teeth, grooved from the alternation of perfectly and imperfectly developed portions of enamel.

conditions of system: the one half of a tooth will be imperfectly, the other perfectly developed. The observation may with equal justice be applied to whole sets of teeth. The whole of the crowns of the central incisors may be altogether imperfect, while a small portion of the lateral teeth will be well formed. In the canine, the good portion of the crown will be larger than the bad, and the second molar will be altogether without any visible defect. Tracing the teeth from front to back, we may see that the defect crops out at definite points, and that there will be in this respect a strict correspondence between the two sides of the mouth.

The defect of structure will be limited to such portions of the several teeth as were undergoing development at the same time, and consequently under the same constitutional state. If, for instance, we find the one-half of the crowns of the central incisors and the first permanent molars imperfect, one-third of the lateral teeth will be in a corresponding condition, while the defect will not extend over more than a fourth of the crowns of the canines. Again, if the extent of the defect be limited to the cutting edges of the central incisors, the lateral incisors may be almost free from imperfections.

As yet, those cases only have been described in which the dental tissue exhibits over a certain portion of a tooth obvious signs of a defective organisation. But we sometimes find teeth which are marked by grooves and ridges, very regularly disposed. The grooves are the result of checked, and the ridges of regular, development of the enamel and subjacent dentine. These transverse markings, resulting from alternations in the developmental process, find an exact parallel in the striæ produced by similar causes on the nails. Owing to the more rapid and persistent growth of the latter, it is often possible to see the mark left by a severe illness in the form of a transverse groove across the nail, this being the result of a temporary cessation of its development. Although it is in many, it is not in all, cases

easy to trace this ridged, or pitted, or honeycombed condition of the teeth to the presence of serious indisposition of the patient during the period when the defective portions of the teeth were being developed; it can, however, be scarcely doubted that an imperfect organisation of the teeth, if not the result of some special disease, such as measles, influencing the system generally, is yet consequent upon a constitutional condition. The fact that if one tooth is affected, those parts of other teeth which correspond in respect to the period of formation will present a similar condition, precludes the supposition that the effect has been produced by a merely local cause. The evidence points to a general cause, but it will not uncommonly be very difficult to discover the precise nature of that cause. The parents may tell you that your young patient has been particularly healthy from the time of birth, having at no time suffered from more than a very trifling and short-lived indisposition. On inquiry, you find that the temporary teeth were well developed, lasted their time, and then dropped out. I have a preparation in which the jaws are particularly well grown, and the temporary teeth unusually fine; yet, on removing the bone to show the permanent teeth, it was found that the latter were honeycombed to a great extent. The converse of this is often seen. The temporary teeth may be lost from caries at an early period, and the maxillæ be contracted, and still the permanent teeth may to all appearance be well shaped and free from structural defects. There is ample evidence to show that the condition of the temporary set cannot be taken as a positive indication of the nature of the succeeding permanent teeth; neither will the evidence furnished by the parent in all cases enable us to account for the presence of the peculiar form of defect in the teeth to which attention has been directed.

These craggy, honeycombed teeth Mr. Jonathan Hutchinson would term mercurial teeth, in the belief that this malformation is almost always due to the free administration of mercurial medicines in infancy, and his views on this matter are endorsed by so careful an observer as Mr. Moon.

One of the writer's own patients, who had teeth thus deformed, in answer to an inquiry as to the health he had enjoyed during childhood, replied, that he had slept with his head on ice, and been fed upon calomel all his early life. This answer, elicited without any sort of leading question having been asked, was at least striking; and, on the other hand, it is matter of the greatest difficulty to be sure that a child has not had mercury given to it, for even without its ever having had convulsions, it is exceedingly likely that some nurse has, at some time, made use of teething-powders to ensure her own repose, and of the teething-powders in the market the majority contain mercury.

Mr. Hutchinson's attention was first called to this matter by noticing the frequency with which children who had suffered from convulsions had these teeth, and, at first, he associated them directly with the convulsions; but after going more carefully into the matter, he came to the conclusion that it was the treatment directed to the cure of the malady, rather than the malady itself, that was to blame. The causation of this deformity of the teeth by mercury can hardly yet be considered as a thoroughly established and accepted fact, but it has, at least, a high degree of probability.

It is believed that the effects of hereditary syphilis may often be traced as the cause of a peculiar dwarfed condition of certain teeth. Attention has been drawn to this point by Mr. Jonathan Hutchinson (1), who has pointed out that, inasmuch as specific inflammations do not occur during the period of intra-uterine life, the teeth belonging to the deciduous series are not liable to be affected, though they may be lost by exfoliation consequent on stomatitis and periostitis. On the other hand, the occurrence of specific affections of the mouth, soon after birth, may be readily supposed to affect the permanent teeth which are at this time develop-

(1) Transactions of the Pathological Society, vol. ix., p. 449, and vol. x., p. 287, and Transactions of the Odontological Society, vol. ii., p. 95, 1857, and Mr. Moon, Trans. Odont. Society, vol. ix., 1877.

ing, and certain characters are enumerated as indicative of such interference with the growing teeth.

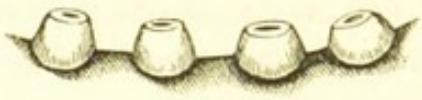
The incisors and canines are of small size, and peg-shaped; the crown is notched, the notch being in the main a concavity from the one corner to the other, though there may be secondary notches in this general concavity.

The existence of a "circumferential notch" encircling

FIG. 75. (1)

A.

B.



the canines near their points, is also noted by Mr. Hutchinson, but is by him attributed to a "circumferential wearing" of the one tooth on its opponent. This explanation is inadmissible; the groove running round the crown of the canine near its apex is simply the mark of a temporary arrest of development, and is precisely analogous to the similar groove across a nail which sometimes is seen after a serious illness. It is very possible that the arrest of development may have been brought about by an attack of stomatitis, and a similar circumferential groove would probably be found encircling the incisors at a point lower down on their crowns, seeing that calcification of these teeth is in advance of that of the canines. As, however, the true origin of the groove on the canine was not recognised, the presence or absence of similar marks on the incisors is not mentioned.

Teeth described as "syphilitic" have a dusky, opaque

(1) "Syphilitic" incisors; copied from Mr. Hutchinson's Paper (*loc. cit.*)

appearance, and are small relatively to the size of the jaws, so that distinct intervals are left between them; moreover, they are of a very soft character, so that they speedily become worn down, and the characteristic transverse notch obliterated.

It must, however, be borne in mind that even though the association of teeth of this form with inherited syphilis were fully established, it by no means necessarily follows that they are the direct result of attacks of stomatitis. The influence of inherited syphilis is capable of profoundly modifying the nutrition of many parts of the body, and it is quite as likely that its effects would be brought about directly as that they should be manifested secondarily through the intervention of an attack of stomatitis.

Moreover, constitutional syphilis attacks the hair, the nails, and the skin generally with great frequency, and the homological relation which exists between the teeth and various dermal appendages may serve, if not to explain, at least to render less surprising, the fact that the developing teeth should be a chosen site for its manifestation.

It has been pointed out by Trousseau (1) that the various syphilitic affections of the mouth in a child are rarely seen before the second week, and seldom manifested after the eighth month (unless they have previously made their appearance).

It becomes, then, a matter of importance, in deciding upon the correctness of Mr. Hutchinson's views, which have been unreservedly accepted in a recent paper by Mr. Berkeley Hill (2), to ascertain with precision the extent to which calcification has proceeded in the affected teeth at this period of the child's development. Unfortunately, the jaws to be found in museums have almost invariably been macerated, and the minute calcifying tips of the permanent

(1) Trosseau. Clinical Lectures (New Sydenham Society's translation). "On Infantile Syphilis."

(2) Monthly Review of Dental Science. June, 1872.

teeth lost, so that it is not easy to acquire definite knowledge on the subject; moreover, the statements of various authors differ in the times assigned to the commencement of calcification in the permanent teeth.

In Gray's Anatomy (the authority for the periods not being given) it is stated that calcification in the central incisors takes place about the sixth or seventh month; in the laterals and the canines about the eighth or ninth month of fœtal life. Should these dates be correct, the theory that the deformity is produced by stomatitis is placed in jeopardy, seeing that the part most profoundly malformed is the extreme tip of the incisor—that is, the part first formed—the calcification of which is said to begin at the seventh month; in other words, at least two months before the probable occurrence of a specific stomatitis.

On the other hand, Kölliker (1), without giving definite dates for the commencement of calcification, implies that it is somewhat later; and Magitot (2) states that the follicles of the permanent incisors and canines first appear three months before birth, and that calcification first commences on the papillæ in the first month after birth.

One point, however, appears to have been overlooked by Mr. Hutchinson, namely, that the calcification of the temporary teeth is not so far advanced at the time of birth but that we may expect them to be influenced by the occurrence of disturbing causes during the first month or two after birth. On reference to Fig. 1 (page 5), it will be seen that only the tips of the temporary canines are calcified, so that any interference with its development might probably be marked by a groove around it below the tip.

At the International Medical Congress the existence of any type of tooth modified by hereditary syphilis was strongly denied by Dr. Magitot, Dr. Quinet, and others, but many of their arguments were directed against, not the true

(1) Kölliker. Manual of Human Microscopic Anatomy. 1860.
(2) Magitot. Comptes Rendus, 1874.

syphilitic tooth, but a honeycombed tooth (which they call an "eroded tooth"), and so missed their mark. Nothing was there brought forward by the opponents of Mr. Hutchinson which could weigh against the evidence brought forward by that gentleman, by Professor Parrot, and Mr. Moon (1), and it may be stated in general terms that ophthalmic surgeons, who have many excellent opportunities for judging, are mostly agreed in accepting the existence of this type of tooth as evidence of inherited syphilis, and our own limited experience is wholly in the same direction. It would take far more numerous positive and accurate records of cases to prove the contrary; on the one side we have notes of cases, carefully compiled family histories, &c., and on the other mere vague expressions of disbelief.

Irregularity in the period of the eruption of teeth is not, as a rule, of great importance. Some degree of variability seems consistent with perfect health, and an otherwise normal arrangement of the teeth; but sometimes teeth will, from accidental malformation, or even from no cause that can be traced, be greatly delayed. The wisdom teeth are not rarely retained in the alveolar border till advanced age, when the other teeth have all been lost and replaced by artificial teeth; and the canines, perhaps, because they are developed farther beneath the surface than the other teeth, seem to be, next to the wisdom teeth, most often retarded in the eruption.

The molar teeth will vary in different individuals as to the time of their eruption, but the amount of variation is seldom sufficient in extent fairly to come under the head of premature eruption. But in those teeth which succeed to members of the deciduous set, a considerable amount of deviation in anticipation of the normal period may sometimes be observed. Before this, however, can occur, the preceding occupant of the space must have been prematurely lost. But in the shedding of the temporary teeth

(1) See also Transac. Odontolog. Society, 1877.

there will be a certain range of variation in respect of time within which the loss of teeth cannot be regarded as premature. The condition of health may hasten or retard the process, and it is probable that hereditary predisposition may also exert an influence in determining the time at which the deciduous teeth fall out, and make room for their successors. In the vast majority of cases, however, the premature loss of temporary teeth depends upon the occurrence of caries, and the consequent extraction of the diseased organs. Many children suffer so much pain from decayed temporary molars, that the general health becomes disturbed, and their removal is consequently necessitated. Now, it is in these cases that the succeeding teeth sometimes appear prematurely, and consequently out of the usual order. A certain number of examples have fallen under my notice, in which one or more of the bicuspid teeth have appeared as early as the lateral incisors ; and although in one or two instances the teeth have been imperfectly developed, in other cases all indications of faulty organisation have been absent. In a little patient of my own, the whole of the deciduous teeth decayed nearly down to the level of the gum, and produced such serious suffering that the child fell into bad health. At the age of three years and a half the decayed teeth were all removed (excepting the second temporary molars), under the influence of chloroform. The operation was succeeded by a restoration of health, and the permanent teeth have since appeared in the usual order, both as respects the time and the place of their eruption. Now, in this case the premature loss of the first has not been followed by the premature eruption of the second set of teeth. In a less healthy subject the result might have been different; or had the teeth been allowed to remain in this case, and, as stumps, had kept up irritation in the gums, it is more than possible that some of the permanent teeth would have been injured, and have appeared prematurely through an inflamed gum.

In a practical point of view, the accelerated is less inte-

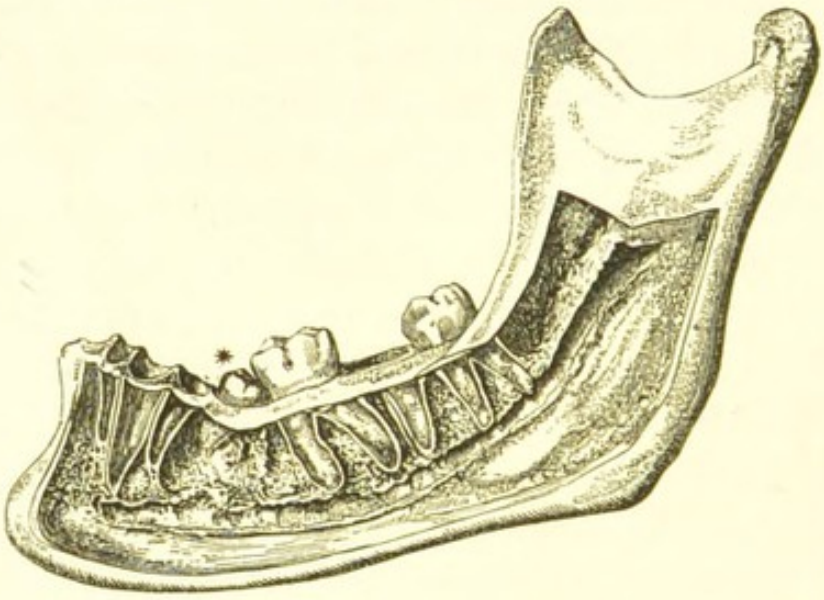
resting than the retarded eruption of teeth. The premature appearance of a tooth cannot be prevented, and when in sight, the mischief it may occasion can be ascertained; but when the eruption of a tooth is delayed, there is great difficulty in learning its relations in respect to the other teeth, its own conditions as regards size, shape, and stage of development, and the amount of influence it may exert either in the production or in the maintenance of neuralgic pains.

Some irregularities of position, and the results to which they lead, have been already described; hence, in the present section the inquiry may be limited to the question of retarded eruption of teeth which are not irregularly placed during the period of growth; in other words, to teeth irregular only in respect to the period of their eruption. It is by no means uncommon to find that certain members of the permanent set do not appear at the usual time, and even after the lapse of some few years are still absent from the usual position; and it is not, perhaps, until long after their presence has been called in question that they penetrate the gum. In a case which is described at page 197, the right central incisor of the upper jaw appeared at the age of thirteen, that is, six years after the fellow tooth. In a second case, an upper canine pierced the gum at the age of two-and-thirty; and in a third, a similar tooth cut the gum after the patient had passed the age of forty. Again, many cases have occurred in which teeth have been cut at a very advanced age. The recognition of this wide range in respect to the time of the occurrence of a process which is coincident with a known epoch of general growth of the body suggests an inquiry into the condition of the teeth themselves at the period of eruption, and also into the nature of the process of eruption in these exceptional cases. In reference to the first point, we have to learn whether, when the eruption of a tooth is retarded, the development is equally delayed, and whether the former is consequent upon the latter condition, or whether the one process may be quite independent of the

other. To meet the second question, two processes by which a tooth may be cut must be recognised. In one, the tooth itself presses forward, and makes its way to the surface; in the other, the gums recede and expose the tooth, which, having been stationary, would have remained in concealment but for the recedence of the gums.

In the cases of retarded eruption of special teeth in which I have had an opportunity of examining the teeth them-

FIG. 76. (1)

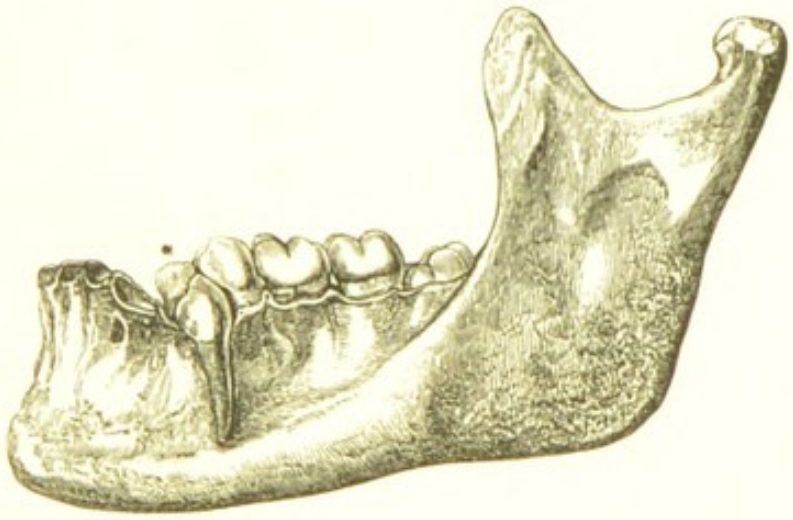


selves, there has been no evidence to show that the development of the dental tissues had been interrupted. The roots may be shorter than usual, and the crowns faulty in respect of form and organisation, but the presence of these defects does not prove that the production of the tooth was delayed. Indeed, there is a want of decisive evidence in support of the opinion that the actual development of the teeth is delayed much beyond the usual period, although the numerous cases of late eruption would at first sight favour the

(1) Shows the persistence of the second temporary molar retarding the reception of the second bicuspid, which is shown, by the small size of the crypt in which it was contained, to have been stunted and deformed. The temporary tooth is marked by the asterisk. The author is indebted to Sir Edwin Saunders for the use of this specimen.

supposition. The period of eruption does not, however, in these exceptional cases, bear any necessary relation with the time at which the development of the teeth was completed. In some examples, the obstructing cause is sufficiently obvious, but in others, we fail to see why the tooth did not take its place in the series at the usual time. In the case of a female, the upper canine was absent, a space being left between the first bicuspid and lateral incisor. At the age

FIG. 77. (1)

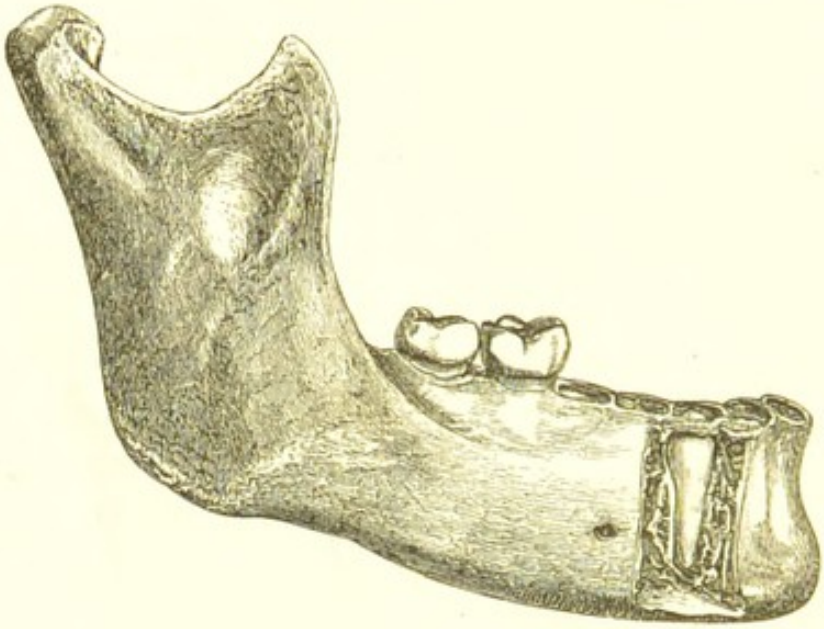


of forty-five, the missing tooth slowly protruded itself. Now, in this instance the way was not prepared by the loss of a tooth, neither were the gums receding; hence we are at a loss to see why the eruption of the tooth was delayed, or why it appeared at that age rather than at any other. The case is, however, instructive, as respects the process of eruption in retarded teeth. There is no reason for assuming that the development of the tooth was later than of the corresponding tooth which appeared at the usual time; supposing, then, it to be admitted that the tooth was completely developed before the process of cutting commenced,

(1) Showing the first bicuspid retarded in its eruption by the presence of a temporary tooth. The bicuspid is a perfectly well-developed tooth, but the outer wall of the alveolus is absent. The temporary tooth is marked by the asterisk.

the process itself must be in some respects different from that which occurs when teeth are cut under ordinary circumstances. When the process is normal, as respects the time and the stage of development of the tooth, the crown

FIG. 78. (1)



appears through the gum long before the root has attained its full length. The crown is in great part brought towards the surface of the gum by the progressive lengthening of the root, and is afterwards still further raised by the same process. Now, when the eruption is accomplished subsequent to the development of the root, the movement of the tooth must be effected by some other means than by the progressive lengthening of root. The completed tooth has to change its place without itself undergoing any change. The bone which stands in its way must be absorbed, and the lower portion of the socket from which the root of the tooth moves, must be contracted by the deposition of bone. Indeed, in the absence of a better hypothesis, it may be

(1) An adult lower jaw, with the canine retarded in its eruption. The outer plate of the jaw has been cut away to show the position of the tooth.

assumed that the gradual contraction of the socket is the means used by nature for bringing teeth to the surface when the process of eruption has been delayed beyond the normal period. In the one case, the movement is effected by the development of bone within the alveolus; in the other, by the progressive development and consequent lengthening of the tooth.

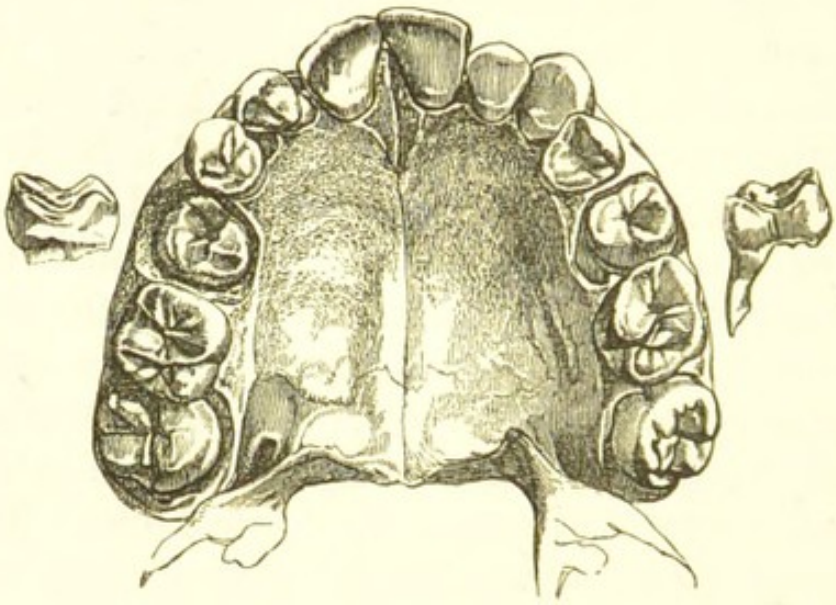
In many cases, however, the retarded teeth become exposed to view by the absorption of the superjacent gum, the teeth themselves being perfectly stationary. The pressure on the gum caused by artificial teeth will not uncommonly cause its absorption and the exposure of a hidden tooth, and this tooth, once having been bared, will often descend to a lower level than that which it had previously occupied. The manner in which this takes place, and the effect produced, may be seen on referring to the figures illustrating irregularities in the position of the permanent teeth.

The cause which most commonly retards the cutting of a permanent tooth is strictly a mechanical one. The space which should afford a place for the missing tooth is already occupied either by a persistent deciduous tooth, or by the crowding together of the contiguous permanent teeth. Under these circumstances, the normal occupant of the spot is either held back or takes some extremely irregular position. In the accompanying figure, the second bicuspids of the upper jaw were retarded by the presence of the temporary molars. The deciduous tooth on the one side of the mouth had lost all its roots, and there appears no reason why the bicuspid did not take its place at the usual time; but on the other side the temporary molar has retained the greater portion of its palatal root, and was consequently held firmly in place to the exclusion of the bicuspid. Although in this example the usual period for the replacement of the temporary molars has not been exceeded by more than two years, it is not on that account less instructive.

When a temporary tooth does not fall out at the usual

time, it becomes a serious question whether we should allow it to remain; whether we should wait until it becomes loose before its removal is attempted, or remove it irrespective of this consideration. It is also desirable that the question should in each case be settled before the period of replacement has been long passed by. Now, in the example which

FIG. 79. (1)



forms the subject of the last figure, the bicuspid on the right side has been slightly, perhaps not injuriously, retarded by the temporary molar, but the latter tooth would have speedily given place to its successor. Not so, however, on the right side of the mouth. The retention of the palatal root on the part of the deciduous tooth, would have enabled it to hold possession of the position, to the exclusion of the second bicuspid, producing, perhaps, a similar result to that shown in Fig. 76. But if we resolve upon removing deciduous teeth in all cases when the normal period arrives for their replacement, the practice will now and then lead to

(1) Showing the second bicuspids, at the age of fifteen years, retarded by the presence of the preceding temporary teeth. A very similar condition existed in the lower jaw of a child supposed to have been murdered (The St. Luke's Mystery), in whose case an erroneous estimation of age had been based upon its absence.

disappointment; we may remove a temporary tooth which is destitute of a successor, as shown in Fig. 57, or we may make way for an imperfect tooth, inferior in every respect to its predecessor. These exceptional cases are, however, of such rare occurrence, that although they should not be entirely disregarded, their influence upon our practice should be but comparatively slight. Then, again, the temporary tooth may not only retard the permanent tooth, but it may also lie at a lower level than the adjoining teeth, and consequently if allowed to remain, render little or no service in mastication, as in Fig. 76.

Regarding, then, the persistence of temporary teeth as a cause which commonly operates unfavourably, not only by retarding the eruption of permanent teeth, but also by producing irregularities in the dental series, their removal must, as a general rule, be attended with advantage.

The wisdom tooth is sometimes prevented from assuming its proper position by being situated immediately beneath the second molar. Very recently a second upper molar was extracted at the Dental Hospital, between the fangs of which was a hemispherical cup of bone with a perfectly smooth surface, which was at first sight imagined to be a portion of the floor of the antrum. On examining the mouth, however, the crown of the wisdom tooth was found to occupy the space whence the tooth had been extracted, so that the cup of bone proved to be a portion of the bony cell in which it had lain buried.

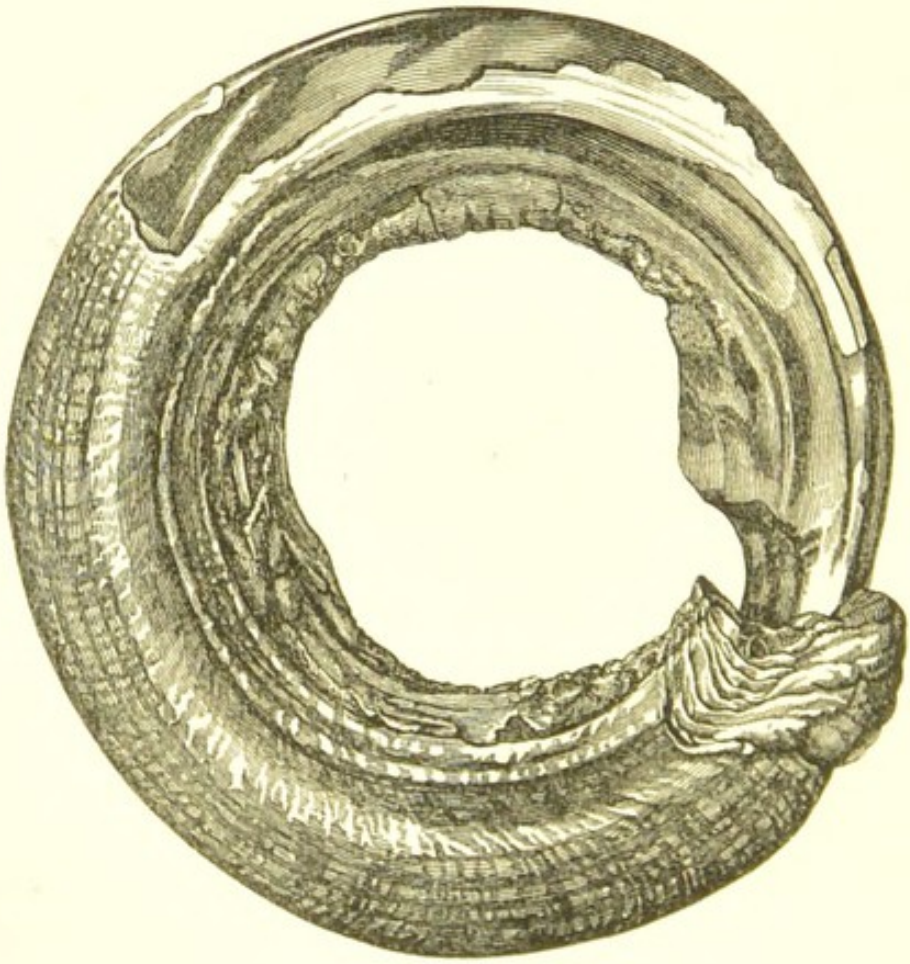
Whether the wisdom tooth will now descend into the alveolar line (the patient being over thirty years of age) remains to be seen.

The consecutive changes in the teeth and jaws, which in the healthy subject keep pace with the general growth of the body, have to some extent been traced; and the results which are entailed when the development of those parts is interfered with have been pointed out; and this brings us to the end of one division of our subject. As an example of over-growth in a tooth, a figure (Fig. 80) is here intro-

duced of an unique specimen from the Museum of the Odontological Society; it is a hippopotamus's tusk, the cutting edge of which, from want of antagonism, and the consequent absence of wearing away, gradually advanced until it entered the pulp cavity, and thus put an end to the further development of the tooth.

Irregularities in the position of the permanent teeth admit of division into two heads. 1st. Irregularity in the

FIG. 80.



position of the teeth, mainly in their crowns, the jaws beyond the immediate alveoli of the teeth not participating in the irregularity. 2nd. Irregularity in the position of the teeth, the alveolar border and the jaws beyond their limits being more or less involved.

Such divisions are convenient, but of course the one form passes more or less insensibly into the other.

The first group admits of further division into those cases in which the crowns alone are involved, the ends of the roots being in their proper position, and those in which the whole roots are bodily displaced.

Irregularities apparently the most trivial may be, in fact, congenital. Thus I have lately seen an instance in which, although there is no crowding in the jaw sufficient to account for it, the right upper central incisor is to a slight extent twisted on its axis, and lies a little behind its fellow tooth: precisely the same irregularity existed in the father, and will be apparently repeated in another child, in whom the tooth is as yet only partially erupted. A case is quoted by Mr. Sedgwick (1) in which, during both dentitions, a double tooth took the place of the left lateral incisor, this peculiarity being inherited from a paternal grandfather.

It might at first sight appear to be the most methodical course to describe in detail the various forms of irregularity, tracing them where possible to their causes, and then to proceed to the discussion of their treatment; but on the whole it will probably avoid needless repetition to take the description of the irregularities and their treatment together, taking the simple forms first.

One of the most common causes of displacement is the persistence of the temporary teeth, as a very slight obstruction is sufficient to deflect a growing tooth from its proper path. The following figure may be taken as a fair example of irregularity arising from this cause. The temporary teeth being retained, their successors have consequently taken a posterior position, which allows the lower teeth, when the mouth is closed, to pass in front of them; and thus, in the absence of mechanical interference, render permanent the mal-position.

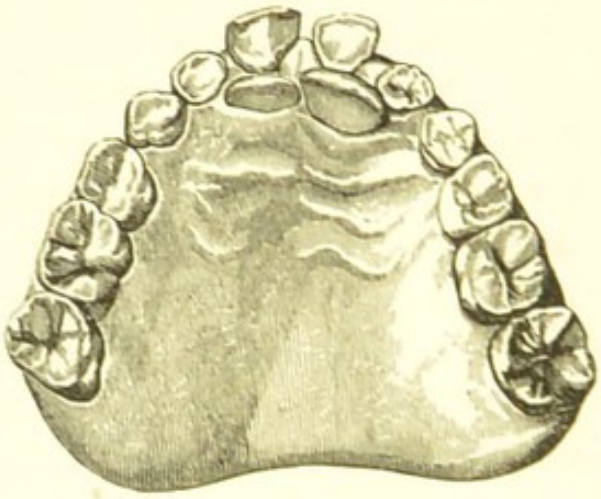
Unless it is remedied by mechanical interference, the under teeth will present a barrier to the outward movement of the inturned teeth.

(1 British and Foreign Medico-Chirurg. Review, April, 1863.

If subjected to treatment at a sufficiently early period, these cases may be brought to a successful issue with much less difficulty than those in which the teeth are everted. The difficulty of keeping the teeth in the position into which they have been moved is remedied by the antagonistic teeth of the lower jaw. When, therefore, the upper are brought sufficiently forward to close in front of the lower teeth, our treatment may be discontinued.

Now there can be no difference of opinion as to the propriety of adopting measures for reducing to a normal position

FIG. 81. (1)



teeth which are permanently turned inwards. We have therefore to consider the age at which the operation can be most advantageously undertaken, and the manner of performing it.

The anatomical conditions of the teeth, and the parts about them, at the period of eruption, have been already described. If these conditions are understood, but little doubt will be entertained upon the propriety of adopting mechanical treatment at a comparatively early period. There would be no advantage gained by waiting till the

(1) Shows the permanent central incisors coming through the gum posteriorly to the persisting temporary teeth, leaving an interval into which the lower incisors pass when the mouth is closed.

sockets are fully formed, as the treatment must then involve their partial destruction, and the reproduction of new ones. On the other hand, if the treatment be commenced sufficiently early, the large open sockets will allow the growing teeth to be moved forward, and those parts of the sockets as yet unformed will be developed in accordance with the direction given to the teeth. So soon, therefore, as it is discovered that the upper fall within the lower front teeth, the treatment may be commenced. If measures were adopted prior to the establishment of irregular antagonism, we should perhaps be effecting by mechanical interference that which Nature would have accomplished with much less inconvenience to the patient. Few can have failed to remark the much greater prevalence of irregularity in the permanent teeth about the time of their eruption, than at a later period, in that class of society the members of which do not avail themselves of the services of the dentist, excepting when the presence of an aching tooth can no longer be borne. That in many instances teeth which on their first appearance through the gums hold an objectionable position, will, if left to themselves, ultimately fall into the proper line, is a fact sufficiently well established to warn us against interference until it is clearly shown that our assistance is required.

From the frequency with which irregularities are remedied by nature, it has been supposed that there is a strong inherent tendency towards the assumption of a normal position, and that teeth will in consequence of this tendency, all mechanical obstacles being removed, take up a regular arrangement.

And although no one can doubt for a moment that there is, and must be, a controlling influence in the organism tending to its assumption of its typical form, yet the existence of certain mechanical agencies which are in constant operation, namely the pressure exerted by the tongue and by the lips must be borne in mind. If any tooth projects outwards or inwards beyond the line of the surrounding

teeth, it will obviously sustain more than its share of the pressure exerted by the muscles of the lips or of the tongue. And as the lips and tongue act evenly and symmetrically on every part of the alveolar arch, their action will obviously tend to the correction of any irregularity that may have occurred, if a regular disposition of the teeth be not rendered impossible by want of space, or other mechanical obstacle.

The muscles of the tongue in its varied movements exert a more powerful influence than those of the lips; and thus it happens that a tooth placed inside the arch is far more quickly pushed into its normal position by the operation of natural forces than one which lies outside the line. A very slight amount of force, if only it be constantly applied, is sufficient to alter the position of a newly erupted tooth; and this even pressure of the lips and tongue is probably the chief agency, not only in correcting any irregularity that may have arisen, but also in determining the regular arrangement of the teeth during their eruption where no mechanical obstacle interferes with their even disposition.

Some difference of opinion exists as to the best mode of pressing the teeth outwards. The older method of procedure consisted in fitting a metal plate to the lower teeth, from the upper surface of which a plate of metal projected, which, on closing the mouth, passed behind the teeth whose position required change. In fact, the lower teeth were by this process artificially lengthened and turned inwards, and consequently the amount of force exerted upon the misplaced teeth depended entirely upon the voluntary action of the lower jaw in closing the mouth. In many cases this method of treatment will be successful, but it is slow, and consequently produces a prolonged impediment to articulation and mastication; and it is open to a further objection. It is not uniformly successful, and at best depends in great part upon the voluntary efforts of the patient.

More recently, vulcanite plates fitted to the palate, and extended over the molar teeth, have been adopted. The

vulcanite over the masticating surfaces of the molar teeth is left sufficiently thick to prevent the upper and lower front teeth from influencing each other when the mouth is closed. The plate is fitted to the necks of the teeth to be operated upon, between which and the plate portions of dry compressed wood or pegs are placed, in cavities cut in the vulcanite for their reception. Each instanding tooth will have its corresponding cavity in the plate, the formation of which requires some little attention. The form should be similar to that of a shallow drawer, the front of which has been removed, and so proportioned as regards the upper and lower surfaces of the plate in which it is cut, that the section of wood will not fall out into the mouth. The wood should be fitted to the cavity, and left a little thicker at that end which lies towards the gum. If the plate be nicely fitted to the teeth which it caps, it will ordinarily hold in very tightly by springing in over their crowns, and in order that it may do so, Mr. Woodhouse is in the habit of cutting grooves into the plaster model at the necks of the temporary teeth, and then vulcanising upon the model. These grooves should correspond to the edges of the gums upon the lingual and labial aspects of the temporary molars, but they should not extend in between the teeth, as they would cause great soreness were they to result in the vulcanite pressing on the tongue or gum in this position. But the labial and lingual aspects of the crown ridges upon the vulcanite, which pass just beneath the abrupt bulge of the enamel upon the temporary tooth, do not cause pain. However, if a good and suitable model have been obtained, this trimming of it is not necessary, and Dr. Coffin advocates strongly the use of guttapercha for taking all impressions for regulating purposes. Guttapercha, owing to its low specific heat, can be employed very hot, and therefore very soft; he recommends that it be thoroughly softened in very hot water, placed in the tray, and the tray and its contents dipped into cold water and held there a few moments. No great excess should be used, and the tray having been firmly pressed up, best by the patient

biting it home, it is to be after a little time abruptly removed and at once placed in cold water. If by accident there be any considerable excess hanging over the back of the tray, this should be carefully supported till it has cooled, lest by its weight it drag the back part of the impression.

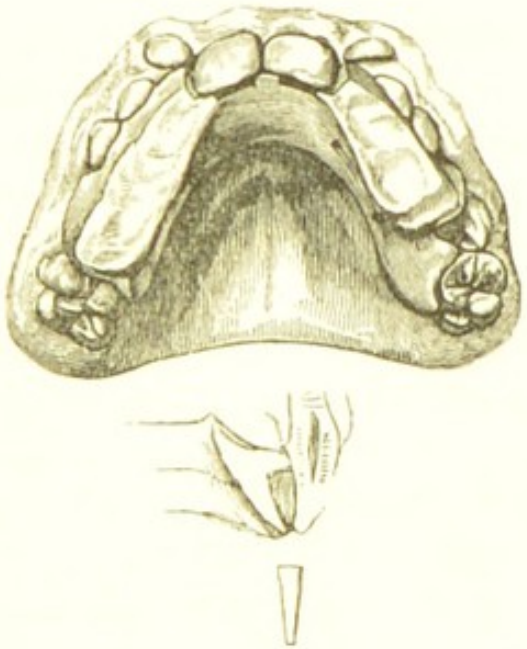
But if, owing to the unfortunate slope of the teeth, or their absence, or other cause, the plate will not stay in securely, it can be tied in, and there is a particular way of doing this, so much preferable to any other with which I am acquainted, that it is worth description here. The plate having been adjusted to the mouth, holes must be drilled through it for the admission of ligatures, which may be passed round and tied to one or other of the molar teeth on each side of the mouth.

In arranging the ligatures, care must be taken that they do not press upon and irritate the gums. It will be remembered that the gums approach nearer to the masticating surfaces of the teeth on the lingual than on the labial side. Hence, the holes in the plate should be made at the point corresponding to the free edge of the gum against which it rests, at the centre of the *lingual* surface of the neck of the temporary molars.

The plate being out of the mouth, long ligatures are passed round the necks of the temporary molars and securely tied: it will be found easiest to make the knot on the labial aspect of the tooth, and then to pass the ends back, one in front and one behind the tooth, so that the free ends hang inwards. The object of having the ligatures very long is that the free ends may now be passed through the drill holes in the plate (which is still out of the mouth) and loosely knotted together, so that they may remain whilst the whole process is repeated on the other side of the mouth. The plate is then put in and held firmly home whilst the ligatures are pulled up taut and tied, the knots being on the lingual surface of the plate, which will then be quite securely held. If these precautions be observed,

the ligatures when tied will pass in a straight line from the labial surface of the tooth to the lingual surface of the plate, without interfering with the gums. In selecting the teeth around which the ligatures are to be passed, we must be guided by the forms and the position of the teeth available for the purpose; but should the temporary molars be present it will be well to make use of them in preference to the permanent teeth. The abrupt termination of the enamel renders them particu-

FIG. 82. (1)



larly suitable for the purpose, and the short period during which they will be retained renders their injury a matter of little consequence.

(1) Showing a vulcanite plate fitted to the upper jaw, for the purpose of forcing outwards the central incisors. The vulcanite is left sufficiently thick over the masticating surface of the back teeth to prevent the lower teeth from influencing those to be operated upon. The plate is retained by ligatures passed through the vulcanite and round the temporary molars; posterior to the central incisors, the apertures of the cells for the reception of the compressed wood are shown.

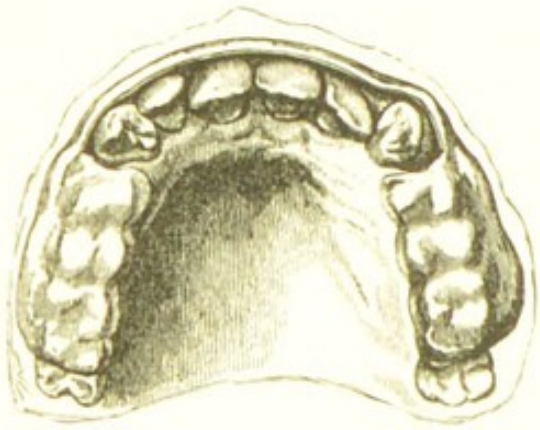
Below the figure, a section of the parts *in situ* is given, showing the cell in its length, with the piece of wood removed and placed underneath.

By the foregoing means the plate may be firmly fixed in order to afford a *point d'appui* for the action of the compressed wood, the cells for the reception of which will be formed on the one side by the teeth to be moved, and on the other three sides by the plate. After compressing for some hours a piece of dry willow, plane, or some other soft wood, small strips may be cut off, and from these fragments must be prepared which will fit with moderate accuracy to the spaces formed by the plate and teeth, taking care that the grain of the wood runs parallel with the long axes of the teeth. So soon as the wood commences to absorb moisture it will expand, and in a direction transverse to that of its grain. In expanding, either the tooth in front of it must move outwards, or the plate must be driven backwards, and with it the molar teeth to which it is fitted. But as the front teeth are capable of the least resistance, they are the first to yield, and therefore gradually advance before the expanding wood. From time to time the wedges must be renewed, each new piece being slightly larger than its predecessor; and as the teeth move upon an axis situated near the apices of their respective roots, the receptacles become changed in form, and it will be necessary to modify the form of the grooves in the vulcanite plate. If this precaution be neglected, there will be a difficulty in retaining the wood after the teeth have been moved from their original position. The receptacle will have changed in form as respects the relative size of the upper and lower portions. Hence it becomes necessary to deepen that end of the groove which lies near the gum, and the excavation must be made sufficiently deep to restore the parallelism which has been lost by the outward movement of the tooth. When the required amount of change in position is considerable, and the half of this has been gained, it may be necessary to discard the original plate, and substitute a new one fitted close to the teeth operated upon, so as to admit a thinner and more manageable wedge than that which would have been re-

quired had the treatment been continuedwith the first made apparatus.

It is doubtful whether, as a general rule, more than two teeth can be advantageously operated upon at the same time. If, for instance, the four incisors are involved in the irregularity, it may be desirable to push forward the central teeth first, and then move the lateral teeth, or *vice versâ*. But in adopting this plan we must not neglect to take means to prevent the teeth first operated upon from retreating to their old place while the others are being forced forward. This may be accomplished by inserting into the vulcanite frame pegs of wood, the free ends of which rest upon the backs of the moved teeth. In this application of the wood the end of the grain will rest upon

FIG. 83. (1)



the tooth, and as there is but very slight expansion lengthwise of the grain, the teeth will be simply held in position.

When the whole of the instanding teeth have been moved outwards to an extent sufficient to ensure their passing in

(1) Shows metal caps fitted to the molar teeth, with a band extending from them in front of the incisors. To the metal band so fixed, ligatures, after being passed round the front teeth, were attached, and drew the inverted teeth forward until they came in contact with the band. The case was treated by Mr. Harrison, to whom I am indebted for the specimen given in the figure.

front of the lower teeth on the mouth being closed, the use of the apparatus may be discontinued. Sometimes, however, it will be found that the back teeth of the upper and lower jaws, from having been kept apart during the treatment, lose their proper antagonism. They become raised in their sockets, and prevent the front teeth from meeting each other; under these circumstances, those portions of the vulcanite plate which extended over the masticating surfaces of the back teeth must be removed so as to allow the teeth to come in contact, while the plate prevents the front teeth from falling back into the former position. In a few days the proper antagonism will be restored, and the plate may be discarded.

Instead of using vulcanite, metal may be used for the plate; but, as a rule, it is neither desirable nor necessary, and has almost passed out of use. The molar teeth on either side may be capped with gold, the caps being made so that they fit tightly upon the teeth. From these a band of metal is extended in front of the teeth. Holes are drilled in the band opposite to the teeth, and strong silk thread is passed round the neck of each tooth and through the corresponding holes, and tied tightly on the outer surface of the band. The teeth will by degrees be drawn towards the band, but the process is a slow one, and requires frequent renewal of the ligatures.

I have commonly used vulcanized caoutchouc in the place of silk; with this material, the tension is more uniform, and the renewals need not be made so frequently. The fixing of the india-rubber to the band may be a difficulty; tying is impracticable, and hooks could not well be used. I found, however, that by cutting fine slits with a hair saw obliquely through the metal band, and then passing the two ends of the caoutchouc in a state of tension into them, the ligatures were firmly retained. Metal springs, which may be made of gold or of steel piano wire, will remain in active operation for a longer period than wooden wedges or pegs, and so the patient need not pay such frequent visits to the dentist.

Silk ligatures require renewal every second day, but the caoutchouc will last double the time, and will produce a much more rapid effect. I have in favourable cases succeeded in bringing teeth out in the course of a fortnight, and the case has been dismissed.

In the place of using metal in the foregoing manner, a plate may be fitted to the palate, and retained by bands passing round the back teeth, or by portions of wire extended over the crowns and bent down so as to clasp the necks of the teeth, or by capping the teeth. To the palatal portion of the plate, bands of metal rendered elastic by hammering, may be attached, adjusting the free ends so that they shall press upon the backs of the malplaced teeth. This manner of proceeding is inferior to the two preceding methods, where a number of teeth are involved, although in cases where two or three teeth only are required to be shifted, not only outwards or inwards, but also upon their axes, it offers some considerable advantages.

Excepting in those cases where the antagonistic teeth serve for maintaining the position acquired by mechanical interference, regulation plates must be worn for many months, and whatever may be the material used in their construction, the teeth to which they are attached gain nothing by being so used. Metallic bands encircling natural for the support of artificial teeth, not uncommonly produce injury to the former; and it is fair to infer that when, in protracted cases, regulation plates are retained by similar means, some amount of mischief may result. Hence there are many who condemn the use of metal. The question arises as to whether vulcanite is really less injurious to the invested teeth than gold; and, judging from the experience gained by watching the effects of artificial teeth constructed with each, I think we shall be constrained to answer decidedly in favour of the former. Still, before any appreciable hurt can be produced, the metallic frame must be worn for a long time, and supposing it can be attached to

temporary teeth, this consideration need not influence our selection.

The advantage in respect to time and the relative amount of inconvenience entailed upon the patient by the one or other method of procedure must not be disregarded. The ever-varying character of the cases renders it difficult to lay down any general rule as to the advantages of the one method over the other, as regards the time required to produce the desired effect. On the whole, perhaps, although cases treated by the use of metal plates are sometimes more speedily completed, nevertheless vulcanite is more generally to be preferred as more comfortable, and less injurious to the teeth.

Although in the majority of cases it will be necessary to rectify such malposition of the teeth as nature alone will not remedy, by the use of plates, there are other methods by which their position may be changed. A patient possessed of sufficient determination may often succeed in bringing forward a misplaced upper incisor by the use of a piece of wood, employed like a lever to force it forward, the lower teeth being taken as a fulcrum.

Ligatures or elastic bands may be adapted to the tooth which it is required to move in such ways as the ingenuity of the operator may devise, always bearing in mind, however, that unless a considerable number of teeth are embraced by it, those taken as the supports will probably be as much acted on as the tooth which is to be moved.

But whatever course of procedure is decided upon, there is one point which must carefully be kept in mind: the direction of the long axis of the tooth may be changed, but that is all. The apex of the fang will remain fixed, or nearly so; while the crown of the tooth will move in an arc of a circle the centre of which lies at or very near to the apex of the fang. It is therefore of the utmost importance in estimating the probability of success to ascertain as far as possible the position of the apex of the fang; and it is obvious that those cases in which the irregularity is due to

some such mechanical cause as the retention of temporary teeth will yield to treatment far more readily than those in which the alveolar border is more largely involved.

And it is often not at all necessary that the position of the bottom of the sockets should be changed, although the margins require to be reduced to a semicircle of much smaller radius. Now we know that moderate pressure, constantly maintained upon bone, will lead to its absorption; if therefore the crowns of the teeth be steadily and constantly pressed upon, that portion of the socket which receives the pressure will gradually disappear. The immediate result will be an enlargement of the socket in which the tooth will for the time move freely; in other words, it will become loose. This condition, if long continued, would lead to the early loss of the tooth; hence, to ensure success in our operations for readjustment, new bone must be produced in those parts of the socket from which and towards which the root of the tooth has moved. The fact of a tooth becoming loose under undue pressure, shows that the absorption may proceed more rapidly than development of bone.

The recognition of this fact, which may be assumed as a constant condition, suggests a very important question—viz., at what rate in respect to time can new alveolar bone be developed, when the removal of the pre-existing tissue has been induced by pressure? The determination of this point will also assist in determining the degree of pressure which can be used most advantageously, and the length of time it will be necessary to employ mechanical means for retaining the tooth in the position into which it has been forced. If an extreme case be taken for treatment, the extent of change produced, supposing the treatment to be permanently successful, will amount to the destruction of a considerable portion of the existing, and the production of new alveoli.

In the absence of well-established facts gained from dissections, in respect to the period required either for the re-development of alveoli, or the degree to which restoration

is carried, we are thrown upon the general results obtained in the treatment of cases, and upon the conditions which are found to obtain in the development of alveoli during the eruptive period of dentition. It has been shown that the socket grows up contemporaneously with the gradual development of the tooth, but in this case the process of growth is extended over many months, and the results obtained in the reduction of irregularities do not tend to show that the alveolar reparation is more rapid than the original alveolar development.

If, for example, slightly projecting teeth are by means of pressure brought rapidly into the proper line, and are then left without mechanical restraint, they will speedily return to their former place, and become firmly fixed in their sockets in a much shorter time than they would have done if retained in the newly acquired position. This circumstance would seem to indicate that in moving the teeth the sockets had been stretched or bent rather than absorbed; but there are many cases in which the assumption that the bone yields by its elasticity in the direction of the pressure applied to the teeth, does not offer a satisfactory explanation; and I am disposed to think that even in the cases where this explanation would at first sight appear tenable, the phenomena may be attributed to other causes.

The immediate consequence of continued pressure upon the crown of a tooth, is irritation and thickening of the peridental membrane; and this results in the tooth being raised in its socket to an amount equal to the increased thickness of the membrane.

The root of the tooth, from its more or less conical form, acquires, when raised in the socket, an increased capability of motion, without the alveolus itself becoming enlarged. Instances in which these conditions are produced by disease are of daily occurrence. A tooth is attacked with pain, and in a few hours the patient discovers that the tooth has become too long, and feels slightly loose. The increased capability of motion is recognised if the tooth be grasped

between the thumb and fingers; but it will at the same time be found, that although it readily yields within certain limits to pressure, yet that the movement is abruptly stopped when the side of the root comes in contact with either wall of the socket. A piece of india-rubber compressed between two teeth will, in the course of a few hours, force them apart, each tooth becoming tender to the touch, and slightly loose; but although the teeth on the removal of the caoutchouc for a time stand apart, they will speedily resume their former positions, become firm, and free from tenderness. In this case, it can scarcely be assumed that the socket became enlarged by absorption, and again contracted by deposition, although the separation was greater in amount than could be accounted for on the supposition that the peridental membrane only yielded to the pressure; but the difficulty of explanation disappears on finding that the teeth are slightly raised in the sockets. In these instances we have examples of the manner in which the position of a tooth may, under pressure, become changed, without the socket undergoing any enlargement. In the treatment of cases, we find that within the first few days the misplaced teeth show most satisfactory results, and we are apt to conclude that the difficulty will be readily overcome; but in subsequent examinations we fail to recognise a corresponding amount of progress. The involved soft tissues readily yield, but until removed or weakened by absorption, the bone of the sockets resists the further movement of the teeth. The rate at which its removal can be safely induced is not satisfactorily ascertained. That we can induce its absorption, numerous examples prove; but in order to bring about the result, it is necessary that the pressure should be uniform in degree and uninterrupted. Destructive inflammation will be set up if the pressure be too great, and if it be too slight the teeth will not move, or the movement will be so slow that both the patient and practitioner become wearied before a successful result has been gained. A certain amount of

irritation in the socket is a necessary attendant upon the treatment, otherwise absorption of the socket would not be induced. Other conditions being the same, the age of the patient will influence the results. The younger the patient, the more readily can the teeth be moved; the older, the more difficult will the operation become.

Supposing the irregular teeth to have been reduced to a proper position, and that the moving of them has been attended with a certain amount of destruction of the existing socket, we have then to inquire whether the lost parts will be fully replaced, and if so, the length of time required for the formation of the new bone. It is not probable that a series of preparations, illustrating the condition of the parts at different stages of treatment, will be obtained; we must therefore be content with less positive information than such a series would furnish, and avail ourselves of such facts as can be gathered from those cases in which teeth have been forced from their former position by a loss of proper antagonism. The dissecting-room will furnish examples of this character, and in them we shall find that the shifted teeth have a less perfect implanation than those which have been undisturbed. The sockets will not rise to the level of those of the other teeth; from which it may be inferred that the loss of the displaced teeth will be hastened. Whether the same conditions obtain in teeth which have in early life been intentionally moved, observations directed to individual cases over very many years can alone determine. But supposing they do, we must put against this disadvantage the fact that the walls of the sockets of outstanding teeth are very commonly deficient in strength, or imperfect, and that teeth so placed are liable to become loose prematurely.

Admitting, then, that sockets partly removed under treatment will be restored, the question arises as to the time which will be occupied in the restoration,—in other words, how long it will be necessary to hold the teeth in the newly acquired situation? If unrestrained by mechanical means, and uninfluenced by antagonistic teeth, the old position will

soon be regained, and the teeth will become firmly fixed in a much shorter time than they would do in the acquired position. It would appear as if there were a natural law tending towards the maintenance of a conformation when once assumed, although an irregular one, which calls into action the reproduction of a lost part more rapidly in the place in which a tooth has been moved from, than in that into which it has been moved.

We constantly hear of and see cases in which teeth have been reduced to regularity, and have subsequently regained the objectionable position, notwithstanding the assurances which have been held out that such untoward results are consequent upon want of proper management on the part of the practitioner. There is, perhaps, no point in the whole field of dental surgery that yields a finer harvest to the charlatan than that afforded by the treatment of irregular teeth. The patients are necessarily young people who have not passed from the care of their parents. There is a great desire on the part of the latter that the teeth should be good-looking, or at least not ill-looking; at the same time, there is great unwillingness, both with the patient and the parent, that the treatment should be extended over a long period of time. The presence in the mouth of a mechanical apparatus pressing upon the teeth interferes with the comfort of the young patient, and the frequent attendance at the house of the dentist encroaches upon the hours allotted for study. Both circumstances render prolonged treatment irksome, impatience is shown, the instructions are neglected, and, as a natural consequence, the results fall short of those which might have been obtained had the treatment been consistent.

It is in accordance with the experience of those who have devoted their attention to the treatment of irregularities, that where, for example, the front teeth have been brought inwards by mechanical means, and where mechanical means are required to hold them in place until they become permanently fixed, the treatment must be continued for twelve months. It may not be necessary

that the apparatus should be constantly worn for the whole period, but it cannot be wholly thrown aside. Towards the latter part of the time, it may be worn occasionally only; but even after the lapse of twelve months, should the teeth show any indication of movement from the desired position, mechanical restraint must be resumed.

The foregoing remarks apply generally, but each case will present its own peculiar characteristics, and the treatment must be varied to meet them. The age of the patient, the state of health, the degree of susceptibility to irritation and pain, the number and condition of teeth present, the size of the teeth themselves, the size and form of the base of the alveolar portion of the jaw, and the configuration of the same part in the parents—all these points must be taken into consideration before a course of treatment is determined on.

In describing the treatment of the first mentioned simple form of irregularity, it has been assumed to be desirable to so raise the bite by capping the molar teeth as to disentangle the upper teeth from the lower incisors, which would hinder their forward passage. But it is not absolutely necessary to do so; when the teeth come nearly edge to edge the patient will avoid touching them, as they are tender, and so they will escape the locking effect. Dr. Kingsley advocates this method; however, I do not think the patient gains in comfort by the abolition of the capping, but the contrary, and that is really the only point to be considered, as such plates are not worn long enough to do injury by covering the teeth, or by want of cleanliness, which may be perfectly secured.

The upper central incisors will occasionally be found to be somewhat widely separated from one another, the frœnum of the upper lip being unusually strongly pronounced, and traceable as far as the gum intervening between the two teeth. The irregularity, though a slight one, is not very easy to remedy, for the division of the frœnum with scissors is not followed by a speedy wasting of the band which is visible upon the gums. In one case I was not successful in bringing and keeping the teeth together until I had destroyed

some of the intervening gum with nitric acid. This condition was first pointed out to me by Mr. Moon ; since then I have repeatedly observed it.

There is another cause of irregularity, affecting only the lateral incisors, which is not generally noticed in works upon the subject : this is the position of the developing canines. When, from want of full space, the crypt of the canine comes to occupy a position immediately over the root of the lateral incisor instead of one between its root and that of the bicuspid, it has a tendency to press inwards the apex of its root, and by so doing to make the cutting edge stick out ; if things are left in this state until the proper period for the eruption of the canine, the irregularity of the lateral will be a little troublesome to correct, and it is, therefore, desirable to give the canine room to pass backwards as early as possible.

In order to do this, the ordinary rule of not extracting the temporary canines should be broken through, and if this appears to be insufficient to allow the canine to get back, the first bicuspid, unless such a course of treatment be otherwise contra-indicated, may be extracted. It is not generally known that this may be done, not only with perfect safety, but even oftentimes with advantage, before it has been erupted, and even before the temporary molar has been shed, by removing the temporary tooth, and thrusting up a fine pair of stump forceps, with which the bicuspid may be reached with surprisingly little disturbance of the surrounding parts. I often resort to this procedure in cases where the first permanent molars are sound and space is greatly needed, and with most excellent results, as, the space being given at such an early date, the teeth accommodate themselves exceedingly well, and I am convinced that in many cases I have averted the subsequent wearing of a plate, which would otherwise have been inevitable.

So far those irregularities, which affect a few only of the teeth, have been discussed. From the consideration of these we may pass on to that of irregularities affecting a good

many teeth simultaneously, and those in which the maxillæ beyond the actual alveolar border are involved. It is often impossible to draw the line at which we may see that the alveolar maxilla is irregular, and oftentimes abnormalities which really do not extend beyond the alveolar border appear to do so at first sight.

Mr. Oakley Coles has proposed a method of measurement which is useful in determining the position and nature of abnormality in the development of the jaws. If the point of a pair of compasses be placed at the margin of the gum on the lingual aspect of the first molars, and the measurement thus obtained pricked upon a piece of paper, and then a measurement be taken by sweeping one leg of the compasses to the interspace between the central incisors, these two distances in a normal jaw will be found to be the same; for those in which the antero-posterior distance is greater he proposes the name of dolichoid, and to those in which it is less the term brachoid (Trans. Odonto. Soc., 1880).

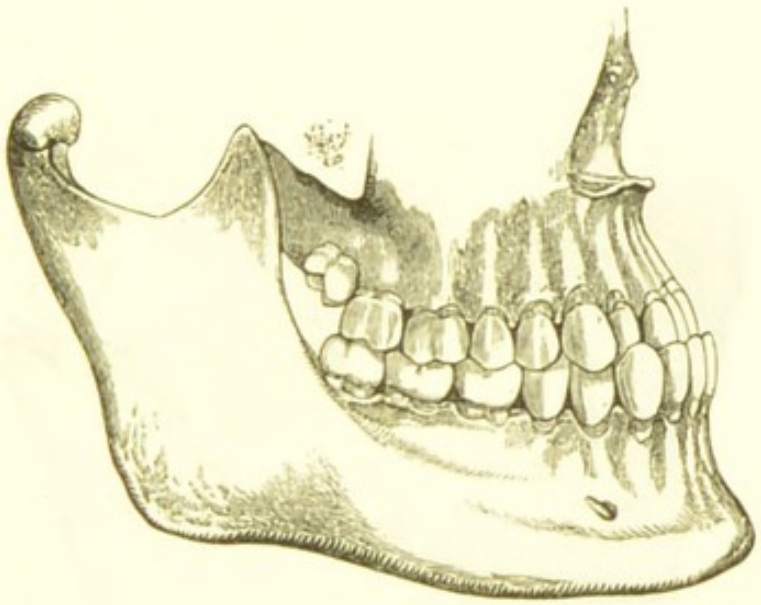
It will be found useful, before forming a judgment upon this point, to try to estimate what the alveolar borders would come to were all the teeth removed and the gums allowed to shrink; presented to the mind in this way, a different and more correct conclusion will often be formed from that derived from a mere cursory inspection of the mouth, and it will be found that cases really involving extensive deformity of the whole bone are much more rare than has been supposed.

One of the simpler forms in which many teeth are involved is that in which the anterior teeth, instead of standing out far in front of those of the lower jaw when the mouth is closed, are directed inwards, and pass behind them. The patient is said to be under-hung. The upper lip is generally short and retreating, while the lower lip and chin hold an unusually forward position.

If the coincident conditions of the jaws be examined, it will be found either that the alveolar ridge of the upper maxilla is unusually small, as shown in the accompanying

figure, or that the lower jaw has departed from the normal form. In the specimen from which the illustration is taken, the inferior maxilla does not differ, either in general dimensions or in configuration, from the normal specimens; but

FIG. 84. (1)



the upper jaw in its alveolar portion is below the usual dimensions. The teeth are placed regularly, but the alveolar line is fully occupied, to the exclusion of the wisdom-teeth; and the second molar closes upon the third molar of the lower jaw in the position usually assigned to the wisdom-tooth, which, from its backward direction, is thrown altogether out of use.

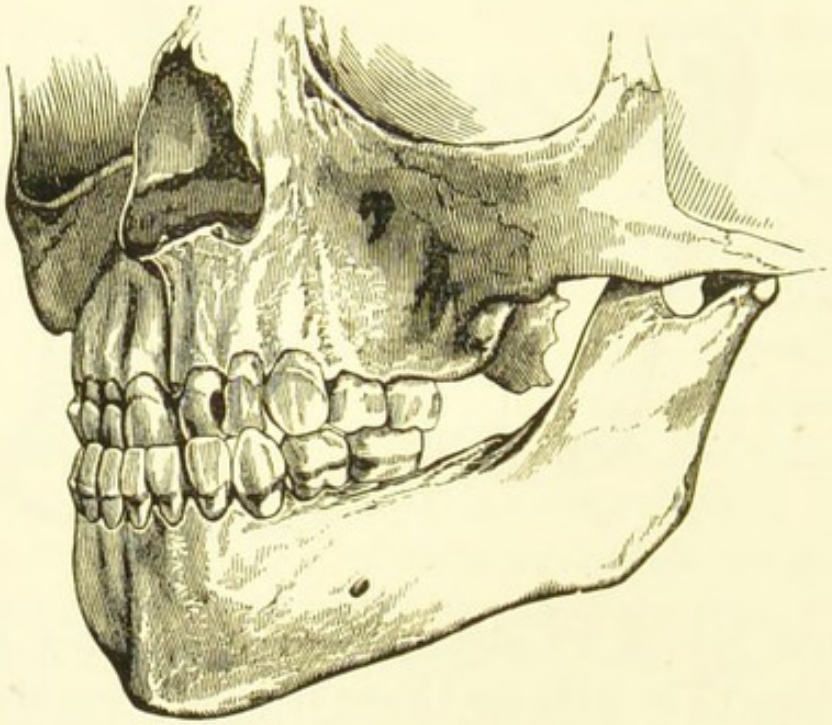
The figure which illustrates the inversion of the upper teeth coincident with a well-grown upper jaw, is taken from a specimen in which the temporary teeth are present. In this case we have an excess of growth in the lower jaw, the body of which is unusually long, and is associated with a ramus which has preserved the obliquity characteristic of an earlier age. The line of growth, as indicated by the position

(1) Showing the condition of the teeth and jaws in a specimen in which the anterior upper teeth were inverted coincidently with defective size in the superior maxilla.

of the articular process, is calculated to give great length of jaw at the expense of depth in the posterior portions of the alveolar line.

The cause of this want of proper relationship between the upper and lower jaws and their respective teeth, is in many

FIG. 85. ( )



cases very obscure. In certain families it occurs as an hereditary character. In other cases, the deformity may have been consequent upon the relatively tardy eruption or the inverted position of the upper teeth in infancy.

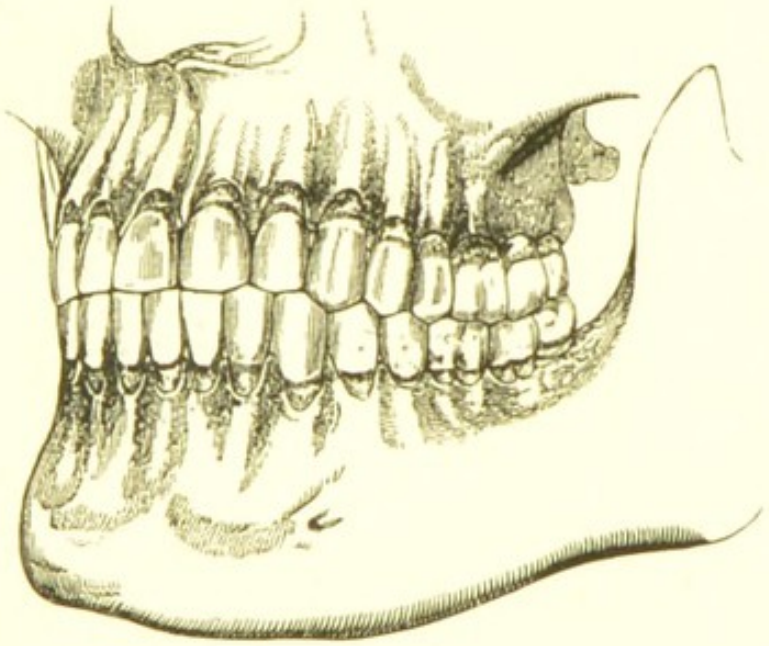
But whatever may have been the cause, the malposition will be persistent, unless remedied by mechanical interference. The under teeth will present a barrier to the outward movement of the inturned teeth.

For the correction of such a deformity many of the ordinary appliances will suggest themselves as appropriate,

(1) Shows inversion of the upper front teeth coincident with unusual development of the lower jaw, the upper maxilla having attained the normal dimensions.

and amongst others the expansion plate in its various developments. But a method adopted by Dr. Kingsley (Oral Deformities, p. 129) deserves special mention on account of its originality: having such a case to treat, it occurred to him that if all the teeth were simultaneously forced apart they could only move by spreading around a larger arch; he, therefore, placed india-rubber wedges between all of the upper teeth, having inserted a plate with points carried well in between the necks of the teeth to prevent the wedges from pressing down upon the gums unduly. In the short time of

FIG. 86. (1)



twenty days the whole of the upper teeth had passed outside the lower row, and the treatment of the case was complete. The wedges were introduced from the inner sides of the teeth.

In another variety the front teeth meet *edge to edge*, as shown in the accompanying figure. (Fig. 86.) It may be regarded as differing only in degree from those cases in which the upper front teeth are inverted, and as dependent upon similar causes which have operated with less force.

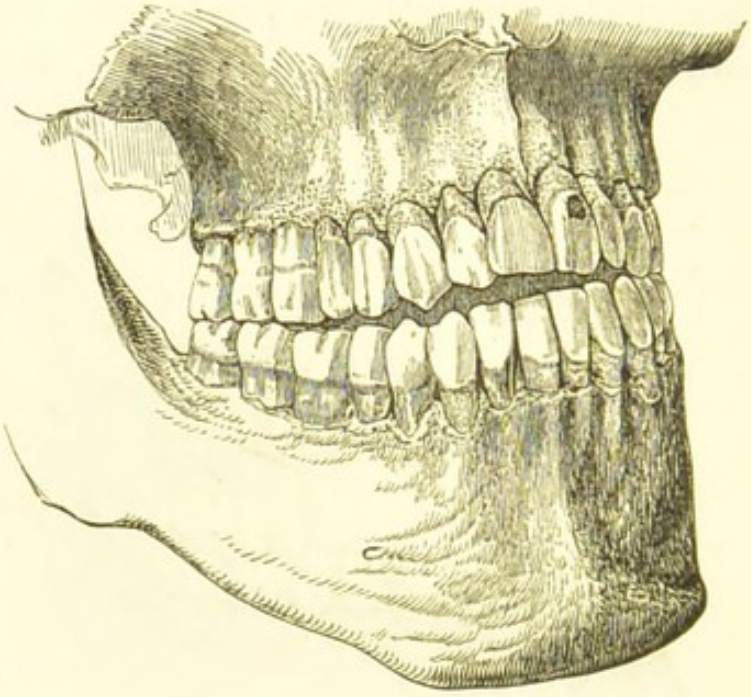
A form of irregularity involving more or less the whole of

(1) Showing the front teeth meeting edge to edge.

the teeth is found associated with an abnormal development of the maxillæ. In the description of case alluded to, the molar teeth, on closing the mouth, alone come in contact; while the upper and lower incisors, without being either unduly turned outwards or inwards, stand apart.

In the specimen from which the illustration is taken

FIG. 87. (1)



(Fig. 87), the degree of separation is moderate in amount, as compared with many cases presented to the practitioner; but it affords an opportunity of showing a peculiarity in the conformation of the lower jaw usually coincident with this form of irregularity. It consists in a great development of the anterior part of the jaw in the vertical direction, with a diminished depth in the parts which sustain the molar teeth, associated with an unusual obliquity of the ascending ramus. The line of growth in the latter part has not taken the rectangular direction which characterizes the well-formed adult jaw. The anterior part of the alveolar ridge of the upper

(1) Showing that conformation in which the molar teeth only come in contact when the mouth is closed, and the peculiar form of the lower jaw coincident with the imperfect antagonism of the teeth.

maxilla has not attained the normal depth—a peculiarity which the accompanying illustration does not exhibit in the degree commonly seen in cases of this nature. I have seen several instances in which in the closed mouth the finger could be passed between the front teeth.

The teeth themselves, and especially the first permanent molars, usually present indications of imperfect development of their tissues. The surface of the enamel is irregular, and marked with pits and transverse grooves, is yellow in colour, and readily broken down.

The anatomical conditions which are coincident with this form of irregularity are readily distinguished, but the causes which have destroyed the relations of the several parts of the jaws during development are very obscure. In most instances the patients have been unable without effort to breathe through the nose, and the mouth has consequently been habitually kept open, even during sleep. Possibly the constant traction exercised upon the anterior part of the jaw in keeping the mouth open may have had some influence in determining the peculiarity of form, and the freedom from the pressure exercised mutually by the antagonistic molar teeth upon each other, may have led to their rising higher with their sockets than they do when their conformation is normal.

I have attempted to diminish the amount of deformity in a few cases. In one the patient was a female, twelve years old. The front teeth were separated by a wide interval when the first molars were in contact, and the lips closed with difficulty. The chin, although retreating, was of unusual depth, and, associated with the unclosed lips, gave a vacant expression to the face. The method of treatment which offered the greatest prospect of success consisted in maintaining a steady upward pressure upon the anterior part of the lower jaw, leaving the antagonizing molar teeth to act as a fulcrum. A sheet of gutta-percha was moulded to fit the point of the chin, and a cap fitted to the head, and the two were connected by strong bands of caoutchouc—one on each side. The amount of pressure exerted by this con-

trivance was sufficient to produce tenderness in those teeth which closed upon each other. This source of discomfort passed away of itself in the course of a fortnight, without any modification of the plan of treatment (1).

At the end of three months the front teeth, which at the time the treatment was adopted were separated by three-eighths of an inch, now came in contact, and the general appearance of the face was greatly improved. The patient was directed to use the apparatus during the night-time for at least six months, and to show herself at the expiration of that period. These instructions were disregarded, and it was only after a lapse of two years that she was again brought to me. The deformity had returned with the eruption of the second permanent molars, the masticating surfaces of which teeth alone came in contact when the mouth was closed. The treatment which two years before had been attended with a fair amount of success was again adopted; but either from want of perseverance or from the increased age of the patient, a slight advantage only was gained. Had the patient persevered, the deformity would to a great extent have been overcome. In examples of the form of irregularity under consideration, the most striking and the most important feature is the obliquity at which the ramus is placed with respect to the body of the lower jaw. The line of growth has been almost directly backwards, and the inferior dental canal, instead of being carried upwards in its posterior third, is almost straight from end to end. That form in which the rectangular position has been prematurely assumed, and the ascending ramus below the usual height, has already been adverted to. Here we have a class of cases in which the obliquity peculiar to infancy has been maintained throughout the whole period of growth, and, as a consequence, an alveolar line of unusual length is produced. In the prematurely rectangular jaw we seldom find sufficient

(1) For similar cases see Kingsley's Oral Deformities, p. 116 *et seq.*, and Monthly Review of Dental Surgery, 1874.

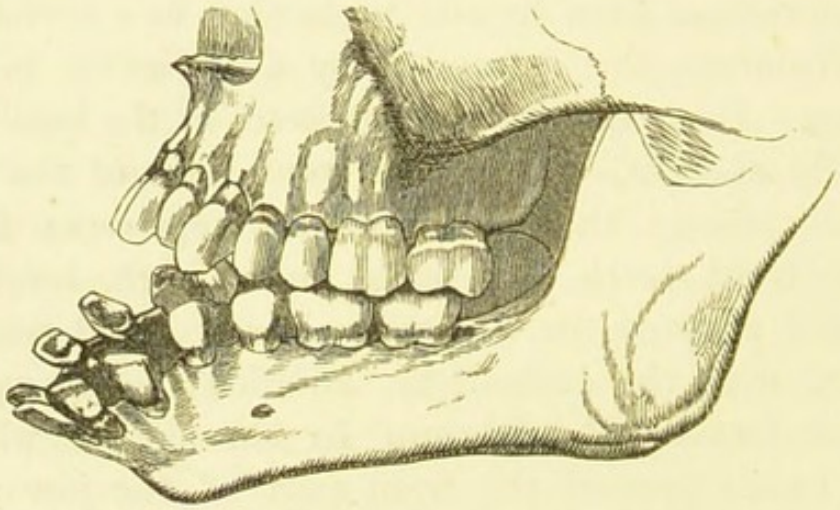
space for the normal implantation of the wisdom-tooth ; in the oblique maxilla, on the contrary, there is room even for a fourth molar.

The specimen from which the preceding figure (Fig. 87) has been taken, affords a better opportunity of examining the anatomical relations of the several parts of the jaw than is afforded in the living subject. In this we shall see that had the alveolar portion been developed in accordance with the usual form, while the obliquity of the line of development was preserved, the separation of the front teeth would have been far greater than it is ; but nature, having departed from the normal form in one particular, to a certain extent counterbalances the deformity by a deviation in another direction. Here, the alveolar processes at the back part are unusually shallow, and in the front part of the jaw are unusually deep ; the back teeth are kept down to a low, and the front teeth are raised to a high, level. The treatment adopted in the case already cited was in accordance with the indications afforded by the specimen ; the back forming the fulcrum by the aid of which the elastic bands pressed the front part of the jaw upwards, and drew the ramus downwards.

The following case exemplifies the extent to which the form of the jaw may be modified by constant pressure during early life. The patient was a strong healthy young woman, aged 22. Her chin was drawn down towards the sternum by a broad cicatrix, consequent upon a burn received when five years old. The teeth of the lower jaw stood out almost at right angles, and were far in front of those of the upper jaw. The accompanying illustration is taken from a cast made when the patient was in the Middlesex Hospital, and shows accurately the position of the teeth and the form of the alveolar ridge. The position and the proportions of the lower border of the jaw and the ramus being enclosed by a tense hard cicatrix, could only be guessed. The accuracy, therefore, of the illustration as respects the hidden parts cannot be depended on. The injury occurred after the

temporary teeth were matured, but prior to the eruption of the permanent organs. Hence the traction exerted by the cicatrix in opposition to the natural action of the jaw, and of the endeavour to keep the face in the natural position, came into operation when the permanent teeth were passing through the gums, and when their alveolar processes were growing up with them. As the permanent alveoli were for the most part developed under the influence of the ever-contracting cicatrix, we shall be justified in assuming that they

FIG. 88. (1)



were originally formed in the everted position shown in the figure, rather than that they were developed in the normal position, and bent outwards and downwards subsequently. But whatever explanation may be adopted as regards the process by which the deformity has been produced, the case offers a very instructive illustration of the amount of change in form that a force incessant in its operation may bring about in the jaw during the period of growth.

(1) Drawing taken from a cast of the upper and lower teeth and gums of a patient, aged twenty-one, who at the age of five years was badly burnt about the neck and chest. The chin was, by the contraction of the cicatrix, gradually drawn down towards the chest, and the alveolar portion of the lower jaw became everted in the manner shown in the figure. The teeth are perfect as regards number, and are tolerably well formed. The outline of the bones has been added by the artist, and hence must not be depended on as faithful representations of the condition of those parts. See Trans. Pathol. Society, 1849—50.

In the museum of the Massachusetts General Hospital is a plaster-cast of a similar case, showing the whole face, head, and neck. The deformity of the jaw is very closely like that here figured, and the history of the cause is identical. The patient died from the effects of an operation in which an attempt had been made to replace the cicatrix with skin raised from the chest.

That the upper jaw may easily be distorted by a frequently repeated slight force is exemplified by the results of thumb-sucking, or the habit of protruding the tongue which some children acquire,—sucking the tongue, if such an expression may be allowed.

The front teeth of the upper jaw, including the canines, may deviate from the usual position by projecting forward. The prominence is sometimes sufficient to prevent the lips from closing; hence the teeth are constantly exposed, even when the mouth is shut. The lower lip, instead of lying over the edges of the teeth, passes behind them, while the lower teeth meet the gum posterior to the necks of the upper teeth. In searching for the proximate cause of this unsightly form of irregularity, we must examine the condition of both the upper and lower jaws, and also the state of antagonism of the upper and lower teeth.

The deformity may result from excessive development of the alveolar processes of the anterior part of the upper jaw; but more commonly we shall find that the molar teeth are unusually short, thereby allowing the incisor teeth of the lower to press unduly upon the inclined lingual surfaces of the teeth of the upper jaw. The upper teeth, yielding to the pressure, are forced outward, and are retained in the malposition by the teeth which have led to the displacement. If, in cases resulting from the latter cause, the inquiry be extended to the condition of the lower jaw, it will be found that with the short molar teeth we have a short alveolar range and short rectangular ramus. This conformation is probably the primary cause of the mischief. Supposing the line of growth in the ramus to have become nearly rectan-

gular, as regards the body of the jaw, prior to the development of the wisdom-teeth, and the amount of growth in the vertical direction to have been deficient, the molar teeth would be limited in height by the antagonism of the corresponding teeth of the upper jaw. That the length of the molar teeth is influenced by the growth and position of the ramus, a case under treatment satisfactorily demonstrates. In this instance the ramus has preserved the obliquity characteristic of childhood, and occasions the permanent separation of the upper and lower front teeth when the mouth is closed. The patient is upwards of fifteen, and the usual number of teeth are present, but the second permanent molars are the only teeth that come in contact, and these scarcely project above the level of the gums. Here the ramus is sufficient in actual length, but the obliquity renders its length unavailable for the vertical development of the molar teeth. If, then, we have a rectangular ramus of diminished length, with short grinding teeth coincident with well-developed incisors, it is not difficult to see that the upper will be driven outwards by the lower front teeth.

The condition under consideration may also arise from the tardy eruption of the molar teeth leaving the incisors to act for a time upon each other, as they do when from any cause the back teeth are lost. Then, again, the incisors of the lower jaw may attain an unusual height, or they may project in an unusual degree, and produce the mischief. Or the result may be consequent upon a regular linear arrangement of large teeth in a jaw having a small alveolar base, in which case the teeth prior to their eruption will assume an unusual anterior obliquity. In some instances the teeth have been slowly forced outwards by mechanical pressure consequent on a child practising the habit of sucking its thumb.

But whatever the cause, the treatment of this form of irregularity is apt to be very troublesome. It is not difficult to reduce the teeth to a proper position, but it is very difficult to keep them there. In a case which came under treatment some years since, the upper teeth projected outwards, so

that it required a great effort to get the upper lip over them, and when the mouth was closed the finger could be laid between the lingual surface of the upper and labial surface of the lower teeth. The habitual position of the under lip was behind the upper front teeth—a habit which in itself no doubt tended to increase the amount of deformity. The arrangement of the teeth, as respects each other, was perfectly uniform and without intervening spaces, while the base of the jaw was normal in size. It was therefore quite obvious that before the teeth could be pressed backward, space must be provided to allow of their movement in that direction. In order to effect this, the two posterior bicuspids were removed; a plate was then fitted to the labial surface of the projecting teeth as far on either side as the canine, and was extended inwards below the edges of the teeth in such a manner as to prevent the under lip from passing behind the upper teeth. A strong band of vulcanized caoutchouc was connected with the plate, and passed round the back of the head. By means of this apparatus the teeth were in the course of six weeks pressed into a very good position. The lips could be closed in the usual manner, and the mouth when seen in profile had lost its objectionable prominence. The patient on leaving for the country was directed to wear the apparatus during the night for six months. After the lapse of eighteen months she returned to town with the mouth just as prominent as it had been before treatment. On inquiry I found that she wore the plate for one month only, the elastic bands had then given way, and the precautionary measures had from that time been neglected. In the interval the wisdom-teeth of the upper jaw had been cut, and they seemed to have exercised some influence in forcing the teeth into the forward position. But some other cause than this was also in operation, as the teeth, although prominent, were not now, as formerly, in close lateral contact. The wisdom-teeth, from their position, being perfectly useless, were removed, and the treatment already described was renewed, and with the former success. The teeth have

now settled down into a position intermediate between that which they held before they were subjected to treatment, and that to which they were reduced by the use of the plate.

A similar discouraging result is related by Dr. Kingsley. A case of extreme protrusion was treated by means of external appliances, brought to a tolerably successful result, and finally, partly doubtless owing to neglect on the part of the parents, relapsed to a state more disorderly than that from which it had started.

The tendency to revert to the old state of things is very strong in all cases of protrusion of the teeth, of which indeed it may be said in a general way that it is comparatively easy to reduce the irregularity, but very difficult to secure any permanency in the improvement effected. All causes which can tend to upset the gains must be carefully studied and antagonised : such points as the influence of teeth not as yet erupted, the bite of the lower teeth, &c., should be noted, and the patient kept under observation for a long time after the discontinuance of active treatment. With proper care on the part of both parent and practitioner, cases of only moderate protrusion may be brought to a perfectly satisfactory end in a majority of cases.

The choice will lie between several forms of plates, but one of the most generally useful is one in which a band of rubber dam passes over the fronts of all the teeth, which possesses the advantage of not needing very frequent attention ; even this, however, is not always an unmixed good, for patients will at times presume upon it, and neglect to attend at the intervals desired.

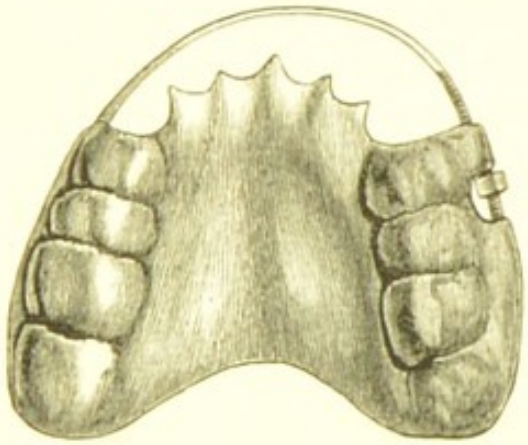
In correcting this form of irregularity less rapidity of action is to be sought than may with advantage be attempted in the treatment of others.

But occasionally more power is desirable than is obtained by the use of the rubber bands, and may be got by a plate carrying a band of gold beaten thin where it crosses the teeth ; it is vulcanised into the plate at one end, and the other terminates in a screw upon which there is a nut.

This is tightened from time to time, and forms an admirably effective appliance.

A form of irregularity which has attracted much attention is that known as the V-shaped maxilla. The teeth instead of occupying an elliptical arch, lie upon two more or less straight converging lines, which meet at an angle at the

FIG. 89. (1)



anterior part of the jaw, producing as an almost invariable result, an extremely high and vaulted palate. The abnormality is apt to be symmetrical upon the two sides, and, in fewer instances, exists in both upper and lower jaws, although it is more generally confined to the upper alone.

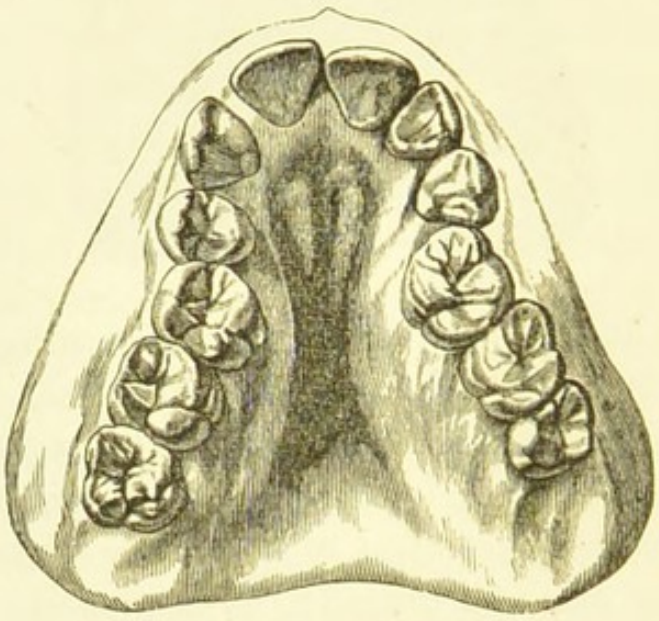
There may be, and usually is, contraction across the bicuspid region, looking as if the jaw had been pinched in at this point, the molar teeth rapidly diverging behind it. This conformation is more fully designated by the term V-shaped contracted maxilla (see Fig. 90), though some writers, amongst whom is Dr. Kingsley, doubt whether more than the teeth and their alveoli are involved in the deformity.

Each case will present its special peculiarities. In one, the mesial sides of the central incisors will project forwards and meet at an angle; in another, angles will be formed at the junction of the lateral and central incisors; in a third, the central incisors will form at the junction of their mesial

(1) Vulcanite plate for drawing inwards the front teeth; the thin elastic band of gold is tightened by means of the nut shown on the right of the figure.

sides an angle directed inwards, and with their distal sides and the mesial sides of the lateral incisors, two angles directed outwards not unlike an inverted W. The deep vaulted form of the hard palate is sometimes carried to such an extent as to suggest the idea of the two sides of the jaw having been forced towards each other, and the roof of the mouth driven upwards. In other cases the height is not greater than would necessarily result from the substitution of the vertical for the oblique positions of the alveolar portions of the jaw, and it is not uncommon to find that the height,

FIG. 90. (1)



although apparently in excess of the normal elevation, does not in measurement exceed that of a finely developed maxilla.

It will not, however, be necessary to enter into all the minor modifications of form presented in cases where this character of deformity prevails. Although numerous examples present themselves in which parentage cannot be adduced as a cause for V-shaped dental arches, yet in many families this peculiar conformation of the mouth will be found as an hereditary characteristic, traceable back in

(1) Shows a case in which the V-shaped conformation was attended with unusual contraction in the neighbourhood of the bicuspid and first permanent molar teeth. On the left side both of the bicuspids were removed, and in the right the second bicuspid was extracted without any advantage being gained as regards the contracted condition of the palate. I am indebted to the late Mr. Harrison for the use of this interesting specimen.

family portraits for many generations, and shared by the great majority of the members of the families at the present day.

Special interest appertains to the consideration of the probable causes of this deformity, inasmuch as Dr. Langdon Down,[1] after making observations upon a very large number of congenital idiots, found, with hardly an exception, that there was always a diminution of width between the posterior bicuspids, and an inordinate vaulting of the palate; in fact, a typical V-shaped maxilla. Although the typical characters of the V-shaped maxillæ are dependent in some degree on the presence of the permanent teeth, Dr. Langdon Down is of opinion that this malformation may be detected at a much earlier period, and he is so convinced of its constancy that he relies upon its presence as a diagnostic test whether the idiocy of the individual be truly congenital, or be the result of pathological processes occurring at some subsequent period.

Dr. W. W. Ireland[2] confirms these results by an examination of the mouths of 81 cases of congenital idiocy, amongst whom he found two cases of cleft palate and 37 of deeply vaulted, keel-shaped palates—he noted the peculiarity as especially marked at the posterior portions of the palate. But the correctness of these inferences is denied by Dr. Kingsley, who, after adducing the fact that contracted palate may be, and indeed often is, associated with a high order of intelligence (which does not tell for much either way), quotes some very important observations made by himself upon upwards of 200 idiots of very various nationalities on Randall Island. He found no case of pronounced V-shaped arch, and very few contracted in the bicuspid region: on the whole, very few dental irregularities. An examination of three or four hundred of the inmates of the Paris Asylums showed substantially the same result; but on visiting Dr. Langdon Down's Asylum he met with a much larger proportion of dental irregularities and of con-

(1) Transact. Odont. Soc., vol. iv., 1871.
(2) Journal of Mental Science.

tracted arches. Dr. Kingsley attributes this to the fact that these latter patients are drawn from higher ranks of life, where dental irregularities are more common, and appears to lean to the conclusion that though in their jaws and in their minds they are degenerate and enfeebled representatives of their families, it is to their family traits rather than to their idiocy that they owe their contracted mouths.

Dr. J. W. White and Dr. Stellwagen, visiting a large Pennsylvania school for feeble-minded children, found large and well-formed jaws to be the rule; and upon the whole Dr. Kingsley concludes that, "taking the idiots as a class and comparing them with the lower order of society as found in this country, there were no more irregularities in the one than in the other."

It has been alleged that *crétins* are apt to have contracted jaws; but this Dr. Pierce, of the Pennsylvania Dental College, denies.

Mr. Coleman (1) has examined a large number of children with a view to tracing the connexion between the general development and that of the jaws, and the conclusions at which he has arrived are so instructive as to call for mention in this place. The antecedents and parentage of the children brought to an hospital must always be a difficult if not an impossible subject of inquiry; but not so their appearance, which will afford a fair guide in determining whether they are coarse, brutal and low bred, or whether they bear the stamp of a higher civilisation—in other words, may be spoken of as "well bred."

Taking children of "well-bred aspect," no less than sixty-nine per cent. were found to have more or less contracted, badly developed jaws; whereas taking children of decidedly low aspect, only from seven to eight per cent. manifested this condition of the jaws. Amongst children of doubtful aspect, who could not certainly be referred to either of the above classes, twenty-four per cent. had contracted jaws, thus coming in an intermediate position betwixt the first two classes.

(1) Transactions of the Odontological Society, 1864, p. 233.

It was remarked by the late Mr. Mummery (1), in the course of a very extended series of observations on the teeth of savage races, that irregularities of the teeth and contracted jaws were as rare as destructive attrition was common amongst them, whilst precisely the contrary is true of civilised races.

And Messrs. Cartwright and Coleman report that they did not find any example of contracted jaws in the large collection of skulls contained in the crypt of Hythe Church,—skulls which are certainly of very great antiquity, though their precise history is, I believe, a matter of dispute.

Dr. Nichols, who examined the mouths of "thousands" of Indians and Chinese in the Rocky Mountains, met with only one trivial case of irregularity; and Dr. Kingsley found no example of contracted jaws amongst 300 Chinese.

That the comparative disuse of the organs of mastication among civilised races, who cook and thoroughly soften their food before masticating it, should have led to a less powerful development of the jaws, is a thing that might fairly be expected, and were the occurrence of contracted jaws a thing *per se*, it would have comparatively little significance. But it happens that the V-shaped conformation of the jaws is very often associated with other deviations from the standard of healthy organisation; thus it is extremely common for the subjects of this malformation to suffer from enlarged tonsils, and to present many indications of weak health, whilst it is rare to meet with it in strong, robust persons.

Although irregularity of the teeth is rare in its occurrence in uncivilised races of men, yet it does occur, as is exemplified in a skull of an Australian in the Oxford University Museum, in which the lower incisors are crowded, whilst close beside it in the same case there is an orang in which the left second upper premolar is not erupted, though the dentition is quite complete, and the right premolar stands between the canine and the lateral incisor.

(1) Transac. Odontological Society, vol. ii., 1869.

And in the same museum there is a gorilla skull, the lower jaw of which is somewhat contracted, so that the molars do not articulate correctly, and the premolars pass wholly inside those of the upper jaw.

It may be that, as was, I think, suggested by Mr. Cartwright, a form of selection may have had something to do with the frequency of the occurrence of under-sized jaws in the well-to-do classes. For if the type of face now-a-days considered to be beautiful be considered, it will be found that the oval, tapering face, with a small mouth, &c., does not afford much room for ample dental arches. On the other hand, the type of face which we consider bestial has a powerful jaw development. Perhaps new generations after generations seeking refinement in their wives may have unconsciously selected those whose type of face hardly allows the possibility of a regular arrangement of the full number of teeth. At any rate there is something tangible in the hypothesis, and grounds for argument *pro* and *con.*; but much as I respect Dr. Kingsley's opinion, I fail to see that he has, in referring back dental irregularities to disturbed innervation, done much in clearing our notions of their *raison d'être*, even granting that his point were proven, which I do not think it is.

It has been usual to assume that the premature extraction of the temporary teeth occasions contraction of the jaw, but I do not think that any anatomical facts can be brought forward in support of the supposition. If a temporary tooth be removed, the crowns of the contiguous teeth may lean towards each other, and give an appearance of contraction, but it does not really involve a diminished size of that part of the jaw from which the tooth has been lost. In the case from which the following illustration is taken, the two central incisors were lost long before their successors were ready for eruption; hence the sockets became obliterated, and the alveolar ridge made good; but we do not see the slightest trace of contraction in the jaw. It

has been stated by Mr. Cartwright (1), that if the central incisors happen to be cut at birth, and at once removed, on account of the injury inflicted on the mother's nipple, the laterals when erupted do not obliterate the space.

Then again, if specimens be examined in which the two sets of teeth are present, it will be seen that the implantation of the temporary teeth occupies but a very small space in the alveolar ridge, as compared with that occupied by the crowns of the permanent teeth. Now, it is extremely difficult to conceive how the removal of the temporary teeth can induce the jaw to contract upon the crowded and growing permanent teeth. Organs in an active state of development induce the expansion of parts about them, and there is no good reason for supposing that the jaw forms an exception to this rule. The persistence of the first, which are placed immediately in front of the second set, may, and frequently does, interfere with the outward progress of the latter; but I cannot see how the removal of the temporary can produce a prejudicial influence upon the arrangement of the permanent teeth. In the case shown in fig. 91, the temporary incisors have been shed some time prior to the eruption of their successors; yet there is no indication of contraction of jaw. A case came under my notice recently, in which the child had been destitute of temporary teeth, excepting only the second temporary molar on the right side of the lower jaw; the maxillæ were, notwithstanding, well formed, and the permanent teeth appeared with an unusual regularity of arrangement. Had the development of the jaws depended upon the presence of temporary teeth, we should surely have seen in this case some amount of contraction.

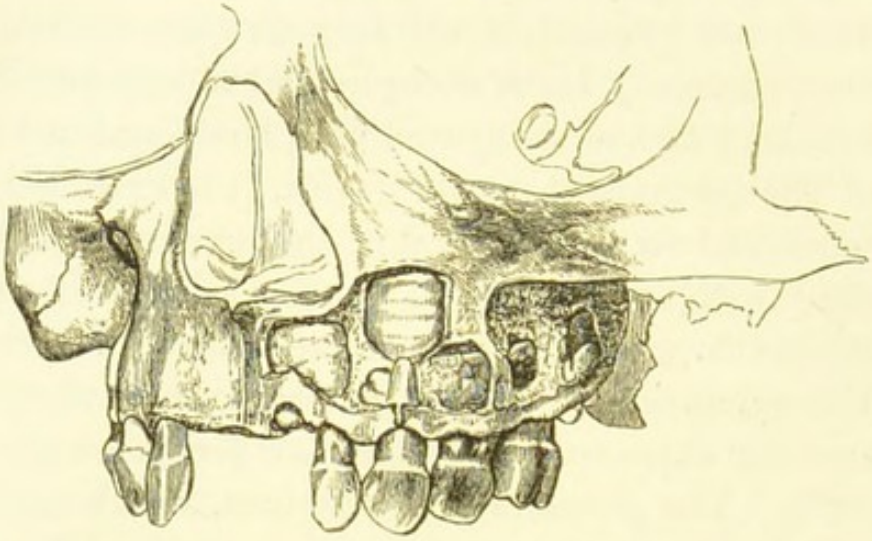
A case is recorded by Dr. Lines in which, in consequence of an accident, all the lower teeth were lost except the second temporary molars, prior to the attainment of the sixth year; yet two years later the incisors, canine, and six-year-old molars were all in place, with ample room left for

(1) Transactions of the Odontological Society, 1863, p. 132.

the bicuspids; and in the upper jaw, where fewer temporary teeth had been lost, there was more crowding. (1)

And that there is not any contraction resulting from the

FIG. 91. (2)



early loss of temporary teeth is endorsed by the late Dr. Gross, of Philadelphia, and the late Dr. Forbes, of St. Louis.

Subsequently, however, there may be some amount of practical inconvenience resulting from the premature removal of the temporary teeth, but it is altogether independent of contraction of the jaw. The newly-cut incisors, in the absence of adjoining teeth, will sometimes lean away from the median line, leaving a central opening between them. This is, however, an evil that generally cures itself. The canines and bicuspids, when they appear, force the slanting teeth into the vertical position, and the space becomes obliterated.

There is, however, inconvenience experienced from early extraction of the milk canines, which should generally be left, even when the incisors are crowded; unless, indeed, the

(1) Monthly Review, Dental Science, January, 1877.

(2) The upper jaw of a subject between six and seven years old. The central incisors had been lost, and the alveolar ridge had become rounded by the obliteration of the sockets of the temporary teeth and the development of new bone. If the premature loss of the temporary teeth were followed by contraction of the jaw, the condition should be shown in this case.

ultimate extraction of a bicuspid is clearly foreseen, when there is less reason for retaining them, as the encroachment of the lateral and bicuspid upon the space wanted for the canine will then be unimportant.

The fact that the temporary teeth are organs of mastication, and that their efficiency is almost essential to the health of the child, is of course a strong reason against their premature extraction, so that it is in some respects disadvantageous to remove the temporary teeth prematurely; but the disadvantages will not be shown in the mal-position of the succeeding teeth at the period of their eruption. But should the first teeth be retained beyond the normal period, the mischief resulting from their presence will be sufficiently obvious.

Before the course of treatment is decided upon, the conditions presented by the jaws must be accurately ascertained, and it should be known whether the deformity is hereditary or accidental; and it must also be ascertained whether the jaws are contracted at their bases—at that point where the alveolar portion merges in the body of the bones. And it is equally important that we should learn whether the mal-position of the second, has arisen from the tardy shedding of the temporary, set. If the case presented for treatment exhibits a form common to the family of which the child is a member, we shall probably have to encounter greater difficulty than if it be a solitary example. After the teeth have been removed, there will be a greater tendency in the one case than in the other to a vicious position. Supposing the V-shaped arch be forced into the elliptic form in a case where the base of the jaws is below the normal size, the position of the teeth individually will be so oblique, as respects the jaw, that they will become unsightly; and, moreover, it is questionable whether the subsequent alveolar development will be sufficient to secure a firm implantation. Hence, in cases which present this character, it may be desirable to remove permanent teeth, one on either side of the jaw, more especially when the front

teeth are unduly prominent, and consequently require to be brought inwards. If the mal-position has resulted from the persistence of temporary teeth, the permanent teeth will tend to fall into the elliptical arrangement so soon as the obstruction is removed, from causes which have been explained on a preceding page.

Appliances used for regulating teeth.—Some of these have been already incidentally mentioned, such as the obsolete inclined plane, wedges of compressed wood, pegs, &c., the uses of which are very various, and the applications of which must be left to the ingenuity of the operator.

The jack-screw is possessed of great power, and may be

FIG. 92.

used for the expansion of the whole arch or for the thrusting outwards of individual teeth; it may be used either acting directly upon the teeth, without any plate, or in conjunction with a plate, a split or detached portion of which it impinges upon. The latter plan is preferable, as being less likely to injure the teeth, and also as rendering the attachment of the screw more easy.

In my own practice I very rarely use a jack-screw, as I greatly prefer some agent in constant operation, such as some form of spring; yet there are a few cases where it answers admirably, for its power is greater than that of any other device in general use.

An apparently neat method of regulating teeth has been lately advocated by Dr. Farrar (Dental Cosmos), which consists in attaching to the tooth to be moved a belt of gold, which is made to embrace it tightly by a thread and nut, and the power is then applied to the belt. In my own hands, however, these little appliances have not proved as useful as they promised, and I have virtually abandoned their employment.

The preference must be given to those agents which are in constant action, with a degree of force easily under the control of the operator, such as springs of various forms, and elastic bands, the applications of which are innumerable (1).

Dr. Coffin has carried out the use of piano-wire springs for the expansion of teeth with a degree of nicety and success not hitherto attained by others, and he claims for his method a far more general applicability than has usually been attributed to it. In fact, he employs his expansion-plate for the correction of the vast majority of the cases he treats, sometimes combining it with the use of separate elastic wires to make pressure in other directions, and sometimes trusting to nature to reduce the teeth to a regular arch after the increased space allows of this happening. The plate employed is of very thin vulcanite, capping the teeth to give a better grip upon them. To secure nicety of fit Dr. Coffin prefers to take his models with gutta-percha, made very hot, dipped for a moment into cold water, and then firmly pressed and bitten up in the mouth (2). The model thus obtained is not scraped nor in any way tampered with, and the plate is vulcanized upon it, with the wire in place. The form of the wire will be understood at a glance by reference to the following figure. It is prevented from sticking to the vulcanite by a piece of tinfoil laid under it, and the plate is only split with a saw at the last, and the edge of the split carefully finished and smoothed. The halves are then strained a little apart, and given any direction that may be desired, and as the case progresses the power is from time to time increased by stretching them further apart. Such a plate is by far the best method of expansion yet introduced. It is perfectly regular and constant in its action, very comfortable, very light and small, and it can be without detriment removed for cleansing as often as the patient desires.

(1) Many ingenious and useful methods of applying elastic bands are given in Dr. Kingsley's work on Oral Deformities.

(2) Transac. International Medical Congress, 1881.

Fig. 93. (1)

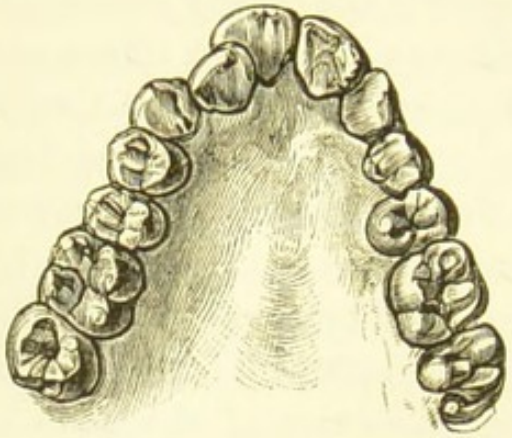


Fig. 94. (2)

Fig. 95. (3)

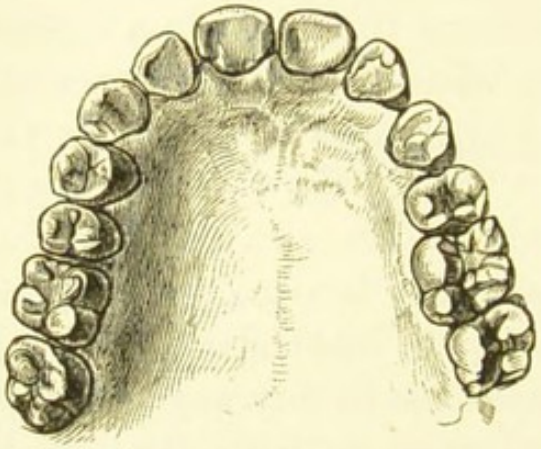


Fig. 96. (4)

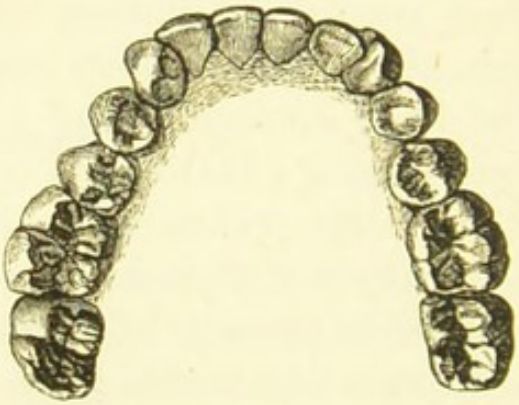


Fig. 97. (5)

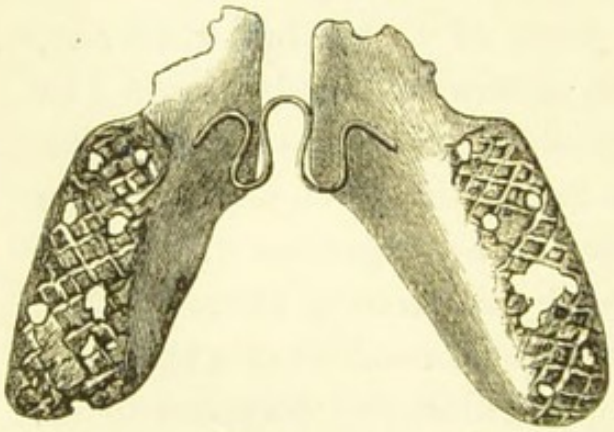
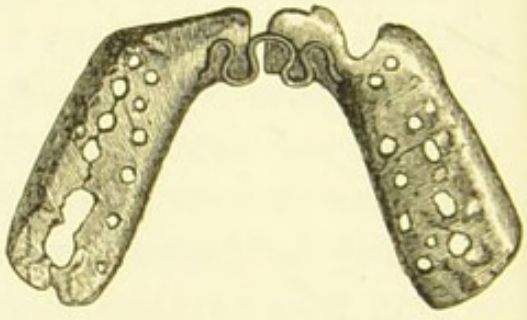


Fig. 98. (6)



(1) Model of upper jaw of child at 14, before treatment.
(2) Model of lower jaw of same case.
(3) Model of upper jaw of same case six months after treatment.
(4) Model of lower jaw of same case.
(5) Dr. Coffin's expansion plate, upper jaw.
(6) Dr. Coffin's expansion plate, lower jaw.
From models lent to me by Mr. Walter Coffin.

It can, of course, by suitably shaping the plate which carries it, be made to operate specially upon individual teeth, or upon several teeth, or upon the whole arch.

And the results attainable with a minimum of discomfort to the patient are very remarkable. The figures here given are taken from casts lent to me by Dr. Walter Coffin, and refer to the result of only six months' treatment in a child of fourteen years of age.

A great deal may be accomplished by the expansion of the jaws, and the reduction to regularity of position of teeth very unsightly without the loss of any of the number is so attractive, both to patient and practitioner, that a word of caution needs to be said upon the subject. Expansion, and the retention of the whole number of teeth, is only good treatment where the teeth are of fairly good quality; if there is the smallest sign of disposition to interstitial caries, as there usually will be in mouths where the teeth are of poor quality, then the interests of the patient are far better served by the extraction of the two or four teeth which are of the poorest quality and space being thus given to the rest.

For it must not be forgotten that an isolated tooth rarely decays, and in proportion to the closeness of contact is the danger which it runs.

Normal teeth in a normal arch touch one another by convex surfaces, and the area of contact is very small; crowded and irregular teeth touch each other by surfaces not appropriate, and over comparatively large areas; and imperfectly developed teeth often have not that shape which gives the least possible area of contact even when they are in proper position.

Now, expansion will do good only to a certain point; that is to say, it will, by placing the teeth in the normal arch, bring their proper surfaces into contact, but it will not make them other than somewhat tight together (ultimately); and some degree of expansion may often be advantageously employed in addition to extraction.

All teeth move a little in their sockets, and so rub against one another. When the contact surfaces are small and in the right position, this does no harm beyond forming small flat facets; but when the area of contact is wide, then attrition of the surface of the enamel becomes mischievous.

Hence the thoughtful practitioner will not allow himself to be misled by the idea that every individual, with or without due jaw space, ought to have thirty-two teeth preserved, no matter at what cost of wearing plates and the like; and it may further be remarked that the whole facial region is often so modelled as to necessitate small dental arches. It is hardly a desirable object to endeavour to mould the jaws of a delicate lady, with an oval tapering face, into the configuration of the ample jaws of the prize-fighter type, fine and typical though their development as perfect dental arches may be.

Torsion, or twisting of the central incisors upon their axes, is far from rare. The defect in position may be common to, and equal in each tooth, or it may be greater in the one than in the other, or it may be confined to one tooth only. Either the mesial sides may be directed towards the palate, or they may be turned towards the lips; or the one tooth may be twisted in the one, and the fellow tooth in the other direction (Fig. 27).

In a case under treatment at the date of publication of the first edition of this work, the right incisor made its appearance at the age of thirteen, with the lingual surface parallel with the median line of the mouth. In this case the tooth is a quarter of a turn out of place; but instances are recorded in which the twisting has extended to as much as half a turn, so that the lingual surface presents towards the lips. I have one example showing this amount of torsion in a bicuspid tooth. In many cases of this kind the mal-position has been assumed during the period of development, and is then consequent upon arrested development of the anterior part of the jaw. Sometimes, however, it results from the retention of the temporary incisors. And it is

not improbable that the root of a temporary tooth, if displaced by a blow or by a rude operation, may disturb and turn the successor upon its axis while within its crypt. The retarded development or eruption of a tooth may also be cited as a cause of its torsion; and it is not difficult to see how the malposition is then produced. The adjoining teeth being already through the gums, lean toward the unoccupied space, and offer an impediment to the progressing tooth, which, from its comparatively loose implantation at the eruptive epoch, turns on its axis, and descends or ascends, as the case may be, in that position in which the least resistance to its progress is offered.

In no case is it desirable to lose a central incisor; hence, if we have reason to suppose that the twisted tooth is in itself perfect, it must be brought to the proper position; and should it appear impossible to obtain sufficient space without sacrificing a tooth, we must remove one or other of the more posterior teeth.

It is quite possible that cases may occur in which such a proceeding becomes necessary, although I have rarely met with them in my own practice. But before deciding upon sacrificing a sound tooth, we must be well assured that the incisor is not subject to deformity, like that shown in Fig. 107, where the descent being arrested by the presence of a supernumerary tooth, the root has been developed in an irregularly curved form. Instances will sometimes present themselves in which the exposed portion of the crown is twisted and directed towards the palate, while the root of the tooth is in the usual position, the crown and the root being joined at an angle, presenting that peculiarity of conformation which has been denominated dilaceration. (1) If, in such a case, a healthy tooth were removed, we should be committing a serious error. It therefore becomes necessary that a very careful examination of the mouth should be made before the treatment is determined on. The position

(1) Lectures on Dental Physiology and Surgery.

of the root of the erring tooth should be ascertained, and this may generally be done by a careful examination of the gum, beneath which the outline of the root, if in the usual position, may be felt.

It is scarcely necessary to remark, that when the necessity for the removal of a tooth arises, our choice will fall upon an unsound one, should such be present, even though it be at some distance from the point where the space is required.

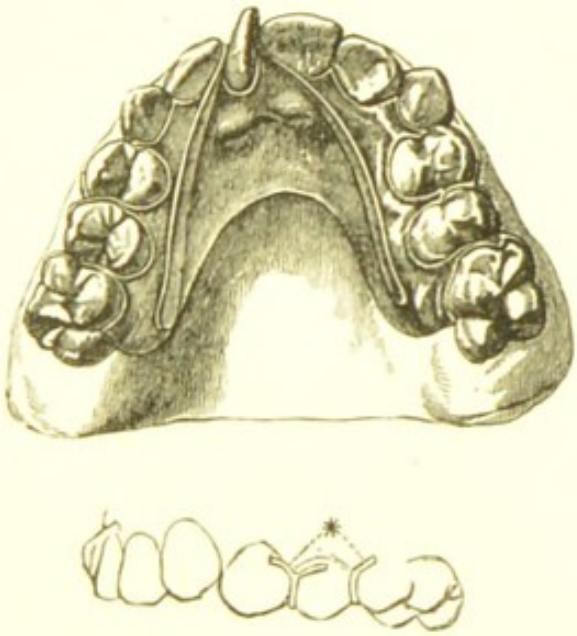
As respects the treatment to be adopted, I cannot do better than describe the course pursued in the following case, inasmuch as the illustrations necessary for the elucidation of details will serve the further purpose of showing the method applicable to cases of irregularities affecting other teeth. The patient was a female, aged fourteen years. The left central incisor up to the age of thirteen did not make its appearance, consequently the crown of the right lateral and left central teeth leaned towards each other, leaving an interval insufficient for the missing tooth to take its natural position. At thirteen, however, the tooth appeared, with its mesial side directed towards the lip; but it was not till a year had elapsed that the case came under treatment. The succeeding figure will show the general position of the teeth; and it may be remarked that the canines were slightly more prominent than the anterior teeth. A careful examination led to the conclusion that, supposing the laterals and the left central incisor were pressed out, so as to range evenly with the canines, sufficient space would thereby be gained to allow the twisted tooth to hold the normal position. Acting under this impression, a plate was made to fit the palate, and attached to the bicuspids by wire continued over the crowns of those teeth on either side of the mouth, and terminated by a small T-like extremity, which, by way of protecting the teeth, was covered with a thin investment of floss silk. In this manner the plate was firmly retained in its place.

The next proceeding consisted in soldering to the back part of the plate two bands, composed of gold, rendered

elastic by the addition of three grains of platinum to one pennyweight of the ordinary eighteen-carat gold. The free ends of the bands were adjusted to press outwards and from the irregular tooth, the two contiguous teeth, in the manner shown in the accompanying figure.

In the course of nine days, sufficient effect had been pro-

FIG. 99. (1)



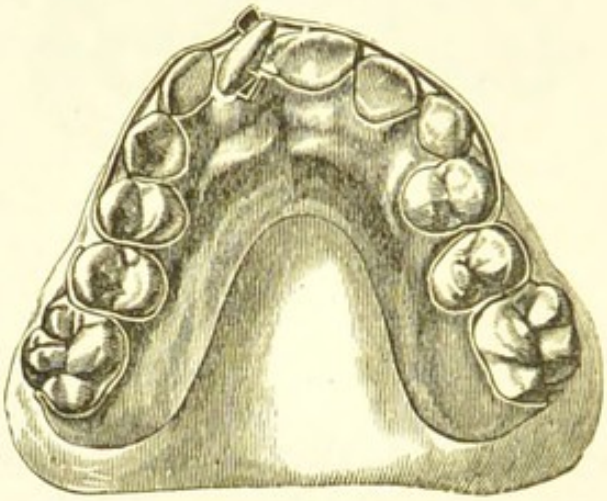
duced to render it desirable that the incisor itself should be acted upon in order that the increased interval should be occupied by the tooth for which it had been obtained. A second plate was constructed. In this a bar of gold was continued in front of the teeth, and attached to the anterior T-piece on either side. Metal cells for the reception of compressed wood were then soldered to the plate and to the band. One was placed so that the wood would press upon

(1) Shows the right central incisor twisted on its axis to the full extent of a quarter of a revolution, with the adjoining incisors in close contact with its labial and lingual surfaces. The metal plate used in the first stage of the operation is shown *in situ*, with the two elastic bands of gold soldered to the back part of the plate, and the free ends in a position for separating the right lateral and left central incisor in order to gain space for turning the displaced tooth. In the sketch below, the manner of adjusting the wire bands for the retention of the plate is shown.

the distal angle of the tooth, the other upon the labial surface near the mesial angle. The forces thus brought into play acting in opposite directions, turned the tooth upon its axis, and were sufficient to influence the impinging lateral and central teeth, and force them out of the way of the slowly turning tooth. In a few days it became necessary to alter the position of the receptacles for the wood, and subsequently to move them from time to time towards the retreating angle of the tooth.

After the second plate had been in use three weeks, the tooth had so far changed its position that the mesial side

FIG. 100. (1)



stood slightly in front of the left incisor, and the distal side a little posterior to the lateral incisor, presenting a degree of irregularity which would attract but little notice.

As the left incisor was still a little internal to the arch

(1) Shows the condition of the case illustrated in the preceding figure after the adjoining teeth have been separated by the elastic bands, and the displaced tooth turned slightly from its original position. The plate used in this, the second stage of the operation, is shown *in situ*, with the metallic boxes for the reception of the compressed wood in the positions suitable for effecting the further progress of the treatment. It will be apparent that the boxes will require a change of position when the tooth has moved away from them.

which would be described if the canines were taken as the guide for its formation, a cell was adjusted upon the plate behind that tooth, and the wood brought into operation. At the same time, the operation upon the lingual surface near the distal angle was continued, and the degree of pressure upon the labial surface was considerably reduced. In the course of a second term of three weeks, the tooth was brought into position, ranging evenly with the contiguous teeth.

The foregoing illustration will show the principles upon which the operation was successfully conducted; nowadays a vulcanite plate would probably be preferred, and many operators would use springs made of piano-wire in preference to boxes for compressed wood.

This case will be regarded as one presenting a considerable amount of difficulty. A successful operation involved not only twisting a tooth upon its axis to the extent of a quarter of a revolution, but also the shifting outwards of the left central and both of the lateral incisors, in order to make room for the crossing tooth to turn. The base of the alveolar arch was, however, sufficiently developed to render the readjustment of the teeth practicable without having recourse to extraction.

The front teeth having been carried into the desired position, it became necessary to take measures to keep them there until they became firmly fixed in their sockets. To effect this retention, an ivory plate was fitted to the palate and to the lingual surfaces of the teeth, extending as far back as the first permanent molars. The bicuspids being a little internal to the proper outline of the arch, pegs of wood were inserted into the ivory at the points corresponding to the necks of these teeth. After adjustment, the pegs projected from the plate sufficiently to press firmly upon the four instanding teeth, and thus perform the double purpose of retaining the plate in its place, and of forcing the teeth, upon which its retention depended, slightly outwards.

Were a similar case now to present itself, the earlier stages of the operation might be more advantageously treated by one of Dr. Coffin's split plates (see page 192), and the requisite space having been gained by an equable expansion of the front part of the arch, springy pieces of piano-wire might be adjusted so as to press on the angles of the incisor and so rotate it. Or the tooth might be rotated by means of a ring of platinum foil made to fit around its neck: a strip of stiff wire is soldered to the lingual surface of the ring, bent so as to conform roughly to the outline of the palate, and traction made upon the end of the lever thus formed by means of an elastic ring tied to one of the back teeth. This plan I believe to have been suggested by Dr. Dodge.

A simple and efficacious method of rotating incisor teeth has been thus described by Mr. Balkwill (Brit. Journ. Dent. Science, 1881).

"After some consideration of the conditions involved, it seemed manifest that the right principle to work on was to consider the tooth as a pulley, to be rotated by a cord in somewhat the same way that a window-blind roller is moved.

"The following case will illustrate the method finally settled upon in applying this principle.

"Fig. 102 represents the position occupied relatively by the central incisors of a lad of thirteen, which it was desired to reduce to their normal position in the dental arch.

"A piece of fine silk twist was tied around the middle of the crown of each tooth, the knot being on the front a little nearer the mesial line than the centre of each crown (see Fig. 101, *a*, *b*).

"The two ends of one of the ligatures, say *c d* of the left hand in the drawing, were then passed between the centrals round on the lingual face of the tooth, and forward between the central and lateral of the same side, as shown in the drawing. It will be seen that if these ends are together

pulled transversely to the long axis of the tooth the strain will be to rotate the tooth. The ends of the other ligature

Fig. 101. (1)

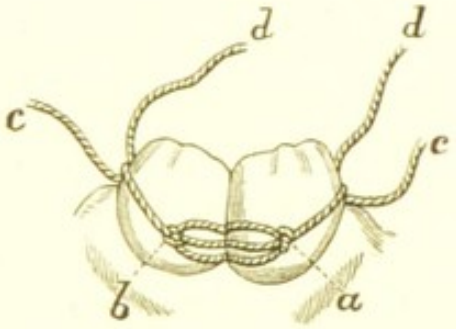


Fig. 102. (2)

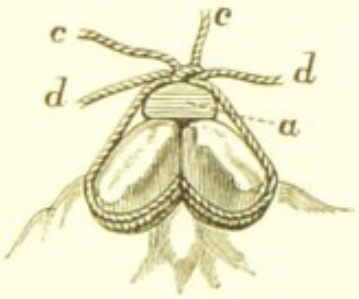


Fig. 103. (3)

were brought round the other tooth, on the right in the drawing, in the same manner.

"A small block of compressed willow-wood was then taken, about the length of the crowns of the teeth, a quarter of an inch wide, and less than an eighth of an inch thick, the compression being in the direction of the thickness. This

(1) Two upper central incisors. A silk twist ligature is tied around the middle of each crown in a knot at *b* and *a*. The two free ends of each of the two ligatures are then passed between the centrals, brought round on the lingual surface, and forward between the central and lateral, as at c, *d*, and *c*, *d*, the two ends in each case belonging to the same piece of string to be used as shown in Fig. 102.

(2) Bird's-eye view of the same teeth as Fig. 101. *a*, a small billet of compressed wood tied upon the front of the incisors by means of the free ends of silk, as shown in Fig. 102, *c c*, *d d*, being brought in front and tightly tied there, *c* to *c*, and *d* to *d*. The wood in swelling pulls upon the ligatures and rotates the teeth.

(3) Result of action on case drawn in Fig. 102 in ten days.

was placed against the crowns of the teeth so that the length corresponded with and covered the mesial division between the teeth, one of the surfaces of its width being against the anterior surfaces of the teeth (see Fig. 102 *a*).

"It will be seen that it also rested against the two knots (Fig. 101 *a*, *b*). The two loose ends of the ligatures (Fig. 101 *c c*) were then brought over it and tightly tied, and then the two ends (Fig. 101 *d d*) in the same manner. When the wood swelled it pulled upon the ligatures, and as it pressed upon the knots (Fig. 101 *a*, *b*) at the same time the ligatures could not slip, but rotated the teeth.

"In the case under notice the piece of wood had to be renewed once, and reduced the teeth to the positions indicated in Fig. 103 in ten days."

But the process of twisting a tooth on its own axis by means of gradual pressure is one that necessitates the use of a plate for a very considerable length of time, and inflicts no small discomfort on the patient; and it has been found that the same end may be attained by seizing the tooth in a pair of forceps and forcibly twisting it round.

It might have been anticipated that such a procedure would be followed by the death of the pulp and consequent alveolar abscess; but this untoward result happens very rarely, and may almost always be avoided by performing the operation only on thoroughly favourable cases.

Before deciding on forcibly twisting the tooth, the operator should satisfy himself that there is sufficient space for the crown in its new position, and also that the direction of the root is such that it will allow of the crown ranging regularly with the surrounding teeth.

The most favourable period for its performance appears to be the age of nine or ten years, when the teeth are fully erupted, but their sockets have not yet attained their full strength. I have, however, successfully twisted the central incisors in a patient aged fifteen, and in several instances in patients aged thirteen; but, as a rule, it should be done at

a much earlier age, for the sockets become very dense and unyielding, so much so that in several cases I have failed to move the teeth with any degree of force which it has seemed safe to apply, and have been therefore compelled to abandon the attempt.

The tooth may be seized by its labial and lingual, or by its mesial and distal, surfaces; and it will often be convenient to change the hold of the forceps after the tooth is partially twisted. Thus, if the tooth stands nearly at right angles to its proper position (as, for example, the right central incisor in Fig. 99), it would be easiest to apply one blade of the forceps to the mesial and the other to the distal surface, but it would not be possible to complete the torsion with the blades in this position, as they would come in contact with the lateral and the other central incisor. Hence, when the tooth is partially turned, the forceps must be applied to the lingual and labial surfaces, by which means the operation may be completed, and the tooth left in a perfectly normal position.

The instrument used should be a pair of straight incisor forceps, the blades of which should be prevented from chipping the enamel, by the interposition of some soft substance. Some operators use a slip of sand-paper for the purpose; others use paper, but this is apt to slip. A piece of leadfoil answers the purpose very well, and is free from the objections which apply to the other two. The tooth should be firmly grasped at the edge of the gum, and steadily twisted in the desired direction until it is felt to yield; no attempt should be made to loosen it by twisting it alternately in opposite directions, as has been done by some operators, as this loosening is precisely what it is desirable to avoid as far as is possible. As the tooth on being released springs back somewhat, it is generally necessary to twist it somewhat farther than into its normal position. Where the tooth has to be twisted through a quarter of a circle in a somewhat old subject, the resistance will sometimes be very considerable, and I have in several instances obtained a

thoroughly satisfactory result by turning it through only half the required distance, and allowing it to get firm again; then, after the lapse of a fortnight or three weeks, completing the operation by twisting it through the remaining distance. Although on the first occasion the resistance may have been very great, the tooth generally yields very readily to the second attempt, and I think such a course preferable to the use of very great force in order to complete the operation at the first attempt.

There is generally very little bleeding, and not much pain resulting from the operation, though, of course, the tooth is somewhat loose and tender at first. In order to ensure it being left at perfect rest, and retained in its new position, it is advisable to soften a piece of gutta-percha and press it over the incisors and canines of the upper jaw immediately after the operation, directing the patient to bite the lower teeth into it while it is still soft.

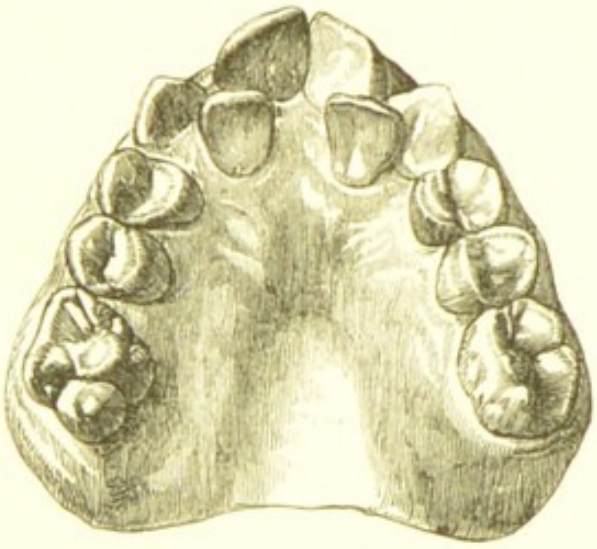
This will keep it in its place, and should be worn for twenty-four hours at least, or longer if the tooth remains very loose; of course it must be removed during meals, but it is safer to confine the patient's diet to soft things for a day. The extreme tenderness and looseness will pass off in a day or two, when the use of the gutta-percha splint may be discontinued. If there is swelling and tenderness over the socket, this may be painted strongly with tincture of iodine, or a leech applied; but the necessity for any such treatment seldom arises.

I am acquainted with one case only in which necrosis of the tooth ensued; the patient was a child of suitable age, but was a hospital patient, apparently not much tended by its parents, and probably no care was taken after the operation to preserve the tooth from movement. In this case, I believe, the pulp cavity was drilled into, through the lingual surface of the crown, and the fang filled with cotton-wool steeped in carbolic acid. This treatment was perfectly successful, and the tooth after a short time became firmly fixed in its socket. I do not know through what

distance the tooth was turned, nor whether it offered more than usual resistance, but the untoward result was attributed to the want of proper care exercised after the operation. But on the whole, the operation of immediate torsion is one which is only advisable, when for some reason or other the rectification of position by means of plates is not available.

Irregularity in the position of the lateral incisors.—In the upper jaw these teeth may be misplaced in any of the directions enumerated and described in the preceding pages in connection with malpositions of the central incisors, hence

FIG. 104. (1)



the description which has served for the one may be applied to the other series of deformities. Perhaps the most common form of irregularity of the lateral incisors is that in which they take a posterior position, the mesial edge of each lying behind the contiguous side of the central incisor, and the distal edge behind the mesial side of the canine.

In the example figured the teeth have retained the position assumed during their development, when, from the insufficient size of the anterior part of the arch, this or

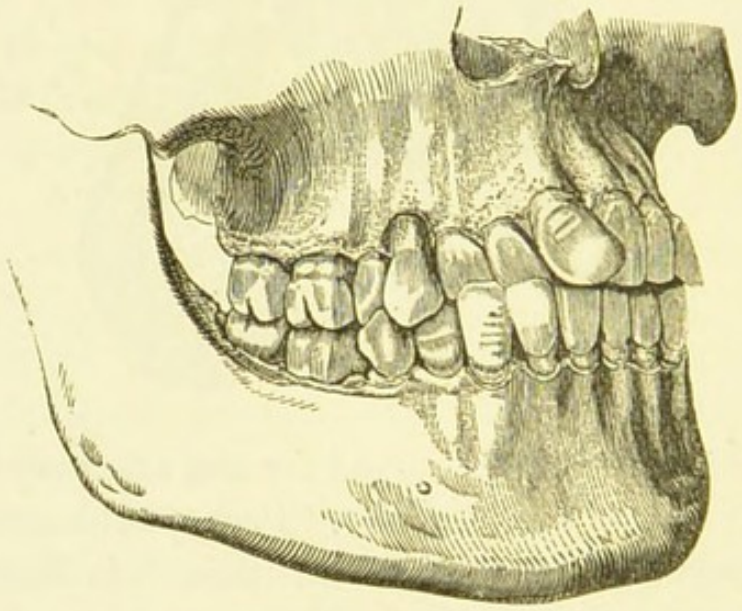
(1) Showing the lateral incisors placed internal to the dental arch, the alveolar arch being contracted. This illustration is taken from a cast of the mouth.

some other form of displacement was a necessity. The canines here hold the place which should have been occupied by the lateral teeth, but had the latter taken their normal position, the former would have been thrown out of the dental line.

We must not, however, in endeavouring to trace the cause of mere misplacement in cases like the one figured, forget that had a proper direction been given to the teeth as they successively appeared through the gums, the alveoli would have grown up with them, and if the base of the jaw had attained a sufficient size, no irregularity would have occurred, even had the teeth, when within the jaw, been somewhat irregularly disposed.

In the case from which the succeeding illustration is

FIG. 105. (1)



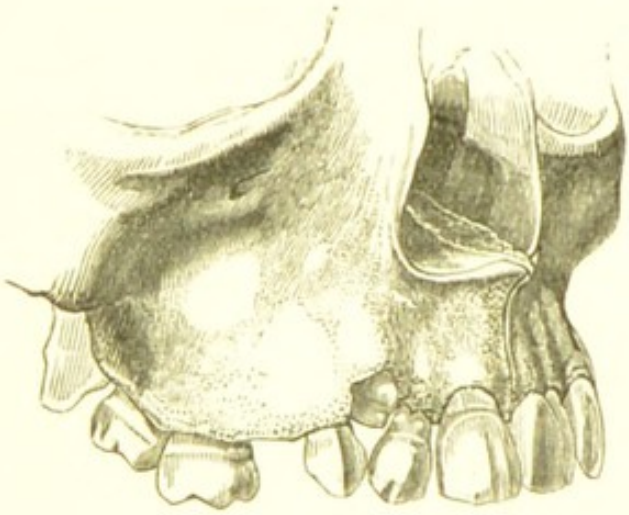
taken, there is no indication of contraction of the jaw. On the one side of the mouth, the teeth are perfectly regular; on the other, the lateral incisor and the canine are directed inwards, and pass, when the mouth is shut, behind the

(1) Showing the lateral incisor and canine inverted, and the central incisor driven outwards and across the fellow tooth, the alveolar arch at its base being free from contraction.

corresponding teeth of the lower jaw. The arch being at this point bent inwards, and the alveolar space thereby contracted, the teeth, in order to find a place for themselves, have forced the central incisor forward, and driven its median edge over the labial surface of the adjoining tooth. In this specimen we have an example of irregularity consequent on the teeth, from some cause (probably the retarded ejection of the temporary teeth), taking an improper direction at the time of eruption, the jaw being normal in size ; in the preceding case, an illustration of irregularity consequent upon a contracted maxilla.

A slight degree of eversion and separation of the lateral from the central tooth at the time when the canine is ad-

Fig. 106. (1)



vancing towards the surface of the gum, is far from uncommon, and when the latter tooth is impeded in its progress by the presence of its temporary predecessor, the disturbance of the lateral incisor becomes still more marked. The accompanying figure shows the effect produced by the foregoing combination of circumstances.

When the conical form of the canine, its crown being so

(1) Showing the lateral incisor pressed out of the normal position by the canine in its descent to the surface of the gum. The presence of the temporary canine has in this specimen occasioned the permanent tooth taking the oblique direction.

greatly wider than its somewhat flattened fang, and the strongly prominent convexity of its median side, are taken into account, we shall not be at a loss to see how during its descent the root of the lateral incisor is pressed upon, and the crown consequently forced out of position. Instances are not wanting in which the root of this tooth has been more or less absorbed, to make way for the canine; and I have an example in which the fang has been bent during its development, so as to form a hollow, within which the convexity of the canine lay.

In connection with malposition of the canine, a figure will be given, taken from a case in which the lateral incisor has been driven outwards towards the lip, by the canine coming through the gum immediately behind the former tooth (Fig. 108).

Under such circumstances the descent of the canine may threaten to force out the lateral, which may become loose and exquisitely tender; but it will speedily recover when the canine is drawn away from it.

The principles which have been laid down for the treatment of the various forms of irregularity in the central, apply equally to the lateral tooth, when similarly situated, excepting that the one is, as respects appearance, a less valuable tooth than the other, and may therefore, under certain circumstances, be sacrificed with less hesitation. When, for instance, the lateral teeth are situated as in Fig. 104, we need not hesitate to remove them, supposing the antagonism is normal, and a more forward position of the central teeth would leave a wide interval between the lingual surface of the upper and labial surface of the lower teeth on the mouth being closed. But if the central incisors in such a case passed behind the corresponding teeth of the lower jaw, it would then be our duty to bring them forward, and afterwards force the laterals into the space which the previous operation had gained. In cases presenting the peculiarities shown in the Fig. 105, the operation is very simple. We have only to bring the inverted tooth,

or teeth, outwards, and the antagonising teeth will keep them there.

Supposing the displacement to be caused by the canine when about to take its place in the series, we must wait until its evolution is completed, removing, of course, any temporary tooth which may operate in disturbing its course. If after the eruption of the canine the lateral does not regain the proper position, the usual means must then be adopted for its restoration. But it may happen that the teeth are driven inwards or outwards, or are twisted by the canines, which, in the absence of sufficient space for their proper evolution, take a position either external or internal to the dental line.

Irregularity in the position of the canine teeth.—Of all the teeth, none are so frequently out of the normal position at the time of eruption as the canines, and it may be stated, without fear of contradiction, that no other members of the set so frequently fall from an objectionable into the proper position without mechanical assistance. We constantly see cases in which, at the age of ten or twelve years, the teeth hold a situation somewhat external to the arch formed by the incisors ; but if they are watched it will be found that before the eighteenth year has been attained all irregularity has disappeared. It becomes a matter of some moment to ascertain by what process the uniformity of arrangement is attained. The agencies which tend to bring about a normal arrangement of the teeth have already been mentioned (page 152), and these will operate not only by bringing in the outstanding canines, but also, probably, by in some degree pressing outwards the incisors. There are, however, many cases in which the interval between the lateral incisors and the anterior bicuspids is so small that the canines necessarily appear external to the dental arch, and stand so much in front of the lateral teeth that the outward movement of the latter or the inward progress of the former by a natural process is rendered impossible. On referring to the preceding figures, it will be seen that if the outward development

of the alveolar ridge is suspended, this position of the canine follows as a necessary result, the degree of displacement according with the amount of suspension. Then, again, if the normal obliquity is not assumed by the front teeth, a similar condition as respects the canines results. The prolonged retention of the temporary predecessor may also be cited as tending to a like effect.

Although the anterior is by far the more common form of displacement, we not unfrequently see the canine piercing the gum posteriorly to the dental line, the terminal portion of the root being in this, as in all the forms of irregularity hitherto considered, in the normal position as respects the base of the alveolar ridge.

In determining upon the method of treatment, we must be guided by the principles laid down in respect to the treatment of similar forms of irregularity occurring in other teeth. Whether the involved tooth is external or internal to the dental line, either the arch must be expanded or a tooth must be removed, before sufficient space can be gained for its admission to uniformity. We have the alternative of pressing outwards the neighbouring teeth or sacrificing a tooth.

The canine is the most durable member of the whole series, hence it must, if possible, be brought into place; moreover, the pointed form of the canine gives it a character not shared by the other teeth, so that its absence is noticeable. And besides this, the length of its root, and the prominence which this occasions just beneath the wing of the nose, results in its loss having a greater effect upon the face than the loss of any other tooth. But circumstances arise under which its extraction becomes expedient. If, for instance, the tooth pierces the gum considerably above the alveolar margin, and is directed outwards, and the interval between the lateral and first bicuspid but slight, we shall then do well to remove it. Teeth so situated, being very frequently short, and having imperfectly formed curved roots, are often incapable of taking their proper place in the series. A case presented itself, only a few days since,

in which the right canine was so placed. On removal, the root was found to be short and curved. Had an attempt been made to bring it into line, the apex of the root would have been forced through the labial surface of the gum, and the crown would have stood at a higher level than the corresponding parts of the neighbouring teeth. To have sacrificed the lateral or bicuspid for this defectively-developed tooth, would have been an obvious error; and to have forced the anterior teeth outwards would have been equivalent to producing a deformity in the whole in order to meet that which had arisen in one of the front teeth. Hence, although the rule that the canine should be preserved is a thoroughly sound one, it must not be blindly followed in every case, but the ultimate prospect of getting the tooth into place must be carefully considered.

When we have reason to suppose that an out- or in-standing canine is not in any way defective, yet the space accorded to it is insufficient, and the anterior teeth, as respects the teeth of the opposite jaw, are well placed, it becomes a question which of the neighbouring teeth should be removed. The selection must be made in reference to the condition of the adjoining teeth. Should either the first permanent molar, or either of the bicuspids, or even the lateral incisor, be carious, we shall have no difficulty in making our choice; and should more than one of these teeth be diseased, we should then select for removal that one which is nearest to the canine. But if all the teeth are sound, we may then sacrifice that which is the most liable to become diseased. It has been shown that the first permanent molar exhibits the greatest tendency to disease; thus under the age of fifteen, the respective liability to loss from caries runs in the following order:—Lateral incisors, $3\frac{1}{2}$ per cent.; first bicuspids, 7 per cent.; second bicuspids, $8\frac{3}{4}$ per cent.; first permanent molars, $68\frac{1}{4}$ per cent. (1) The statistical facts advanced in the lectures from which the foregoing details have been

(1) Lectures on Dental Physiology and Surgery.

extracted have met with confirmation at the hands of Mr. Underwood, in a paper containing similar statistical results published in the "American Journal of Dental Science."

But were statistics at a later age collected, it is probable that the bicuspids would not come out in so favourable a light.

Supposing, then, a sound tooth must be sacrificed, there can be but little doubt that we shall do wisely in selecting the first permanent molar.

After the condemned tooth has been removed, the next step in our proceeding may be considered. We must determine whether the bicuspids will fall back and allow the canine to take a proper position without mechanical assistance, or whether our assistance will be required. In determining this point, the age of the patient and the degree of irregularity as regards the canine, will form our principal guides. It is also necessary to notice how far the articulation of the upper and lower teeth may prevent the bicuspids falling back; for instance, when the upper jaw is small the lower bicuspid may bite behind the upper, in which case it would present a serious obstacle to its movement backwards.

Should it be determined to bring an outstanding canine into the dental line, either by acting on the tooth itself, or by operating on the neighbouring teeth, as well as upon the canine, the methods described as having been successful in turning into place a twisted central incisor will be found effective.

Irregularity in the position of the bicuspids.—It rarely happens that the front teeth are crowded, without the bicuspids to some extent participating in the general irregularity. They are usually situated internally to the normal position, and are instrumental in throwing the canines out of the proper line, or in giving the appearance of undue prominence to those teeth. The bicuspids may be regarded as forming the base of the semicircular dental curve, which, if contracted, necessarily involves either a

deviation from the normal figure, as seen in the V-shaped mouth, or obliges some of the teeth to take either an external or an internal position.

If the curve described by a perfectly well-arranged set of teeth be examined, it will be found that it approaches a semicircle as far as the bicuspids, and that the molars occupy curvilinear lines, diverging slightly as they proceed backwards. The arch admits of division into two parts; the anterior semicircular portion being occupied by the successors of the deciduous teeth, the posterior division by the true molars—teeth which have no predecessors. Should, therefore, the breadth of the jaw at the junction of the two divisions fall below the proper extent, and the bicuspids of either side consequently approach too near the median line, not only will the front teeth be thrown out of the semicircular curve, but the molar teeth will occupy lines which, although diverging from the starting-points, will nevertheless fail to attain an amount of separation as respects the two sides of the mouth, consistent with a well-developed denture. The case figured at page 182 illustrates the condition, and indeed shows an indentation in the arch at the points of junction of the molar and bicuspid teeth, the origin of which has been already explained.

Although not a common cause, cases may be found in which disease in the temporary molars, and subsequent alveolar abscess, have occasioned the displacement of the bicuspids. And dead roots of milk-teeth, being apparently less readily absorbed than healthy roots, often oppose the normal eruption of bicuspids. In the case figured at p. 60, the first bicuspids have been driven outwards by disease about the first temporary molars. Like the teeth in the front of the mouth, the bicuspids may be diverted from their proper position by the persistence of temporary teeth.

When one only of the two bicuspids is involved, we shall generally find the second bicuspid to be the misplaced tooth. In that case, the mischief may have been

produced either by want of sufficient space for a regular arrangement, or from the presence of the whole or a part of its predecessor.

When the former cause has led to the deformity, the degree of displacement will vary in accordance with the amount of contraction of the allotted space. Thus, when the first bicuspid and first molar are closely approximated, the second bicuspid or premolar commonly comes through the gum internally to the arch.

It is far from uncommon to find the latter tooth twisted upon its axis by the presence of the lingual root of the second temporary molar, wedged between the first permanent molar and the former tooth. In a succeeding figure (Fig. 110), the second bicuspid is completely turned round, so that the lingual has become the labial surface, and in this case the labial root of the temporary tooth has been retained.

In determining upon the course of treatment, we must be guided, in the first place, by the condition of the jaw. If the base is contracted, it may be necessary to remove a tooth, but should the teeth be turned inwards, and their outward movement possible without derangement of the anterior part of the dental arch, we must then adopt a plate, and have recourse to the compressed-wood wedges, to jack-screws, an expansion-plate made to bear specially upon certain teeth, or to springs. Either metal or vulcanite may be used in constructing the apparatus, and wedges, if properly proportioned, will serve for its retention without the aid of ligatures or clasps. The movement is very readily effected, being sometimes unintentionally brought about by the very moderate pressure of artificial teeth; but we must not neglect to take into account the antagonism of the opposing teeth. Usually the lingual cusps of the upper close between the outer and inner cusps of the lower teeth, and unless the lower bicuspids are moved outwards contemporaneously with the upper teeth, the normal antagonism will be destroyed. Moreover, there will

be a strong counteracting force exercised by the stationary teeth upon those under operation. If the upper teeth, for example, are moved outwards so that the lingual cusps close on the apices of the labial tubercles of the lower teeth, the other teeth will be kept apart until the lingual cusps of the moved teeth slide down either upon the inner or outer surface of the labial cusps of the lower teeth. In those cases in which we find a faulty antagonism, our treatment becomes more simple. If, for example, an upper tooth closes externally or internally to its antagonist, our operation will be confined to the misplaced tooth, which, so soon as it approaches its proper position, will be carried onwards in the proper direction by the influence exerted by the antagonising tooth of the lower jaw, in the manner described in connection with misplaced central and lateral incisors.

Irregularity in the position of the crowns of the permanent molars, without the roots participating in the displacement, is of less frequent occurrence than derangement of the more anterior teeth; still, cases sometimes present themselves in which the normal positions are not maintained. Perhaps the most common form of deviation is that in which the second permanent molar on either side is turned inwards towards the median line of the mouth. In a cast given to me by the late Mr. Alfred Canton, the three molars are arranged in a triangle, the second being placed internally to the other two molars. In this case, the obvious remedy would be the removal of the misplaced tooth. In cases where the first molar leans in towards the palate, the position might, I presume, be changed by the persistent use of compressed wood applied in the manner already described; but we rarely find these teeth out of place without the anterior teeth participating in the derangement, in which case the treatment would become very tedious, were we to attempt to reduce to order the whole of the teeth situated anterior to the second permanent molar. In the vast majority of the cases which have come under my notice, this treatment has been rendered inadmissible by the co-

incident contraction of the base of the jaw, and in those in which pressure might have been used, not only must the upper teeth have been operated upon, but the corresponding teeth of the lower jaw also, in order to maintain the proper antagonism.

As mal-position of the wisdom-teeth almost invariably involves their removal, whatever may be the position of the roots, the consideration of the whole subject in respect to these teeth will be given in connection with complete irregularity.

In treating of those cases of irregularity which admit of mechanical correction, I have confined the description for the most part to the teeth of the upper jaw, under the impression that it would be unnecessary to give a detailed account of the defects of arrangement in the corresponding organs in the lower maxilla. It may, however, be stated generally, that the forms of irregularity which occur in the upper may also arise in the lower teeth, and that the treatment suitable for the one will be equally fitted for the other. The construction of the plate, whether metal or vulcanite be used, will of course be modified. We have here to adapt the apparatus to the teeth and the lingual surface of the gums only; excepting in the foregoing particulars, the methods of operation will be precisely similar to those already described. The vertical position of the lower teeth renders the retention of the compressed wedges of wood particularly easy, and this advantage is still further increased when the teeth so operated upon are inclined either outwards or inwards. The operations for the adjustment of irregularities of position are, however, less frequently attempted on the lower than the upper jaw, owing to the former being hidden to a great extent by the lip; hence they fail to attract that amount of attention which is given to upper teeth.

Irregularities of the permanent teeth in which both the crowns and the roots are out of the normal position—total or complete displacement of the permanent teeth.—Transposed teeth come under this head, but as they do not admit of restorative

treatment, examples illustrative of this form of departure from the normal arrangement may be given at the conclusion of the present division of the subject.

The following illustration (Fig. 107) shows the amount to which a central incisor may be thrown out of the proper position. Here the cause is sufficiently obvious in the presence of a supernumerary tooth. Cases in which the centrals are completely displaced are, however, comparatively

FIG. 107. (1)

rare. All attempts at treatment would in any such case as that which is figured necessarily be useless, supposing the development of the root to have been advanced. Had the supernumerary tooth been removed as soon as it appeared, the incisor would probably have taken its normal position, although even then the displacement during development might have been too great for the operation to have resulted successfully.

I do not remember to have seen any cases in which a lateral incisor had been totally displaced, excepting when teeth have been transposed ; there is, however, no reason to suppose that they are more exempt than the central teeth from this form of irregularity.

The foregoing observation cannot be applied to the canine teeth. They are more frequently than any other description

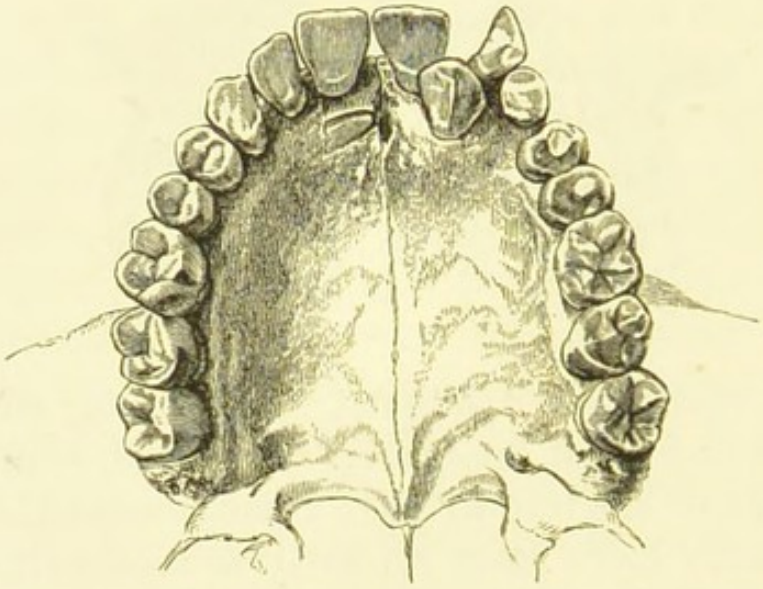
(1) Shows the right central incisor with both the crown and root displaced, its normal position being occupied by a supernumerary tooth.

of teeth the subjects of total displacement. Even in my father's collection there are many examples illustrative of the abnormal positions into which these teeth may be thrown.

Transposition of the teeth is not confined to the human subject, there being a skull of an orang in the Oxford Museum in which the canine and premolar are transposed.

Perhaps one of the most common forms of displacement is that in which the canine is situated posterior to the dental line, at a point corresponding to the space which

FIG. 108. (1)

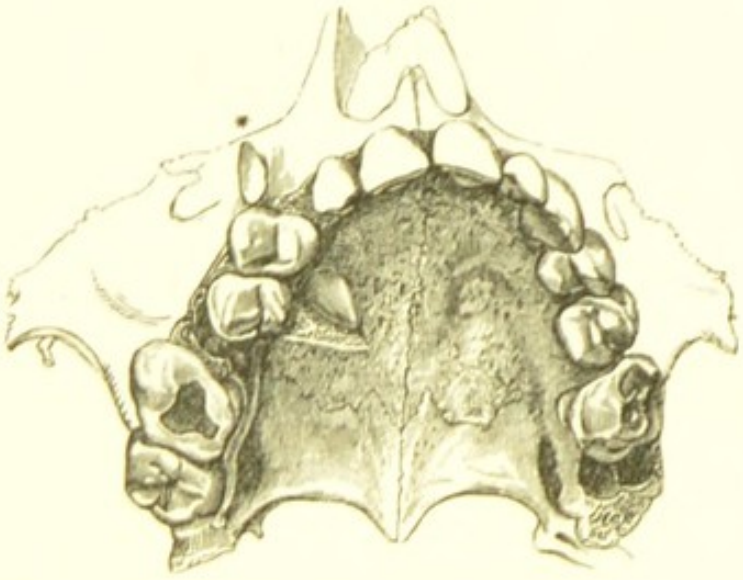


divides the central and lateral incisors. It may happen that the crown only occupies this position, in which case the deformity would admit of remedy; but where the root participates equally with the crown, as in the example which forms the subject of Figure 67, restoration to the normal arrangement, though perhaps not impossible, would be attended with difficulty. The question then arises as to

(1) Shows the left canine placed behind the dental line, its crown holding a vertical position, and the root, unless greatly curved, equally with the crown, displaced. The lateral incisor has been everted by the canine, while the temporary canine holds the position which should have been occupied by the displaced tooth. The right temporary canine is retained, and the permanent tooth placed horizontally, a portion of the crown only being seen.

which of the teeth should be removed. The temporary canine, if left, may endure for some years, but if it be extracted we may be unable to force the permanent tooth into its place, and should we succeed, the crown only would be moved, hence the tooth would hold a slanting and probably unsightly position. My own choice would fall upon the canine. It would, I think, be more easy to press the lateral

FIG. 109. (1)



tooth inwards, the terminal portion of its root not being displaced, than to draw outwards into line the canine. In deciding on our treatment, we must in no case lose sight of the fact, that although it may be quite possible to force a tooth from an irregular into a regular position, yet that the operation may, under some circumstances, be so prolonged and painful, that the proposed advantage will not compensate for the suffering which its accomplishment would entail.

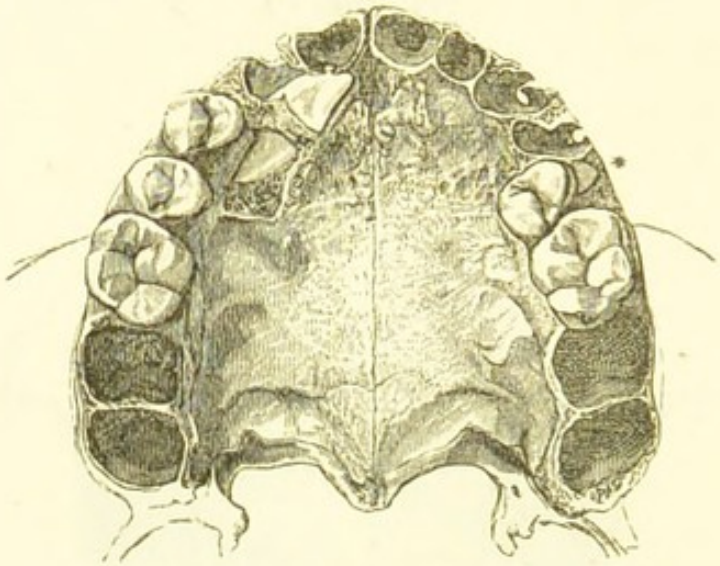
In the preceding figure a case is shown in which the right canine is placed across the dental arch, the root being

(1) Shows the right canine placed transversely in the base of the alveolar tract, the crown being directed towards the cheek, and the root towards the median line of the mouth. The bone has been removed to show the course taken by the root of the displaced tooth.

directed towards the median line of the palate, and the crown towards the cheek. The point of the crown was the only part which was not completely buried in bone. The latter tissue has been cut away for the purpose of showing the course taken by the tooth.

A horizontal position in the base of the alveolar ridge is

FIG. 110. (1)



sometimes taken by the canine, the apex of the crown being exposed to view, or covered only by gum, or imbedded deeply in bone.

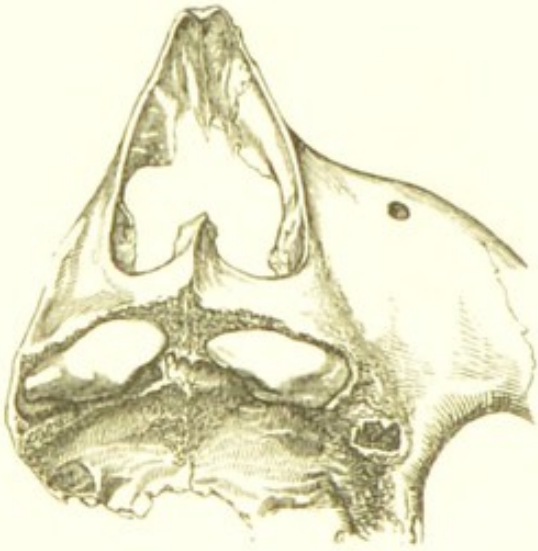
Teeth so placed may remain without producing inconvenience through a long life, and be discovered only towards its close. When with advancing age the teeth fall out, and the alveolar processes disappear, the long hidden teeth are brought to light, and the patient fancies he is cutting a third set of teeth. The two following illustrations are

(1) Shows the right canine of the upper jaw buried in the base of the alveolar prominence, its course corresponding with that of the latter part. The bone has been cut away to show the direction taken by the tooth. The first bicuspid has become slightly twisted on its axis by the misplaced canine. On the left side of the maxilla the second bicuspid has been twisted round until its lingual surface is directed towards the cheek. The presence of the root of the second temporary molar has probably been instrumental in producing this change from the normal position. This case is referred to in a previous page.

taken from a remarkable specimen given to me by the late Dr. Brinton, in which the canines were symmetrically arranged in the horizontal position described in the preceding case.

Fig. 111. (1)

Fig. 112. (2)



A patient admitted into the Middlesex Hospital under the care of the late Mr. De Morgan, lost a portion of the upper maxilla from syphilis. The dead bone on its coming away

(1) Front view of a specimen in which the canines are placed horizontally in a line corresponding with the base of the alveolar processes. They have been exposed to view by the loss of the teeth and subsequent absorption of the entire part.

(2) Palatal view of the same specimen shown in the preceding figure.

was found to contain a canine tooth, which ran under the

Fig. 113. (1)

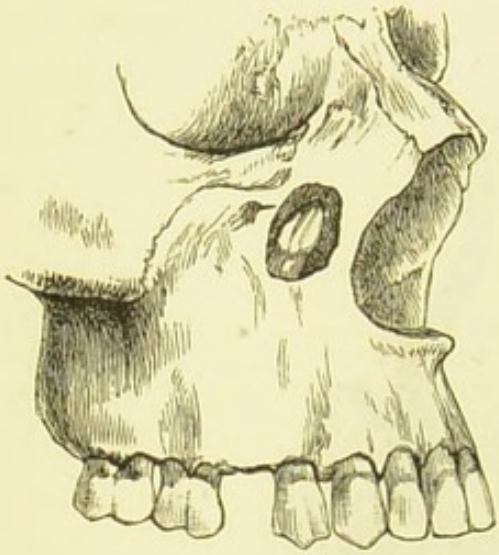
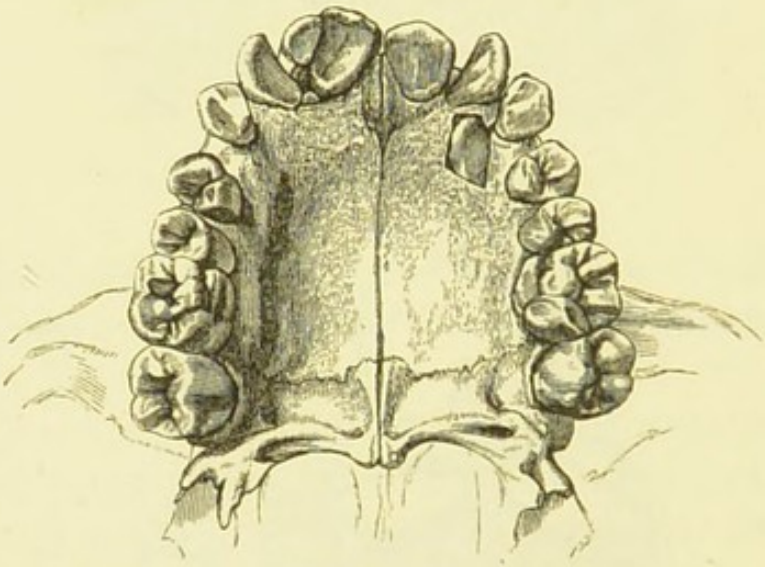


Fig. 114. (2)

Fig. 115. (3)



floor of the nose in a direction paralle with the median

(1) Drawn from a specimen in the Museum of Massachusetts General Hospital.

(2) Shows a sequestrum from the upper jaw which became detached during an attack of syphilis. It contains a canine tooth situated horizontally in the floor of the nose, its direction being parallel with the median line of the palate.

(3) From a specimen in which the temporary canines were persistent, and the permanent canines placed horizontally. On the left side a sufficient amount of bone has been removed to show the position of the buried tooth. On the right side the point of the canine may be seen between the lateral and the central incisor. The right temporary lateral incisor has been retained, wedged between the permanent central and lateral teeth.

line of the palate (Fig. 114). Excepting the absence of the canine, the dental series was normal. Several examples of the canine being found in the antrum have been recorded, in one instance its attachment appearing to be to the floor of the orbit.

And in the museum of the Massachusetts General Hospital at Boston is an example of a canine imbedded in the nasal process of the superior maxilla, with its point directed upwards (Fig. 113).

Although total displacement of the canine teeth is less common in the lower than in the upper series, examples of this form of irregularity in the lower jaw are sometimes met with. Of the two specimens selected for illustration, the one in which the tooth is placed horizontally is the more peculiar. In the second, the temporary canines were retained, and the permanent canines became matured within the substance of the jaw. The retention of the temporary may be adduced as the prevailing cause of total displacement of the permanent canine. In several of the preceding illustrations, these members of the temporary set are present. In other cases, however, the arch is fully occupied by the permanent teeth, to the exclusion of the canines, and as these are commonly the last to take their respective places in the series, they are, when so excluded, liable to be turned completely out of their normal position.

The presence of disease, or the occurrence of mechanical injury in that part of the jaw in which the canines are situated when undergoing development, may drive them from their proper position. I cannot, however, call to mind a case which would serve for illustration on this point.

The results entailed by total mal-position of the canines are usually unimportant. Tumours arising in the osseous structure of the jaw have, however, in a few cases, been found to contain a hidden tooth in their centre, and the teeth so placed have been regarded as the cause of the disease; and in more than one instance, a missing tooth has been removed from the interior of a tumour, and the

operation been followed by subsidence of the disease. That teeth imbedded in the substance of the jaw may become a source of irritation, and predispose to disease in the part in which they are situated, can scarcely be doubted.

FIG. 116. (1)

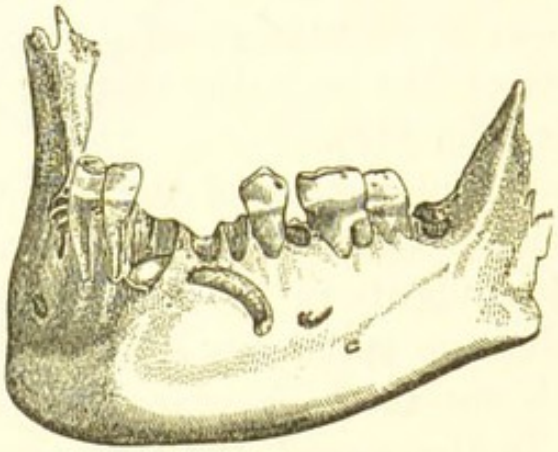
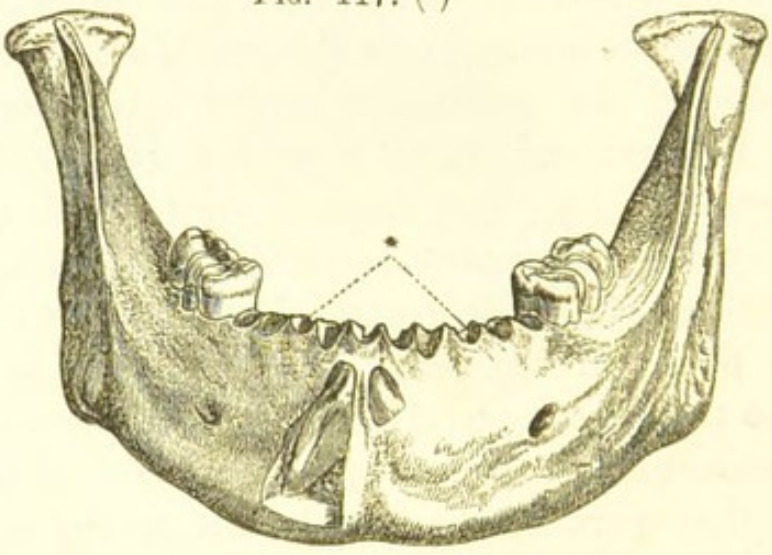


FIG. 117. (2)



In the case shown in Fig. 114, it is probable that the presence of the canine not only determined the site of the necrosis,

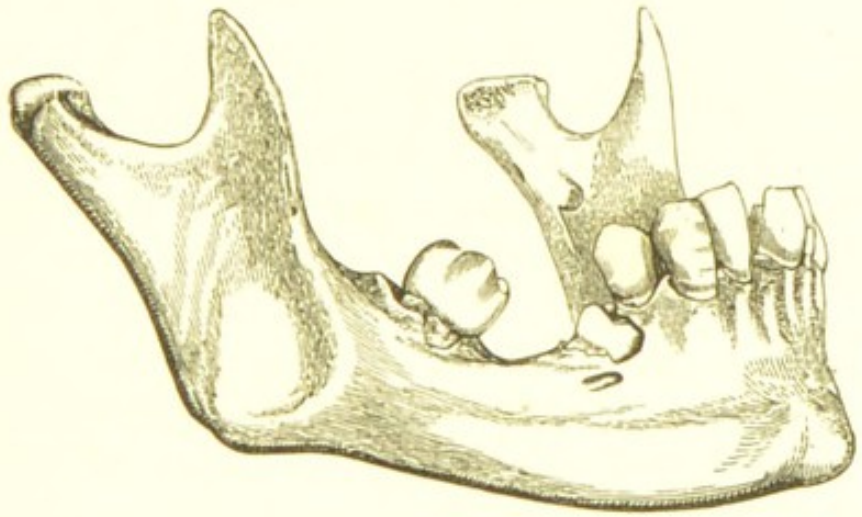
(1) Shows an inferior maxilla in which the left canine is placed horizontally in the alveolar border anterior to the dental series. The tooth was exposed to the extent shown in the figure.

(2) Shows a lower maxilla in which the temporary (the sockets of which are shown by the dotted lines) were retained, and the permanent canines developed within the substance of the jaw. The bone has been removed on the one side to show the direction taken by the tooth, which has been twisted on its axis to the extent of a quarter of a turn.

but also the occurrence of the disease, seeing that the loss of the bone was, as regards the alveolar portion of the jaw, limited to the parts immediately around the tooth. In the year 1859 a specimen was exhibited to the members of the Odontological Society, in which a canine tooth lay horizontally on the floor of a large cavity formed in the substance of the lower jaw near its lower border. The history of the case, with the characters presented by the enlargement of the bone, induced the surgeon to excise that portion of the maxilla in which the disease was situated, and it was the excised portion which was shown at the Society. This case will be found more fully described in the chapter treating on diseases of the jaws induced by misplaced teeth.

Complete irregularity in the position of the bicuspids to the extent shown in some of the preceding figures of misplaced teeth, is of very rare occurrence. In the most

FIG. 118. (1)



strongly pronounced case which has come under my own observation, the root of the second bicuspid of the upper jaw passed backwards between the lingual and labial roots of the first molar. In the case illustrated, the direction of the tooth is much the same as in the foregoing case, although

(1) Shows a lower maxilla in which the right second bicuspid is placed obliquely, the root being directed backwards. The crown, though exposed, does not rise above the level of the alveolar margin.

situated in the lower jaw. The first molar had been lost, hence the relations between the roots of that and the displaced bicuspid can only be surmised.

Examples in which a bicuspid stands obliquely across the dental line are not uncommon, but in these the displacement is rarely complete; the extremity of the root is usually in the normal position, and the crown, if there were sufficient space in the dental line, could be brought into the normal position. Now and then, however, a bicuspid may be found with the crown directed towards the tongue, and situated below the alveolar margin. Such a case is figured by Goddard. (1)

The first permanent molar appearing, as it does, posteriorly to the temporary teeth, at a time when the jaw is in a state of active growth, seldom, if ever, becomes the subject of complete displacement; and I know only of one case in which a fully developed second permanent molar has been found below the alveolar margin. It is figured by Goddard from a preparation in the cabinet of the University of Pennsylvania.

The third molars, or wisdom-teeth, being the last to take their place in the series, are, from the obstacles opposed to their eruption, a frequent cause of suffering, more especially those of the lower jaw. The second molar immediately in front, and the terminal point of the alveolar line behind, bound the space accorded to the wisdom tooth; each tooth which has no deciduous predecessor is developed beneath the base of the coronoid process in the first instance, and as the coronoid process recedes by absorption on its anterior and deposition on its posterior surfaces, the tooth is enabled to come into its proper position; but if the backward development of the maxillæ has been arrested, the interval will be insufficient for the normal arrangement of the presenting tooth. It would appear to be the exception rather than the

(1) The Anatomy and Physiology of the Human Teeth. By Paul B. Goddard. Philadelphia, 1844.

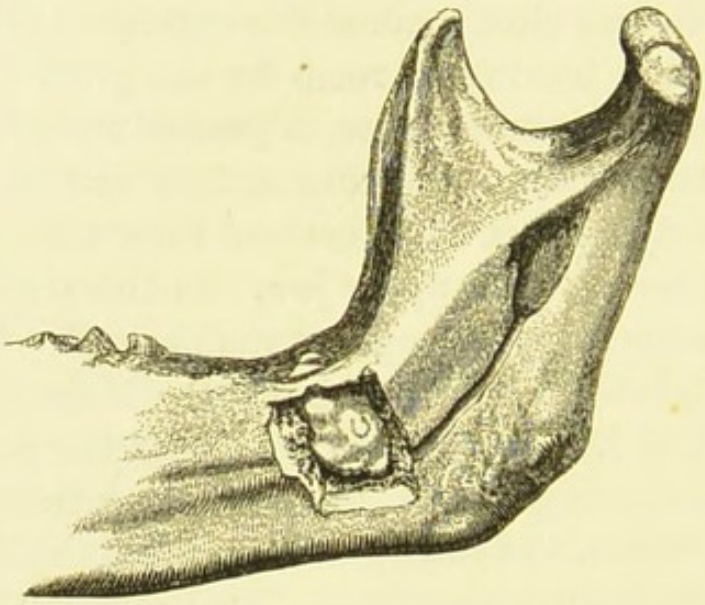
rule for the wisdom teeth, especially of the lower jaw, to take their place among the organs of mastication, without producing some amount of suffering at the time of their eruption, and the degree of inconvenience experienced is often sufficiently great to induce the sufferer to apply for professional assistance. In many of the cases which arise in the lower maxilla the teeth can scarcely be said to be displaced. The deviation from the normal conditions is confined to the jaw itself. The tooth takes its natural direction, but the space into which it has to force itself is insufficient, consequently the distal side lies close against the anterior surface of the coronoid process, leaving no room for the gum. The latter part, under these circumstances, is pressed upwards, and lies more or less over the masticating surface of the tooth, and is consequently subject to be bruised from time to time by the tooth or teeth of the upper jaw. In this manner inflammation in the gum is set up and maintained. The disease seldom limits itself to the part injured. It more commonly extends to the adjoining parts, involving the soft textures about the ascending ramus, and extending from thence to the fauces. The act of deglutition becomes painful, and the motions of the jaw are restricted. The patient tells you that it is quite impossible for him to open the mouth sufficiently wide for you to make an examination of the tooth which has occasioned his misery. After a time, the overlying gum suppurates, and the movement of the jaw becomes less constrained.

The patient, however, is extremely cautious in using the teeth, until the inflammatory action has subsided, leaving in some cases the gum in a position to be again wounded by the upper teeth; in other cases leaving the whole of the masticating surface of the tooth perfectly uncovered. If the patient be seen before any great difficulty in opening the mouth has arisen, the tooth may be removed; indeed, in all cases where the tooth is wedged tightly between the parts already described, this treatment will be the most judicious we can adopt; for should the gum, after the inflammatory

symptoms subside, retreat behind the tooth, still the backward position renders the latter useless as an organ of mastication. And should the gum retain its unnatural position, the patient will be liable to repeated attacks of inflammation until either the gum-covered tooth or its antagonist has been removed.

There may not, however, be sufficient space between the

FIG. 119. (1)



second molar and the ramus for the wisdom tooth to protrude itself; it then either becomes developed below the alveolar margin, or it comes up partly within the base of the ramus —one half of the crown of the tooth being covered by bone, the other by gum. In either of these cases the patient may or may not be subjected to suffering, consequent upon the abnormal position of the tooth; and the absence or presence of mischief will be determined partly by the height to which the tooth rises in the jaw, as respects the antagonistic tooth, and partly by the constitutional state of the patient. The same condition of parts which in one person would lead to

(1) From a specimen in which the third molar has been developed below the alveolar margin, with the distal side under the base of the ascending ramus of the lower jaw.

little or no inconvenience, would in a less healthy subject produce great irritation, and even necrosis; the extent of the disease varying, again, with the susceptibility of the individual. In any case the involved tooth should be extracted so soon as it is found to be a source of irritation. Moreover a buried wisdom-tooth may remain quiescent for a number of years, and then, even in advanced life, set up violent inflammation.

Two such cases have recently come under observation. In the one, repeated growths of irritable polypi sprouted from the gum over the unerupted tooth, necessitating its removal, which was a matter of great difficulty, and was followed by much exfoliation. In the other, disease of the bone was suspected, but a narrow sinus was found to lead down to a buried tooth. All inflammatory symptoms disappeared after dilatation of the sinus had been accomplished by repeated packing with strips of lint, and the patient's advanced age rendered any more radical proceeding undesirable.

In the two preceding forms of deviation from the normal position, the teeth presented themselves in the alveolar line. But cases now and then occur in which, while the vertical position is maintained, the tooth is removed from the alveolar portion of the jaw. In the upper maxilla, it may be situated in the posterior portion of the tuberosity, above the level of the alveoli, and in the lower jaw within the ramus. We are indebted to Sir Edwin Saunders for the use of the specimen which forms the subject of the following illustration. In this example the wisdom-tooth on either side is situated high up in the ramus, the crown reaching nearly to the level of the sigmoid notch. Although situated in such an unusual position, judging from the state of the bone, it does not appear that they were a source of irritation. There is a total absence of that porous condition indicative of increased vascularity in the parts immediately surrounding the teeth. It is probable that during life the presence of the third molar could not have been detected, and in the absence of disease about the jaw, their detection was a matter of no

great importance. Still, it is desirable that it should be

FIG. 120. (1)

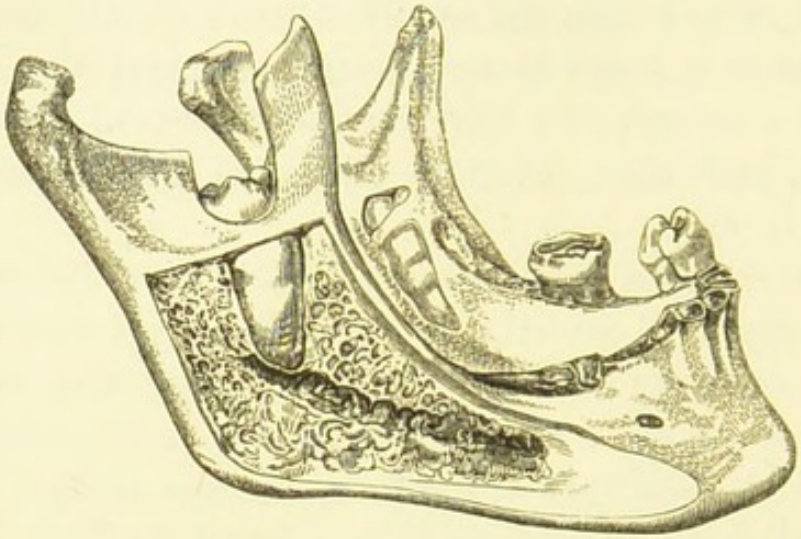
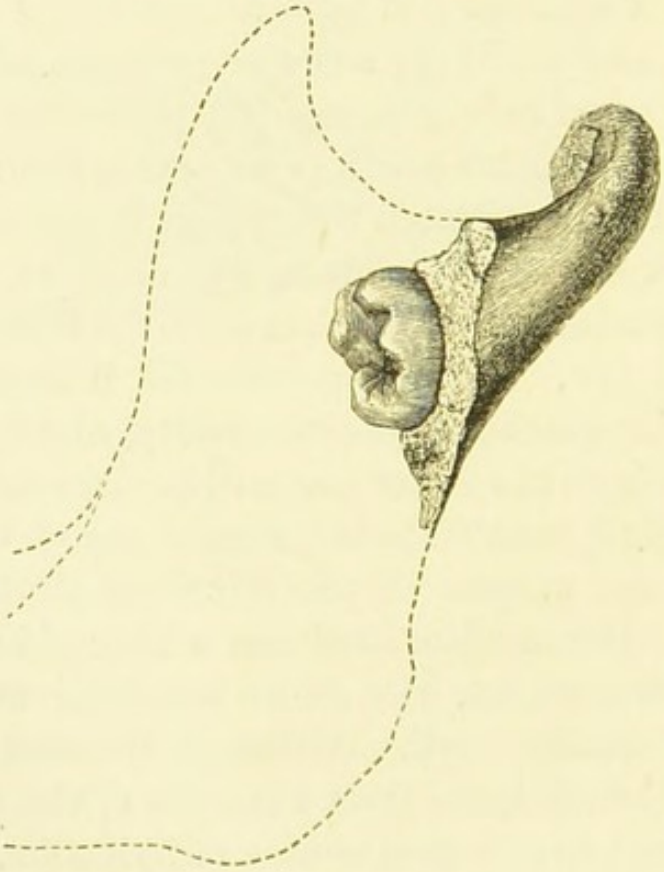


FIG. 121. (2)



borne in mind, when disease about the posterior part of the

(1) Showing the wisdom-teeth imbedded in the rami of the lower jaw. Presented by Sir E. Saunders to the museum of the Odontological Society.

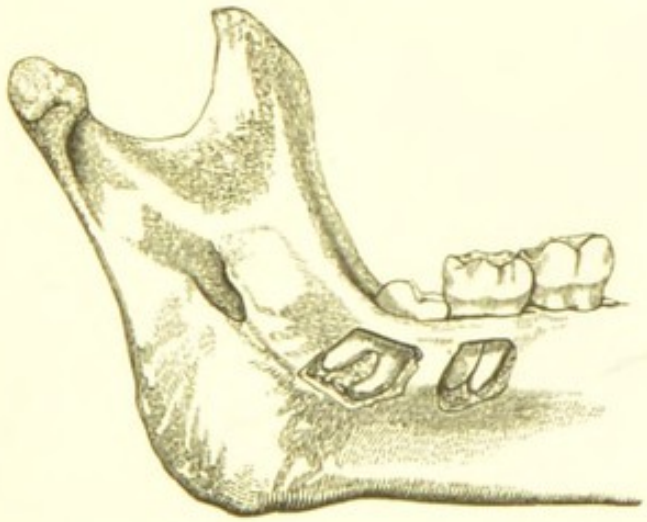
(2) Wisdom-tooth buried in the ramus. After Mr. Marshall

jaws is coincident with the absence of the wisdom teeth from the usual situation, that the lost teeth may lie buried in the substance of the bone, and be the exciting cause of mischief.

Another remarkable case of displacement of the wisdom-tooth, in which it stood (horizontally) close to the sigmoid notch and the condyle, is recorded by Mr. Marshall (Chicago Med. Journal, 1884).

In the majority of cases, however, the third molars, when misplaced, lose the vertical position. They commonly take an oblique direction, either forwards, outwards, inwards, or backwards. In the lower jaw, the forward direction is by far the most common form of irregularity, the degree varying from a slightly oblique to a perfectly horizontal direction. The succeeding series of figures show various degrees of this form of misplacement.

FIG. 122. (1)



In endeavouring to trace the causes which have produced this class of irregularities, we must recognise two distinct conditions. In the one, the tooth, in pressing forwards, has taken the direction in which the least resistance was offered to its progress; in the other the mal-position has been

(1) View of the inner surface of left side of the lower jaw, the bone being removed to show the oblique direction of the third molar.

assumed at a comparatively early period of development, irrespective of resistance at the time of eruption. In Figs. 123 and 124, the teeth appear to have advanced until

FIG. 123. (1)

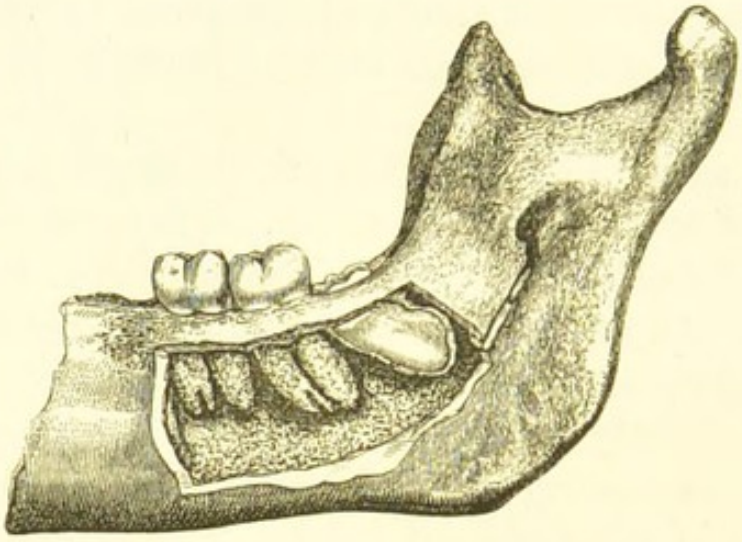
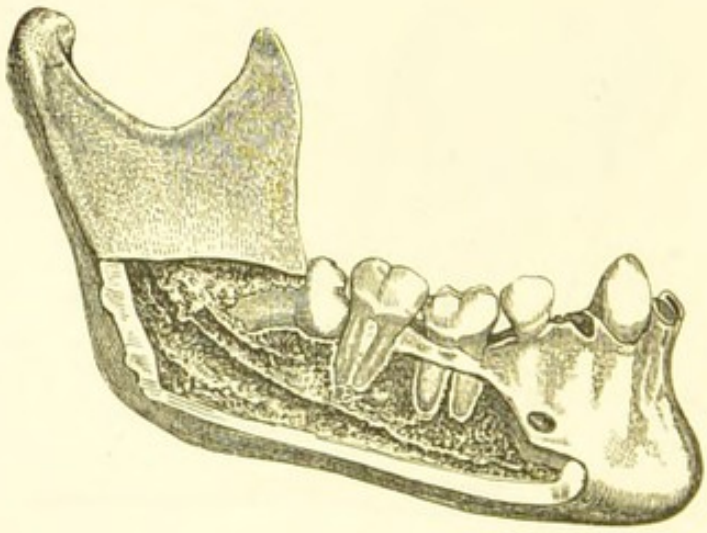


FIG. 124. (2)



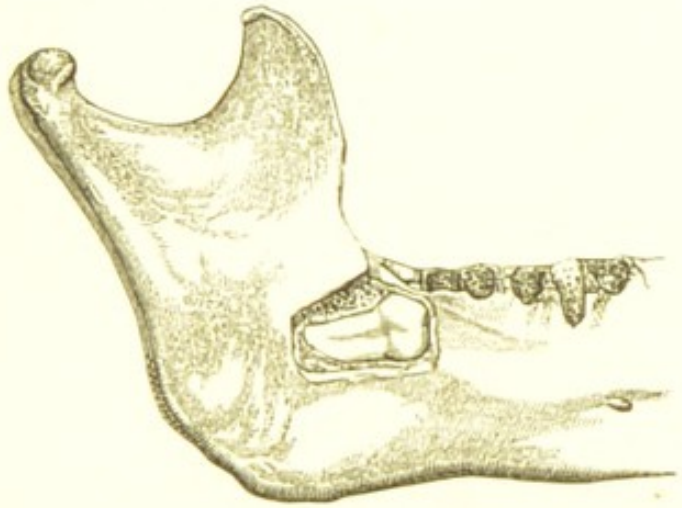
the mesial edge or angle of the crowns impinged upon the necks of the anterior molars. The forward movements of

(1) View of the right side of the lower jaw, the inner alveolar plate having been partially removed to show the oblique direction of the third molar.

(2) Showing the outer surface of the lower jaw, with the third molar placed horizontally, the side of the crown of which rises slightly above the level of the alveolar margin.

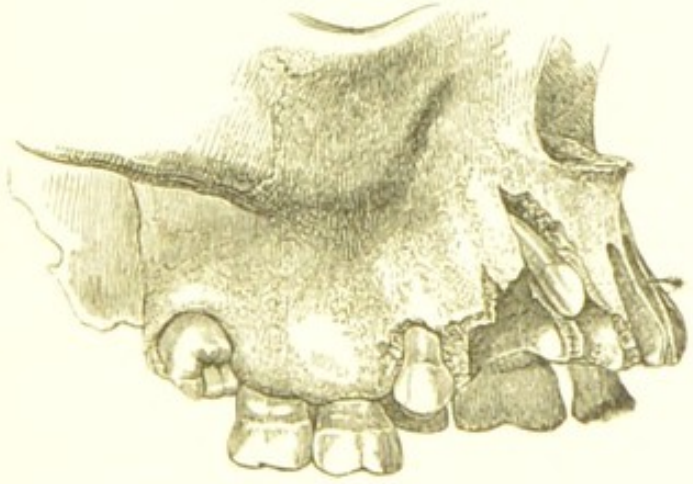
the teeth then became completely arrested. In Figs. 120 and 125, the teeth must have been from the first formed pretty much in the position which they are shown to occupy.

Fig. 125. (1)



In the upper wisdom-teeth the oblique direction forwards is less frequently assumed. The following figure will, how-

Fig. 126. (2)



ever, illustrate this form of irregularity in the upper maxilla (Fig. 126).

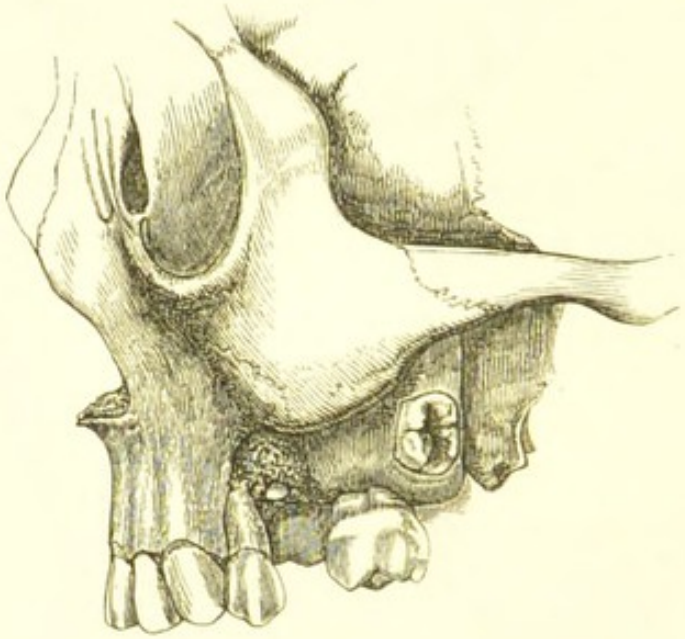
(1) Shows a lower jaw in which the wisdom-tooth has taken a horizontal position below the level of the alveolar margin.

(2) Showing an upper jaw, with the third molar directed forward, and impinging upon the second molar. The small tooth situated high up in the anterior part of the jaw, was forced there by the spade of the grave-digger. The artist's accuracy in delineating all parts of the specimen has rendered this explanation necessary.

In the lower jaw it is not common to find the third molar directed obliquely outward, although cases have occurred in which it has assumed that position. In one or two instances I have seen the crown of the tooth buried in the substance of the cheek, and so much obscured by the swelling and inflammation of the soft parts around, that its presence was detected with some difficulty.

In the upper jaw, however, the outward direction is more frequently taken. In the accompanying figure (Fig. 127), taken from a specimen in my own collection, this form of

FIG. 127. (1)



mal-position is shown. A few years since, many practitioners had an opportunity of seeing a case in which the wisdom-tooth pierced the cheek. The crown of the tooth was, however, hidden by the whiskers, and appeared to produce no inconvenience. Casts of the cheek, with the projecting tooth, were taken, and I believe one of them may be seen in the museum of the College of Surgeons.

A case occurred in the practice of the late Mr. Craigie, in

(1) Shows the wisdom-tooth of the left side of the upper jaw directed outwards.

which a lower wisdom-tooth had made its way to the surface and pierced the skin close to the angle of the lower jaw. The crown of the tooth, as is seen in the accompanying figure, was firmly embraced by the puckered skin, which presented the appearance of cicatricial tissue.

Fig. 128. (1)

In this case the tooth was removed, and the opening in the skin closed spontaneously, without necessitating any further surgical interference.

Cases in which the third molar is directed with more or less obliquity inwards are met with in the lower jaw, but in the upper maxilla they are very uncommon. Examples of teeth which lean inwards in a slight degree may be seen from time to time, but such hardly call for description in this place.

I do not remember to have seen a case in which a lower wisdom-tooth assumed the horizontal position, with the crown directed backwards towards the posterior border of the ascending ramus of the inferior maxilla; but of this form of irregularity in the upper jaw I have several examples. In one specimen the crown of the tooth rests against the pterygoid plate of the sphenoid bone; in another, it takes the horizontal position, with the crown directed backwards

(1) The figure is taken from a wax model which is deposited in the museum of the Odontological Society.

and a little outwards, and in the museum of the Odonto-

FIG. 129. (1)

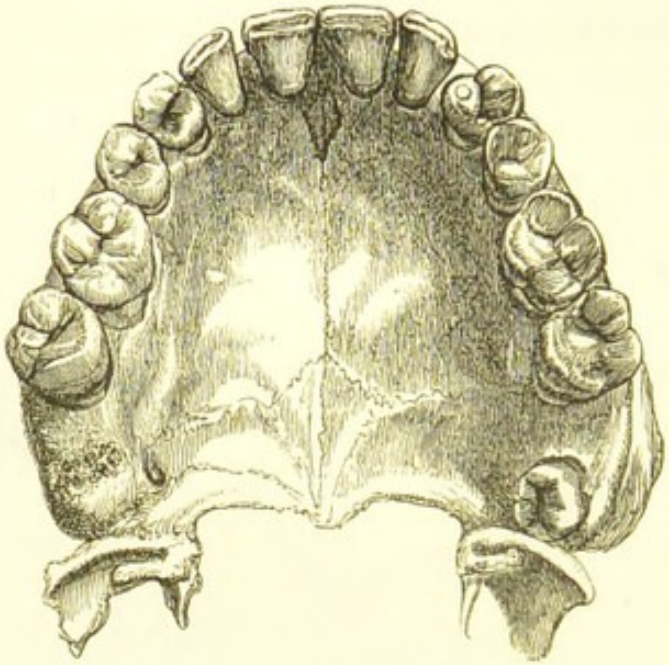
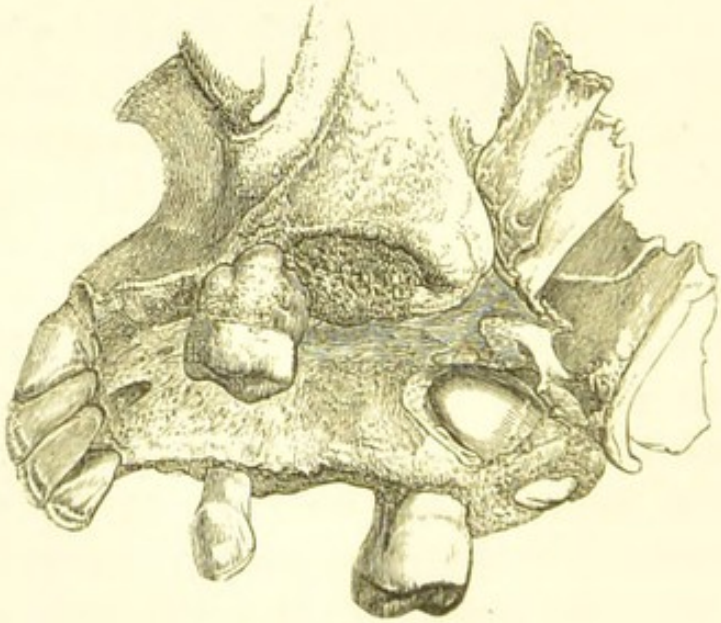


FIG. 130. (2)



(1) Showing the wisdom-tooth of the left side of the upper jaw, with the crown lying against the pterygoid plate of the sphenoid bone.

(2) Shows the wisdom-tooth of the right side of the upper jaw placed horizontally, and the crown directed backwards and a little outwards. The bone has been removed to show the position of the tooth.

logical Society is a model showing a wisdom-tooth erupted in the middle line of the palate.

There is no reason for supposing that the irregular tooth in these instances produced any inconvenience,

Two cases have come under my notice, in which the direction of the third molars has been completely reversed. The teeth have been upside down. The first example of this rare form of displacement came into my possession with the following history. The patient suffered pain from a carious

FIG. 131. (1)

second molar of the upper jaw. The aching tooth was removed, and with it came the third molar, the fangs of which were interlocked with those of an inverted wisdom-tooth.

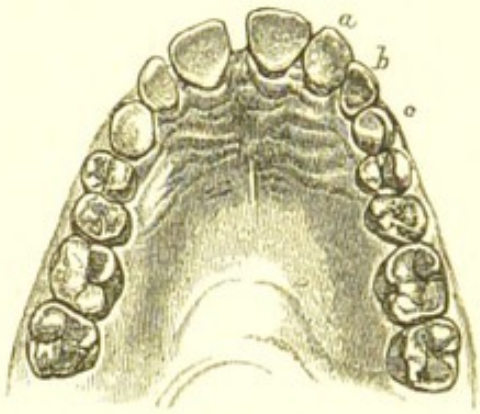
And on one occasion, on account of severe neuralgia, for which no other cause was apparent, I removed an upper wisdom-tooth, the crowns of which were directed outwards towards the cheek; after the lapse of two years another wisdom-tooth, nearly normal in position, came down.

Irregularity from transposition of permanent teeth.—In a practical point of view, no great interest is attached to this form of irregularity, as it does not ordinarily admit of remedy. The succeeding illustration is taken from a case in which the canine is placed between the central and lateral

(1) A second molar of the upper jaw, with the wisdom-tooth inverted and embraced within the roots.

incisor. Sometimes the canine will be found between the bicuspid teeth. The manner in which transposition may arise will be seen if some of the earlier figures are examined. The position of the canine of the upper jaw is, during the period of development, so much above the adjoining teeth that any irregularity in the growth of the neighbouring parts of the alveolar ridge, or of its contents, may throw it

FIG. 132. (1)



either in front of the lateral or behind the first bicuspid tooth. Even the position of the developing cusp of the canine itself may lead to a similar result. If, for instance, the point be directed either forwards or backwards, the tooth in its descent may lose the proper position, and come either between the incisors or the first and second bicuspids.

Other examples of transposition of teeth have been quoted at page 218; but while, as a general rule, little or nothing can be done in the way of treatment, yet the possibility of successful transplantation of teeth should, however, be kept in view; thus a case of the kind has been successfully treated by Mr. Spence Bate, and in the Transactions of the New York Odontological Society for

(1) Taken from the cast of a mouth in which the canine (*a*) occupies the place of the lateral incisor (*b*). The temporary canine (*c*) is retained, and placed between the lateral incisor and first bicuspid. In all other respects the series is normal.

1875, a case is described in which the centrals were separated to the extent of five-eighths of an inch, two supernumeraries standing between them. The right central was extracted, and the right supernumerary twisted by immediate torsion. The left supernumerary was extracted, as also the left central, which was transplanted into the supernumerary socket. Two years afterwards the case was doing well.

Mr. Coleman, after consultation with the writer, performed a somewhat similar operation upon a patient in the Dental Hospital; an account of this case will be found in the Odonto. Soc. Trans. for 1881.

CARIES.

The enamel and the dentine are the tissues which are more especially liable to be affected by caries. In them the process of destruction usually commences, although the disease may extend to, or may even commence in, the cementum of teeth from the necks of which the protecting gum has been removed. But these are exceptional cases; we may therefore, for the present, treat of the disease as an affection of the enamel and dentine only, leaving for future consideration the results which follow when the disease becomes complicated by extending so far into the tooth as to lay open the pulp-cavity, and involve the pulp itself in rapid destruction or in chronic disease.

Although dental caries has been investigated and described by all who have written upon the subject of dental surgery, from the earliest period when disorders of the teeth first attracted attention down to the present time, yet it can scarcely be said that the nature of the disease is perfectly understood; for even now two broad hypotheses prevail. In one, the disease is assumed to be no disease whatever, but merely the result of chemical solution of the dental tissues, and therefore dependent, both in its origin and its progress, on the uncontrolled action of physical and chemical laws.

According to the other hypothesis, the fact that teeth are part of a living organism, if not essential to the origin of the mischief, at all events profoundly modifies its progress.

The physical signs which mark the presence of caries are first visible in or through the enamel. But they will vary

somewhat in accordance with the character of the surface affected. If the disease arises in a fissure on the masticating surface, or in a depression on the crown of a tooth, a dark-coloured spot will be the first indication of its presence; but if the disease has attacked a surface free from any indentation or fissure, the affected part will lose its translucency, and become opaque and white: subsequently the white will be succeeded by an ash or slate, and finally by a brown colour, more or less deep. If the enamel be examined when in the earlier stages of disease, it will be found that the presence of opacity is accompanied, and no doubt occasioned, by an increased porosity of the tissue, a condition which may have succeeded to some form of imperfect development.

In fact there is a somewhat close similarity between the appearances presented by enamel affected by the earlier stages of caries and that which is of imperfect development. In each the prisms are unduly distinct, the spaces between them larger than they should be, and the prisms themselves granular and dotted, and often pigmented.

It would seem also that the solvents which are acting in caries behave very much as dilute acids applied to a section upon a slide behave in attacking the axial portions of the prisms before their peripheries are affected.

The histological changes which occur in caries have been from time to time carefully studied, and although each writer has sought to interpret the appearances to suit his own views, there is a pretty general consensus as to most points of actual fact.

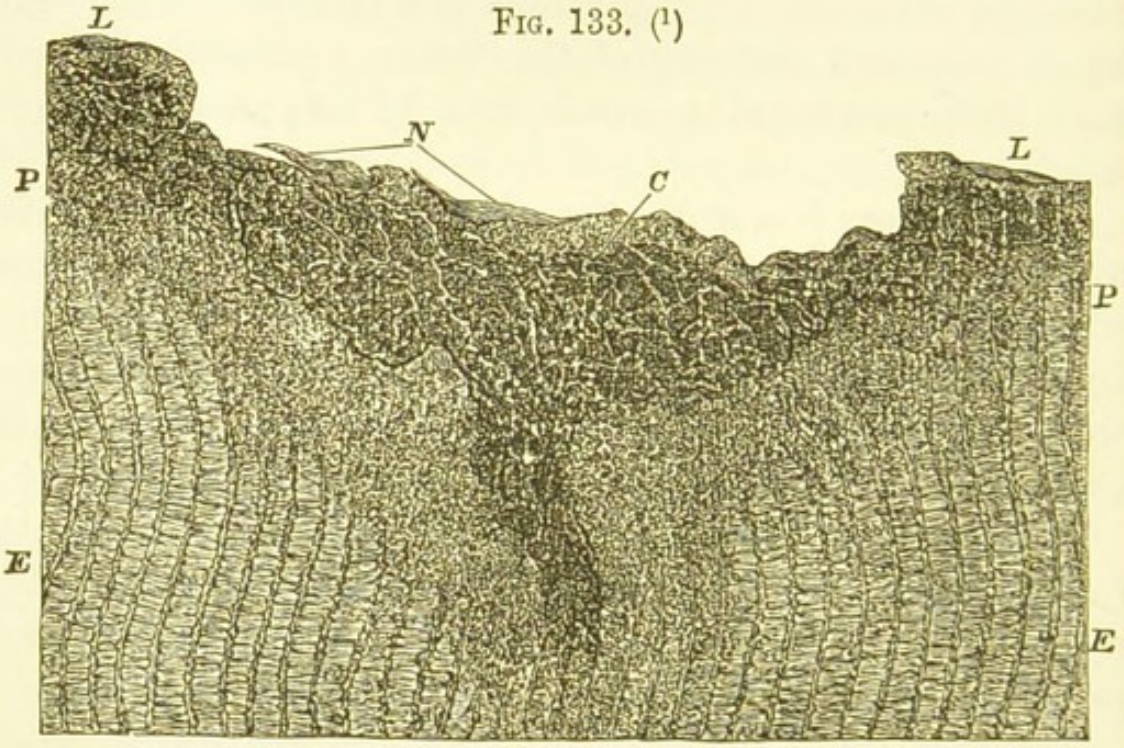
Carious enamel is very much like enamel which has been submitted to slow decalcification, as for instance by weak chromic acid; something like its embryonic condition of granular prisms, adherent to one another, and, according to Dr. Abbott (Dental Cosmos, Feb. 1879) united to one another by delicate threads. But it is generally pigmented in a manner that cannot be imitated by any artificial decalcification.

Subsequently it breaks up, and granular debris, in which little trace of enamel structure is to be found, remains.

It has, however, been claimed by Dr. Abbott, working with Prof. Heitzman, that in caries the enamel is not only decalcified, but that the protoplasmic bodies which he believes to exist in it re-assert their individuality.

In the accompanying figure copied from Dr. Abbott (Dental Cosmos, 1879), E represents the unaltered enamel,

FIG. 133. (1)



P is a partially decalcified zone, this being the condition which is seen in the familiar white spot. At C we have fully decalcified matter, which readily takes a stain (according to Dr. Abbott, protoplasmic in its nature), and at N flat cells derived from Nasmyth's membrane, which has sunk in.

Whether we agree with Dr. Abbott's views or not, his figure faithfully represents the appearance of carious enamel.

(1) Carious enamel, after Dr. Abbott.

The disease may commence upon a surface free from depressions, and extend through the porous enamel into the dentine. Not that the process of decay materially differs in conformity with the character of the surface attacked, but the progress is somewhat varied, both in respect to the direction in which the disease extends, and in the rate of destruction. When the disease is established in a fissure the enamel to a great extent escapes, and the indications of its presence are not strongly pronounced, until a very considerable amount of destruction has been produced. The disease extends into the dentine, penetrating to a considerable depth in the direction of the tubes, and spreading laterally under the enamel, without affecting its outer surface: with the softening of the dentine, the inner surface of the enamel becomes softened from within, until the tooth at that point is so much reduced in strength that the enamel breaks in, and suddenly reveals a large and scarcely suspected cavity.

The most conspicuous change in the dentine is that it has become softened in various degrees: it may be but little altered in consistency, or it may be of horny consistency, or it may be like soft cheese, or even more friable. No sharp line of demarcation between healthy tissue and that which is already carious exists, either to the sight or the touch. It has also become darkened in colour, the depth of the discoloration standing in something like inverse ratio to the rapidity of progress of the disease. There is also an increase in tenderness, which may be great or slight, this standing in direct relation to the rate of progress. "White" decay and "brown" decay are processes not differing in kind, but only in degree and in rapidity of destruction, and it is probable that some part at least of the discoloration is due to accident, *i.e.*, to staining of the absorbent decalcified dentine by food introduced into the mouth, although this will not account for all the phenomena observed.

If a tooth in which caries is progressing slowly, and in

which the disease is limited in extent be divided, the relations of the diseased to the healthy parts may be examined. The affected dentine will be either opaque in appearance, or it will have assumed a brown colour; and these changes from the condition of health will be seen to extend underneath the enamel beyond the limits which bound the external indications of disease in that tissue. But it will be in the direction of the dentinal tubes that the disease will be found to have made the greatest progress. Supposing the disease to have commenced upon the masticating surface of a molar tooth, it will commonly be found that the mass of diseased tissue, when limited in amount, presents the shape of a cone, the apex of which is directed towards the pulp-cavity, and the base towards the enamel.

The section will show that the destructive agent, having gained access to the dentine through an opening in the enamel, has spread, to a certain extent, upon the peripheral surface of the tissue, through the terminal branches of the tubes, and thus formed the base of the cone; and that it has spread to a greater length in the course of the trunks of the involved tubes, following their convergent course towards the pulp-cavity, and thus produced the apex of the cone. But if an example be taken in which the disease has assumed the spreading character, the conical form of the disorganized part will be less strongly, if at all, pronounced. In certain cases, indeed, the whole of the masticating surface of a molar tooth is lost before the disease has advanced to a sufficient depth in the direction of the pulp-cavity to expose its vascular contents. In some teeth, particularly in those described as "honeycombed teeth," the disease, after the enamel has been destroyed and the dentine reduced in thickness, becomes in certain cases arrested. The exposed tissue assumes a polished surface, deep brown colour, and acquires a density which enables the crown, though deprived of enamel, to serve the purpose of mastication with scarcely less efficiency than an uninjured tooth.

Coincident with structural changes in the dentine a certain

amount of uneasiness exists and marks the presence of the disease ; and of this we have yet to speak.

I believe it rarely happens that the presence of caries in its earlier stages is altogether unattended by some uneasiness in the affected tooth. The amount is often very slight, so slight, that the attention will be directed to the part in those only who are in the habit of devoting considerable care to the preservation of the teeth ; on the other hand, there are many who immediately recognise the presence of disease by the discomfort it occasions ; and in exceptional cases the patients describe the affected teeth as giving them a considerable amount of pain long before the disease has progressed to an extent capable of directly involving the pulp. Toothache of this description must be distinguished from that which is consequent upon inflammation of the pulp, whether resulting from exposure produced by caries, or arising from any other cause ; and the distinction may be made by observing the characters of the pain. There is an absence of throbbing, and a less degree of intensity as compared with that occasioned by inflammation of the pulp. Contact with hot or cold fluids does not usually produce any very unpleasant effect.

I believe the seat of pain to be mainly in the peripheral portion of the dentine, and that after the destruction of vitality in this part of the tooth has been completed, the sensation of discomfort in great part passes away.

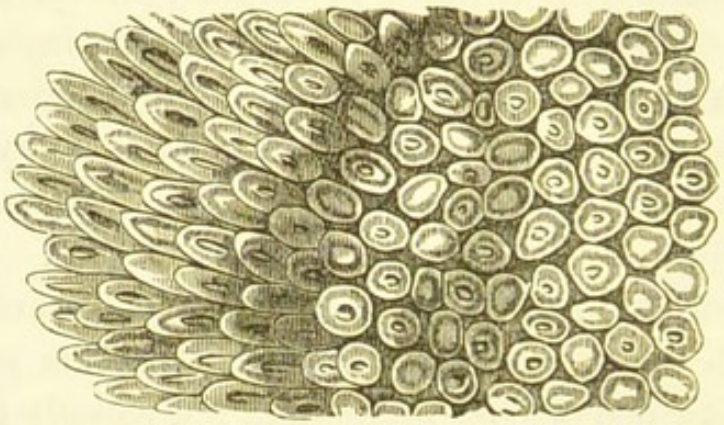
No doubt there are cases in which the presence of caries is unattended with any feeling even of discomfort, for we find those in whom the pulp becomes exposed and disappears without a moment's toothache. If a part endowed with vessels and nerves, and a very high degree of sensibility, can be destroyed without pain, as it were unconsciously, it would be unreasonable to suppose that the dentine cannot undergo disintegration without manifesting sensation. Why in one person the destruction of a tooth should be attended with so much, and in another with so little suffering, is a question which we are as little able to answer, as we are to

account for the great difference in susceptibility to the action of remedies, so frequently manifested in patients in whom such constitutional peculiarities can be discovered by experiment only.

Of the appearance presented by carious dentine, much more is to be said.

One of the first and the most obvious changes observed is, the enlargement of the dentinal tubes, which become dilated to many times their original dimensions; and the parietes of the enlarged tubes having undergone

Fig. 134. (1)



partial decalcification, we get the so-called "tobacco-pipe" appearance.

It will be remembered that the dentine is formed from cylindrical cells, or rods, of the dentinal pulp, the individuality of which is lost in the process of calcification. If we take a thin section from a carious tooth, it may be seen, in those parts of the preparation where the tubes are divided transversely, that each tube is surrounded by a very thick sheath—the diseased condition has, perhaps, undone the work of development and thrown light on the question how this was effected; it might almost be said to have restored the outline of the formative-cells—the tissue is to a certain extent broken up into its histological elements.

(1) A section from dentine softened by caries.

Under the microscope the section looks as though it might have been built up of multitudes of tobacco-pipe stems, united by an intervening substance. Such is the condition when disorganization has advanced up to a certain point; at a later period short lengths of the walls of the tubes (*dentinal sheath, zahnscheiden of Neumann*) are found isolated; and finally the whole tissue breaks down into minute granular particles, which are by degrees washed away in the saliva.

The first chemical change consists in the removal of the lime-salts from the gelatine, leaving the dentine of a consistence capable of being readily cut with a sharp knife, when it will be found to exhibit the structural characters just described. It might be supposed that similar results would be produced from decalcifying a tooth by the aid of a dilute mineral acid; such, however, has not been the case in experiments instituted with the view of determining the point. Indeed, I know of no artificial means whereby the appearances which have been described can be as fully brought out as by the progress of disease. The question naturally suggests itself, may not the appearance of dentinal rods be nothing more than a certain stage in progressive decomposition, due to a solvent fluid obtaining access to the tissue through the tubes, and the outline of each rod be indicative only of the depth to which the fluid has permeated?

As a matter of fact the connecting material is the first, and the walls of the tubes the last, to become disintegrated; and this, previous to the discovery by Neumann of the very indestructible nature of the dentinal sheaths, seemed to answer the question in the negative. Knowing, however, as we now do, what great powers of resistance the walls of the canals possess, this explanation of the tobacco-pipe appearance is rendered far more probable. Occasional exceptions to this sequence of disorganization, will, however, be found in teeth which are destroyed with great rapidity. In them the tubes will appear to have become enlarged in an

altogether irregular manner, and the distinction of the tubular and intertubular parts of the tissues will be but faintly pronounced, and indeed may be altogether wanting. But supposing a section from a carious tooth in which the destruction has been gradual, be taken, the following conditions may be observed: commencing at the part where the dentine presents pretty nearly its natural appearance, we then pass to a point where the appearances depicted in the preceding figure are seen; still further on, this condition becomes yet more strongly marked; and at the extreme edge, supposing the section to have extended to the surface of the cavity, the process of disintegration may be seen.

If the dentinal tubes be isolated by the application of acids, they will often be found to present varicosities and globular swellings (1).

The dentinal fibrils are subject to a change more or less complete, the existence of which may be recognised even by the naked eye. If we divide a sound tooth through its long axis, the dentine exposed by the section will present a tolerably uniform degree of opacity; but if the tooth has been attacked by caries, in addition to the discoloration of the part which has undergone chemical change, we shall find a comparatively transparent zone removed a short distance from, and surrounding the disorganizing mass.

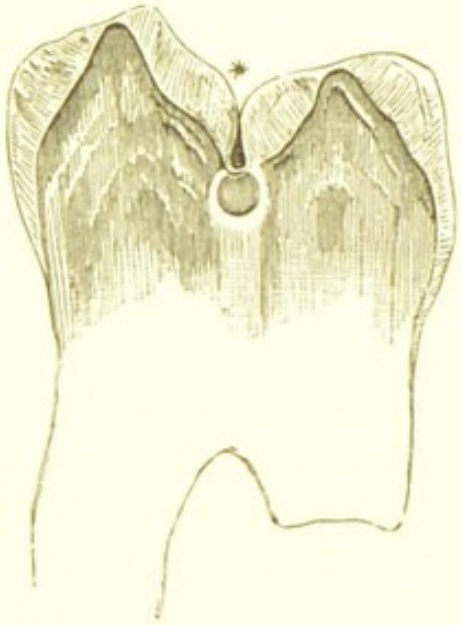
This region of increased transparency, almost always to be found between the advancing caries and the pulp-cavity, does not invariably present the regular form above depicted: it may form a cone, the apex of which is directed towards the pulp, and the base towards the caries, or it may be present as hyaline stripes and spots having no very determined form. It corresponds in naked-eye and microscopic appearances to the dentine of the roots of the teeth of old persons, or of healthy stumps which have remained long in

(1) Excellent figures are given of these beaded, elongated bodies, in Heider and Wedl's Atlas zur Pathologie der Zähne, part iii., pp. 792, 793; and they are further described in Wedl's Pathologie der Zähne, translated by the late Dr. Hitchcock of Boston.

the mouth, which acquire this peculiar horny, translucent appearance. The comparative opacity of healthy dried dentine is simply due to the difference between the refractive index of the air contained in the tubes and that of the matrix, and any cause which tends to bring these more near to one another will increase the transparency of the tissue.

Thus the tissue might be rendered more transparent

FIG. 135. (1)



either by the obliteration of the canals by calcification of their contents, or by the decalcification of the matrix, which, by lowering its refractive index, would bring it more nearly into accord with that of the air in the tubes.

The true nature of this transparent zone acquires additional interest from the fact that it is the last remaining evidence of supposed vital action; the other appearances have all been shown to be due to purely external causes, so that this alone remains to be discussed.

In the first edition of this work it was stated that the

(1) Shows a transparent zone of dentine, removed a short distance from and surrounding that which is undergoing decomposition, consequent upon caries.

translucency was due to the exclusion of air from the tubes by the calcification of the fibrils.

In favour of the view that the dentinal fibrils become calcified, several arguments may be adduced; one is its *primâ facie* probability—we know that slow progressive calcification does go on in the tubes long after the apparent completion of the dentine, and seeing that the irritation of caries does unquestionably cause calcification to start afresh in the pulp, it seems very natural to suppose that it would have the same effect in the dentinal tubes.

Again, there is the resemblance in the appearance of the translucent zone to that of the fangs of old teeth, which are supposed to be more rich in lime salts than ordinary healthy dentine.

Dr. Magitot ("Recherches sur la Carie des Dents," Paris, 1871, p. 511) believes that the dentinal fibrils do become obliterated by calcification, and regards it as an indication of resistance to the progress of the disease.

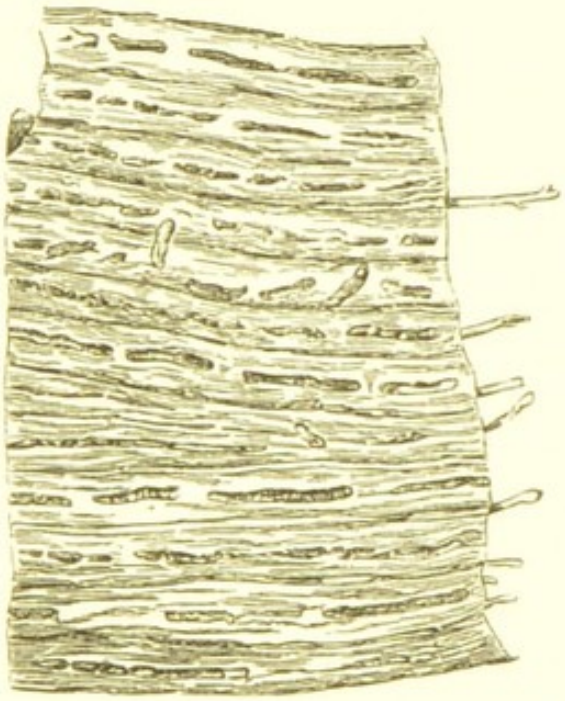
Professor Wedl, however, although he attributes the increased transparency to the absolute exclusion of air from the tubes, speaks of the calcification of the fibrils as "noch problematische" ("Pathologie der Zähne," p. 334); and by treating dried sections from the horny-looking fangs of the teeth of old persons with carmine, he found that they retained the power of imbibition, the colouring matter thoroughly permeating the tubes, though they appeared to be impervious to air. MM. Leber and Rottenstein also deny the existence of calcification in the fibrils, attributing the transparency to the disappearance of calcareous salts, and stating that the translucent tissue is distinctly less hard than the surrounding dentine (*op. cit.*, p. 39).

But the fact which tells most strongly against the supposition that the zone of transparency is due to the obliteration of the canals by calcification has yet to be mentioned; it is, that when caries attacks human teeth which have been inserted on pivots or on plates, *all* the appearances of ordinary caries may be traced; namely, the dark pig-

mented zones, the thickening and varicose swelling of the dentinal tubes, the granular condition of the fibrils, and also the *clear, translucent zone* (Wedl, *op. cit.*, pp. 320 and 334).

Owing to the almost entire abandonment of the use of human teeth as artificial substitutes, I have not been able to get a sufficient number of examples of caries occurring in them to enable me to speak very certainly on this point; but, judging from those which I have seen, I am inclined to

FIG. 136. (1)



think that the transparent zone is as constant in them as in living teeth; though Dr. Magitot (*op. cit.*, p. 511) is of the contrary opinion, and considers that this clear zone constitutes the only difference between caries as occurring to living teeth and others.

Globular masses of calcareous salts may sometimes be found in the dentinal tubes near to a carious cavity, but

(1) A section in a plane with the tubes, from carious dentine. These rods may be portions of consolidated fibrils, or they may be bits of the sheaths of Neumann, or they may be mere casts of the enlarged tubules.

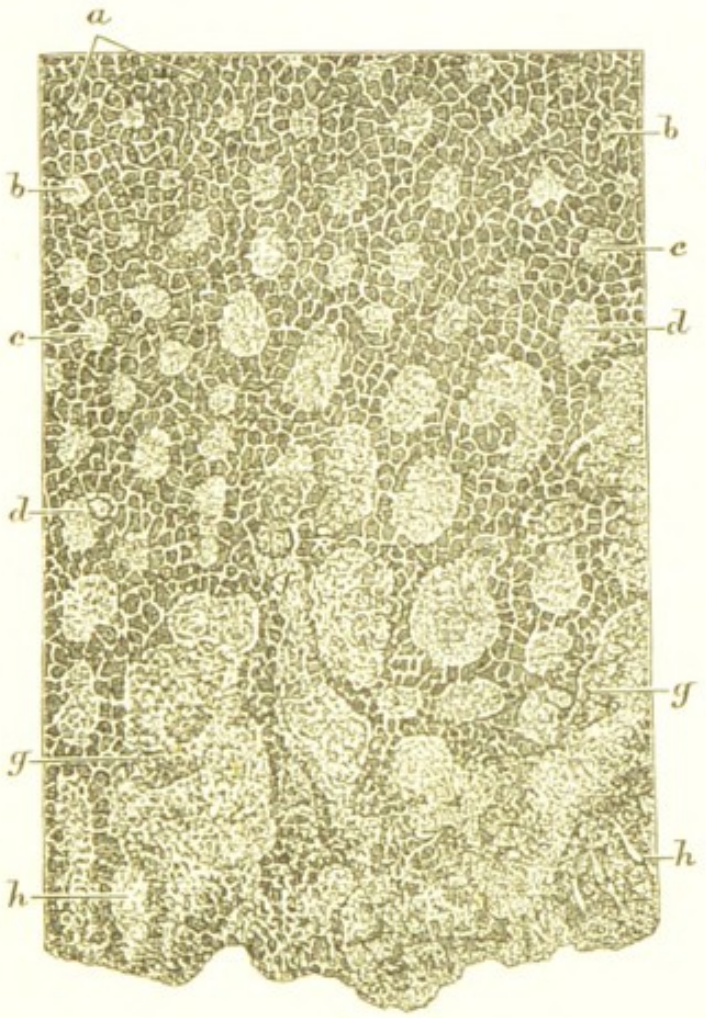
inasmuch as they are met with in dead teeth as well as in living ones, they are probably to be explained as depositions from solutions of salts, and not as evidences of vital action. Indeed, even if it were conclusively shown that the dentinal fibrils became obliterated by calcification, this would not amount to absolute proof of vital action; for albumen out of the body is able to form combinations with calcareous salts which have a definite structure, and it would be conceivable that the same thing might happen in a dentinal tube.

An appearance seemingly indicative of consolidation of the fibrils may be found by taking a tooth in which the progress of decay has been slow, leaving the disorganizing dentine of a deep brown colour, and comparatively firm in texture. If we cut with a sharp knife a thin section in the direction taken by the dentinal tubes from the discoloured portion (if the tooth be well selected), the disconnected rods will be seen broken abruptly into short lengths. Sometimes they are present in great numbers, scattered over the specimens, many lying within the tubes, others upon the surface, and occasionally they may be seen with one end projecting from the edge of the section, and the other within the tube.

In a paper descriptive of the histology of dental caries (Dental Cosmos, March, 1879), Dr. F. Abbott states that at a certain distance from the decay the canaliculi look enlarged, and each contains the dentinal fibril: nearer to the line of decay we meet with moderately enlarged canaliculi, the centres of which are occupied by protoplasm, stainable by carmine. One step further on the canaliculi are double or treble their original size, and they are filled with yellow protoplasm, exhibiting the net-like arrangement of living matter, whilst ultimately these enlarged canaliculi coalesce and large spaces filled with the same material occur with but traces of basis substance intervening. It will be noticed that the main peculiarity of Dr. Abbott's account lies in the fact that he claims a high vitality for the contents of the

enlarged tubules and the spaces ultimately formed by their coalescence, but to this we shall have presently to recur.

Fig. 137. (1)



Professor C. Wedl states that in a transverse section a greater or less number of canals are seen whose limiting walls (the so-called dentinal sheaths,) describe moderately large circles, and whose cavities are filled by a mass in some places homogeneous, in others of molecular appearance, which forms convex projections beyond the surface of the section, but he does not lay down any positive statement as to what the nature of this material may be.

Leber and Rottenstein (Recherches sur la Carie Dentaire,

(1) Carious dentine (after Abbott). *a*, healthy tissue; *b*, dentinal fibrils; *c*, dentinal fibrils slightly enlarged; *d*, dentinal fibrils further enlarged; *g*, large protoplasmic masses; *h*, larger coalesced masses of protoplasm.

1868), took up the observations of Ficinus that a cryptogam to which the name of leptothrix is given, was very constantly present in carious dentine, and pointed out that it was to be found not only on the surface but that it penetrates far into the dentinal tubes, and that it is a chief agent in their enlargement and the softening of the surrounding matrix; they found that the contents of the enlarged tubes were characteristically stained by iodine.

More recently Messrs. Underwood and Milles (Transact. Internat. Med. Congress, 1881), have shown that in the enlarged canals, and even in some which show but little enlargement, micrococci and oval and rod-shaped bacteria are to be found. They penetrate at first in Indian file, accumulate and choke up the channels, and when the matrix is disappearing and neighbouring channels coalesce into irregular spaces, the whole tissue becomes a mass of conglomerated organisms.

Thus what is for Dr. Abbott reticulate protoplasm is for Messrs. Underwood and Milles a mass of organisms.

Sections cut from apparently healthy tissues beyond the sphere of visible decay, show here and there a narrow line of micrococci or bacteria, like an advanced guard, and these percolate far into tissue which the naked eye would pronounce quite unaffected.

Dr. Miller's conclusions differ in some respects from those of Messrs. Underwood and Milles, for he holds that large areas of softened dentine exist which contain no organisms, which therefore are not co-extensive with the decalcification. He also holds that the various anatomical changes found in softened dentine are caused by the invasion of micro-organisms. Moreover he appears to have been successful in producing an artificial caries which, under the microscope, cannot be distinguished from the real disease, whilst Messrs. Underwood and Milles have failed to reproduce the exact effect, although analogous changes are abundantly brought about.

Such being the histological changes which occur, so far as

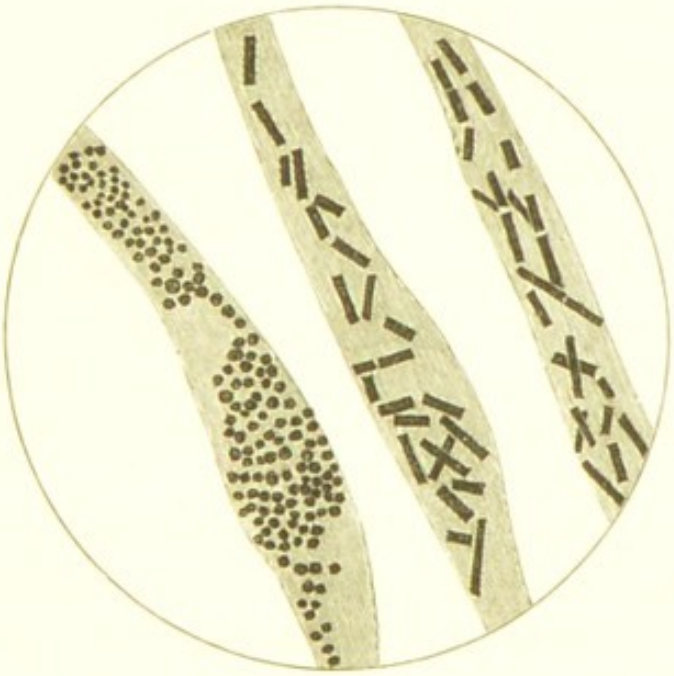
they are known, we may proceed to the consideration of the pathology of the condition. The views held as to the nature of dental caries may be, for the sake of convenience, grouped under the three following heads :—

Those which regard it as a real "disease," a vital phenomenon, strictly comparable to morbid conditions of other more highly organised parts of the body.

Those which regard it, in the main, as the effect of mere chemical action, but also consider that some very constant appearances are only explicable on the hypothesis of vital reaction.

Those which regard it as wholly and entirely the effect of

FIG. 138. (1)



chemical action, in no degree modified by the connection of the tooth with a living organism.

It was at one time very generally supposed that dental caries was an inflammatory affection, a true "disease" of the dentine, and the name "Odontitis" was given to this supposed disease : amongst the older writers, Hunter, Cuvier,

(1) Dentinal tubes filled with bacilli and micrococci, after Underwood and Milles.

Fox, T. Bell, and others held this opinion, and it has of late years been revived by Neumann, Hertz, and Dr. F. Abbott.

In support of this idea, the occurrence of so-called *caries interna* was adduced; but if there be any one thing certain about caries, it is that it always starts from the surface, and cannot occur at any spot devoid of communication with the exterior.

Neumann believes that in the varicose swellings of the dentinal tubes evidences of cell proliferation may be seen, and he hence draws comparisons with inflammatory and ulcerative affections of soft parts. Wedl ("Pathologie der Zähne," p. 333) strongly dissents from this view, and thinks that the appearances may be easily otherwise explained.

And Dr. Abbott considers that "caries of a living tooth is an inflammatory process, which, beginning as a chemical process, in turn reduces the tissues of the tooth into embryonic or medullary elements, evidently the same as during the development of the tooth, have shared in its formation; and its development and intensity are in direct proportion to the amount of living matter which they contain, as compared with other tissues. The medullary elements, owing to want of nutrition and to continuous irritation, become necrosed, and the seat of a living growth of organisms."

Dr. Abbott bases his belief in the inflammatory proliferation of the plasm which permeates the dentine upon the appearance described at a former page, and, as has already been hinted, these same appearances have been under the observation of and have been otherwise interpreted by other observers. And although Dr. Abbott has employed high powers and very careful methods of preparing his specimens, I hardly think that his interpretation of the appearances he has seen and figured is beyond all question. And, supposing an inflammatory action in the living contents of the dentine to be an important factor in the phenomena, it may be asked, how is it that this, once started, never goes on after the carious cavity has been excavated and filled, and

that with materials which by their conductivity or other cause not infrequently actually induce an inflammation in the pulp? It might be thought that a comparison of caries as occurring in a dead and a living tooth, would at once set the question at rest, but unfortunately there is difference of opinion as to the appearances there presented.

Dr. Abbott gives no figures and no detailed description of any cases of caries occurring in teeth worn as blocks or as artificial teeth, save of a very slight degree of caries in a piece of hippopotamus tooth: in this he notes that there was no enlargement of its dentinal tubes; but this might well be the case in many a specimen of equally slight caries in a living tooth, and moreover it is but a single observation; he gives it as his opinion that in "dead and artificial teeth caries is a chemical process assisted only by the decomposition of the glue-giving basis substance of dentine and cement."

Hertz ("Virchow's Archiv," Bd. xli.), on comparing sections of carious teeth with those from teeth softened by acid fluids, came to the conclusion that there were real differences, mainly consisting in swelling and fatty degeneration of the dentinal fibres, which pointed to the existence of some vital action, but he does not describe the condition of extraneous teeth softened by the fluids of the mouth.

On the whole, then, it may be said that the notion of caries having any relation to inflammation of the living portion of the dentine has met with but few adherents, whilst on the other hand, in support of the theory that most, if not all, the phenomena of caries may be produced by chemical action, without the intervention of vital forces, a great and conclusive body of evidence has been brought together. In the first place, it always starts from the surface; it may be in a fissure, or at some point where the tissues are defective, but it never occurs at any place which is not exposed to external influences.

Again, the use of litmus-paper proves that in many places in the mouth an acid reaction exists; and experiments performed out of the mouth have conclusively shown that most

dilute acids, vegetable as well as mineral, have the power of speedily decalcifying dentine and enamel.

The question for solution is, are there any appearances which cannot be explained without the intervention of vital forces? And perhaps, before proceeding to the discussion of this matter, it will be well to define what is, and what is not, meant by "vital" force.

There is not the smallest reason for supposing that the ordinary laws of chemical and physical action are suspended in the body; on the contrary, the advance of science brings every day fresh evidence that the phenomena of development and nutrition are in strict accordance with these laws, did we but know them. But we are no nearer to the knowledge of the mystery of life; we have no cognizance of such a thing as "vital" force; all that we do know is, that the various chemical and physical actions are set going and co-ordinated in a living body by an impulse of the nature of which we know nothing. If we say that it is by the action of the nervous system, we only remove the difficulty a very little farther, for we know nothing accurately about nerve force.

"Vital action" is, then, in the following pages to be understood simply as meaning something which, for its occurrence in that particular place, is dependent upon the tooth forming a living part of a living organism.

In some mouths the hippopotamus ivory formerly used for artificial teeth was very rapidly attacked: thus Dr. Magitot ("Traité de la Carie Dentaire," 1867, p. 102) mentions the case of a lady in whom these plates could only be worn for six or eight months: at the end of that time they were translucent and amber-like in appearance, flexible and spongy to the touch, and very offensive; in places actual dark walled cavities were formed. The gums were tumid and spongy, and a considerable number of softened stumps remained in the mouth. When the crowns of human teeth are inserted into the mouth, either upon a plate, or pivoted on old stumps, they often become carious; such

teeth are especially prone to be attacked on the surface which is in contact with the gum, though it is not unusual for interstitial cavities to be formed in them. Nevertheless, some writers have denied the identity of the destructive process in these artificial substitutes with that which occurs in living teeth ; and others, whilst admitting their substantial similarity, believe that differences may be found.

The appearances which have been supposed to indicate vital action in caries are mainly two : the "tobacco-pipe" structure apparent on transverse sections (see p. 246), which looks like great thickening of the walls of the canals, and the obliteration of the canals between the caries and the pulp-cavity, which gives rise to the appearance of a clear translucent zone.

Neumann ("Archiv für klin. Chirurgie," Bd. vi.) believes that the apparent thickening of the walls of the tubes is a real thickening of the dentinal sheaths at the expense of the matrix, and that the fibres participate in the process, the canal ultimately becoming obliterated ; he believes that in a single instance he saw calcification of the fibrils.

But Leber and Rottenstein ("Recherches sur la Carie Dentaire," Paris, 1868) have given figures, drawn from a human tooth which had become carious whilst worn as an artificial tooth, in which the dilatation of the canals and the thickening of their apparent walls are exceedingly well seen ; so that these two characters, at all events, are produced purely by causes external to the tooth, and have nothing whatever to do with its vitality.

Wedl also ("Pathologie der Zähne," p. 326) gives a description, illustrated by figures, of the microscopic appearances met with in caries thus occurring in artificial teeth, which put it beyond all doubt that the process is identical with that which occurs in a tooth connected with living parts. The tubes are beaded, and have pearl-like rows of globules in them, and when isolated by decalcification and boiling, are seen to have the varicose swellings so characteristic of caries.

Seeing that the characters of caries, in its destructive processes at least, have been repeatedly met with in human teeth worn as artificial substitutes, and also in hippopotamus ivory placed under similar circumstances, it must be admitted that there is at present a balance of evidence in favour of the view that caries—in so far as it is a process of disintegration—has no relation whatever to the connection of the tooth with the living body. It is, however, equally a fact of every-day observation that the pulp is, so to speak, sensible of the approach of caries towards it, and that secondary dentine is in consequence deposited on that wall of the pulp-cavity which is threatened by the advance of the disease. So far, then, there is an attempt to bar the progress of the disease; or, to speak more accurately, the stimulus or irritation transmitted to the pulp starts afresh the process of calcification in that organ.

As the irritation set up by caries is thus capable of inducing calcification in the pulp, it was not unnatural to suppose that it might have a similar effect on the contents of the dentinal tubes; and this, it was thought, was to be seen in the translucent zone of the surrounding caries.

But those whose daily clinical experience brings under their notice caries occurring in the same mouth in teeth with and without living pulps, will surely find it impossible to believe that there are under their eyes two diseases in their very essence different: that the caries of the living tooth is an internal inflammatory change, and that the caries of the dead tooth is an effect of external chemical and physical causes alone. And I have never seen this difficulty fairly faced by any of the advocates of the "vital" theory.

Litmus-paper applied within the cavity of a carious tooth almost invariably gives strongly marked acid reaction, and thus furnishes evidence of the existence of an agent capable, if unresisted by the vitality of the dentine, of depriving that tissue of its earthy constituents, leaving the gelatine to undergo a gradual decomposition favoured by the heat and moisture of the mouth.

In examining the circumstances under which the decomposition of the dentine takes place, and under which it is resisted, apart from the influence of vitality, any one must be struck with the power that is exerted by the mere form of the surface involved. Supposing the disease to be situated in a deep fissure, or upon the side of a tooth, against which another tooth is placed, the decomposition will go on with more or less rapidity, the rate being varied in accordance with the condition of the oral fluids. But if the cavity be superficial, and so placed that it is subject to friction during mastication, the progress is usually relatively slow; and if the low walls of such a cavity be removed, the part will become polished by the act of mastication and by the motions of the tongue, and decomposition will be completely arrested quite independently of any power of resistance exercised by vital action. Again, let a tooth be placed under circumstances the opposite of the preceding. For example: take a bicuspid of the upper jaw, the distal surface of which is decayed, and remove the softened dentine; then let dry cotton-wool be forced between the defective tooth and its neighbour, and renewed only once in three or four days; at the end of a fortnight or three weeks it will be found that the surface of the cavity which was left hard and dense after the first operation, has become soft, and that the softening extends to a considerable depth. Had the cotton, prior to its introduction between the teeth, been dipped into a solution of any resinous gum, such as mastic, the surface of the cavity would have remained unaltered, owing to the exclusion of moisture. But where wool only is used, the secretions of the mouth are not only not excluded, but are held in constant apposition with the exposed dentine by the saturated wood.

Experiments of this character lead to the conclusion that within the mouth agents are present which, under favouring circumstances, are capable of decomposing the dental tissues, and the source of these agents becomes the next question which naturally suggests itself.

The secretion from the mucous membrane is ordinarily slightly acid, while the salivary fluid, when normal, is alkaline. The result of the admixture of these, if equally proportioned, would be a neutral fluid. In certain conditions of health even the saliva (1) may be acid, and the mucus would then retain its original character after the mixture of the two fluids. Again, the degree of acidity of the mucus may be increased beyond the normal amount, and its tenacity may enable it to remain in certain situations unmixed with, and consequently uninfluenced by the alkaline character of, the salivary fluid. The quantity of the mucus may be excessive either from a local or general cause. We not uncommonly find in mouths tenanted by numerous carious teeth, the gums thickened and vascular, and covered with a coating of thick adhesive mucus capable of being drawn from the gums in long strings. A case is fresh in my memory in which the teeth were rapidly destroyed by caries, and coincident with the destructive process the salivary fluid was scanty in amount. The mouth owed its moisture to the secretion of the mucous membrane. The patient complained of great discomfort from the dry and clammy condition of the mouth and throat. The teeth that were first lost decayed in those situations in which we usually expect caries to show itself; but at a later period the whole of the remaining teeth were almost simultaneously attacked near the edge of the gum, producing round each tooth an annular belt of softened tissue. The patient suffered from long-standing dyspeptic symptoms; and among these a vitiated condition of mucus secreted from the surface of the mouth, and a diminished amount of saliva formed prominent features.

In the foregoing case there could be no doubt that the state of the oral fluids was dependent upon the general condition of the body; but in many cases it is by no means easy to determine how far the disorder of the teeth is dependent upon a general derangement of the system having a

(1) See the chapter on the Saliva.

coincident existence, or how far the general disturbance of health may be dependent upon the diseased condition of the teeth. Young people are often brought to us in whom, coincidently with the extensive development of caries, we find an abundant flow of saliva, and a free secretion of mucus; but I think the latter is usually in excess, and is found clinging to the teeth, instead of becoming dissolved in the saliva. In cases like those just cited, I believe we must regard the mucus as furnishing the agent by which the dental tissues are decomposed; and this opinion has been strengthened by the results which followed upon treating several teeth in a manner calculated to test the capability of the mucous membrane to furnish an agent destructive to the teeth. The softened tissue was removed from a cavity on the distal side of a first bicuspid of the upper jaw, and some dry cotton was forced between the bicuspids in such a manner as to press strongly upon the gum. The cotton was renewed once in three days. After the first application the gum became slightly inflamed, and bled on the removal of the cotton, and in the course of a fortnight the softening of the dentine was found to have extended to a considerable depth, showing forcibly that the rate of decay had been increased by the treatment. Having frequently observed with more or less distinctness similar results follow a similar mode of treatment, and the absence of such results where the gum has not been irritated by the pressure of the cotton, the conclusion, that the mucous membrane when irritated throws out a secretion capable of injuring susceptible teeth, follows as a necessary deduction. This conclusion will also be justified by the results which often follow when the filling introduced into a cavity is allowed to project so as to keep up a state of irritation in the gum. The patient after a time returns with toothache, and on examination we find that the tooth has decayed above the stopping in the immediate vicinity of the irritated gum. The irritation, if continued, may lead to the secretion of pus. But pus, when secreted by the mucous membrane, presents the ordinary

alkaline character of that fluid, and does not appear to exercise an influence upon the dentine.

A disordered state, local or general, of the mucous membrane, must not, however, be regarded as the only source from whence may be produced agents capable of decomposing faulty enamel or dentine. For instance, examples present themselves in which the teeth rapidly decay in mouths free from any increased vascularity, local or general—free from adherent mucus about the teeth, and also from any sign of that fluid being either excessive in quantity or vitiated in quality. Several patients (females) returning after a prolonged residence in India, have presented the foregoing conditions of the mouth. They have been pale, bloodless, and greatly debilitated, though not necessarily greatly attenuated, subjects.

But after all the examination of the reaction of the saliva and of the buccal mucus in mouths where caries is rapidly progressive has hitherto disclosed discordant results.

In speaking of the oral fluids as having constituents possessing sufficient activity to rob dentine of its phosphate of lime, we must not lose sight of the fact, that where teeth decay very slowly, and the disease arises in situations in which defective organization is very often found, an abundant supply of acid to produce the effect may be introduced with the food, or may find its way from the stomach.

The results of the experiments of Westcott, Allport, Mantegazza, Magitot, and Leber and Rottenstein agree in showing that not only the mineral acids, but also the vegetable acids, even in weak solutions, have the power of dissolving out the lime-salts from a tooth. The various acids, however, act differently on the teeth; thus some attack the enamel almost exclusively, whilst others effect the destruction of the dentine and the cement, leaving the enamel intact. In the experiments of Dr. Magitot ("Traité de la Carie Dentaire," 1867, p. 108) some most instructive results were arrived at. The teeth were submitted to the

action of the various reagents for very long periods, in some instances amounting to ten years; and in certain cases the tooth was protected by a layer of wax, save at one point, so that definite cavities were produced.

With solutions of sugar the naked-eye appearances of dental caries were exactly imitated: the destruction was far greater in a solution to which a fragment of animal matter had been added than in the pure sugar solution; whilst in a third experiment, in which some drops of creosote had been added with the view of retarding fermentation, the enamel alone had been destroyed where exposed, and the dentine only very superficially softened. In these experiments the solution acquired a distinctly acid reaction. When a greater quantity of creosote was added, no effect whatever was produced on the teeth, and the solution remained neutral; the same negative result followed when the solution was boiled and hermetically sealed whilst still boiling. From these and the numerous similar experiments of other observers, we may fairly come to the conclusion that sugar itself has no power of acting upon the teeth, but that the various fermentation-products which are derived from it are exceedingly potent for evil. M. Mantegazza arrived at confirmatory results in a different manner; the teeth were dried and weighed before and after the experiment, and in this way the actual loss of salts was determined. Under the influence of albuminous ferments, the chief products of the fermentation of sugar will be lactic and butyric acids, together with other derivatives, such as propionic and valeric acids.

As a confirmation of these conclusions, teeth were submitted to the action of lactic acid; in a very weak solution (one part in one thousand) the teeth had undergone no alteration at the end of two years, but in a stronger solution (one per cent.) they were discoloured and soft, and the enamel very friable at the exposed points. As lactic acid is very constantly present in the mouth, either as a fermentation-product formed on the spot, or regurgitated from the

stomach in pyrosis or vomiting, it is probable that it is an active agent in dental caries.

It will perhaps be hardly worth while to recount in detail in this place the effects of all the different acids employed in experiments; it may, however, be noted that with butyric acid great discoloration of the softened part was obtained, and that citric and malic acids, both so frequently present in fruit, were found to act very powerfully as decalcifying agents. With respect to the latter, it is generally abundantly present in cider, and some teeth placed in a cider cask disappeared entirely.

Carbonic acid, when present in large quantities (*i.e.*, under pressure) acts as a feeble solvent, but at atmospheric pressure does not act at all. Albumen and other albuminous substances effect the destruction of teeth by giving rise to fermentation-products such as valeric and butyric acids.

The fermentation-products derived from sugar and from albumen, and citric, malic, and carbonic acids, were found to act on the tooth-tissues alike; whereas alum, oxalic acid, and acid oxalates dissolved the enamel only; acetic and tartaric acids, and acid tartrates, the dentine and cement only. It has also been found that the chloride and perchloride of iron, as also the sulphate, have a solvent action on the teeth.

Mr. Coleman ("Transactions of Odontological Society," 1862) found that the fluid resulting from the addition of fragments of bread and a small quantity of saliva to the water in which the teeth were placed acted very energetically, so that after twenty days flakes of softened dentine could be removed from the surface.

Without further pursuing this part of the subject, it may be fairly concluded that agents fully capable of effecting the decalcification and softening of the dental tissues exist in the mouth; but there is one character of dental caries which is difficult of explanation, namely, the dark discoloration. It has been usual to attribute this to some change in the organic constituents of the tooth, but this can hardly

be the case, seeing that the enamel, which is so exceedingly poor in organic matter, is oftentimes quite as deeply pigmented as the dentine.

Hence, in order to account for the phenomena of dental caries other agencies besides mere chemical solution have been suggested.

It was first pointed out, I believe, by Ficinus, that a cryptogam to which the name of *leptothrix* is given, was very constantly present in carious dentine. It was found not only upon the surface, but in the dentinal canals, and probably had a considerable share in the production of the beaded appearance before alluded to; it also intrudes itself into clefts and fissures in the carious dentine, and sometimes finds its way into the interglobular spaces.

Other cryptogamous growths may be detected; thus the mycelium of Oidium albicans is often seen; and another form, to which the name of Protococcus dentalis has been given, has been described by Schrott as an agent in the production of caries.

Leber and Rottenstein ("Recherches sur la Carie Dentaire," 1868) suppose that this cryptogamous growth—the *leptothrix*—is an active agent in caries, and they say that its presence may be detected in the dentinal canals some distance beyond the zone of softened dentine. They do not altogether reject the agency of acids, but they consider that when once a surface of enamel or dentine has been softened by acids the fungoid growth thrives upon it, and effects its destruction far more rapidly than the mere solvent action of the acid could alone have done.

They conclude that there are two principal agencies at work in dental caries: the one the action of acids, the other the rapid development of a parasitic plant. Before actual loss of substance has occurred, in the stage which they speak of as "la carie sèche proprement dite," they have never discovered the *leptothrix*, and they attribute the whole mischief, up to this point, to the solvent action of acids, but so soon as there is a loss of substance, *leptothrix* may

constantly be found; and to its influence in effecting a more rapid disintegration of the tissues than acids alone could accomplish they attribute the difference observed between the progress of caries in enamel, where the fungus does not grow, and in dentine, where it does.

When caries has run on to softening, the canals are, as has been already mentioned, irregularly dilated; and they are found to be occupied by a molecular mass, which is identified with *leptothrix* by its coloration with iodine and acid. This observation, first recorded by MM. Leber and Rottenstein, has received full confirmation at the hands of Professor Wedl, who, however, believes that its growth is subsequent to the complete decalcification of the tissue, so that it does not play an active part in the destruction.

It is rather difficult to form a just opinion of the share taken by the fungoid growth; its presence is very constant, and it is found to insinuate itself along the tubes, and into fissures, so as to penetrate to a considerable depth; but it is almost impossible to decide whether it has any power of boring out cavities for itself, or whether it simply occupies the vacant spaces which have been formed by other agencies. And as the *leptothrix* is to be found abundantly in all parts of the mouth, its constant presence in such a favourable site as is afforded by a carious tooth may be readily accounted for without attributing to it any share in causing the disease.

The experiments of Messrs. Underwood and Milles upon the artificial production of caries proved that in an aseptic flask the phenomena characteristic of it could not be reproduced, so that the presence of organisms must be necessary either directly to the production of caries, or indirectly to the formation of destructive fermentation-products.

And the intrusion of the bacteria into dentine beyond the line of apparent mischief leads these writers to attribute to them a primary role in the matter. *Per contra* may be

cited the opinion of Dr. Miller, who holds that they cannot *per se* produce caries, and that you cannot experimentally infect one portion of dentine by contact with another, as you might fairly expect to do if bacteria were the most important factor.

Dr. Miller has conducted a series of careful experiments upon the fermentations which go on in the mouth ("Independent Practitioner," Vol. 5, Nos. 2, 3, 5, 6 and 7), to which the reader interested in the subject should not fail to refer; they may be very briefly summarised as follows. A sterilised starch solution in a tube fastened to a molar tooth on going to bed will be found in the morning to have a strong acid reaction; various check experiments prove that the ferment exists in the saliva, and further ones that it is not ptyaline, but that it is with every probability an organism which is able to multiply without the free access of air, so that it is likely to be efficient when buried far in the dentine.

The organism which is found in these cultures agrees in aspect and in all its behaviour with the lactic acid bacterium, and the presence of lactic acid can be determined by analysis.

The conclusion, then, at which he arrives is, that the chief work in the production of caries is lactic acid, and that other acids when present are only auxiliary factors; and these lactic acid fungi, of which he distinguishes two varieties, he holds to be identical with the bacilli demonstrated in the dentinal tubes.

An experiment of great significance determined the amount of acid produced by two equal infections, the one prior to, the other after the careful cleansing of the mouth with tooth-brush, floss-silk and tooth-pick; the amount of acid produced by the latter being often as low as one-fourth of that by the former, while after the use of strong antiseptics the amount may be reduced almost to nil. "There is no known solution, alkaline or antiseptic, applicable in the human mouth, which will penetrate between the teeth, or to the bottom of fissures and cavities when these are

filled with food, in sufficient quantity to have any appreciable effect. Therefore, before all antiseptics or alkaline washes come the tooth-brush, tooth-pick and floss-silk."

According to these experiments the organisms have not any diastatic power to transform starch into sugar, but there must almost always be an amount of sugar in the mouth sufficient to enable them to exercise their fermentative effects.

Other theories have been propounded, such as that of Dr. Bridgman (Tran. Odontol. Soc., vol. iii.), in some degree taken up of late by certain of the "new departure" school in America, according to which all the phenomena of dental caries are attributed to electro-voltaic action, though upon grounds which are far too indefinite to amount to anything like logical proof. Although to fully discuss the subject would involve a somewhat elaborate disquisition on physical laws, which would be much out of place in these pages, still some few points in the argument may be noticed, the more so as this theory long escaped criticism. An excellent summary of the matter by Dr. Dexter may be found in the Transac. New York Odontol. Soc. 1878.

At the very outset it appears to involve a slight misconception of the intimate relation existing between the physical forces; that is to say, it is hardly in accordance with the most recent views, which regard electrical phenomena, chemical action, heat, and even motion, as only different manifestations of "force," and as mutually convertible. Now, this theory of caries proceeds throughout upon the assumption that electric disturbance is always present, and that it is, so to speak, a cause and not an effect. It is perfectly true that electric disturbance is convertible into chemical action, but it is equally true that chemical action is convertible into electrical disturbance; so that they are mutually capable of standing in the relation of cause and effect to one another. But the presence of chemical action by no means enables us to say that it was set up by electric disturbance: it is rather to be regarded as one manifestation

of a force which, if it had not been expended in chemical change, might have been apparent in the form of electricity, or of heat. But if we were to accept Mr. Bridgman's theory we must regard electricity as the ruling agency, if not the prime mover, in every act of development, nutrition, or growth in the animal and vegetable kingdom, and must exalt it to a position of the regulator of all other physical forces.

To pass to the application of Mr. Bridgman's theory, we come first to the assumption that the cutis and the blood-vessels are electro-negative, whilst the epithelium, or epidermis, is electro-positive, and the two are compared to electrodes (p. 380, *op. cit.*). No ground whatever is given for this belief, save the fact that litmus paper sometimes shows an acid reaction on the epidermis (from the sweat?); and the comparison to electrodes falls to the ground, for electrodes cannot exist save as a part of a voltaic circle through which a current is circulating: a condition of things which has no parallel in the relations existing between the cutis and the epidermis.

The next step in the argument is that, inasmuch as dentine replaces epithelium in the case of the tooth-papilla, its electrical relations will be similar (p. 383). This appears to involve the assumption that parts which are homologically similar will remain so in point of function, whereas comparative anatomy furnishes us with countless examples to disprove this. And even setting aside this objection, the dentine does not, either functionally or homologically, replace the epithelium; it essentially belongs to the cutis, and it is to the enamel, and not to the dentine, that Mr. Bridgman's argument, if valid, would apply.

It would be impossible to go *seriatim* through the arguments brought forward in the paper quoted, but it may suffice to say that, supposing Mr. Bridgman's theory to be correct, in so far that a condition of electric polarity exists in the teeth, and that this is capable of producing caries, it is difficult to see how a tooth should ever escape; it would,

in fact, contain in itself an arrangement necessitating its own destruction. And it may be added, that experimental researches on the electrical conditions of other parts of the body have brought out such unforeseen results, that any attempt, with our present knowledge, to predict or determine on merely theoretical grounds the electric conditions of any part of the body, must, of necessity, prove futile.

Enough has, perhaps, been said to show that we must seek for the agencies which cause dental caries among the chemical transformations which go on in the mouth. The decomposition of food has been proved to furnish acids perfectly capable of decalcifying enamel and dentine, and the buccal mucus not rarely has an acid reaction.

Professor Wedl thinks that the influence of the viscid buccal mucus has been underrated; and it was mentioned in the former edition of this book that where there are many carious teeth, the gums are usually swollen, vascular, and coated with thick, stringy, tenacious mucus.

And, it may be added, that wherever mucus, &c., is readily and speedily removed by the tongue, or other agency, caries is very rare.

It seems also that a decomposed pulp may give origin to acids capable of softening the dentine; thus MM. Leber and Rottenstein (*op. cit.*, p. 11) mention a case in which three incisors became deeply discoloured without any breach of surface; this condition had supervened after a blow. On drilling into the teeth, the entire dentine of the crown was found to be utterly decomposed and softened. M. Scheller also reports two similar cases.

It is, perhaps, from observations on such teeth as these, that the idea of "central" or "internal" caries has sprung; but the condition has little or nothing in common with true caries.

Some writers have held the opinion that Nasmyth's membrane is a frequent site of incipient caries, and have gone so far as to say that the greenish discoloration often visible around the necks of the teeth in young people was due to

the carious disintegration of the cuticula dentis (Ficinus), in which, ultimately, leptothrix may be found.

That the cuticula dentis is permeable to fluids is clearly proved by its separation from the enamel when the crown of the tooth is immersed in acid; but its resistant nature renders it very unlikely to be itself the seat of caries. Moreover, this greenish discoloration near the necks of the teeth in young persons often spontaneously disappears, leaving no ill results behind it; and, again, similar discoloration may be found on the teeth of certain wild animals.

The different teeth are not equally subject to the attacks of caries; in the first place, the upper are more frequently attacked than the lower—according to Dr. Magitot (*op. cit.*, p. 48), in the proportion of 3 : 2; whilst the yet more comprehensive tables of Dr. Hitchcock (1) give the ratio of 1·9 : 1, or very nearly two to one—the first and second lower molars, however, suffering even more frequently than the corresponding upper teeth. There does not appear to be any noteworthy difference between the two sides of the mouth in their relative liability to caries, so that this portion of the tables has been omitted in this place. Dr. Hitchcock (*loc. cit.*) gives the following analysis of twenty thousand cases:—

Central incisors	2,189	2,101 upper 88 lower
Lateral incisors	1,954	1,827 upper 127 lower
Canines	1,261	1,058 upper 203 lower
First bicuspids	2,073	1,588 upper 485 lower
Second bicuspids . . .	2,585	1,715 upper 870 lower
First molars	4,499	2,273 upper 2,126 lower

(1) Wedl's "Pathology of the Teeth." Translated by W. Boardman, M.D., and edited by T. B. Hitchcock, M.D., D.M.D. 1872, p. 399.

Second molars	3,615	1,675 upper 1,940 lower
Third molars	1,924	899 upper 1,025 lower
Total		Upper 13,136 Lower 6,864 — 20,000

Another table, compiled by Dr. Magitot from ten thousand cases, gives the following results :—

Central incisors	642	612 upper 30 lower
Lateral incisors	777	747 upper 30 lower
Canine	515	445 upper 70 lower
First bicuspid	1,319	949 upper 370 lower
Second bicuspid . . .	1,310	810 upper 500 lower
First molar	3,350	1,540 upper 1,810 lower
Second molar	1,736	690 upper 1,046 lower
Third molar	360	220 upper 140 lower

Analysis of 2,628 cases of extractions on account of caries, or its consequences. From "Lectures on Dental Physiology and Surgery," by J. Tomes, F.R.S. 1848 :—

Central incisors	25
Lateral incisors	62
Canines	36
First bicuspids	227
Second bicuspids	393
First molars	1,090
Second molars	575
Third molars	230

The tables drawn up by other observers, on the whole, correspond with the last two of these: that drawn up by Dr. Hitchcock differs in some particulars of interest. Thus, in his tables, the carious first molars do not show that great preponderance in numbers over all other teeth which is exemplified in most other tables; and as his tables embrace fillings as well as extractions, this cannot be attributed to the early attention given by Americans to their teeth.

Dr. Magitot has given an additional 2,000 cases, which, combined with his first Table, give the following proportions:—

First molars	upper 1,791 lower 2,127	3,918
Second molars	upper 829 lower 1,282	1,011
Third molars	upper 282 lower 207	489
First bicuspid	upper 1,104 lower 425	1,525
Second bicuspid	upper 949 lower 570	1,519
Canine	upper 557 lower 95	652
Lateral incisor	upper 939 lower 33	972
Central incisor	upper 779 lower 32	811[1]

Analysing his table we get 4,971 carious lower teeth as against 7,029 upper teeth, or, excluding the incisors and canines of both jaws, in consideration of the well-marked immunity of lower incisors and canines, 4,951 carious upper molars and bicuspids, as against 4,611 lower molars and bicuspids. Of these, lower molars furnish us with 3,616, as against 2,902 upper molars, so that the protective effect which

(1) Dr. Magitot's own tables do not add up quite right.

helps lower teeth is not efficacious at the back of the mouth, indeed becomes less efficacious as we go backwards from the incisors; this would seem to confirm the idea that it is the secretion of the submaxillary glands that is the protective agency.

The female sex is distinctly more liable to dental caries than the male, though in what proportion the caries occurs remains uncertain, for the want of sufficient data; so that different authors arrive at widely different estimates. The patient's age, likewise, markedly influences the disease; thus, if it has not occurred before the age of five-and-twenty, there is a strong probability of immunity till about the fiftieth year, when, coincidently with other manifestations of bodily decline, the teeth again become liable to be extensively attacked with caries.

Various conditions of the system markedly favour the occurrence of caries; thus, the period of pregnancy is especially destructive to the teeth, and it often happens that widespread and rapid destruction occurs in previously healthy teeth during some severe illness. Professor Wedl (*op. cit.*) enumerates dyspepsia, cancer of the stomach, diabetes, scrofula, rachitis, phthisis, and aphthæ as promoting the development of caries. I myself have recently seen a case in which almost every tooth was attacked by caries during a severe and protracted attack of rheumatic fever, though up to this time (the patient having reached the age of forty) the teeth had remained sound. And it may be remarked that medicines often get the blame of having done the mischief, when the ravages of caries are more truly attributable to the patient's general condition. Thus, for example, it is common to see great destruction of the teeth in young anæmic females, and this is often attributed to their having taken large quantities of iron in the form of the muriated tincture. Although if the mouth be not scrupulously rinsed after the exhibition of acid medicines, the teeth may not improbably be acted upon, yet the constitutional condition which necessitated prolonged treatment

with such drugs as iron would greatly predispose to the occurrence of caries.

Acute stomatitis occasionally exercises a most disastrous influence upon the teeth ; and all conditions which tend to an unhealthy, congested state of the buccal mucous membrane will have a deleterious influence. It is in this way that dyspepsia and other disorders of the intestinal mucous membrane affect the teeth.

During many acute diseases, notably in fevers, there is great dryness of the mouth from deficient secretion of saliva, while at the same time the buccal mucus and epithelium is constantly shed off, so that sordes accumulate round the teeth : it is easy to see how this state of things will act prejudicially upon the teeth.

Certain articles of diet appear to have a directly mischievous action ; thus it has been found that in children who have been soothed with a "sucking bag" (containing sugar and milk) the crowns of the upper incisors are rapidly destroyed, though the molars usually escape. Cooks and confectioners are also especially liable to dental caries ; and it is stated by Dr. Magitot (*op. cit.*) that caries is especially prevalent amongst cider-drinking populations.

Dr. Richardson mentions that the teeth of fur-dyers, who are much exposed to the fumes of nitric acid, are frequently destroyed.

Whether smoking exercises any preservative influence on the teeth must be doubted ; although the impression that it does so is wide spread, it is not based on any definite grounds, and there is no difficulty in finding cases of excessive destruction of the teeth in the persons of habitual smokers.

There can be no question that the tendency to caries, whether induced by structural deficiencies or perverted functions, is strongly inherited ; so strongly, indeed, that sometimes as the several children of the parent successively arrive at a certain age, the corresponding teeth will become decayed.

This inherited predisposition, so strongly marked in families, extends to whole races, and probably is often due to defective developments. On this subject Professor Wedl remarks, "If it be true that geological and climatic conditions, and the means of subsistence which are connected with the same, have such a preponderating influence in respect of the frequency of caries, then it is impossible to explain the fact that foreigners belonging to different races, who are exposed to the same conditions with the native inhabitants, still retain the typical structure of their teeth as well as that of their bodies, and continue to furnish the proportion of dental caries peculiar to their race. This is found to be the case with the isolated Sclavonic races of Austria and the descendants of the Celtic race in France." To this Dr. Hitchcock appends the remark, "As geological, climatic, and social conditions exercise a predominant influence upon the growth and development of the various races, mentally as well as physically, it is evident that the development of the dental organs cannot fail to be controlled by the same causes. In this country, which is annually receiving large numbers of foreigners by emigration, the typical traces of race are usually effaced after the lapse of a generation or two, the descendants possessing all the peculiarities, and their teeth apparently being as liable to caries as the teeth of Americans generally."

The frequency of dental caries in various races, both ancient and modern, has been investigated by Professor Broca and by Dr. Magitot, and subsequently, in greater detail, by Mr. Mummery.

Dr. Magitot (1) states in general terms that negro and Arab races are remarkable for the soundness of their teeth, the Caucasian for the contrary, while the Mongolians hold a middle place. Races not indigenous, but freshly imported into a country, appear to suffer in an exalted degree.

Amongst the anthropological series of the Paris museums

(1) "Traité de la Carie Dentaire," 1867, p. 60.

he found no example of caries amongst the crania of Mexicans, Peruvians, or Patagonians, or amongst those of natives of Australia, Madagascar, New Caledonia, &c. ; no example of caries amongst the Malay and Javanese crania in the collection of Professor Vrolik. Amongst Egyptian mummies he found a good many examples ; among modern nations, he notes that the inhabitants of Iceland are almost exempt.

To Professor Broca is due the observation that caries was far less frequent amongst the ancient populations of Europe than it is at present, and that the teeth were usually excessively worn down ; but that mere wear is of itself insufficient to have prevented the ravages of caries, is shown by the fact that the Basque crania (eighty in number) in the Paris museums were alike remarkable for the extent of the wearing down, and also for the tolerably frequent occurrence of caries.

Dr. Magitot ([1]) observes that in France those regions which are populated by peoples of Celtic descent present a comparative immunity from dental caries.

Mr. Mummery ([2]) subsequently examined and tabulated a very large number of ancient crania with the following results :—Caries was met with in 2·94 per cent. of the Ancient Britons of dolichocephalic type, in 21·87 per cent. of the brachycephalic Britons, in 28·67 among Romano-Britons, in 15·78 of Anglo-Saxons, and in 41·66 of Ancient Egyptians. It would appear from these percentages that the frequency of caries bears a tolerably close relation to the habits of luxury of the several peoples, and it may be added that contracted jaws were met with three times among the Romano-British skulls ; a thing quite unknown in savage races.

Amongst modern races, the Esquimaux, North American Indians, Arabs, Africans, New Zealanders, Caffres, and Northern Indians were distinguished for having generally

([1]) *Op. cit.*, p. 65.
([2]) Transactions of the Odontological Society, new series, vol. ii.

sound teeth; whilst the Chinese, some American Indians dwelling in cities, Southern Indian tribes, and South Pacific Islanders furnished a large number of examples of caries.

There appears to be no room for doubt that increased civilisation predisposes to the occurrence of caries, though as yet it is uncertain in what way it does so.

Caries is of very rare occurrence in animals, but when it does arise it is usually in domesticated beasts (1): thus it has been met with in the horse. It has, however, been met with, according to Dr. Magitot, among the anthropoid apes, whilst in the feral state.

The following conclusions seem to be most nearly in accordance with the preceding facts, viz. : -

That caries is an effect of external causes, in which so-called "vital" forces play no part.

That it is due to the solvent action of acids which have been generated by fermentation going on in the mouth, organisms having no small share in the matter; and when once the disintegrating process is established at some congenitally defective point, the accumulation of food and secretions in the cavity will intensify the mischief by furnishing fresh supplies of acid.

(1) The fact that stall-fed animals are liable to a swollen, spongy condition of the gums has already been noted.

DEFECTS IN STRUCTURE.

Defect in the structure of teeth attains to a special importance as predisposing causes of dental caries.

Teeth may fall short of the desirable standard in two ways: the whole of the dental tissues may be of such material that, although there is no patent visible defect, yet they are almost sure after but a short time to succumb to the attacks of caries, or there may exist tangible local defects in their constituent tissues, the rest of the teeth being perhaps of excellent material.

Certain classes of teeth, easily recognisable by the eye of the observant dentist, are especially vulnerable: thus great translucency and bluish white colour are of especially ill omen, and such teeth generally but not invariably fall short of full size.

And it is very common for these non-resistant teeth to coexist in many members of the same family, so that it is common to hear persons speak of the badness of the family teeth.

Yet it is not always possible to trace them as the result of heredity, and still less as the result of any tangible form of ill health in the individual.

It may however be mentioned that the few patients within my own cognisance who have exceeded the age of ninety years have all been possessed of typical strong yellowish teeth.

To pass first to what may be termed local defect in teeth:

The most apparent defect in the enamel is that in which the surface is irregular, either from the presence of numerous pits, or indentations, or of deep transverse grooves, the intervening parts being normal in appearance. In either case the

defect may be rather in quantity than in the quality of the tissue, although in the latter respect the organization may also be imperfect. Teeth presenting such characters are commonly spoken of as honeycombed, and an extreme form of honeycombing has already been alluded to as probably caused by the administration of mercury (p. 135). They frequently want the clear colour and the semi-transparency of healthy organs, for which is substituted a dull yellow appearance, the deeper shades of colour being confined to the depressed portions of the enamel. If a section be made from a tooth which presents these external characters, it will be seen that the surface of the dentine does not necessarily deviate from the usual form, but that irregularity in thickness is confined to the enamel which lies upon it; at one point the dentine will support only a thin and perhaps imperfectly developed layer; at another, a considerable depth of well-formed enamel.

In teeth which are only grooved while the natural colour is maintained, it may be found that the deviation from the normal condition is confined to alternations in the quantity of the tissue, the natural characters, as respects the structure of the enamel, being preserved throughout. But it is frequently seen, that in the deeper portions of the grooves the colour differs from that which obtains in the contiguous healthy structure. In this, as in the case of the honeycombed teeth, the abnormal colour indicates a defect in the structure.

It has been stated, that irregularity in the surface of the enamel does not imply a corresponding irregularity in the surface of the dentine; under ordinary circumstances, the elevations and the depressions on the surface of the crown, have counterparts on the surface of the subjacent dentine, differing only in the extent of the elevation. The enamel attaining its maximum thickness over those parts of the tooth which are most prominent, consequently breaks the parallelism of the lines formed by the surfaces of the two tissues. Although this is the general rule, many cases will

be seen in which the surface of the dentine presents the usual form, while the enamel, from defect of quantity, fails to contribute its share in building up the crown of the tooth; and the cusps of the molars are consequently stunted.

On the other hand, the surface of the dentine may deviate from the natural conformation; the masticating surfaces of the molar teeth may be flattened, as is seen in syphilitic teeth, or the cusps may be thin and spear-shaped, as though pinched flat, and the incisors may have the same compressed form. In all such cases the enamel will be defective in amount and irregular in its distribution. The same cause which influenced the development of the dentine on the surface of the tooth, will have equally influenced that portion of the enamel which lies in contact with the dentine. Had the formation of the superficial portion of the dentine been normal, the enamel, which is developed upon its surface so soon as that surface is formed to receive it, would have been free from defect, although more external portions, formed at a later period, might have been defective.

There is another form of defect in quantity. A molar tooth may present to the naked eye all the appearances of a well-developed organ, and yet the enamel may be imperfect, and the imperfection may be in such a form as to insure the early loss of the tooth. From the natural depressions which separated the cusps of molar teeth, minute but deep fissures may be extended through the enamel to within a short distance of the dentine, and they may become larger as they recede from the surface of the tooth. In most cases which I have examined, they have been filled with cementum, or rather with that modification of cementum which constitutes Nasmyth's membrane, and very commonly they become the seat of caries.

These minute crevices, the existence of which in many teeth an ordinary examination would not lead one to suspect, are constantly met with in connection with those forms of defective enamel which have been already described.

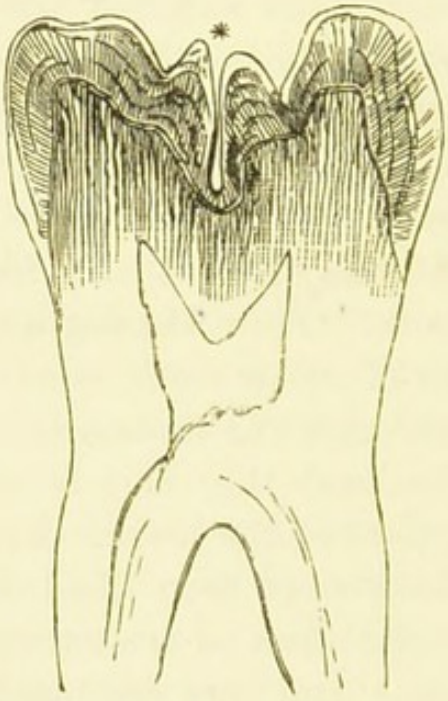
Independent of the quantity, the quality of the tissue may

be defective, and consequently unable to resist the influence of agents calculated to injure the tooth.

The fibrous character of the enamel, which in the perfect tissue is lost by the blending or fusion of the sheaths of the columns of the enamel-pulp in the process of calcification, may be permanently maintained. Each fibre may to a considerable extent preserve its individuality, a condition which gives an opaque appearance to the tissue, and at the same time greatly impairs its strength. The fibrous character may prevail in certain parts of a tooth, or it may extend through the whole of the enamel. More commonly, however, it will be seen in lines parallel, not with the surface of the enamel or of the dentine, but with the line of growth.

The fusion of the sheaths of the original fibres may, however, be perfect, while the central portions or contents

FIG. 139. (1)



may have fallen short of perfect development. In the place of faintly-marked striation, we may find either parallel series of well-defined rounded masses, or a line of fine granules.

(1) Shows a deep fissure in the enamel invisible to the naked eye. The section was taken from a first permanent molar of the lower jaw, removed soon after its eruption.

Again, minute cavities arranged in single lines may occupy the centres of the fibres, and in some few cases I have seen by the confluence of a series, a tube produced.

The foregoing conditions may be sometimes found in patches amongst the normal tissue of teeth which have the general appearance of being perfectly developed; but when the enamel is obviously imperfect, and presents the honeycombed character, the structural defects will be much more generally diffused.

Not only may the fusion of the sheaths be imperfect, and the central portions of the fibre fall short of the normal conditions, but even the arrangement of the elements of the tissue be lost. Both the longitudinal and transverse markings may be replaced by a general granular condition, as though the tissue had been formed by the calcification of unarranged spherical masses, about the size of blood-globules, with perhaps here and there a cavity of irregular form interposed.

In the most perfectly developed enamel, the longitudinal and the transverse markings are comparatively faint, and under a high magnifying power with a good light, they appear, not as dark, but as light lines, enclosing spaces which are occupied by a material which is a little more dense or opaque than that which forms the lines. Any departure from this condition may be justly regarded as a predisposing cause of caries, the degree of predisposition being proportioned to the relative amount of porosity in the tissue. In the foremost rank, as a predisposing cause, must be placed the deep but minute fissures found on the masticating surface of molar teeth; and next in order, the imperfect fusion of the sheaths, and the consequent retention of the fibrous state of the enamel so frequently seen on the sides of teeth.

There are, however, several points connected with the structure of the enamel which have yet to be noticed, but as they are connected equally with the dentine, the structure of the latter tissue may be described before the relations of the two tissues at the point of union are traced.

If the thin edge of the forming cap of dentine be examined, it will be found to have the appearance of being made up of globules of varying size, this appearance being in great part destroyed by treatment with a dilute acid.

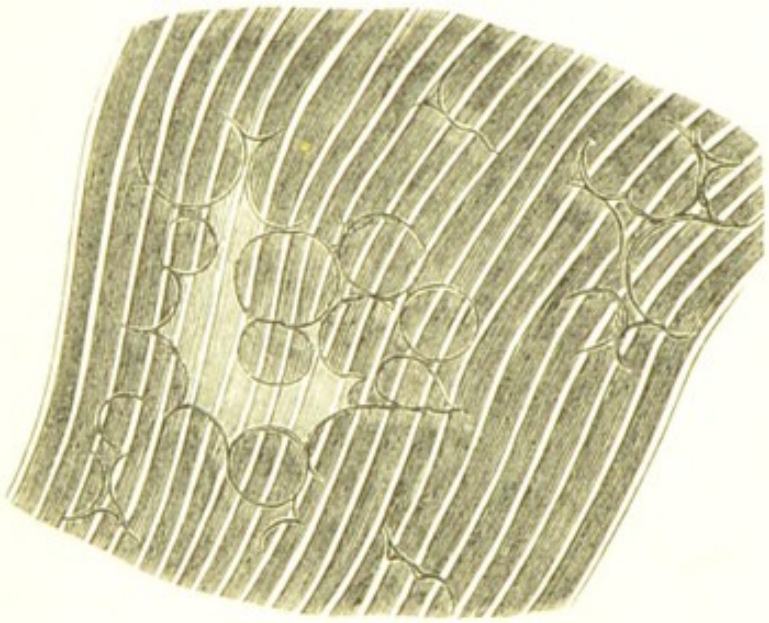
This condition has been well figured by Messrs. Robin and Magitot, and is familiar to all who have watched the development of dentine. The calcareous matter is in the first instance deposited in the matrix in the form of isolated globules, these increase in size and ultimately coalesce, their outlines becoming obliterated by the deposition of calcareous salts in their interstices.

Dentine in the globular form may be found in semi-detached masses adherent to the surface of the pulp-cavity, and in perfectly detached spherules in the substance of the pulp itself, in the teeth of adults. In the latter situation these bodies are very abundant in teeth which have been attacked by caries; and Mr. Salter appears to consider the presence of the detached masses of dentine in the pulp as the consequence of disease. I do not think this view is quite correct, for in three out of five specimens of perfectly sound molar teeth removed from subjects in the *post-mortem* room of the hospital, I found globular masses of dentine within the substance of the pulp. Again, in the developing teeth of ruminants, these globular masses are scattered freely through the dentinal pulp, and as ossification advances, become surrounded by, and lost in, the general mass of the dentine. If the surface of the pulp-cavity of a partly-formed tooth of a ruminant be examined, the globules will be found embedded to various depths in the substance of the dentine. Messrs. Robin and Magitot call attention to the existence of small isolated calcareous granules of spheroidal form, which are to be found in considerable numbers scattered through the substance of the pulp at an early period of dentine development; they have also been described by Henle and others in the teeth of man, as well as in those of ruminants and rodents, and they may be found at all periods of development, as well as in adult teeth.

Sometimes, however, the coalescence of the globules formed in developing dentine only takes place imperfectly; that is to say, contiguous globules may coalesce in such a way as to cut off and isolate a portion of the formed matrix which has not as yet been impregnated with salts. When the tooth is dried the soft matrix which had occupied this situation dries up and shrinks so that a more or less irregular cavity, looking black, from its containing air, is left.

These cavities are known as "interglobular" spaces, and were so described by Czermak; they may be excellently seen in teeth which have been rendered translucent by boiling in wax. In the specimen here figured (which has been

FIG. 140.



so prepared) it may be seen that the walls of the cavity are made up of globules, and that its irregular form with processes running out from it is referable merely to the fact that interspaces are left between a number of unyielding spherical masses.

As has already been mentioned, in the fresh state these cavities are not empty, but are occupied by formed structural matrix which has not been as yet calcified.

At times the contents of the interglobular space appear to be protoplasmic, and nuclei are to be found, so that they

are closely analogous to the lacunæ of cementum; at times they appear to have become transformed into basis substance, which may never be calcified, or may undergo calcification at a period subsequent to its formation, and this does not have the effect of entirely obliterating all traces of its original contour.

In this way an appearance may be produced exceedingly suggestive of portions of areolar tissue having become involved in the calcifying process; but the more probable explanation of the appearance is, that an interglobular space has been formed, and subsequently obliterated by the further process of calcification.

In the neighbourhood of well-marked interglobular spaces, more or less distinctly defined globular forms may almost always be traced.

Teeth in which globular and interglobular spaces abound suffer very rapid destruction when attacked by caries—a result which is consequent upon the porous state of the tissue; but they present considerable variations in this respect, those teeth which present the appearance which has been described as areolar dentine, often possessing great powers of resistance, so that the progress of caries in such teeth is slow, rather than otherwise.

It is stated by Mr. Spence Bate that interglobular spaces are more abundant in the teeth of the present day than in those of the remote ancestors of our race, but as yet no detailed observations have been published on this point.

Although the presence of defects in the structure of the dentine no doubt contributes to hasten the destruction of teeth when attacked by caries, yet, as a predisposing cause, they are secondary in importance to similar faults in the organization of the enamel. Sufficient importance, however, attaches to the departures from the normal condition of the dentine, to render it desirable that some account should be given of the characters by which such departures are distinguished.

When the organization is perfect, the subdivisions of the

dentinal tubes pass up to the line of junction formed between the inner surface of the enamel and the outer surface of the dentine, the intertubular tissue being at this point clear and transparent. In less perfect teeth the clearness and transparency are replaced by a granular condition of the tissue; granules, or spherules, or minute globules, although united, yet retain some traces of their individuality, and among these the coronal dentinal tubes are lost. This condition, in a greater or less degree, is almost uniformly present in the peripheral portion of the dentine of the root; but its existence in the crown of the tooth must be regarded as an indication of faulty development. In seeking to explain the cause of this granular condition, Mr. Rainie (if I have read his paper correctly) would regard the phenomenon as resulting from an arrest in the coalescence of the dentinal globules; and this is probably the true explanation of the fact, the so-called granular layer, which underlies the cementum in the fangs, being made up of a great number of minute interglobular spaces.

Any change in the direction of greater porosity of the dental tissues, may be regarded as favourable to the destruction of teeth, supposing them to be attacked by caries; and it is only to such forms of departure from the normal state of the tissue that attention need be directed. Under ordinary circumstances, the dentinal tubes diminish slightly in diameter as they approach the peripheral portion of the crown of the tooth, but it will in some specimens be seen that in passing an interglobular space they are considerably dilated. Again, the terminal coronal branches, instead of terminating by anastomosis, or by becoming imperceptibly minute, may pass into small irregular cavities situated near the surface of the dentine.

In a well-developed tooth a certain number of the dentinal tubes will be seen to pass across the line which marks the junction of the enamel and the dentine, without suffering any increase in size, and after proceeding a short distance in the former tissue, become extremely minute and are lost.

But in teeth of less perfect organization the dentinal tubes, after passing into the enamel, become suddenly dilated into comparatively large elongated cavities, irregular in outline, but tolerably uniform in direction, which terminate abruptly after advancing but a short distance into the enamel.

Besides these definite histological defects, there are teeth which, to the practised eye, are doomed to early decay, and others which are counted so strong that their durability may be confidently predicted. The materials for the proper classification of these varieties of teeth do not at present exist, as only their naked-eye characters are known, and of their chemical composition, and histological peculiarities, if any, nothing is certain. At the one extreme stand the bluish-white, undersized, unduly transparent teeth, with the fluting of the incisors strongly marked, as also the cusps and grooves of the molars; at the other, the dense highly polished yellowish-white teeth, with smooth and somewhat opaque-looking enamel surface.

It is believed that the bluish-white teeth are less richly impregnated with lime salts—at all events the enamel and the dentine are very easy to cut, even beyond the boundaries of caries, and this latter spreads in such teeth with astonishing rapidity, whilst on the other hand the dense yellowish enamel is oftentimes of flinty hardness.

Dr. Galippe (Recherches sur les propriétés physiques, &c., Société de Biologie, Mai, 1884, summarised in British Dental Association Journal, 1886) has published a series of observations upon the specific gravities of the various teeth, which, according to him, may be taken as representing in a rough way their proportionate richness in inorganic salts, though he does not pretend that it does so with mathematical exactitude.

He finds that the average mean density of the upper teeth is greater than that of the lower teeth; and that the teeth of the right side are a little denser than those of the left, a fact which seems to correspond with a less liability to caries.

The milk teeth have a less specific gravity than the permanent, and the roots of teeth than their crowns; and there appear to be differences between the various teeth, which are given in detail in the paper referred to, but these differences do not stand in very close relation to their power of withstanding caries, as the molars have a specific gravity as high as the canines.

He further believes that the density of teeth increases with age, and that they may lose or gain in inorganic constituents after their eruption, contending that they may suffer from constitutional conditions just as bones may.

In point of chemical composition the milk teeth were found to be not only poorer in inorganic constituents, but also to have more of carbonates and less of other salts.

The influence exerted upon the pulp when the disease is advancing towards it, may be noticed before the question of treatment is entered upon. With the advance of age, the area of the pulp-cavity becomes gradually diminished by the slow addition of dentine to that which was formed when the tooth was in a state of active growth; and this condition is still more strongly marked in those teeth which have been worn by mastication; indeed, in some cases the cavity is almost, in others perfectly, obliterated. In either case the effect is, as respects the contraction of the cavity, general, but the local development of dentine continuous with the pre-existing tissue, is very often coincident with caries. When the crown of the tooth is attacked, the pulp very commonly resumes its formative functions at a point corresponding to that towards which the disease is advancing, and adds as it were a patch, or plate, of new dentine (or secondary dentine, as it is commonly called), the tubular and intertubular substance of which is continuous with that of the older tissue, and thus the tubes of the two parts are continuous, although at the point of junction they are often marked by a slight dilatation. When the tooth is strengthened by additions made upon the walls of the pulp-cavity, in consequence of the tooth becoming weakened by disease opera-

ting upon the outer surface, we have a remarkable example of the manner in which Nature attempts to remedy a defect. But the reparative efforts are not always productive of favourable results. In the place of additions being made to the pre-existing dentine by the calcification of the superficial part of the pulp, several, or even many, independent centres of calcification may be established within its substance. In some cases, we find numerous irregularly globular masses of dentine; in others, one or two nodules sufficiently large to occupy nearly the whole of the cavity. It seldom happens that the larger masses are developed from a single centre. They appear to have been produced by the aggregation and coalescence of a number of lesser globules. This secondary nodular dentine may or may not be adherent to the walls of the pulp-cavity; it is, however, more frequently free than attached, and in that case fails to answer the useful purpose of protecting the pulp from exposure.

Mr. Salter speaks of the calcification of the pulp when it occurs upon the surface, producing new dentine continuous with the older tissue, as extrinsic calcification, and the new tissue as dentine of repair (1).

Dr. Bödecker, in a careful paper (Dental Cosmos, August, 1879) in which he summarises the views as to the nature and structure of secondary dentine, divides it into three varieties: (i) secondary dentine resembling primary dentine; (ii) secondary dentine with a laminated structure; (iii) secondary dentine in form analogous to Haversian system. This latter variety has been termed "Osteo-dentine." He further points out that it is exceedingly common to find that the surface of the secondary dentine looking towards the pulp is excavated by absorption spaces, showing that coincidentally with its formation inflammatory conditions have existed in the pulp. "The pulp-tissue exhibited all the features of inflammation, to which also the bay-like excava-

(1) For further information relative to the occurrence of dentine nodules, see Diseases of the Pulp.

tions in the secondary dentine were doubtless due. If you consider the formation of secondary dentine as the result of slight but long-continued irritation, we readily understand that such an irritation may occasionally terminate in an inflammatory process—pulpitis.

"The newly-formed dentine, partly at least, will be destroyed by the inflammation, and thus produce a combination of both formative and destructive processes, so common in inflammation of bone-tissue. The presence of inflammation would also explain the pain which sometimes accompanies the formation of secondary dentine."

TREATMENT OF CARIES.

In the treatment of simple caries two methods are employed. The removal of the diseased, together with the surrounding healthy tissue, to such an extent as to leave a perfectly smooth surface, constitutes one method; the removal of the diseased tissue, and the substitution of some indestructible material for the lost part, constitute the other method of treatment. In either case the diseased part must be removed, or, at all events, such portions of it as have been softened by the abstraction of the lime salts.

In selecting between these two operations, we must be guided in the first place by the depth to which the disease has penetrated, and by the situation in which it is established. If the disorganization has not extended into the dentine to a depth which greatly exceeds the thickness of the enamel, and either the median or distal surface of a tooth (especially of a front tooth) be the part attacked, the operation of excision may be performed with advantage. But if the teeth are irregularly placed, the advantages of this method of treatment may be either increased or diminished by the peculiarity of the case. Teeth when crowded together, will be improved by the operation if they have been attacked with disease on the lateral surfaces, but when a separation exists already, the widening of the aperture by the file will produce an unsightly appearance, without offering any advantage over filling the cavity.

The operation of filing is not confined to the simple removal of the affected portion of a tooth by the file. Not only must the diseased part be cut away, but it must be removed with such other portions of the surrounding parts of the tooth as will enable the operator to leave a perfectly

smooth surface, and one which can readily be reached when the teeth are cleaned. Files of several degrees of coarseness, or cut, as it is called, are required, and of various shapes. Both these conditions have been carefully considered, and we can now find at the dental instrument makers almost an endless variety of the required forms. But nowadays, though the file remains the best instrument in some cases, it has been to a large extent displaced by corundum disks, and emery-cloth disks used in the engine. It would be an endless task to describe every form of file which has been used in operating on the teeth, more especially as each operator will seek for himself such shapes as suit his own views, and are adapted to his own method of operating. The use of the file or other coarse cutting instrument completed, the rough surface left by that instrument has next to be removed, and a smooth and polished one, free from angles or depressions, substituted. In the production of this surface pumice powder may be used after the file is abandoned, and subsequently chalk, applied by means of a strip of linen or a piece of wood cut into a suitable shape.

The median or distal side of a front tooth is the situation in which the file is most commonly applied, and the operation will leave the dentine exposed to a greater or less extent. Now, if the rough or grained surface left by the file be allowed to remain, and be so situated that the food in mastication, or the tongue in its constant motion over the part, fails to remedy by friction the defective operation, we shall soon find the exposed dentine extremely sensitive, discoloured, and softened. Examples are sufficiently numerous in which a dividing file has been passed between two sound front teeth for the purpose of relieving lateral pressure. The division so produced has closed up, and the part placed beyond the influence of friction. In the course of a comparatively short time, each tooth the enamel of which has been cut through is attacked by decay; a cavity results, less favourable for plugging than would have arisen had the operation of filing been omitted.

Nature sometimes performs for herself an operation which is analogous to filing when properly performed, both as regards its physical peculiarity and its results. The walls of a broad but shallow cavity produced by caries break down, the softened tissues are exposed to friction and rubbed away, till at last the hard dentine is reached; this becomes brightly polished, and endures for an indefinite time unaltered.

The frequent occurrence of unfavourable results has led many to regard with considerable distrust the operation of filing, and the distrust is justified when the instrument is used upon sound teeth for the purpose of relieving the lateral pressure of one tooth upon another. But we may see cases in which great advantages have resulted from the operation, and it will not be difficult to discover the conditions the observance of which has led to those advantages. In the majority of cases it will be found that, with the whole of the disorganized, a considerable portion of sound tissue has been cut or filed away, and the surface resulting from the operation placed within the influence of the food in mastication, and of the tongue. In order to secure these two conditions, it may be necessary to remove so much of a tooth as will interfere with its appearance. It is better, however, that the form should suffer slightly than that the whole tooth should be lost.

The file only has been spoken of, but instruments known as enamel cutters, or chisels, are frequently used in conjunction with the file. With these instruments the diseased part may, in many cases, be removed much more rapidly, and with less inconvenience to the patient, than with the file, and the surface will be quite equal to that produced by the latter instrument.

And the comfort of the patient is not the only advantage possessed by the enamel cutter over the file, for with the latter it is often difficult or impossible to avoid removing much of the labial surface of the tooth, which so far as the ultimate results of the operation go, might have been allowed

to remain, and the absence of which must prove very disfiguring. Thus, it need hardly be said that, in operating upon an upper incisor, the anterior surface of the tooth should be as little encroached upon as possible, the removal of the enamel and dentine being confined to the median and lingual surfaces. Supposing the contiguous surfaces of two teeth to be affected, the interval between them produced by the operation should be wedge-shaped, the edge of the wedge being directed towards the lip, and the base towards the tongue.

If the bicuspids or molar teeth were subjected to a similar operation, the edge of the wedge-shaped interval would be directed towards the gums, and the base on a line with the masticating surface of the teeth; the separation would also be wider towards the tongue than towards the lips.

A very useful form of enamel cutter has been recommended by Dr. Arthur for the cutting down of teeth with the object of leaving a smooth and well-shaped surface. It consists of a thin flat blade, of hardened steel, the edge of which has been ground off square. Thus the cutting edge is a right angle, and it will be found very efficient in removing dense enamel; it may be made of very various shapes, its peculiarity being that as the edge is a right angle, it can only be conveniently sharpened when the blade is thin; it may be left almost or quite hard without danger of chipping, if the quality of steel be good.

Corundum disks used in the engine have greatly facilitated the excision of caries and the subsequent polishing of the surfaces, and much was hoped from the introduction of disks charged with diamond dust, but these have proved on the whole far inferior to those made of corundum and shellac; recently disks made of corundum and vulcanised rubber have been made, and promise to be superior to anything of the kind hitherto produced, but as yet they have been successfully made only by individuals, and those in the market are not nearly as good as they can be made.

Sand-paper and emery-paper disks are also very serviceable.

The results of cutting away superficial decay in such a manner as to leave a polished and thoroughly exposed surface are often exceedingly satisfactory; the difficulty, however, lies in the selection of cases, for it is at times attended with the most disastrous results. It is often possible to recognise cases of caries in which, although the diseased part might be removed by the file, its use would be injudicious. At all times the sensation produced by filing the teeth, to say the least, is very disagreeable; but in certain states of the teeth the procedure is attended with great pain, so much so that the operation cannot be properly performed. Again, when we find associated with caries a thickened and vascular condition of the gums generally, and more especially of those parts which pass between the teeth, together with an exudation of the thick ropy mucus to which I have already referred, the operation of filing will be attended with very doubtful success. If we filed out a small cavity, it is probable that in a short time another, equal to the extent of dentine exposed, would take its place.

Yet it has been proposed by Dr. Arthur [1] to very greatly extend the applicability of this operation, and to use it not merely as a remedy, but as a preventive against the attacks of caries; and his views, with certain differences, have been endorsed by Dr. Bonwill (Dental Cosmos, August, 1879). Starting with the assumption that in certain individuals decay of the teeth is perfectly certain to occur, and that these individuals may be, with but little chance of error, recognised by the dentist, he proposes to cut away sound teeth soon after their eruption, in such a manner that they may be isolated from one another. Where doubt exists as to the necessity of such a procedure,

[1] Treatment and Prevention of Decay of the Teeth. R. Arthur, M.D. Philadelphia, 1871.

he advocates separating the incisors from one another as soon as they take their places, and carefully examining their proximal surfaces; he states his conviction that if the smallest indication of caries is detected on their proximal surfaces before the twelfth year, the molar and bicuspid teeth are perfectly certain to be attacked. To quote his own words, "What I propose is the separation of teeth closely in contact, which are of such frail character, and are exposed to such destructive influences, that their decay is inevitable, or has already occurred."

Although it is probably true that the treatment of caries by excision and subsequent polishing of the surface might be practised with advantage more frequently than it is, yet it may be doubted whether there is much evidence in favour of so bold a plan of treatment as this. In the first place, it is undoubtedly true that there are some mouths of which the dentist may confidently predict that almost all the teeth will successively decay; but are not these exactly the cases in which every point of exposure of the dentine made by the file, or enamel cutter, becomes a starting point for caries? And, on the other hand, are not those favourable instances in which caries has never recurred after its first excision, almost always to be found in mouths where the strong early tendency to caries which prompted the operation has ceased to exist, though in such a case it will have done some good service in tiding over a period of danger.

Then, too, it is admitted by Dr. Arthur that the operation may have to be repeated over and over again, and that constant care and attention is required on the part of patients. But, as has very truly been remarked by a critic, had all this polishing with tape, &c., been carried out by the patient without any operation having been performed, interstitial caries would probably have never occurred, and it is exceedingly difficult to secure such a degree of attention in any patient, much more so in one of early age.

If the separation be carried right through down to the gum the teeth are very prone to shift their position and close

up again, necessitating repetitions of the operation, and involving great loss of tooth substance; even if they do not, the inevitable exposure of the gum at the bottom of the wedge-shaped spaces will lead to its being kept in a state of irritation by food forced down upon it.

They can only be kept from closing together by leaving a shoulder of limited area close to the edge of the gum, and caries is very apt to occur in the neighbourhood of these points of contact.

The treatment by free excision may be resorted to in those cases where teeth of obviously delicate structure are attacked in every interspace shortly after their eruption. It is within the experience of almost every practitioner that there are cases in which, after endless pain and trouble, the teeth are nearly all lost at a very early age, and the operation of filling, no matter how well conducted, ends in utter failure. Excision also may fail, probably will, but it offers a chance for the preservation of the teeth.

A higher degree of success is attainable with front teeth than with others, as their shape lends itself to the formation of a good self-cleaning interval, without the leaving of an awkward shoulder at the gum.

Another means of arresting caries may be touched upon here. Where the necks of teeth are superficially softening all along the periphery of the gum, so as to render it impossible to fill them, at all events without the sacrifice of a large amount of as yet sound tissue, a free application of powdered nitrate of silver will often succeed in arresting the attack. The softened tissue becomes quite black and slowly wears away, leaving, if the treatment have been successful, a polished mahogany brown surface on which caries does not recur. Many teeth may be saved by this means which would probably have been lost had any other form of treatment been adopted, but it is hardly admissible in the front of the mouth where the teeth are much seen.

In the treatment of caries, filling must ever be regarded as the great remedy by which the disease may be arrested,

and the defective tooth restored to a state of efficiency. The operation consists in the removal of the disorganized tissues, and replacing them by a material fitting perfectly the cavity produced by their removal, and capable of resisting the chemical influence of the oral fluids, and the mechanical effects of the food during mastication.

The disorganized portion of the tooth is cut out, and the lost part is made good by an inorganic material.

There is, perhaps, no other operation performed upon the human body which is attended with the same unqualified success as that of filling teeth, for we not only succeed, in the great majority of cases, in arresting the further progress of disease, but we also replace the part which has been lost by an imperishable material, and render the organ as useful as it was prior to becoming the subject of caries. It is, however, a great error to suppose that filling will, under all circumstances, permanently save the tooth, even in cases which at the time the operation is performed promise favourably.

There are those who are disposed to regard the decay of a tooth which has been filled as the result of want of skill or of care in the operator; such an opinion is perfectly untenable, when the character of the operation is considered in connection with the tissues which are involved, and the various conditions under which disorganisation may be effected. The very fact that caries has appeared in a tooth demonstrates its predisposition to disease ; and a filled tooth is not better than the same tooth was before it decayed, except in so far as the caries may have occurred at some spot specially weak, so that this having been cut out and the cavity filled, no other spot equally susceptible remains. This is notably the case in crown cavities in molar or bicuspid teeth, in which caries has occurred at the bottom of a natural pit or crevice. We can, for the time being, arrest the disorder and put the tooth back to the point whence it started, but it may reappear in some other part of the tooth, and may in fact commence a second time in the enamel and

dentine in the immediate vicinity of the plug, which will then form part of the circumference of a new cavity. Such results will occasionally arise in the practice of those who use the utmost skill in their operations, and they will be seen still more frequently among the patients of those whose cry is infallibility. The ultimate success of an operation will in great part depend upon the skill with which it is performed, but it will not depend wholly upon the operator. There are other sources of failure than the assumed want of skill in operating, and such as are not under the control of the dental surgeon or of the patient.

In some mouths the majority of the teeth will contain plugs of various ages, ranging perhaps over a period of twenty or even forty years, all of them looking bright, and the contiguous dental tissue free from discoloration, the mucous membrane of the gum healthy in appearance, and free from adhesive mucus. In another mouth, again, in which there are many plugged teeth, treated by the same operator, we may find each plug surrounded by discoloured dentine, associated with a thickened and vascular state of the mucous membrane. With the lapse of time the decay indicated by the discoloration extends, and the plug falls out. Again, instances will be seen in which a number of plugged teeth, after standing without appreciable change for years, show signs of giving way—not, however, in consequence of the defective character of the operation, but in consequence of failure in the general health, and a concomitant vitiation of the oral fluids.

Attention has been called to the fact, that instances will occur in which the operation of filling fails to secure a permanent advantage, not for the purpose of depreciation, but in order that its value as a mode of treatment may be fully recognised and rendered independent of the injurious effects which the exaggerated expectation encouraged by some, and the want of justified confidence entertained by others, have a tendency to produce in the minds of those whose field of observation has been but limited.

The operation of plugging is divided into two distinct stages—the first of which is confined to the removal of the disorganized tissues and the production of a cavity of suitable shape; the second consisting in the introduction of the material used for making the plug. For the present the preparation of the cavity for the reception of the plug must receive attention, and upon the proper performance of this the ultimate success of the operation will in great part depend.

In the treatment of a case, one point for decision will be the extent to which the diseased dentine can be removed. The general rule is to cut out the disorganized tissue, until the walls of the cavity present the colour of healthy dentine; but there are exceptions to this rule. In the first place, the dentine may have become to a certain extent discoloured, and yet have retained its normal hardness. Again, the discoloration, and even softening, may have advanced so far into the tooth that the removal of the whole would endanger the exposure of the pulp. If the pulp be exposed during the operation, the loss of the tooth is to some extent endangered; consequently it is better that a layer of discoloured dentine should be allowed to remain for the protection of the pulp, than to run the risk of sacrificing the tooth. Supposing that the walls near the orifice are strong and sound, it does not appear that the retention of a little slightly-softened dentine at the bottom of the cavity interferes seriously with the durability of the plug. The presence of any softened tissue at or near the orifice of the cavity must, however, be carefully guarded against, for the neglect of this precaution would be followed by the extension of the disease.

An exposed edge of disorganized dentine will allow solvent fluids to pass through it to the sound tissue, rapidly or otherwise, as the surface exposed is relatively great or small, and spreading from a single point at the circumference of a plug, the decay will by degrees encircle it with a softened and porous layer. This, though a sufficient, is not the only reason for attending carefully to the removal of all the dis-

organized tissues near the orifice of the cavity. It is next to impossible to produce a sound and solid plug the circumferential boundary of which is soft and yielding, and the difficulty would be still farther increased if the substance against which the gold is pressed be saturated with moisture. The retention of softened dentine, even in the bottom of a cavity, should, if possible, be avoided ; but if it be allowed to remain both in the bottom and on the side of a cavity, the operation of plugging will be attended with but temporary advantage. The gold in such cases cannot be fully condensed either by direct pressure against the bottom or against the sides of the cavity by the process of wedging.

The first step of the operation is not, however, completed on the removal of the softened tissue, for the resulting cavity would seldom present a form favourable for the retention of the plug. When the disease has penetrated to a short distance only, the removal of the decayed part would leave a mere concavity, the sloping sides of which would favour the escape of the plug when pressed upon one side only. It consequently becomes necessary, after the disorganized matter has been taken away, to proceed with the excision of more or less of the healthy tissue, until a cavity of suitable form has been produced. A cylindrical hole may be regarded as presenting the most advantageous form for the reception of a plug, but it is in a comparatively limited number of cases only that this regular figure can be obtained. A certain degree of approximation can, however, be generally reached, and the nearer the approximation the greater will be the facility with which the operation of plugging is performed, and the greater also will be the chance of producing a durable plug.

When the disease has advanced to a greater extent than it is assumed to have done in the preceding example, the removal of the softened tissue will often leave a large cavity, the orifice of which is considerably contracted, owing to the enamel, and perhaps a thin layer of the subjacent dentine,

having resisted the influence of the destructive agents more successfully than the more deeply-seated tissue. It might be thought that the overhanging of the sides of the orifice would favour the retention of a plug, and the assumption would perhaps be justified if it were practicable to introduce a perfectly solid plug in a cavity so shaped. Unfortunately it is extremely difficult to force a filling under a projecting ledge so as to produce even a moderate degree of solidity in the part which occupies the angle; and the consequent imperfection is still further increased when, in condensing the surface, considerable pressure is directed in a line from the top to the bottom of the plug, the effect of which is to depress the gold and carry it away from the under surface of the projecting margin of the cavity. The plug may have a very satisfactory appearance when finished, but in a comparatively short time evidence of failure will be discovered. That portion of the tooth which overhangs the plug being but imperfectly supported from within, will break down, moisture will find its way around the plug, decay will be re-established, and if the operation is not repeated, the tooth will be lost.

In order to avoid unfavourable results arising from the foregoing cause, the overhanging edges must be cut away, if not sufficiently to produce rectilinear walls, yet to reduce the angles to moderately curved surfaces. The walls of a cavity may bulge outwards or inwards, but anything approaching to receding angles or sharp corners must be avoided. It may be necessary to repeat, that the pressure applied by the filling instruments condenses the gold only in the line in which the force is directed. The metal is condensed beneath the instrument, but it does not spread to any appreciable extent in the lateral direction, unless a perforation be made by the instrument, and the direction of the force thus changed; and in no case will the condensation extend to any considerable distance. For instance, if gold be pressed into an acute angle, it will become hard upon the surface pressed upon by the instrument, and also upon the

surfaces which have rested upon the sides of the cavity which at their point of junction form the angle, but the gold which lies in the angle will remain porous. If the instrument used were in each case sufficiently sharp or pointed to fit into the terminal point of the angle, of course the gold could be forced into it, but in practice it would be extremely inconvenient to encounter such a difficulty, and under the circumstances of an angular depression extending around the cavity, impossible.

When the cavity is very shallow, the general rule with respect to the sides being parallel may be deviated from with advantage. It will be well to make the bottom comparatively flat and the sides rectilinear, or divergent from without inwards. It may happen, however, that this form cannot, owing to the condition of the tooth, be produced; that the convergence will be from without inwards, giving the outline of an inverted cone. To render a cavity so shaped capable of retaining a plug, one or two shallow grooves should be cut around the circumference of sufficient depth to hold the gold firmly in its place when forced into them in the operation of filling.

It will be unnecessary to enter farther into the form of cavities until we consider the operation of filling in special cases; but there are other points in respect to the procedure which may be considered in connection with cavities generally.

The strength of the walls of a cavity is a very important subject. It is useless to leave a portion of a tooth standing which a trifling degree of force will at any time break down, and thus expose the plug; and it is worse than useless to leave that which will give way during the operation of filling, and thus perhaps endanger the whole tooth. An unwillingness to interfere with the appearance of a tooth not uncommonly induces the operator to attempt the preservation of a part which eventually gives way, and necessitates the performance of a second operation under circumstances less favourable than those obtained on the first occasion, and

the tooth is left in a more unsightly condition than it would have been had the fragile portion been freely cut away in the first instance. The absolute strength required will vary with the position which the tooth occupies in the mouth. In a molar tooth, which has to sustain the full force of mastication, the walls of the cavity must be composed of enamel and dentine, with a considerable thickness of the latter; whereas in front teeth a much thinner layer will be found sufficient. Indeed, in incisor teeth the enamel alone, if the extent be limited, is sometimes sufficiently strong, when supported by a plug, to endure for many years. The colour of the gold may show through at the point where the dentine is entirely absent, and yet there may be sufficient strength in the enamel for the maintenance of the plug and of its own structure.

There is yet another point in the formation of a cavity to which attention may be advantageously directed.

The character of the margin of the orifice is scarcely less important than the shape of the cavity itself. As a general rule, the plugs which are surrounded by enamel are more durable than those inserted in cavities the margins of which are partly formed by dentine or cementum. It is consequently desirable to preserve, if possible, the former tissue, and to remove the dentine at the margin of the orifice in such a manner as to allow the gold to come in contact with the enamel, so that the dentine may be wholly covered over and protected. Where the circumference of a plug is bounded by strong enamel, as on the masticating surface of a molar tooth, the undulating character of what we may call the top of the wall is unimportant; but should dentine form a part of the whole of the boundary, as it may do when the disease is situated on the mesial or distal side of a tooth, it will be necessary to reduce the orifice to a flat and smooth surface.

There are a variety of other considerations which come into play in determining the amount of tissue which shall be cut away; one is the nature of the filling material which is

to be inserted; for instance, if it is proposed to use gutta-percha, the chief failing of which is its softness under wear, it is well to leave all the enamel which can possibly be allowed to remain, for there is no difficulty in filling under deep undercuts, and the plug will last much the longer from being a little more protected by enamel.

But were we about to use gold, the retention of similar rather thin edges would be quite bad practice for reasons partly detailed above. Again, a gold filling being tough, can itself afford to have thin edges which run out over the enamel, and it is often advisable to bevel outwards the margins of the cavity so that the gold may overlie it; but had amalgam been selected, the margins should be left quite square, as its brittleness would render any thin edge certain to speedily break off and leave a dangerous crevice round the plug; moreover, feather edges are never watertight in amalgam fillings.

Another point for consideration in shaping the cavity is the relation of the tooth to its neighbours; if, for instance, we are filling two contiguous cavities, it will be better that filling shall touch filling, instead of enamel touching enamel, so that it will be sometimes well to cut away more than would otherwise be necessary simply for the sake of removing the junction of the filling and the enamel from contact with the next tooth, and bringing it to a point where it will be fully exposed to the cleansing action of the tongue. But this will have to be again discussed in connection with contour filling, so that it will be sufficient to merely allude to it here.

Then again it is desirable that the lines of cleavage of the enamel prisms be borne in mind, and the margins be so shaped that no half fibres remain; *i.e.* that the edge shall be composed of enamel fibres the ends of which are solidly supported by dentine.

It is hardly possible to enter at any length into the very various forms of instruments which have been devised to prepare cavities for the reception of the filling materials, but

a few words may be said as to the chief groups into which they may be divided.

For the removal of enamel, which is in a large proportion of cases the first step to be taken in order to get access to the cavity, enamel chisels of different sizes are employed; these should be made of the finest steel, and the temper left very nearly hard. This necessitates that the edges shall not be thin, or they would fly, and so enamel chisels should have an edge formed at a somewhat obtuse angle; indeed, Dr. Arthur's pattern consists of a thin blade, the edge of which is ground quite square, *i.e.*, the edge is a right angle. Such a chisel does not cut, nor can it advantageously be used to cleave off large pieces of enamel, but it works admirably when applied so as to pare or scrape away from the surface of the tooth substance, and may, for example, be used to make V-shaped separations between the backs of front teeth.

In the use of those enamel cutters which are brought to an obtuse-angled edge, the lie of the enamel prisms at that particular part of the tooth should be kept in mind, and the instrument if possible be so applied as to cleave off successive layers; it will be found of advantage to scratch the surface along the line of the intended cut before putting pressure upon the instrument, so as to cleave off the piece attacked.

Figures of a few of the most popular forms of enamel chisels are appended, but no two operators will affect precisely the same forms.

Dentine is removed by means of excavators, instruments of almost endless variety of form; figures of a few are here given, and it may be mentioned that the so-called spoon-shape will be found to be of all others the one which is capable of the widest application.

There is, however, one property which should be possessed by all, whatever the shape or size of the instrument. It should be made of good steel, and kept perfectly sharp. A blunt instrument tends to prolong an operation which is

Fig. 141. (1)

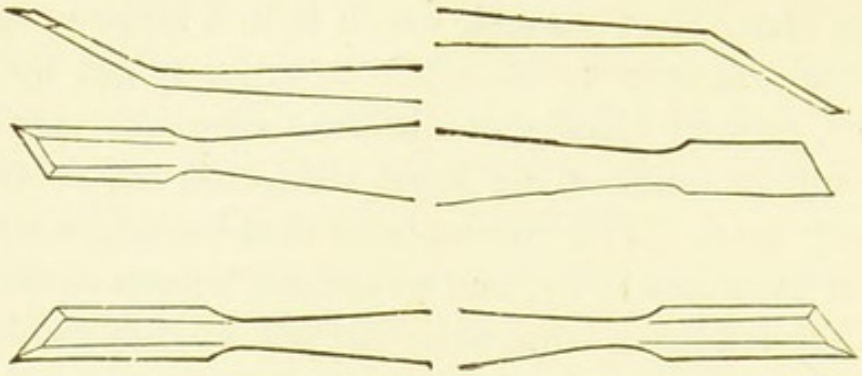
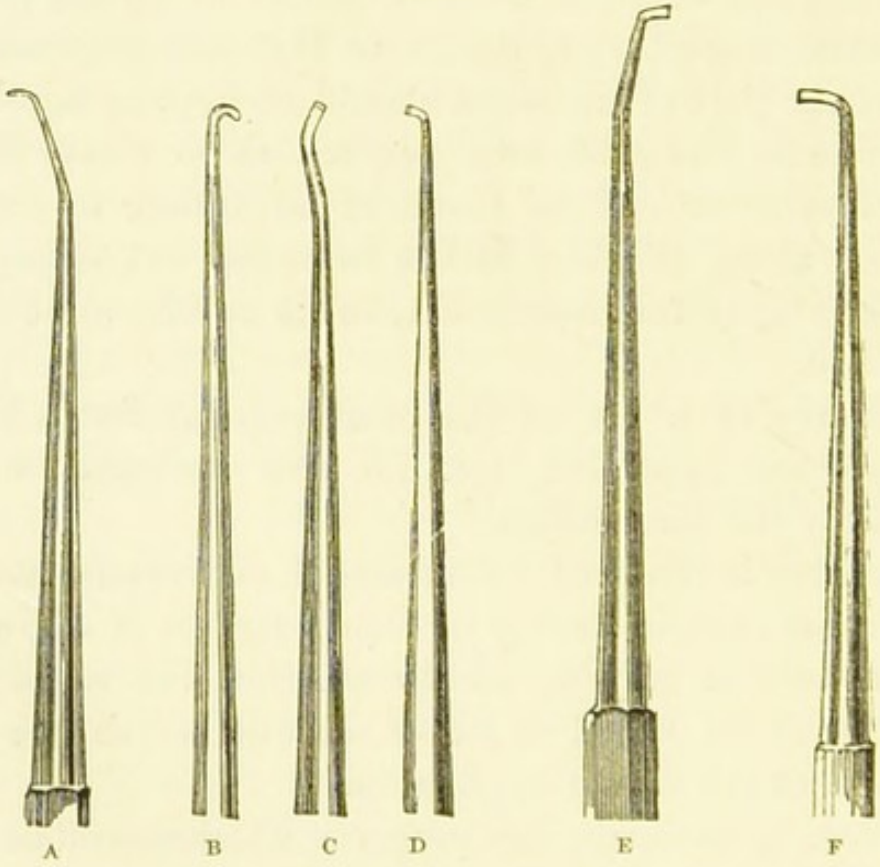


Fig. 142. (1)

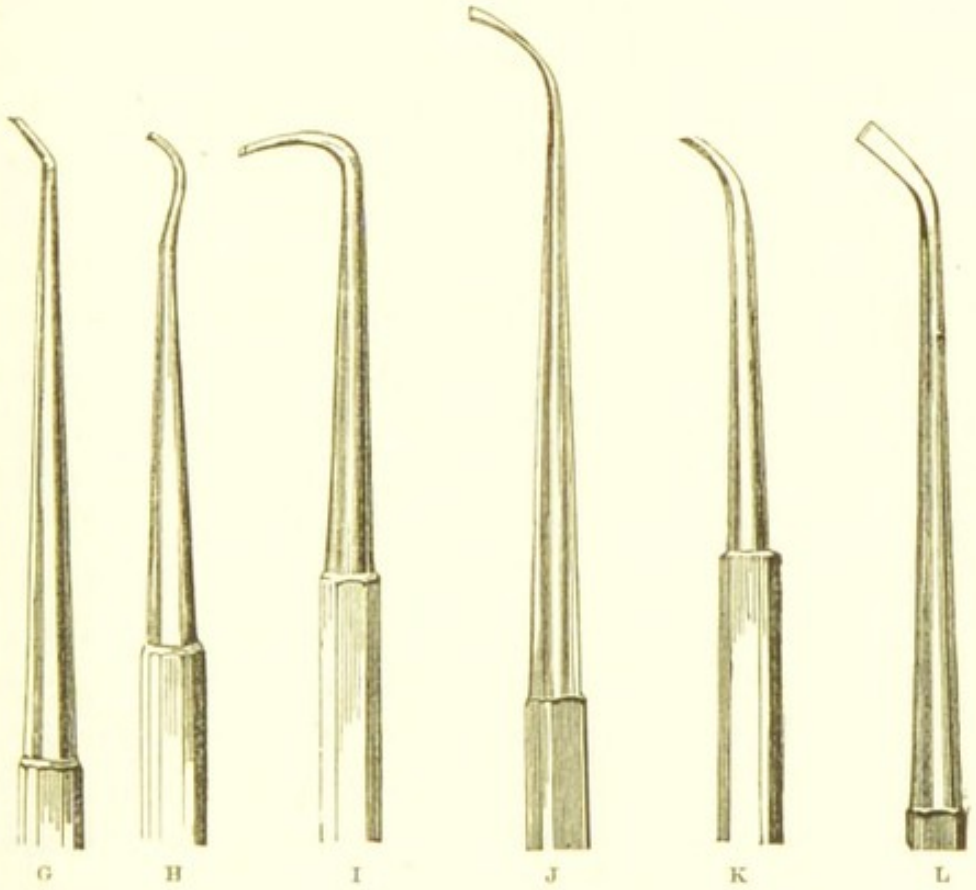
Fig. 143. (2)



(1) Enamel chisels.
(2) Excavators.

always disagreeable and sometimes very painful. With a perfectly sharp excavator the diseased tissue is quickly removed, and with a comparatively slight amount of discomfort. A few rapid and well-directed strokes of the

FIG. 144. (1)



blade, and the softened tissue is cut away, and although a proper form has yet to be given to the cavity, the subsequent steps of the operation are seldom productive of as much discomfort as attended the removal of the softened tissue. In the removal of softened dentine from a tender tooth, the excavator should be used in such a manner as always to *cut*, and not *scrape;* this is a point which can hardly be too strongly insisted on, though it is very often neglected.

(1) Excavators.

The introduction of the dental engine has in no small degree rendered obsolete the old-fashioned rose head, which cut by a slow revolving movement; but even now for certain purposes it holds its own as superior to the more modern instrument. A well cut rose head, with coarser teeth than would be appropriate in an engine burr and left of very hard temper, will cut enamel in a way that cannot be attained by a rapidly revolving tool, and will moreover keep its edge long, while the other will not; so that a few rose heads of fine quality and temper will always be found useful.

FIG. 145. (1)

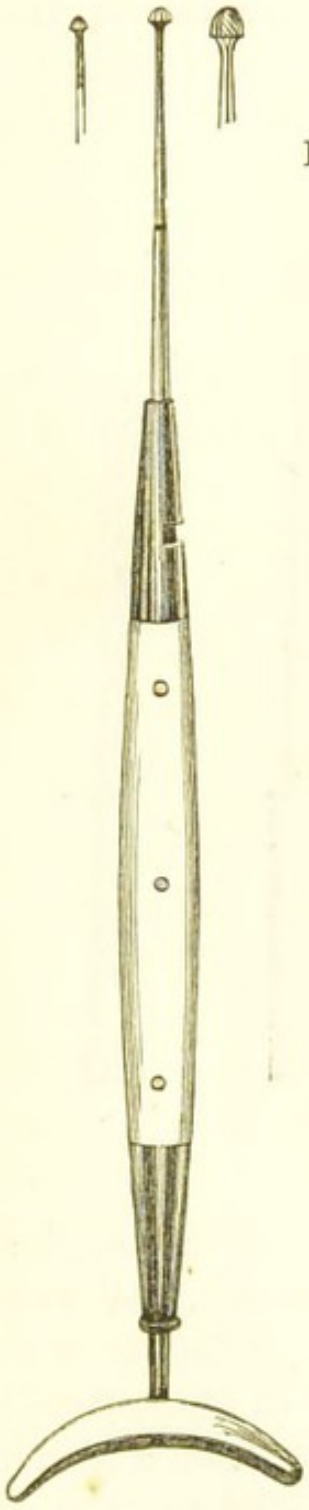


FIG. 146. (1)

Not much need here be said about dental engines, but it is only fair to put upon record something of its early history, which, in the universal adoption of its principle, is perhaps in some danger of being forgotten.

Whatever may be the facts as to priority in the invention of the principle of conveying rotary motion by means of flexible spirals of steel, whether it was first propounded by Nasmyth, the inventor of the steam hammer, or whether it originated with the patentee of a horse-clipping or sheep-shearing machine, of which we heard much in the early days of the machine, there cannot be the smallest doubt

(1) Rose-head burrs.

that we owe the instrument in its practical form for dental use entirely to the mechanical genius of Dr. Morrison, and the different forms which have been since constructed have merely rung the changes upon his ideas.*

Dr. Bonwill's engine, however, makes no use of the rotating spiral, the endless band being in the case of this instrument carried down to the hand piece over a series of pulleys situate at the points of flexion of a jointed arm; and Jamieson's new engine makes use of friction wheels in place of a band.

Cases are not infrequently met with in which the carious dentine possesses such an exalted degree of sensibility that its removal cannot be borne, and the patient flinches from the slightest touch of any instrument. A minute quantity of arsenic placed in the cavity, and retained for a few hours, will render the part absolutely insensible to pain. The objection, however, to such a course is the difficulty of limiting the action of the arsenic to the surface on which it is applied. It may find its way to the pulp, and occasion the death of that organ —a condition speedily followed by discoloration of the whole crown of the tooth, and very probably by the supervention of alveolar abscess. Thus Dr. Kingsbury relates an instance in which arsenic had been used for the purpose of obtunding the sensibility of dentine, and had caused the ultimate death of the pulp in no less than seven teeth in the mouth of one individual.

Hence the use of arsenic is perfectly inadmissible when the cavity is deep, and it can only be used with any degree of safety for allaying tenderness of the layer of dentine immediately beneath the enamel. If it is to be used at all, it should be applied *dry*, or very nearly so, to avoid the risk of its reaching the deeper portions of the dentine, and the cavity carefully sealed, preferably by a temporary filling of gutta percha. But as there are other agents which are

* The earliest specification of a dental engine is that of Dewar: but it does not appear to have been of practical utility.

capable of reducing the sensitiveness of dentine, its use is to be strongly deprecated; though it must be admitted that it is the most efficient and most certain in its action of all the remedies proposed for the purpose.

Next to arsenic, in point of efficacy, comes zinc chloride; a small fragment of the partially deliquesced salt, or a piece of wool dipped in the solution produced by allowing the salt to deliquesce, will, if held in the cavity for a few minutes, greatly reduce the sensitiveness of the dentine. The application of the zinc chloride often causes severe burning or aching pain for a few minutes, but after this has passed away, little tenderness remains. Although the application is painful and less efficacious than that of arsenious acid, it is to be preferred, inasmuch as there is little danger of causing the death of the pulp. I have lately adopted a manner of using the zinc chloride which is convenient, and yields satisfactory results. A small fragment of cotton wool is teased out till it is very thin, and mixed up in some very fluid zinc oxychloride; then put into the tooth and left to harden there, just as though a dressing of gum sandarac were being applied. Zinc oxychloride, even when mixed up thick, contains some little free zinc chloride, and when used very fluid (which we are enabled to do by incorporating a little wool with it), there is an ample amount of the free salt to allay the sensitiveness of dentine. After the lapse of a few days, this dressing, which does not cause so much pain at the time of its application as that of the pure salt, is removed, and the tooth is then usually tolerably insensitive to the touch of an instrument.

Ethylate of sodium is of some avail for this purpose; it appears to act by the formation of caustic soda, which while in the nascent state (being formed when the ethylate meets with the water in the tissue) acts as a powerful caustic without giving rise to much pain. The salts of cocaine, from which so much was expected, have proved disappointing as applications to sensitive dentine; when concentrated they appear to actually give rise to pain.

A variety of substances, such as chromic acid, caustic potash, and other escharotics, have been used for this purpose, but the results are by no means such as to recommend their employment. Camphorated spirits of wine, tannin, carbolic acid, or thymol, repeatedly applied on cotton wool, will generally reduce the sensibility sufficiently to allow the operation to be performed; and, in fact, any form of temporary filling introduced, with sufficient care to exclude the saliva, will soon be followed by a subsidence of the extreme sensibility of the tissue.

Of sedative applications, perhaps the most efficacious is the extract of Cannabis Indica, thinned with water, spirits of wine, or chloroform. In many cases this will, after the lapse of a few minutes, materially reduce the sensitiveness; its use was, I believe, first suggested by Dr. Harlan, of Chicago.

MATERIALS USED FOR FILLING TEETH.

The perfect material for filling teeth has yet to be discovered, those ordinarily employed being all, some for one reason and some for another, imperfect. The qualities that are to be desired are—

(i.) That it shall be hard enough to resist mechanical attrition.

(ii.) That it shall be able to resist the chemical actions to which it is exposed in the mouth.

(iii.) That it shall be easy of adaptation to complex forms of surface, so as to enable it to form an exact water-tight plug.

(iv.) That if introduced soft it shall undergo no change of form or bulk in hardening.

(v.) That it shall be a non-conductor.

(vi.) That it shall be non-irritant.

As no one of the materials known fulfils all these desiderata, and yet each has its own points of excellence, it behoves the operator to think what he most desires, and what he can best dispense with in the individual case, and so to make his choice of material intelligently.

Clinical experience has furnished us with much information on the relative merits of different preparations, but there are other points which can be best elucidated by experiments carried out under conditions of greater rigour than can be secured in the mouth. One of the most useful tests which can be applied is the capability of the filling to form a perfect or water-tight plug, known as the

"ink test." This consists in taking an extracted tooth (properly moistened if it have been long extracted), carefully preparing the cavity of decay, filling it, and then immersing it for five or six hours in an ink-pot—preferably Draper's ink. The tooth is then broken, and the extent to which, if any, the ink has penetrated between the filling and the tooth ascertained. Any one who experiments in this direction for the first time will be quite astonished at the extreme difficulty of making a tight filling with either gold, amalgam, or gutta percha.

Other experiments, to be alluded to later, have been made with a view to ascertaining the changes in the form and the bulk of amalgams as they set, employing the methods of specific gravity determination, or of exact measurement of thin slabs of the material.

It will be convenient to take first in review those materials, the imperfections of which are so manifest that plugs made with them can only be regarded as temporary fillings.

There are a variety of conditions, such as a doubtful exposure of the nerve, extreme sensitiveness of the dentine, or the pouring out of a certain amount of discharge through or from the pulp cavity, which render it undesirable to insert a permanent filling. We may have resort to some of the various temporary fillings, either for the specific object of curing one of the conditions which preclude the immediate use of a permanent filling, as, for example, the use of gum mastic and creasote when the nerve is slightly aching, or the insertion of a gutta percha filling in a tooth very sensitive to changes of temperature ; or we may employ them simply then as experimental fillings, to be replaced by permanent plugs so soon as we are satisfied that no mischief is going to be set up by the tooth being filled.

When from any such cause it is inadvisable to place a permanent filling in a tooth, we have recourse to various substances suitable for temporary purposes. Solutions of various gum resins in ether or alcohol are exceedingly

useful; gum sandarac, animi, mastic, copal, or dammar, reduced by the solvent to the fluidity of thin treacle, may be introduced into the cavity on a suitable piece of cotton wool. By evaporation of the solvent, and partly by its dilution by the saliva, the gum is precipitated, and forms with the wool a tolerably hard mass, capable of lasting for some days, or even a few weeks, though, as a general rule, it should be renewed every two or three days. The cavity should be dried out with cotton-wool, or what is better, amadou, before the introduction of the mass.

There is but little choice between the gum resins enumerated; either of them, in a state of solution, will answer sufficiently well. I give the preference to gum sandarac, as being more free from taste than the others, if copal be excepted. But ether being the solvent of copal renders the solution rather less manageable than those made with alcohol. The rapidity with which the ether escapes, however well the bottle in which it is kept may be corked, very soon reduces the solution to a condition unavailable for dental purposes.

Gutta percha, with which some mineral substance, such as powdered silex or glass, has been incorporated, makes a remarkably good temporary filling, capable of lasting for some time. In using this compound, pieces of suitable size must be taken, and warmed over a spirit lamp until the whole mass is softened. The cavity having been dried, the heated gutta percha is introduced, and the superfluous portion removed with a warm instrument. Care must, of course, be taken that the filling is not too hot, otherwise its introduction will be attended with pain. But, on the other hand, it must be sufficiently warm for the surface to be a little sticky, or it will not adhere to the surface of the cavity. Care must also be taken that the gutta percha is not burnt when it is heated over the flame. An excellent method of securing its adhesion to the walls of the cavity is, after thoroughly drying the cavity, to mop it out with a pledget of wool dipped in chloroform; or better still, in a

solution of gutta percha in chloroform; this secures good adhesion. A little chloroform applied in this way is also often very useful for smoothing the edges of gutta percha fillings.

Of all the temporary fillings in use, the preparations of gutta percha are far the most reliable, for it is not acted upon by the fluids of the mouth in any very appreciable degree; in fact it lasts better in the moisture of the mouth than it does when freely exposed to the air. In situations where it is protected from mechanical attrition it is exceedingly durable, and may rank with so-called "permanent" fillings. It is exceedingly difficult to make an absolutely water-tight filling with gutta percha, so as to withstand the ink test perfectly, and yet its record as a preservative of the tooth from an extension of decay is usually very good. Some advise the use of very small pieces, each introduced and consolidated into place before the next is added; others advocate the employment of a piece nearly as large as the cavity. Whichever method be followed the filling should be finished with cold burnishers, slightly greased, as in this way the surface is cooled somewhat and the edges sealed as completely as the nature of the material allows.

Some of the advocates of a more extended use of gutta percha prefer to use red gutta percha, believing that the admixture of glass, or what not, and the bleaching of the gutta percha, although hardening it somewhat, yet renders it more destructible; and the red "base plate" gutta percha preserves a smoother surface in the mouth than the other forms.

For dead teeth gutta percha is exceedingly valuable, as it can readily be removed if need be; and its non-conducting powers and low specific heat render it useful in cavities which are sensitive to heat and cold to a degree which prohibits the employment of a metallic plug. But although its greater durability where protected from wear gives it an advantage in many tender teeth, yet as a means of render-

ing comfortable an irritable tooth upon the verge of aching, it must yield the palm to the so-called "osteoplastics."

Those in ordinary use are modifications of oxychlorides or oxyphosphates of zinc. Zinc oxide is mixed with a strong solution of zinc chloride into a thick paste, which, after the lapse of a short time, becomes perfectly hard. Different makers introduce different substances which in some degree modify the rapidity with which it sets, and possibly alter the resultant compound to some slight extent. Thus borax is often introduced into the fluid; and powdered glass, or actual silica, into the powder, for the purpose of mechanically conferring greater hardness on the mass when it has set. But the various osteoplastic fillings which I have examined differ only in slight and immaterial points, and the objections which can be urged against one, apply, I believe, almost equally to all.

The zinc oxychlorides are a class of bodies for the most part readily decomposed by the action of acids and alkalies; moreover, the manner in which the mixture is made precludes the possibility of a definite chemical compound, without excess of either constituent, being formed. As a matter of fact, there is always free zinc chloride to be found in the finished filling, and the filling is consequently hygroscopic. The objections to its use, which embody the results of many experiments, have been elsewhere described (1), and it is only necessary here to say, that experience of its use in the mouth goes to confirm the conclusions which had been arrived at on chemical grounds, namely, that it is unreliable.

I have never seen an instance in which a zinc oxychloride stopping, which was at any point in contact with the gum, remained intact for any considerable length of time. No matter how carefully it has been applied, if it reaches down to the gum, sooner or later it will assuredly fail; and this practical result is nothing more than what might have been expected from purely chemical considerations.

(1) C. S. Tomes, in British Journal of Dental Science, vol. xiii., p. 552. On Zinc Oxychloride.

Where, however, it is away from the edge of the gum—as, for instance, on a grinding surface—it lasts much longer, though it wears down with the friction of mastication. But where it is wholly protected by being covered in under a gold filling, it lasts an indefinitely long time.

And where it has been successfully introduced, without setting up undue irritation in the pulp, it is perhaps the most comfortable of any filling in a tender tooth. And notwithstanding the escharotic qualities of zinc chloride, a thin cream of zinc oxychloride has been often flowed over an exposed pulp with successful results, so far as capping of the nerve went. For the purpose of capping nerves, Mr. Fletcher has introduced a preparation which consists chiefly of zinc oxysulphate; this has the advantage of being merely astringent and not escharotic, but it lacks hardness, so that it is necessary to complete the filling with some other material.

As a *temporary* filling, then, zinc oxychloride is very valuable; but it has no claim to the name of a permanent filling. In applying it the paste should be used very dry, and the filling carefully protected from moisture till it has fully set; this may be done either by keeping the rubber dam applied to the tooth, or by varnishing its surface with a solution of gutta percha in chloroform. But all our precautions are to some extent futile, for the paste has hygroscopic properties which cause it to imbibe water from the atmosphere even after it has hardened; nevertheless, it is very essential to prevent a flood of saliva from washing away the zinc chloride before it has had time to combine with the zinc oxide.

Within the last few years a fresh group of osteoplastic fillings has been introduced, in which phosphoric acid takes the place of hydrochloric acid.

Phosphoric acid has modifications—metaphosphoric and pyrophosphoric acids—which differ from it in the number of equivalents of water; and these forms pass into one another somewhat readily. Thus, a solution of metaphosphoric acid

when boiled passes into orthophosphoric acid; pyrophosphoric acid may be prepared by evaporating a solution of orthophosphoric acid at a temperature about 215°; but it, in presence of water, slowly passes back into the ortho-acid at ordinary temperatures. Each of these acids is capable of forming a number of different salts—monobasic, dibasic, tribasic, or tetrabasic salts—with the same metal, and thus a large number of zinc phosphates are known. The subject is one beyond the scope of these pages, but even from what has been said it will be seen that very small differences of treatment will give rise to different results, and thus it happens that there are quite a number of rival preparations in the market, differing not greatly, but still distinctly from one another. Their exact constitution is usually a trade secret, but most of them are believed to form pyrophosphate of zinc with varying quantities of other phosphates admixed.

The insolubility of the different salts varies greatly, so that for each preparation there is probably a method of manipulation as respects heating, &c., which yields the best results, and this may help to explain the difference of opinion which exists as to the respective merits of the various preparations.

As a class, the zinc oxyphosphates are to be preferred to the oxychlorides, as they are not only less irritating, but they are less affected by the fluids of the mouth. They, nearly all of them, require protection from moisture while setting, though "Fossiline" appears to need this less than the others; to many of them the access of water appears to be specially destructive, apparently quite altering the nature of the compound formed. As they all require to be mixed stiffly, they are less available for nerve-capping, and some other protective should be placed immediately over the point of exposure. Poulson's cement, Fossiline, Weston's and Ash's phosphate cements are all favourite forms, but which is really the best is as yet quite undecided. A slightly greased agate burnisher will be found very useful

for giving a surface to them, and they all cling well to the dentine, so that much undercutting is not needed in any cavity. At the margin of the gum they fail, like oxy-chlorides, but far less rapidly; so that many practitioners pack a layer of gutta percha against the cervical margins before introducing the cement.

Amalgams.—It is difficult to read with any patience the literature which has accumulated about the use and properties of amalgams, for not only is it very voluminous, but it consists for the most part of mere vapourings and tirades, every other sentence of which would serve to demonstrate the writer's ignorance of the rudiments of physics and chemistry, or would form a capital parody upon the methods of scientific experiment. Of course there are exceptions, and valuable unpretentious papers do exist, which really advance our knowledge of the subject, amongst which may be mentioned those of Mr. Fletcher, Mr. Kirby, Dr. Hitchcock, Dr. Bogue, Dr. Foster Flagg, Dr. St. George Elliott, and a few others.

Metals, when melted together in certain definite proportions, undergo changes in specific gravity, which prove that they are not quite mere mechanical mixtures, but that some sort of chemical union has taken place between their components. Of this the several varieties of fusible metal are a good example, for they have melting points below those of their constituents. Mercury has the property of dissolving many of the metals, and, after the lapse of a little time, of entering into a loose or firm combination with them; thus, when palladium is rubbed up with mercury it is at first dissolved, but very speedily a compound is formed, with the evolution of a sensible amount of heat, which is solid, and so the amalgam sets. The compound thus formed is not easily broken up again, but in the case of copper it is different; in the well known Sullivan's amalgam the mercury originally mixed with the precipitated copper is set free under the influence of heat, and the mass becomes plastic; left at rest again for a time it recombines

and the amalgam sets again, this process admitting of indefinite repetition.

When, instead of a simple metal like copper, a mixture of a number, such as tin, silver, and copper, or tin, silver, and gold, be taken, the mercury at first dissolving them brings them into intimate relation with itself and with one another, just as melting would have done, and then they combine with greater or less speed, according to the particular metals and the proportions in which they are present; thus, some amalgams set in ten minutes, while others take two or three hours.

There are defects to which all amalgams are open, and as yet there is a good deal that is imperfectly understood in their behaviour.

It would be out of place to enter at any great length into the chemical and physical properties of amalgams in this work; they have been more fully discussed elsewhere (1); but there are some few characters shared by all of them which require mention here. Dissatisfied with the amalgams then in use, I undertook an extended series of experiments with the view of determining the real sources of failure, and was led to the conclusion that chemical action on the alloy had little or nothing to do with it, but that amalgams at no time form perfect plugs. Every one of those which were submitted to experiment contracted as it became hard; some very greatly, others less; but still all contracted to an extent that must imperil the preservation of contact all round the circumference of the plug. But this contraction takes place with the greatest rapidity in the first few hours after the amalgam has been mixed up, and subsequently is slight in amount, though it is often not completed for twelve hours. Hence we may partly get over the difficulty by employing an amalgam which sets with great rapidity, such as palladium. In using this metal as an amalgam the

(1) C. S. Tomes, on "Physical and Chemical Properties of Amalgams." Transactions of Odontological Society, March, 1872.

greater part of the shrinkage is over before the plug is completed.

General experience had already shown that of all amalgams in use, palladium was decidedly the best, and that next to this came copper; and it was exceedingly satisfactory to find, in my experiments on this matter, that these two displayed less shrinkage than any of the others. But of the numerous amalgams submitted to experiment there was not one which did not contract markedly as it hardened; so that they must, one and all, *à priori* be pronounced imperfect. It seemed that the addition of platinum to silver and tin amalgams greatly hastened their setting, whilst the addition of gold lessened their contraction; there is, however, a limit to the quantity of gold which can be advantageously added, inasmuch as it eventually interferes with the complete setting of the compound; but subsequent researches have shown that no statement quite so simple as this is of universal applicability.

There is, however, another fault possessed by amalgams, which was pointed out by Mr. Kirby: not only do they contract, but they often undergo considerable changes in form as they harden. Thus, he found that on moulding specimens of amalgams into the form of long bars, with a view of measuring their longitudinal contraction by a micrometer screw, that in some instances it was impossible to replace the sample in the little trough used for the purpose.

From various grounds, it might seem advisable to use as little mercury as possible in mixing up an amalgam, and to be probable that the most durable plugs would be made in this way; but it should be mentioned that in Mr. Kirby's hands the bars which showed the greatest alteration in form were those which had been mixed very dry.

Inasmuch as the solvent powers of mercury are greatly increased by warmth, if it be desired to introduce the amalgam in a very dry and almost friable condition, warm instruments should be employed.

The experiments which I made were in the first instance

conducted by filling teeth out of the mouth and immersing them in the ink-pot; upon splitting them subsequently it was found that with the exception of palladium water-tight plugs were rarely or never obtained. But as this method gave no means of comparing the results with one another, it was soon abandoned in favour of the plan of taking the specific gravities on first mixing, and then at intervals until the amalgam had set. This, which was done by means of a very delicate chemical balance, with the observance of every precaution against error which occurred to me, in the way of the observance of constant temperature, the use of an exceedingly fine wire for suspension, &c., afforded a means of comparing the contractions of different compounds, and of the same compound used in different ways. More recently Dr. St. George Elliott, adopting the same method, has carried out a far more extended series of experiments upon about forty of the compounds most commonly in use (Trans. Odonto. Soc., Feb., 1884). He finds that almost all contract, Fletcher's "expanding" amalgam included, unless this last was used very dry; but with palladium he did not experiment, owing to difficulties in the way of making it, with its quick setting, compare with his other experiments.

There are some factors which render it probable that the results obtained are all more or less wrong, but up to a certain point the results may be fully relied upon as indicative of important facts as to the relative shrinkages; one thing which probably upsets the accuracy of all the determinations is that amalgams give out heat as they set, and this in very varying degree, and they many of them set very quickly. The first weighing must, therefore, be performed pretty rapidly, and thus it is impossible to give time to ensure the temperature of the interior of the mass being at exactly the same point as that of the water. In the paper will be found a good deal of valuable information as to the strength of the various amalgams when made into disks of uniform size and shape, and it is most clearly

brought out that no general law can be laid down as to the proportion of mercury to be used, as different compounds behaved their best, some with little, some with much ; it was, however, unusual for very dry amalgams to give results satisfactory in respect of shrinkage.

Another curious result was, that there often appeared to be a slow change going on in bulk for a long time after apparent setting, that is for days and even weeks ; but I strongly suspect an experimental error in these minute estimations of change, not so much from any inherent improbability in their occurrence, as from their minuteness, which approached the limits of sensibility of any balance which could be employed.

Dismissing for the moment the most serious defect of amalgams, viz., that of failure to produce a water-tight plug, some of their other shortcomings may be touched upon, such as their tendency to discolour themselves, and also to stain the tooth. Given the same amalgam, the discoloration is greatest when much mercury has been used ; palladium, which combines with a very large amount of mercury, gets very black itself, but it does not stain the dentine at all ; copper which takes up far less, stains the tooth deeply ; the old amalgams made by filing up silver coins also stained the tooth deeply, and the cadmium amalgam, at one time introduced, stained the tooth a deep yellow colour, thereby demonstrating conclusively that the staining was due to the formation of the sulphide of the metal in the substance of the dentine ; and although they are most of them hard enough to resist wear, yet they are brittle, so that the edges are prone to chip away. Yet with all these disadvantages, they are a class of bodies so useful as to be quite indispensable to the dentist. But before going into the demerits of amalgams, and the best ways of meeting them, it will be as well to say a few words about a charge which, if proven against them, would banish them wholly from the materials of the dentist as being unsafe.

It has been said that the mercury in amalgams is so

feebly held that it can escape and exert its poisonous effects upon the person in whose mouth the filling is, and upon those who handle them. Mercurial salivation, headache, insomnia, diarrhœa, amaurosis, aphthæ, loss of memory, gangrene of the mouth, and most other ailments, have been attributed to this fell agency. But it happens that there is ample internal evidence in the reports of the cases to relieve us of the necessity of paying much attention to the dicta of the writers, and it is at least curious that these gentlemen see not one, or two, or three cases, but they see them by dozens, though other practitioners seeing at least as many patients, but handicapped by the habits of scientific accuracy, never see one at all.

Some years ago it was alleged that the use of red rubber for plates had in numerous instances within the experience of a single hospital physician produced salivation and other untoward results. The Odontological Society of Great Britain, recognising the great importance of ascertaining whether this belief was true, sent out a circular inquiring from all its members whether they had ever had reason to suppose that such a result had come under their personal notice. The outcome of this collective investigation was, that not a single instance could be found in which there was the least ground for accepting the conclusions of the writer alluded to, and it was clear that he had accepted evidences of ordinary inflammation arising from irritations of the most familiar kinds, such as want of cleanliness, &c., for the effects of a specific poison. The fallacy of *post hoc ergo propter hoc* runs through almost all that has been written on this subject, even where there is not actual carelessness of observation or recklessness of assertion.

To any who may be curious to see to what a climax of absurdity some writers have attained, I would recommend a perusal of a paper which is to be found in the Ohio State Journal of Dental Science, 4th December, 1882. I spare the writer the mention of his name, though he hardly deserves to be spared anything in the way of severity of criticism.

A few cases have occurred which have attained to a degree of notoriety, which renders it desirable that they should be noticed here. In the Medical Union of New York, Jan., 1873, a case is related which at the time attracted much attention. A lady in good health, free from strumous or syphilitic taint, had arsenic applied to an exposed nerve; it was removed next day, but after a week of pain she sought the advice of another dentist, who, finding the nerve dead in the one, but alive in the other root, cautiously applied it again. *At that time, however, he had noticed that some exfoliation of the anterior wall of its socket was commencing.* Three days afterwards, though the parts around were then exquisitely tender, he filled the tooth with amalgam. A period of intense suffering followed; she became prostrate with hectic fever, and was at times delirious; pus oozed from the sockets of the teeth, which all became loose, so that several were removed without the use of any forceps, and mingled pus and saliva were constantly oozing from the mouth. As the patient was evidently in great danger, the whole lower jaw was removed, the periosteum being carefully preserved. The patient rapidly recovered, and in the space of six months a new jaw formed, which was firm enough to allow an artificial denture to be inserted.

There hardly seems a possibility for doubt that in this case the escape of arsenic, known to have occurred, was followed by extensive acute necrosis; and it seems hardly credible that the medical attendant, as well as several dentists, should have adopted any other view; yet it was confidently set down as a case of mercurial salivation, caused by the amalgam filling. This diagnosis was based largely on the occurrence of salivation, ignoring the familiar fact that there is always a profuse flow in any acute inflammation in the mouth, and the still more significant fact that commencing exfoliation had been noticed prior to the insertion of the filling, at which time there was excruciating tenderness around the tooth.

The foregoing case I have quoted at some length as being

a fair sample of the sort of evidence that we are often asked to accept as proof that amalgams do all sorts of mischief; it so happens that it was reported in sufficient detail to allow of our forming our own opinion upon it, but it more commonly happens that the report is so imperfect that the data for a conclusion are really not there; but even in such there are often little pieces of internal evidence which lead one to doubt the competence of the reporter to form a just opinion; indeed, I may say, that, having given close attention to every instance known to me of alleged mercurial influence from an amalgam filling, I have never met with one single account which upon internal evidence appeared to me to be worthy of any particular consideration.

Without going so far as to say that it is a physical impossibility that an amalgam should exert the effects of mercury upon a person in whose mouth it has been placed, it may safely be said that clinical experience is wholly opposed to such an idea, and that I personally have never read of any case which would even tend to make me suspect its having exerted any baleful influence. Indeed I may go so far as to say that a careful perusal of the papers of those who have advocated a contrary opinion has done much to convince me that it never does happen, and I venture to predict that with the advance of liberal education which will ensure to the dentist some degree of acquaintance with collateral subjects such as physics, chemistry, and therapeutics, we shall hear no more of this bugbear. Dismissing, then, this objection, we may classify the valid defects as follows:—

1. Shrinkage in setting.
2. Change of form in setting.
3. Want of toughness or of hardness.
4. Discoloration of the surface of the amalgam itself.
5. Staining of the substance of the tooth by it.

Shrinkage, the defect from which none of them are free, save only palladium, is perhaps the worst fault that an amalgam can possess, for it renders the production of a

water-tight plug with it almost an impossibility. Great improvement, has, however, taken place in the alloys sold in this respect, and much credit is due to Mr. Thomas Fletcher for forcibly calling attention to this point at the same time that he was experimenting to get rid of the fault with some little success. But although the addition of gold and of platinum has effected improvement, the fault still exists, and it becomes necessary to study by what methods of manipulation we may minimise it, which requires a study of the peculiarities of the compound we elect to make use of. From this point of view excessively dry amalgams appear at a disadvantage ; on the other hand, rapidity of setting, which is, *cæteris paribus*, promoted by dryness of the mixture, is a great desideratum. For it has been found by experiment that the greatest changes of bulk occur early in the process of setting, so that no small part of the total shrinkage will take place in the case of very rapid-setting amalgam before the plug has left the operator's hands, and while the edges are still being burnished against the margins of the cavity ; there is, of course, the further advantage, that there is less likelihood of injury to the filling before it has become hard enough to take care of itself. In ink experiments I have found it useful to embed in large fillings fragments of old amalgam which has already set, thereby diminishing the bulk of that which has still to undergo change, and for the same reason it is often more advantageous to patch old fillings which are falling at particular points rather than to remove them and insert a large mass of new amalgam.

Very excellent results are obtained by a method of insertion which was shown to me by Dr. Bonwill : if a piece of softish amalgam be squeezed in a pair of pliers, the excess of mercury will be forced out at the edges, and that which remains between the jaws will be found to be very firm and to set very rapidly. Something of this effect he obtains by squeezing it in the tooth itself; he introduces it in a thoroughly plastic condition, in moderate sized pieces, and subjects it in the cavity to heavy pressure, with small

pledgets of paper, the result being that very fluid portions appear round the edges, whence they are removed, and more amalgam introduced, to be treated in the same way. As much force is employed as would be required to consolidate a soft foil plug, and if a rapidly setting alloy such as Dr. Bonwill's own be used, by the time the last portions are introduced those first compacted will be far advanced towards hardening; very fine results may be obtained by this method of manipulation.

This method of dealing with an amalgam is quite opposed to the tenets of many of those who have written on the subject, who say that an amalgam should never be squeezed because the more fluid part which is expressed is not merely mercury, but contains some of the constituent metals in greater quantity than others, so that the alloy is altered in its chemical composition. There can, however, be no doubt that any *large* excess of mercury in the first mixing is very detrimental, for it is not likely to be thoroughly squeezed out, and any large proportion is almost sure to lead to ultimate discoloration of the filling.

In the case of Sullivan's copper amalgam, Dr. Elliott's and my own experiments concur in showing that when used exceedingly dry the shrinkage is increased; this applies with more or less force to many amalgams, but not quite to all.

Discoloration. — Palladium, however manipulated, will become of a lustrous black, and copper amalgam likewise will become black, unless its surface is exposed to rapid attrition, in which case it will keep tolerably bright. Other amalgams differ greatly in respect of liability to darken, but the dryer they are used the better they will resist, and the addition of gold to the alloy is of advantage. The bestowal of a fine surface by polishing after the amalgam is hard will do much to preserve it, and there are quite a number of amalgams in the market, which thus placed under favourable conditions, will keep colour fairly well in the majority of mouths; there are some mouths, however, in

which no amalgam will preserve even a tolerable brightness of colour.

Staining of the Tooth.—The greatest offenders in this direction are copper amalgam and the old silver coin amalgam; palladium is free from this defect, perhaps because it is truly water-tight; and several of those which contain a material quantity of gold and platinum discolour the tooth but little if used with proper care. Much may often be done to prevent discoloration by lining the cavity with oxychloride or phosphate of zinc, or even by varnishing the cavity with a solution of copal or of gutta percha in chloroform; leakiness of the filling of course brings about discoloration by the decomposition of the surface of the amalgam, which is in apposition with the tooth, and it must be remembered that amalgams are almost always imperfect in this respect, while the white plastic fillings are quite perfect.

Change of Form in Setting.—There is not very much exact knowledge upon this, but extreme dryness is believed to be unfavourable in its results; on the other hand it is certain that rapid setting would be advantageous, inasmuch as there would be less change after the filling had left the operator's hands, and some of it might have been corrected by the final burnishing of the edges.

Want of Toughness or of Hardness.—There is no amalgam in ordinary use of such toughness that its edges can safely be left thin, as the edges of a gold filling may be; the edges of the cavity should be so formed that nothing like a feather edge should be left, and if this precaution be neglected, the edges of the amalgam will infallibly break away and leave a crevice likely to leak. But amalgams differ much in their strength; here again the reduction of the mercury to moderate amount is usually advantageous, whilst its extreme diminution is often the reverse of advantageous.

The so-called felts of tin are to be classed among the amalgams, and though they are not exactly plastic and do not set, yet they are compounds of mercury and tin,

and owe their physical properties to this. They are not of much use as materials of which to make a complete filling, but many operators like them as foundations for a large gold filling, as the gold will to a certain extent adhere to the tin, to a sufficient extent, at all events, to render easy the commencement of the building on of cohesive gold: for my own part, however, I prefer actual tin-foil in these positions where anything of the sort is desirable.

Tin.—Owing to its greater softness tin may be manipulated in larger pieces than gold, and therefore with greater rapidity; for the same reason it is comparatively easy to make water-tight plugs with it, and it is less spoilt by the access of moisture during the progress of the work. These qualities render it useful as a filling for children's teeth, and for certain portions of the fillings of adult's teeth; it resists attrition fairly well, and although its surface becomes dark it does not stain the tooth, nor is it acted upon by the fluids of the mouth beyond this superficial discoloration.

It is by many operators used for commencing the cervical edges of interstitial fillings, its use being abandoned in favour of gold when that part of the cavity has been lined; and it is thought that failure at that most vulnerable point is thereby rendered less frequent. The only disadvantage appertaining to this method is that there is in time a black line at the edge of the filling, and this may be mistaken for failure at this point, particularly by an operator not accustomed to see tin thus used.

Tin is also employed in conjunction with gold, the metals being more intimately mixed; a sheet of tin is enclosed between two sheets of gold and then twisted into ropes or cut into strips, &c., according to the fancy of the operator, and when thus dealt with the mixed metal works with almost the softness of pure tin.

It, however, possesses this peculiarity, that after a time some chemical action takes place which extends deeply into the mass, in consequence of which the plug takes on much

the appearance of an amalgam, and becomes exceedingly hard, cutting with a peculiar gritty cut.

Some think that this change takes place more fully if the access of moisture has not been prevented; however this may be, it is certain that a most serviceable plug may be made with the mixed metal under circumstances where the partial access of moisture would have wholly ruined a gold filling. The fillings are quite hard enough to withstand the wear of mastication, and are in certain places very valuable, but they do not look very nice, and are therefore not suited to places exposed to view.

Gold.—Gold, as prepared for the use of dentists, takes two very distinct forms, which are distinguished by the terms cohesive and non-cohesive, or soft. The difference does not appear to be one of purity, as soft foil at once becomes cohesive on being strongly annealed, but it appears to consist in some trifling difference in physical condition, of a nature not well understood; indeed, it may be doubted whether even the most successful manufacturers of soft foil know more than an empirical plan of treatment which they very generally keep to themselves. However that may be, there is far more difference between the soft foils of various makers than there is between the cohesive foils, which are, of comparatively speaking, uniform quality. An endless controversy goes on as to the respective merits of the two forms, which seems no nearer to its settlement than it was when it commenced.

If fragments of cohesive foil be shaken up together in a pill-box, they will cohere so firmly that they can only with difficulty be torn apart, but pieces of soft foil so treated will not stick together at all. It is obvious that this quality is a very valuable one when we wish to make a filling; but there is unfortunately a fault to set off against it, namely, that it is a harsh material which does not readily adapt itself to an irregular surface like that of an average cavity, but on the contrary, it has a strong tendency to ball up under the instrument, and so curl away from the tooth. At

one time I made a large number of experiments with various forms of gold, inserting fillings into teeth out of the mouth, and dropping them into an ink-pot to test them as to water-tightness. The general result of our experiments was to show that with tin or with soft foil it was a matter of ease to get a tight plug, but that with cohesive foil it was so difficult that we but rarely succeeded, and then only by the use of gold in exceedingly small pieces, such as $\frac{1}{2}$ A cylinders. In fact, we came to the conclusion that the difficulty being so great when the tooth was in a vice, on all sides accessible, it was only in a minority of cases that the same result could be hoped for in the mouth.

A form of gold has been recently introduced by Wolrab of Bremen, which combines, in a degree not hitherto attained, the qualities of softness and cohesiveness; this has been imitated with more or less success by other makers, their preparations being named "velvet gold."

The qualities which we desire in a soft foil are, that it shall be tough, so as not to crumble under the instrument, and that it shall be exceedingly yielding and free from harshness; as there is no true cohesion, the portions of the plug are held together by being intimately interlaced and wedged against each other, and this is only attainable by the several portions sliding readily over one another as they are introduced; any approach to cohesiveness is therefore destructive to its working properties and would result in the plug containing hollow places.

With cohesive foil, a totally different set of properties is desired; each piece should cohere to that already in place at the smallest touch, and so far from sliding over it, it should never move in the very smallest degree after it has once touched the filling. The cohesiveness of foil is destroyed by the least moisture, grease, &c., so that it is important that it should not be handled; exposure to the air even seems to have an effect in destroying its properties, so that it should be kept protected. Annealing restores its cohesiveness, but it is difficult to anneal it with such regu-

larity as to get its best properties when once it has deteriorated.

Soft foil is used in the form of foil variously folded or rolled up, the object being, whatever the form preferred, to secure some degree of parallelism in the layers; it is also frequently rolled up into cylinders of various sizes and hardness, and in this form the parallelism is excellently well secured.

Cohesive foil is prepared in pellets which consist of many super-imposed layers of very thin foil, but it is more frequently used simply folded in strips or in ropes; many operators in place of folding it prefer to use rolled or beaten foil of a thickness equivalent to that which they would have obtained by folding a thinner foil; these so-called heavy foils are numbered 10, 20, 40, 60, 70, up to 240; these numbers denoting that a sheet of the ordinary size would contain that number of grains.

Another form of gold adapted for filling teeth has been produced by chemical means. The metal is thrown down from a state of solution in a more or less crystalline form.

Mr. Makins, late Lecturer on Dental Metallurgy to the Dental Hospital of London, was, I think, the first who procured sponge or crystal gold, as it is now called, with a view to its being used for dental purposes. His preparation consisted of minute octahedral crystals, connected loosely together by fibres, which at parts exhibited a crystalline character, the whole forming a spongy mass of dead gold colour. The sponge under pressure became consolidated, in which state it could not be distinguished from solid metal. Additional pieces of the sponge, if added to that which had already been condensed, on the employment of moderate pressure became adherent. This adhesive or welding property rendered the gradual formation of a plug, solid in all its parts, a matter of but little difficulty, and in the absence of a distinct recognition of the adhesive properties of certain samples of foil, the new gold appeared to offer

great advantages, and seemed likely to supersede the use of foil in certain characters of plugs. I have seen, from time to time, fillings which were made with Mr. Makins' first batch of sponge, and up to the present period they have remained unaltered. A description of the gold, with the manner of using it, was published by my father.

Mr. Makins did not enter upon the manufacture as a commercial matter. The subject having attracted notice, others attempted to produce a similar preparation, but the results were so unfavourable, that for a time the use of the sponge gold was abandoned.

Subsequently Mr. Barling, of Maidstone, gave his attention to the subject, and introduced a sponge gold not altogether dissimilar to that which Mr. Makins produced. It was formed mainly of octahedral crystals and indistinct fibres.

Soon after the production of sponge gold in this country, the attention of transatlantic practitioners became directed to the subject. Many experiments there as here were made, with very questionable success. Ultimately, however, a very beautiful preparation was made by Mr. Watts, and this is, I believe, the only form of sponge gold used in America. We know it as Watts' American crystal gold, the valuable properties of which have been very strongly put forward by Dr. Dwinelle and others in the American dental journals. The gold comes to the hand of the operator in the form of light spongy cakes, readily compressible between the thumb and finger. Several degrees of density are produced, but the character of the gold is otherwise the same. By the aid of the microscope we are enabled to see that the American differs in its structure from the English sponge gold. Each is crystalline, but while the latter consists of crystals of the form normal to the metal, the former is made up of beautiful foliaceous crystals closely resembling in general appearance the leaf or frond of a common fern. They have considerable superficial extent with very slight thickness, and lie together greatly entangled and interlocked.

In the earlier samples a considerable amount of amorphous

gold was entangled amongst the crystals, and in some cases oxide of gold was present in a small amount. These imperfections have been remedied, and the reguline condition is obtained by all the manufacturers. More recently samples of sponge gold prepared in Paris reached this country.

In order to command the best results in the use of the crystal gold, four points require attention.

The gold must have been recently manufactured, or recently annealed, in order that the adhesive property shall be fully pronounced. The plugs must be built up of small fragments, each one being perfectly consolidated before another is added. The metal must be preserved from the contact of moisture until the plug is formed. And appropriate instruments must be used in performing the operation. The neglect of either of these conditions will be followed by an unfavourable result.

Sponge gold on exposure to the atmosphere soon loses its peculiar adhesive quality, and becomes quite unmanageable; instead of welding together under the stopping instrument, it falls to pieces, and all attempts to make additions to that which is already consolidated are unsuccessful; on this account it is desirable to anneal the metal where any doubt exists as to its condition. By the process of heating, the adhesive property is restored, even though the temperature to which the gold is exposed falls short of a red heat. But to whatever extent the welding property is produced, the presence of moisture will at once render it unavailable. The metal, from its porous condition, absorbs like a sponge, and instead of consolidating under the pressure of the instrument, works up into powder. We must therefore guard against the admission of the saliva, and also protect the tooth under operation from the expired breath, which being charged with moisture will, if the metal be of a lower temperature than itself, deposit upon it a sufficient amount of fluid to interfere with the cohesive property of the gold.

Sponge gold has not very many constant adherents, though properly manipulated it is capable of yielding the

finest results; there is however a somewhat general impression that there are pitfalls which render a failure of a kind not always visible at the time rather more likely to occur with it than with any other form of gold. Thus it is possible to get a plug which looks very hard and dense on the surface, but which is porous beneath, and perhaps against the edges; such a result is very likely to happen if the operator, seduced by the facility with which it is packed, is tempted to use fragments which are too large.

It is, however, very useful to make a foundation whereon to build cohesive foil, as it is easy to make it lie dead, and it will occasionally help out of a difficulty in filling a shallow cavity in which it is for some reason or other not desirable to make retaining points, and where the cavity is of such shape that there is but little hold; in such positions its property of packing dead and not rolling is of much value.

In instituting a comparison between gold foil and crystal gold, the microscope may be called into requisition with advantage. If plugs be made in perforated pieces of ivory (in the manner already alluded to) with the various forms of crystal gold, we shall find that the surface which has been pressed upon, and has rested against the ivory, is made up of crystals, the forms of which have been unaltered by the pressure. Their presence in this situation indicates a certain amount of porosity, and it is due to the dentine not offering sufficient resistance to interfere with the crystalline character of the metal. Had the hole been in metal, instead of ivory, the inserted plug would have presented a much greater density upon the lower surface; or had the cavity been lined with enamel, a similar advantage would have been gained. In practice it is very frequently necessary to plug a tooth from which the whole of the diseased tissue cannot be removed; hence a substance softer than healthy dentine forms the surface, the resistance offered by which will be quite incapable of producing condensation of the gold to the extent obtained where the disorganized part is wholly removed: consequently, if crystal gold be used,

the enclosed surfaces of the plug will be imperfect, they will be capable of absorbing moisture, and may after a time be broken down with very slight force. On the other hand, when the cavity is shallow, with the bottom hard, and the orifice surrounded by enamel, perfectly satisfactory results may be obtained. In those cases where decay has commenced upon the labial surface of the front teeth, the crystal gold may be used with great advantage. The plug should be made to project, and then be filed down to the level of the surrounding surface of the tooth.

The attainment of absolute solidity in a gold plug made in the mouth, is not possible. If crystal gold be used, the microscope will show a certain amount of porosity; if foil be employed, it will show the presence of fissures in the peripheral surface of the plug. Now, if moisture finds its way to the surface of the former, it will spread over the whole circumference of the plug; but in the latter it will be confined to the minute fissures situated at distant intervals over its surface. After using crystal gold for some years, and examining very closely into the results, my father came to the conclusion that it is inferior to foil for the construction of that portion of the plug which rests against the dentine. But if the operation be commenced by lining the cavity with foil, the central portion of the plug may be advantageously made with crystal gold. By thus combining the two forms of gold, plugs may be produced, the density and impermeability of which cannot be surpassed.

Sponge gold, when long kept, appears to undergo some molecular change, greatly interfering with its welding properties, which are only in a measure restored by annealing.

Gold foil is prepared by beating, or sometimes, in the case of very heavy foils, rolling, into thin sheets a perfectly pure metal. The sheet when prepared for dental purposes is usually four inches square, and is numbered in accordance with its weight. Thus the Nos. 4, 5, 6, 7, 8 indicate the number of grains contained in each four-inch sheet, and recently very much heavier foils have been employed,

reaching as high as two hundred and forty grains per sheet.

The gold leaf of commerce is an altogether different article. In order to produce a leaf sufficiently thin for gilding purposes, it is necessary to introduce a certain amount of copper, as otherwise the metal when greatly reduced in thickness will not leave the vellum, between sheets of which it is beaten.

Considerable care is necessary in the preparation of the gold leaf, as it is absolutely essential that it shall possess certain physical characteristics as well as chemical purity. Thus it must be tough and soft, and must possess either a high degree of adhesiveness, or else must be completely non-adhesive. In the one case, if several strips be placed in a pill-box and well shaken, they should become inseparably united, whilst in the other they should not adhere when firmly pressed together.

Much light has been thrown on this matter of adhesiveness in a valuable paper read by Mr. Makins (1), in which it was laid down that the requisite conditions for complete welding were a perfect absence of impurities from the surface, adherent air even operating disadvantageously; freedom from moisture; and a soft, yielding condition of the metallic particles, which must not have suffered great previous compression. Thus, although silver, copper, or platinum, when in the pulverulent condition, may be welded by pressure, careless manipulation of the powder by which the particles have become in a measure burnished effectually prevents their union. Mr. Makins, in speaking of adhesive foil, says, "The surface obtained is not a smoothed one, and is far from polished; when examined by the microscope it will be seen to be covered with corrugations with corresponding depressions. The upper edges of these appear burnished, but the depressions with which the greater part of the

(1) G. H. Makins, "On the Union of Metals by Welding." Transactions of Odontological Society, June, 1872.

surface is covered are perfectly matted; and this is particularly the case in what is sold as adhesive foil, which is far more matted, and of that brown colour which, in precipitated gold, denotes but slight condensation of the metal." Again, he says, "In adhesive foil we have a rough surface, and also many of the conditions present in sponge gold. Thus, in adhesive gold it seems that the metal is only partially welded, so that it is in a very favourable condition for further welding under an instrument; whilst in non-adhesive foil the surface is already burnished, so that it has no great tendency to cohere. A very slight amount of molecular change, such as may be brought about by annealing, suffices to convert the non-adhesive into the adhesive form; this process of annealing is, however, advantageous from other causes, besides that of altering molecular condition, as it secures the absence of moisture, and also gets rid of adherent air."

Like crystal gold, gold leaf appears to undergo some molecular change when kept for a length of time, leading to its assuming a hard, harsh texture.

Whatever filling material may be decided upon it is necessary to thoroughly dry the cavity, and to keep it dry during the whole performance of the operation.

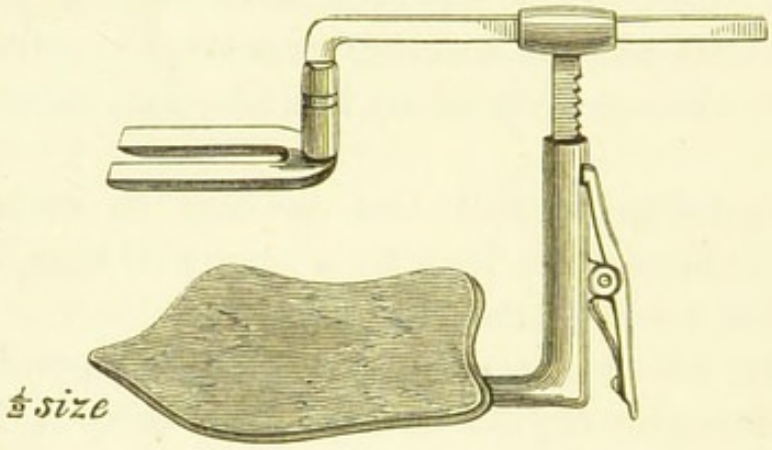
The most generally useful appliance is perhaps the napkin, variously folded, and supplemented by pledgets of bibulous paper; and this will be found adequate for most short operations, and indeed in some hands for long ones, though there are but few now-a-days who venture to trust to it in long or difficult fillings.

In applying the napkin no two operators will adopt precisely the same disposition of it, and it would be unprofitable to devote much space to a description of what can only be taught by demonstration; but it may be said in general terms that it is advisable to employ it not only to sop up the moisture in the immediate neighbourhood of the tooth, but also to prevent to some extent the entrance of saliva into the mouth by making pressure on the mouths of the

salivary ducts; thus when working in the lower jaw it should be pressed well under the tongue against the orifices of the submaxillary glands, and the parotid of that side guarded by a pad over its ducts.

On the left side of the jaw the first and second fingers of the operator's left hand may be most conveniently used to hold the napkin down, whilst in operating on the right side of the lower jaw, it will generally be more convenient to stand behind the patient and employ the thumb of the left hand on the inside and the first finger on the outside of the teeth; or the patient may be made to hold it down with one

FIG. 147. (1)



finger of the left hand. It is often, however, excessively fatiguing to hold the napkin in its place, and this may be done by a Hawes's tongue-compressor applied over the inner portion of napkin, whilst a single finger of the operator's hand holds down the outer fold. Dr. P. Smith has modified and greatly improved Hawes's tongue-compressor, and the instrument so altered is extremely useful. The figure which is here given will explain itself; in applying it the napkin is first adjusted, and then held down by the introduction of the horizontal arm with its horse-shoe end, which has been previously detached from the rest of the instrument. Whilst this is held in its place, its free end is slipped through the

(1) Dr. Smith's tongue-holder.

hole at the top of the upright (which has been previously raised to its full extent), and the padded plate adapted below the patient's chin. The upright, which is furnished with a ratchet at its back so that it will slip down, but not upwards, is then pressed down until the napkin is securely fixed. As a rule, patients much prefer the use of this instrument to the introduction of the operator's fingers.

In prolonged operations the napkins are apt to become saturated, and the difficulty of keeping a lower tooth dry by their means is often very great.

To meet this difficulty, as well as to relieve the patient of

FIG. 148. (1)

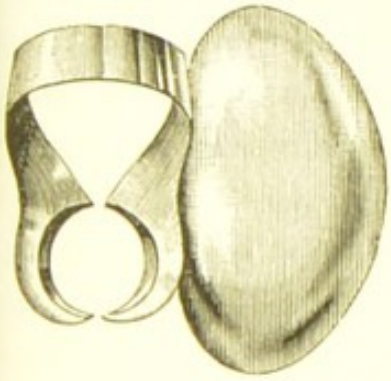


FIG. 149. (2)

the disagreeable accumulation of saliva in the mouth, saliva pumps are employed; of these there are a good many patterns, but they all have much in common, suction being exercised in a flexible india-rubber tube terminated by a glass mouth-piece, by means of the fall of water down a vertical tube. The flexible tube is so arranged that when once it is filled it goes on acting as a syphon, but the fall of water from a supply down the vertical tube is needed to start it again whenever it has drained itself empty.

In conjunction with the saliva pump a form of clasp designed by Mr. Claude Rogers, which has a shield on one

(1) Mr. C. Rogers' clamp, for use on the right side.
(2) Dr. Stokes' clamp.

side to hold the tongue out of the way, is exceedingly useful; with a pad over Steno's duct and this clamp crown cavities can be quite securely filled.

Another useful form of clamp is that of Dr. Stokes, which is a further development of Rogers' clamp; in this there are downward curved shields, beneath which rolls of bibulous paper are packed.

But the appliance which gives the greatest security against the inroads of saliva is the rubber dam, which was invented by Dr. Barnum of New York. This consists of a sheet of thin india-rubber, which must be sufficiently tough to stretch readily without tearing. A sheet of such size is taken that all four corners may be brought outside the mouth when it is applied; holes are then made in it in a suitable position, through which the crowns of the teeth are passed. These holes may be made with a punch, by scissors, or by stretching the rubber tightly over the end of an excavator handle, which must have a flat end, and touching it while stretched with the edge of a knife; a perfectly circular clean-edged hole will then be obtained.

It is seldom sufficient to pass the rubber over one tooth only; unless the tooth to be operated on stands alone, the rubber would rise so high around it that the light and the view of the cavity would be obscured. Hence it is usually passed over the tooth in front and that behind the one to be operated on; but, of course, no general rule can be laid down on this point. If the teeth stand close to one another, only about the eighth of an inch should intervene between the holes in the rubber, but if there is an interval between the teeth a larger space must be left, so that the intervening gum may be covered.

In applying the rubber the sheet is put on the stretch between the forefingers of the right and left hands, placed on either side of the first hole: it is thus forced over the front tooth, then over the next, and so on from before backwards, till all the teeth which are intended to be included are through their respective openings in the sheet.

The rubber is then slightly pulled away from each tooth, and the free edge lying against the neck of the tooth, which, from the manner in which the rubber has been applied, will look upwards, is tucked in by the side of the neck of the tooth so that it is directed downwards; this may easily be effected by the use of a burnisher, or other blunt instrument, or by waxed silk forced up. When the shape of the teeth is favourable to its retention, no further measures are required to keep it in its place; but should it tend to slip off, pieces of waxed silk may be passed down between each tooth, and their ends tied together. In other cases wooden wedges may be employed to retain it in its place, or ligatures of waxed silk tied around the neck of the tooth previously to the application of the rubber, so as to form artificial ledges, which may be increased by threading one or two small glass beads on the silk prior to applying it.

It is seldom necessary to apply the rubber dam in order to fill cavities in the grinding surfaces of upper teeth; a fold of napkin placed between the cheek and the alveolar ridge will generally answer the purpose in such cases.

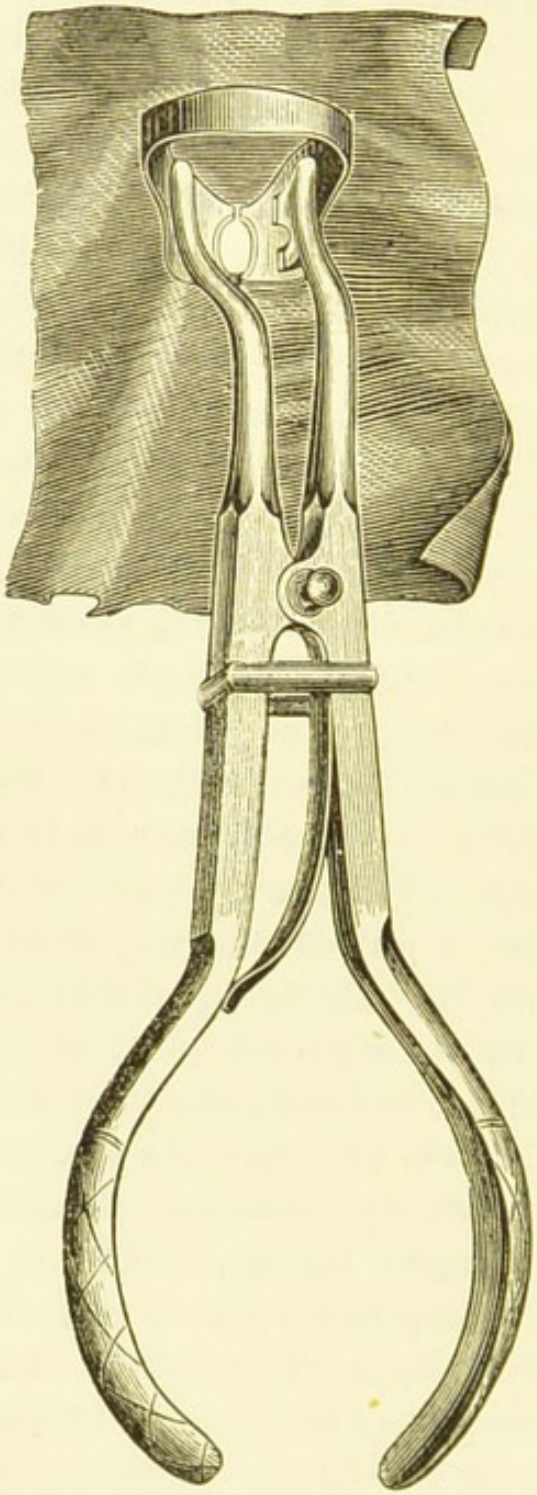
Another means of holding the rubber down, and also of keeping the tongue out of the way when it is inclined to obscure the view by bulging up the rubber, is to employ clamps; these in their proper place are quite invaluable, but they should not be used indiscriminately, as is done by some, for they add to the patient's discomfort and are not so very often absolutely necessary, though some operators seem never to consider the application of the rubber complete without a clamp being placed somewhere.

There are two ways of applying the clamp and the rubber; the clamp may be adjusted in place first and the rubber passed over it and the tooth simultaneously, or the clamp may be held in the clamp-forceps and passed partially through the hole in the rubber, and clamp and rubber put on to the tooth at once; this latter plan is often the most expeditious and the easiest.

Clamps are also very useful in holding the rubber above

the edges of cavities which extend below the cervical edges of teeth.

Fig. 150. (1)



There are a few cases, however, in which the difficulty and the pain attendant on the adjustment of the rubber

(1) Clamp and clamp forceps, ready for application to the tooth.

are such as to make it hardly worth the trouble. Minor difficulties may, however, be got over; in the first place, it may be stated as generally true that, wherever the floss silk will pass down between the teeth, it will carry down the rubber with it. When, owing to the conical shape of the tooth, the rubber, after being fairly applied, slips off, and cannot be retained by a ligature of waxed silk, it may be held down by a piece of soft iron wire, bent so as to roughly fit the tooth, and having its free ends carried out on the buccal side, where they are held down by a single finger.

In certain positions the rubber may be held out of the way by an instrument grasped in the left hand; thus, in an interstitial cavity, the cervical edge of which is below the gum, a view of the upper part of the cavity may be obtained by the use of a blunt-ended instrument bent at a right angle, which is employed to force the edge of the rubber above the margin of the cavity; when the upper part of the cavity is filled, the necessity for holding back the rubber is over, and the instrument may be laid aside.

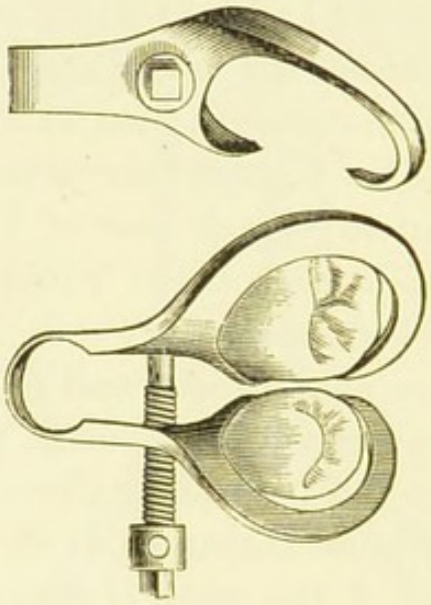
Separating Teeth.—As the teeth, and more particularly the incisors, are in close apposition, it often becomes necessary to effect some separation in order to allow of the introduction of instruments. In some instances we do not hesitate to cut away sound portions of the tooth to effect this purpose, but such a course is not always advisable. In the case of front teeth, if the decay has a considerable superficial extent, it will be well to cut away the lingual surface of the tooth with an enamel-cutter, in such a manner as to leave a V-shaped division, which does not encroach on the buccal surface. If this be not done, a cavity with brittle, ragged walls may be the result; but where the superficial extent of the disease is limited, it will be better to avoid cutting away. The required space may be gained by the introduction of strips of wood, of india-rubber, or of cotton-wool, or what is much better, of tape between the teeth.

The separation may be effected at once, or the force may

be more gradually exerted, which latter is the safest course if any considerable amount of space has to be gained.

The method of "quick wedging," as it is termed, has, however, a good many advocates, and may be first described. For this purpose two wedges of orange wood are required; one is forced between the necks of the teeth, and the second, which is more tapering, is forced between the points of the teeth. Gentle taps of a mallet are given to the latter, and the space thus gained is secured by a tap on the first wedge. Thus, by alternate taps on the wedges, the teeth are forced apart, and when an adequate interval has been gained, the

FIG. 151. (1)



second wedge is withdrawn. The force which may be exerted in this way is very great, and many untoward accidents have been reported from an incautious use of the mallet.

This method can only be recommended in the case of incisor teeth, which require to be moved through a very short distance; and it must not be resorted to where there is any unhealthy condition of the gums or alveoli.

A method of rapid separating which has a good many

(1) The Perry-Bogue separator. Dr. Perry has since added a second screw on the other side.

advocates is that by means of screw separators; these were introduced by Dr. Jarvie, and have since been modified and improved by Dr. Perry and Dr. Bogue. Figures of them are appended, which will explain themselves.

By the use of these separators an amount of space adequate for the performance of most operations may be obtained at the first sitting.

But in a large proportion of cases slow wedging will doubtless continue to be adopted. If wood be employed, only a moderate degree of force should be used in inserting the wedge, which may require to be replaced by a larger one after the lapse of a few days. If india-rubber be employed it should be in very thin pieces, which may be cut from the solid lump, or thick rubber dam may be used for the purpose. It should not be left many days without renewal, and in no case should a thick piece be introduced at once, as this would exert a degree of force which might prove injurious.

In many cases the separation may be very conveniently effected by the use of cotton-wool, firmly pressed between the teeth: this should be frequently renewed. But tape is the most comfortable to the patient, and is to be generally preferred as causing less soreness, and being less liable to worry the edge of the gum; and where several cavities have to be reached, Dr. Coffin sometimes employs one of his expansion plates.

The time required for separating teeth will vary from two to seven days, much depending on the age of the patient.

When teeth have been moved by the process of wedging, it will generally conduce to the comfort of the patient to place a wedge moderately tightly between the teeth while they are being filled, as this will keep them firmly fixed, and to a considerable extent obviate the tenderness which always exists in teeth forced from their proper position. A clamp which serves this purpose well on molars and bicuspids has been designed by Dr. Perry.

METHODS OF INTRODUCING GOLD.

In the use of noncohesive gold it is desirable that the portions of foil should slide over one another with the greatest facility, the solidity of the plug being secured by the interlocking of the several pieces, which have to be as it were entangled together, as well as keyed by the application of the last portions introduced. It is therefore not desirable to use deeply serrated instruments, and many of the most skilful manipulators use perfectly smooth points.

Dr. Dunning, of New York, and his followers, amongst whom may be mentioned Dr. Lord and Mr. Davis, made use of wedge-shaped points of various sizes, quite sharply pointed; indeed it is their practice to constantly sharpen them upon a piece of Arkansas stone which has never been oiled, so as to preserve sharpness both of the point and of the edges during the progress of the work. For the packing of soft foil I myself prefer these points to any others with which I am acquainted. The gold is prepared either in the form of twisted ropes, or of firm pellets of graduated sizes: if ropes are selected, the middle or one end of the rope is carried down to the bottom of the cavity by using the side of the instrument, and pushed up against one side of the cavity; successive portions are tucked in, taking care to preserve some little parallelism of the layers which pass from the bottom to the orifice of the cavity, and the portions tucked in by each application of the instrument should be of such length that a slight excess protrudes from the cavity. As there comes to be some little quantity of gold in the cavity, the sharp point of the plugger is used to force the gold into the undercuts, but the surface of the

plug is avoided till no more gold can be introduced. When the cavity is nearly full, small pieces of tape, or tight little pledgets are used, and when no more can be got in, the surface is condensed with a broad-faced plugger with a flat end, and then the whole surface severely tried over with a

Fig. 152. (1)

Fig. 153. (2)

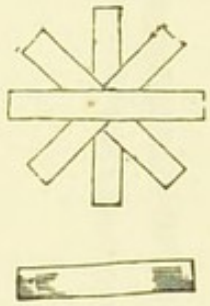
Fig. 154. (3)

smaller sharp point. If the operation has been skilfully performed the cavity is now filled with layers of foil generally parallel with one another and perpendicular to the surface of the plug, carried in by the sides of the sharp wedges, and, when in, consolidated towards the walls by the applications of the sharp points; such a plug will finish to have almost

(1) Pointed plugger of the form used by Dr. Lord.
(2) Serrated plugger, used for condensation, and also for packing annealed foil. Dr. Lord's form.
(3) Sharp-pointed plugger. Dr. Dunning's form.

the appearance of cohesive gold, but of course some degree of strength is needed in the walls of the cavity, and it must be of some depth in proportion to its surface. Instead of a rope, somewhat firmly folded pledgets might have been used, smaller ones being packed in as the filling approaches completion. A method by which a perfectly satisfactory plug may often be made with non-adhesive foil, consists in folding the sheet into a long, flat riband of suitable width, and cutting it into narrow strips. These strips, which should be rather more than twice as long as the cavity is deep, are successively picked up by a blunt-pointed plugger, so that they are arranged on its point like a star; or the strips may be so arranged on a thick piece of vulcanised

Fig. 155. (1)



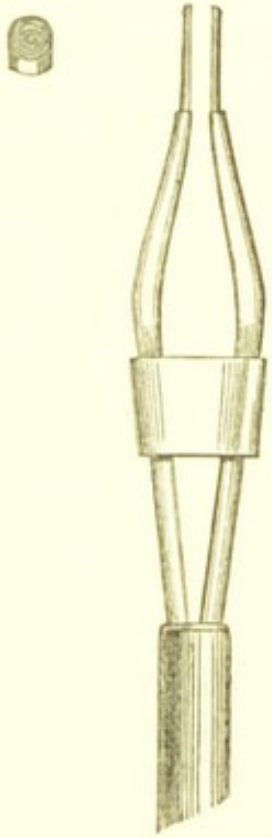
caoutchouc, and picked up by pressing the point of the instrument on the centre of the star.

In this form the strips are carried to the cavity and pressed in, leaving the radii of the star projecting; a second and a third star are taken up in a similar manner, and forced into the cavity. When the centre has become full, the projecting ends or radii may be forced in near, but not at, the circumference, by the use of a fine-pointed instrument. If the instruments have been well chosen with respect to a gradual diminution of size, an extremely dense plug will be the result.

The Americans were the first to propose the formation of the foil into cylinders; these cylinders may be made in two ways, the one by loosely folding the sheet three or four times and then twisting it into a rope, from which short

lengths are cut off; the other, by closely folding it into a flat riband, and rolling the riband round a fine broach, or what is better, an instrument made for the purpose. The cylinders produced by the first method are soft and very compressible: those by the last, much less so, the respective advantages of the two forms being dependent on the nature of the cavity.

Fig. 156. Fig. 157. (1)



The cylinders are made a little longer than the depth of the cavity which they are intended to fill, and are introduced by plugging forceps. (See Fig. 164.)

Every cylinder is placed in such a position that one end rests on the bottom whilst the other projects from the orifice of the cavity; thus, if the cavity be on the grinding surface, each cylinder will stand vertically, but if it be interstitial, every cylinder will lie horizontally. As it has been happily expressed, the cylinders are placed in the cavity like cigars in a tumbler.

Two methods may be pursued in their introduction into the cavity: a number of the tightly-rolled cylinders may be set upright in the cavity till it is loosely filled by them; a wedge or trocar-shaped instrument is then forced in between them at any point where it can be made to enter, and the holes thus produced filled by fresh cylinders. At the last, when only small perforations can be made, it will be found

(1) Instrument for rolling the foil into cylinders. The sheet is cut into two, and folded on itself till the resulting riband is somewhat wider than the cavity is deep; it is seized close to one end between the thin points of the instrument, which are closed by pushing up the sliding ring. When a sufficient length has been rolled up, the riband is cut off, and the cylinder released by very slightly drawing back the sliding ring. It is convenient to make a stock of cylinders of convenient sizes, keeping them in a bottle until required for use.

easier to fill these up by the use of stars of gold foil, or of adhesive gold, the heavy numbers of foil answering this purpose admirably. The last small perforation may even be closed by a short length of actual wire driven in.

Or, to begin with, a cylinder of such a size that it will only just enter the orifice of the cavity is placed in it, care being taken to avoid pressing it, lest it become condensed before it has reached its place : this cylinder is then forced against one wall of the cavity by the use of a foot-shaped plugger, and malleted, if the mallet be used ; other cylinders are then placed in the space so made, and similarly condensed against the walls of the cavity and the gold already introduced, the filling being, as in the first method, finished by making perforations in the centre and filling these up.

As the foil, rolled up into cylinders, is already closely pressed together, great care must be taken not to render the cylinders hard, unmanageable lumps, by compressing them against the edges of the cavity during their introduction, or by incautious touches of an instrument. The cylinder should be carried to its place perfectly soft, and there condensed by pressure applied to its sides, and not to its ends.

The great point to attend to is to apply all the force to the sides of the cylinders ; we are then compressing together parallel layers of foil, and can succeed in making an extremely solid plug, whereas if we attempt to condense them by compressing their ends, they at once become knotty and hard. Of course, when the utmost solidity attainable has been produced by force applied to the sides of the cylinders, whether by wedging or by the use of foot-shaped pluggers, then the surface of the plug must be condensed ; but if the preceding directions have been followed, very little impression can be made upon it.

When, from the shape of the cavity, it is likely that the first portion of gold introduced would roll about, the softer cylinders loosely rolled are the most convenient to commence with, changing to the firmer ones when the first pieces are

well fixed. By introducing the foil rolled up into cylinders, the layers all run from the orifice to the bottom of the cavity, instead of lying in any chance direction, so that it is quite impossible for fragments to peel off the surface of the plug : moreover the foil, being arranged in parallel layers, is readily condensed by a force applied in the proper direction, so that far larger quantities of foil may be safely introduced in a single piece than by any other method. Hence for large cavities with strong walls the method of cylinder-filling is the most expeditious, and, I think, also the most certain in its results. Of course, the softer the quality of the foil, the easier the operation : with a hard, harsh foil, very unsatisfactory results would be got by using cylinders.

Hitherto the methods of filling described have depended on "packing," or the pieces being wedged in so that they cannot escape, though they remain individually separate, and on breaking the tooth might be parted from one another. But there is a property of gold, in the first instance, I believe, accidentally discovered, which enables us to fill cavities where some of the walls are defective ; this is the capability of pure gold of welding into a solid mass under pressure. In filling a cavity with foil in which this adhesive property has been developed to its fullest extent, a very different manner of procedure is a necessity. Perforating with a large wedge-shaped instrument is inadmissible : were it attempted the result would be that the gold would become hard just around the instrument, and nowhere else. Hence each small fragment has to be thoroughly consolidated as it is introduced. The first step is to thoroughly fix a mass of foil at some part of the cavity ; this may be done by drilling a small hole at some point, and wedging a small portion of foil into it, but more commonly it is possible to securely fix a ball of non-adhesive foil against some part of the cavity ; or, by using a second instrument in the left hand, the first piece of gold may, in difficult cases, be retained in position until it is fixed by being thoroughly condensed.

But before proceeding to the description of the use of

cohesive foil, mention may be made of another method of introducing the gold which has lately attracted a good deal of attention, viz., that proposed by Dr. Herbst. It consists in the moulding of the gold, best used in the form of cylinders, to the walls of the cavity by means of rapidly rotating burnishers. When thus introduced the adaptation of the gold to the walls of the cavity is beautifully close, and the fillings stand the ink test perfectly; with the recollection in my mind of the extraordinary difficulty of making water-tight fillings with cohesive gold, I was much struck with the complete success in this respect of even my earliest experiments with this method. And if the tooth be cracked open, the surface of the gold against the walls will be found to present a dense burnished surface quite unlike that obtainable by any of the ordinary modes of packing, so that for the lining of the cavity it presents great and obvious advantages.

Although the surface of the gold already introduced is always burnished, fresh portions adhere without difficulty, the gold which is soft or but very slightly annealed acquiring some degree of cohesiveness during the process. The resultant fillings, although of less specific gravity than malleted plugs, are yet of sufficient density for anything save contouring, and Dr. Herbst claims that even this may be quite safely done by the rotation method. It is essential that the gold employed be very soft, and yet capable of readily becoming cohesive, and these requirements are admirably fulfilled by the gold supplied by Wolrab of Bremen.

If it is desired to complete the whole filling by the rotation method it is desirable to carry the edge of a matrix a good deal higher than is usual for the ordinary use of a matrix, else so much difficulty will be experienced with getting the last portion to cohere, that all the advantages of the method will disappear. Although it is often possible to make use of the rotation method in open and accessible cavities, yet its advantages in the way of easy and rapid manipulation are chiefly found in interstitial cavities, and

with a matrix carefully adjusted. Large loose cylinders are packed into the cavity until it will hold no more without condensation, and then a large burnisher slowly revolving is plunged into the middle and then towards each side. When the first portions are thus fixed, a blunt cone point is taken and worked against the matrix and into the undercuts; the

FIG. 158. (1)

process is repeated till the cavity is nearly full, when it is completed with cylinders slightly annealed, or by the abandonment of the rotation method in favour of the mallet. In the earlier stages of the filling, the soft foil becomes slightly cohesive under the burnisher, perhaps from the heat developed by the friction; at all events, at starting, soft large pellets may be used, their cohesiveness only becoming developed as they become partly condensed.

One of the drawbacks of the process is that the instruments themselves become gilded, and as soon as this has taken place they will not work properly till they have been cleaned on a stone or upon fine emery-paper, for if this be

(1) Burnishers of the forms approved by Dr. Herbst.

not done the gold coheres so strongly to the instrument, that it is ripped off by it in small fragments. It has been proposed to overcome this difficulty by the use of agate points, but though these are free from the fault indicated, they are difficult to make on a sufficiently small scale, and can hardly be got to run true. Bloodstone points have recently been produced which are superior to anything else in the market.

In the early stages of the operation, round burnishers, used either in the engine or by hand rotation, are employed; then, as it becomes desirable to develop a greater degree of cohesiveness, roof-shaped points are substituted, and revolved very rapidly. Under their use the surface speedily becomes highly cohesive, and successive portions are built on.

Time alone will show what place the Herbst method will take; for my own part I believe that it is often of great value in the earlier stages of a filling, and for the whole of those cavities which might almost have been filled with soft foil; but I distrust it where great cohesion is wanted, as, for example, where a tooth exposed to mastication has to be extensively contoured.

In treating of the filling of particular cavities I shall have to recur to the use of this method.

In the working of cohesive gold it is absolutely essential that no piece of gold once at all condensed shall again shift: to secure this end retaining pits may be drilled, not for the sake of holding the filling when completed in place, but merely to anchor securely the first fragments.

As has already been intimated, the whole cavity should if possible be so shaped that it will retain the filling quite independently of retaining pits; but in difficult cavities this is not always feasible, and in any case certain precautions should be observed in forming the retaining pits. They should be drilled with a very sharp square-ended drill just inside and more or less parallel with the enamel, and, if possible, their direction should be such that, as they are deepened, they do not approach any nearer to the pulp;

that is to say, that the point at which they start should be so chosen that it shall be possible to drill away from, or at least parallel with, the pulp surface, so that the point of entry shall be the nearest to it. They may be very efficiently filled by a plugger made of an excavator broken squarely across, and the roughness of the fractured surface left. The gold must be made as solid as it can be, and thin strips either of heavy foil, or of folded lighter foils, will be found the most convenient. The subsequent steps of the operation may often be advantageously performed with foot-shaped pluggers.

Another mode of giving support to filling in teeth of which the walls are largely destroyed, is the insertion of a post, or several posts, fixed into holes drilled into the dentine.

These posts may be little gold screws, which are screwed into holes previously tapped in the dentine, though it must be remembered that the dentine is not a first-rate material in which to form a fine screw thread; or they may be simply jammed into holes which they tightly fit, their

Fig. 159. (1)

Fig. 160. (2)

Fig. 161. (3)

(1) Foot-shaped plugger. Dr. Varney's form.
(2) Dr. Lord's form of hand-plugger.
(3) From Dr. Redman's set of pluggers.

function being mainly to resist lateral shifting of the filling; or again, they may be anchored into the empty pulp cavity or the enlarged root canals by plastic cements which are allowed to get quite hard before proceeding with the body of the filling. In the restoration of very badly decayed teeth they will be found to be of great advantage, and many operations are rendered practicable by their aid which would otherwise be barely feasible. They are useful alike for gold, amalgam or white plastic fillings, but much caution must be used in drilling holes for their reception in teeth with living pulps, lest this organ become seriously irritated.

When once the first part of the plug is fixed and thoroughly consolidated, the subsequent steps of the operation are comparatively easy: small portions of foil, which may be loosely rolled, or simply torn, are firmly pressed with the point of the instrument upon the gold already in the cavity, care being taken that the instrument is applied to every part of the surface, and that the gold added is distributed pretty evenly over that upon which it is placed. Piece after piece is added, each one being thoroughly consolidated on the gold already in the cavity before any more is added, until the plug projects slightly from the orifice of the cavity. In applying the gold, it should be pressed against the walls of the cavity as well as on to the rest of the plug, else minute fissures are apt to be left. Now, if the foil has been good, and the operation carefully performed, we shall not have a plug made up of a series of small masses, and retained together by the walls of the cavity, but we shall have a solid mass of gold, which, if the tooth be broken, will form a cast of the cavity from which it has been liberated.

The use of the term solid as applied to gold plugs, requires qualification. I believe it is quite impossible to produce with foil, or, indeed, with any form of gold, a plug having a degree of solidity equal to that of an ingot of pure metal. The resistance to pressure of which the tooth is capable would prove insufficient for the production of absolute solidity. Again, the dentine, against which the metal is

pressed, is not sufficiently hard to afford the resistance which would be required. For the sake of testing the working qualities of specimens of gold, I have been in the habit of clamping a slip of ivory, having cylindrical perforations, upon a block of the same material. After filling one of the holes the slip is removed, and the lower surface of the plug is presented for examination. In no case have I seen a foil filling in which minute fissures could not be discovered by the aid of the microscope. However, sufficient density can be produced to give the plug the appearance and the feeling of perfect solidity, and to ensure durability. More is not required.

Whatever method of inserting the gold be adopted, the compression should be exerted mainly in a lateral direction, towards the walls of the cavity, and it is on this account that the foot-shaped pluggers are so valuable, whether as mallet or hand instruments. Nothing should be left for a compressor applied to the surface to do: on a properly inserted plug, it will have but little or no effect.

Difficulties in the use of adhesive foil may arise from the gold already in the cavity having been insufficiently consolidated, and so yielding before the instrument and the superadded layer, instead of affording an unyielding surface against which the latter may be welded; or the failure may arise from the surface of the gold being soiled, or wetted by saliva, the condensation of the breath, or condensation from the atmosphere. If the gold does not adhere readily it should be annealed, either in the sheet, or by passing each fragment through the flame of a spirit-lamp; with the heavy foils the latter course is preferable. Very heavy foils, which may be rolled in the place of being beaten out, are remarkably adhesive; the manner of using them does not differ in any material particular from that just described, save that they should be cut into pieces nearly the size of the cavity, as it is difficult to fold them: by having pieces of a suitable size, each piece is laid on flat, and forms a complete layer in itself. The very heavy numbers, such as 140, are not

easily condensed without the use of some form of mallet; still with care, and in a suitable position, very dense plugs may be made by hand-pressure alone.

Although the very heavy foils will probably never have more than a limited applicability, such numbers as 20 are exceedingly useful, and in large cavities, where it is necessary or desirable to commence the use of an adhesive gold early in the procedure, they are very valuable.

Wherever adhesive gold is employed, each successive piece should be laid on as flat as possible, and no attempt made to crumple it up into deep holes, as though it were non-adhesive; and the best adhesion will be gained by using a moderate-sized point at first, afterwards exchanging it for one somewhat smaller; and this applies with double force to the use of heavy foils.

It must not be supposed that in the formation of a plug any one of the methods which have just been described in general terms is necessarily adhered to from beginning to end. Thus, for example, it is very often exceedingly inconvenient to commence a filling with adhesive foil: on the other hand, it is often a great convenience to finish the surface of a plug constructed of non-adhesive gold with additions of gold used adhesively.

In using adhesive gold there is perhaps rather more risk of the gold rolling away from the edges of the cavity, and so leaving minute fissures, than when non-adhesive gold is employed; hence we sometimes see beautiful hard, solid fillings failing, and comparatively soft fillings succeeding, simply because the gold is in the latter case better applied to the edges. On an adhesive filling, properly consolidated, the burnisher can do comparatively little in securing good contact round the edges, but in a soft-foil plug, however firmly it may have been condensed, the edge may be efficiently burnished down.

A failure will, however, sometimes depend upon the character of the foil, which, although perfectly good, may be unsuited to the method of manipulation employed. Take,

for example, the results of the following experiments, with leaves of foil taken from the same book. The foil employed had been prepared from crystal gold, reduced to four-grain sheets by beating in the usual manner. Although annealed from time to time during the process of reduction, it had not been submitted to heat after the final beating. The condition was therefore that of unannealed foil.

Several sheets were folded and cut up into short strips for the purpose of using in the stellate manner. In working it was found to be adhesive, but at the same time very brittle, and consequently required unusual care in introducing it between the teeth, otherwise portions broke off and fell into the mouth. Another sheet was torn in six or eight pieces, and rolled up between the fingers into as many small balls. These were introduced, one after the other, into a lateral cavity, with a small instrument having a slight spiral curve near the point. The centre of the ball was first pressed lightly into the cavity, and the edges subsequently turned in, and then the whole was thoroughly compressed. During the operation the gold went down before the instrument into a very solid condition, but there was not the slightest tendency to turn up on one side when the other was pressed down, or to roll in the cavity. The gold filed freely, and when completed the plug presented a most satisfactory appearance.

From the same book a leaf was taken and rolled into rather firm balls, which were subsequently annealed. Under this treatment, although the adhesive quality was brought out more strongly, each ball, instead of going down dead before the instrument, had a tendency to turn up and clog the orifice of the cavity. Another leaf was annealed first, and then rolled into balls, which on trial proved superior to the annealed, but inferior to the unannealed balls.

From the same book two leaves were taken; one was annealed, and after division into thirds, twisted into three loose ropes; the other leaf was divided, and rolled without annealing. The latter showed a tendency to break to pieces

and waste, while the former packed and adhered, the one fold to the other, with great readiness, and produced an extremely good plug.

The foregoing results have been brought forward to show that different samples of gold, though each perfectly good of its kind, may require different methods of manipulation in order to produce the best results. And they have been noticed before describing the various methods of operating upon the incisors, because the front teeth require delicate treatment, and because there is good reason for supposing that the defects are often consequent upon the manner of use being ill suited to the particular sample of foil employed. Had the use of the stellate form of the unannealed leaf been persisted in, the plugs would have crumbled; and had the use of the annealed balls been continued, the plug would have been with difficulty restrained from rolling in the cavity; moreover, the force required for its consolidation would in many cases have been greater than the incisor teeth are able to bear without endangering the bursting outwards of the labial wall of the cavity. There are few who have not seen a crack run across the enamel, perhaps in more directions than one, just as the operation was about to be completed.

Instances will occur in which the surface of the plug is good, and the circumference solid, excepting at the upper part near the labial surface of the tooth, a situation reached with some difficulty by the plugging instrument; and even then the imperfection is not discovered until the file wounds the gum, and a little blood steals in, and renders apparent a line, in the course of which the gold has not been forced into contact with the surface of the cavity.

These remarks have been made, not with the view of deprecating the use of annealed adhesive foil, but in order to draw attention to the necessity of observing great care in the construction of plugs when that form of gold is employed, and also for the purpose of showing that although a sample of foil may not answer the expectation of the operator when used in one manner, yet that it may be perfectly satisfactory

when a different method of introduction is employed. Even the degree of hardness to which the balls are rolled or the ropes twisted, will influence the facility with which they are respectively used. The degree of heat to which the metal is submitted in annealing will also exert a considerable influence in determining the manner in which it can be most effectively manipulated. It would, however, be very difficult to enumerate every circumstance that may arise in connection with the use of the different forms of gold employed in plugging teeth, and to give a detailed description of the methods of overcoming every difficulty that may present itself to the operator. The task would be almost endless, and if accomplished, would not even then relieve the dentist from the necessity of making himself practically acquainted with the subject by means of carefully-conducted experiments, both in respect to the materials used in the formation of plugs, and the instruments employed in conducting the operations.

At the risk of recapitulation, attention may once more be called to the experiments made some years ago by Mr. Fletcher, and by Mr. Ewbank and myself. We all found that it was a matter of the most extreme difficulty to make truly watertight plugs with cohesive foils, and Mr. Ewbank and I found that we could only do so by using very small portions of gold at a time with the most extreme care. While therefore cohesive plugs look far better, at all events after a little wear, and can be made in places where soft-foil fillings are hardly possible, yet it must be remembered that there is a liability to invisible imperfections that does not pertain, at all events in the same degree, to soft foil.

So far it has been assumed that the consolidation of the gold has been effected by the use of hand pressure; but there are few operators who do not make use of malleting in some form or other, though the extent to which it is resorted to will vary with every individual. A greater degree of solidity will be conferred upon a soft-foil fillings, whether cylinder fillings or others, by the use of a mallet;

but it is in cohesive fillings that its employment becomes in the majority of cases all but essential.

Reference is made to the use of the mallet by Koecker (Prin. Den. Surg. 1826), and it was used by Dr. Hoffman of Margate about 1846, but it is to our American *confrères* that its introduction into every-day practice is due. In its simplest form the dental mallet consists of a hammer, a very good form consisting of a head of lead enclosed in a cylinder of German silver, with a handle about eight inches long. Steel heads of varying weight, wooden heads, &c., are preferred by some. But this actual hammer is only well adapted to the needs of those who employ an assistant to mallet for them, and hence a variety of automatic mallets have been devised. Several of these repeat, in the form of a blow, the pressure which has already been put upon the filling in the form of pressure; but this is no real objection to their efficacy, inasmuch as the same force, applied in the form of a blow, is far more effective than in the form of a steady push. Of this class Salmon's, or Snow and Lewis' are the favourite forms, but Kirby's is also very good.

All these mallets give a somewhat slow, heavy blow, more or less resembling that of an actual hammer, and I regard one or other of them as almost indispensable.

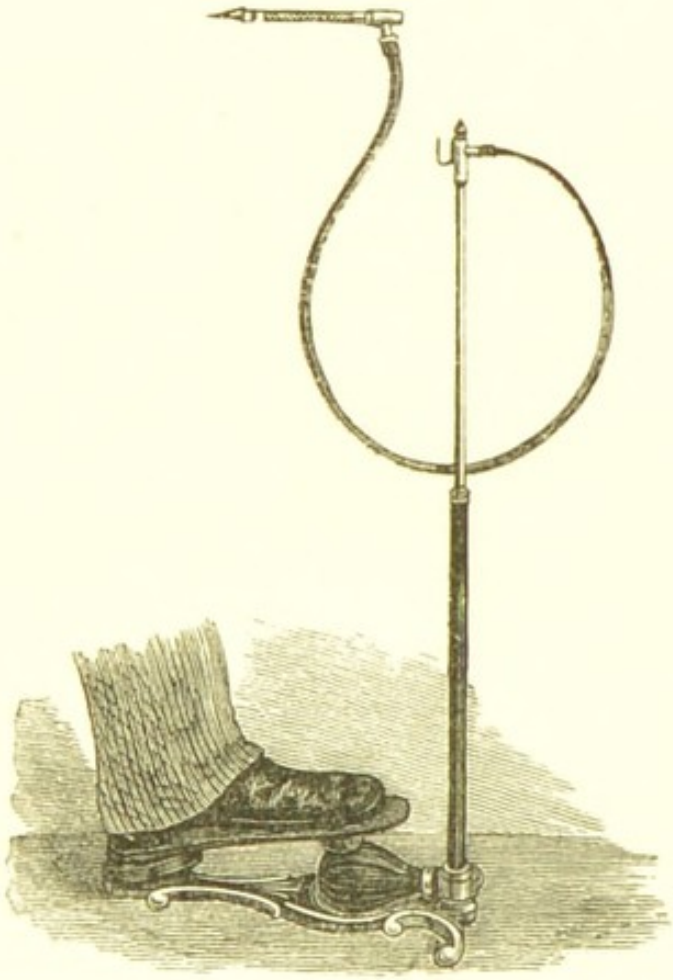
A spring mallet, giving a very direct blow without antecedent pressure, was invented by my father, but this, though at the time of its introduction an admirable instrument, has been superseded by the forms already alluded to.

From these we may pass to the consideration of those which give very rapid blows, a linking form being the pneumatic mallet also invented by Mr. A. S. Kirby. In this the blow is given by a puff of air acting upon a freely moving piston of some weight, the puff being given by the pressure of the foot upon an india-rubber ball. This is an exceedingly good instrument, and is in extensive use: it has more in common with the automatic mallets previously described than with those which are to follow.

Several forms of mallets have been contrived which con-

vert the rotatory motion of the dental engine into a succession of blows, the traverse of the point being short and great rapidity of blow being obtained; of these Power's is the best, with one exception. These rapid, short taps are

Fig. 162. (1)



only well suited to the packing of cohesive foil, and for a long time the electric mallet took the first place amongst those which give this character of blow.

The electric mallet now used owes most of its good points to the great mechanical ingenuity of Dr. Bonwill. With the mallet in thorough adjustment, the battery at its full strength, and all conditions favourable, it is a nearly perfect tool, and is admirably adapted for the packing of

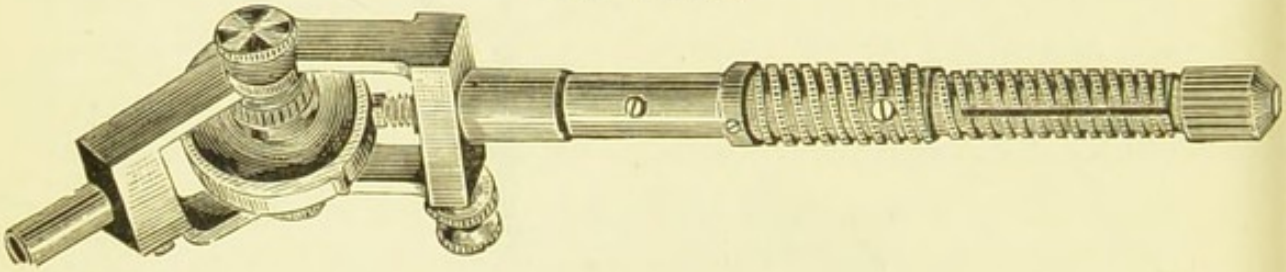
(1) Kirby's pneumatic mallet.

strips of cohesive foil, of a thickness of "20," or even up to "60;" for its effective use it is absolutely necessary that the first pieces of gold should be very secure, or it will shake them loose hence those who employ it generally start from a strong retaining point.

But there is one great objection to the electric mallet, and that is the entire impossibility of getting any primary battery which is fairly constant and yet possesses sufficient electro-motive force for its requirements, and the result is that the battery needs perpetual attention, and is seldom going with just the same degree of vigour.

This trouble, insuperable in the present state of electrical knowledge, has led Dr. Bonwill to discard the child of his

FIG. 163. (1)



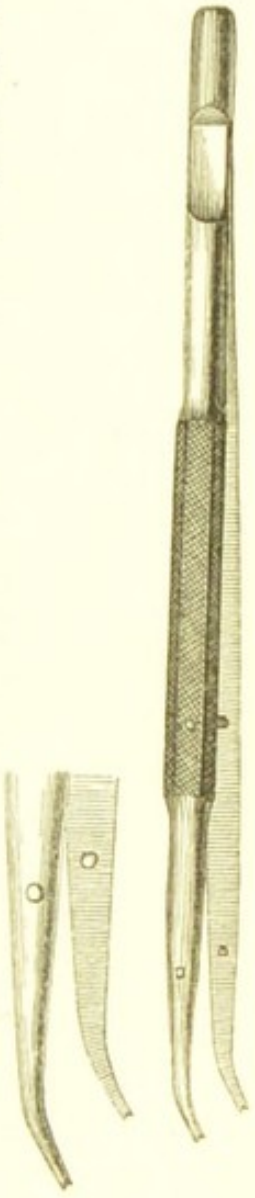
own brain, and to invent an engine mallet which he uses to the entire exclusion of the electric mallet, and he predicts that it will drive its rival altogether out of the field, as indeed it has already done to a very large extent, many of the most enthusiastic workers with the electric having transferred their allegiance to it.

It is very simple, the blow being given by a slight steel prominence upon a revolving disc, against which the end of the plugger is pressed, and forms of it have been introduced to work with any of the engines in the market. So far as my own experience goes it does not work its best except upon Dr. Bonwill's own engine; but used with this it is in my opinion far the best of all rapid-blow mallets. The

(1) Dr. Bonwill's engine mallet.

force of the blow is under complete control by a side adjustment, but without altering this it may be greatly varied by more or less rapid rotation of the engine, and more particularly by more or less pressure of the point of the plugger upon the filling.

FIG. 164. (1)



To teach much about the filling of teeth by description is a very hopeless task, but it may, perhaps, best be approached by the description of a few of the more frequent styles of cavity, leaving the reader to fill in the rest from his own intelligence. As the simplest that can be selected, a crown cavity of moderate size in a strong molar tooth may be dealt with first; we will suppose the caries to have been removed, all overhanging portions of enamel cut away with enamel chisels, or with a bur in the engine, and all deep undercuts got rid of, the interior of the cavity being only in the smallest degree larger than its orifice, so that it is almost cylindrical. If caries has extended into the fissures they of course have been opened up.

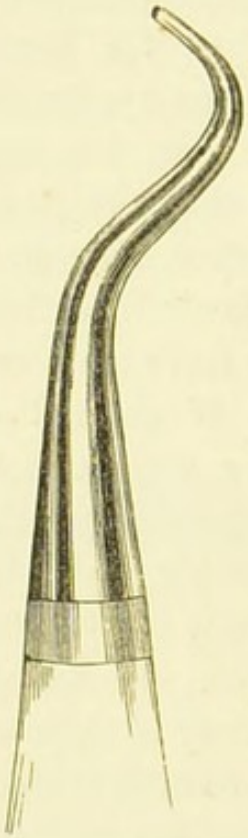
We have next to make choice of the method to be adopted, and for such a place almost all the methods already alluded to are available; it is a cavity eminently well suited for cylinder filling, so we will first take that. Choice having been made of the napkin, rubber, or clamp with the saliva pump, cylinders are placed in the cavity by means of plugging forceps, like cigars in a tumbler, and it may be mentioned that it is quite a waste of time to use very soft cylinders containing but little gold; Ash's style C, or the hardest of Williams's or Hood and Reynolds's are well suited to the purpose in hand. The cavity being loosely

(1) Plugging forceps.

filled with cylinders of such length that their ends project a little beyond the edge, they are consolidated towards the walls by pressure put upon their sides by means of foot-shaped pluggers, and malleted or not, according to the taste of the operator; or they may be consolidated by hand

Fig. 165. (1)

Fig. 166. (1)



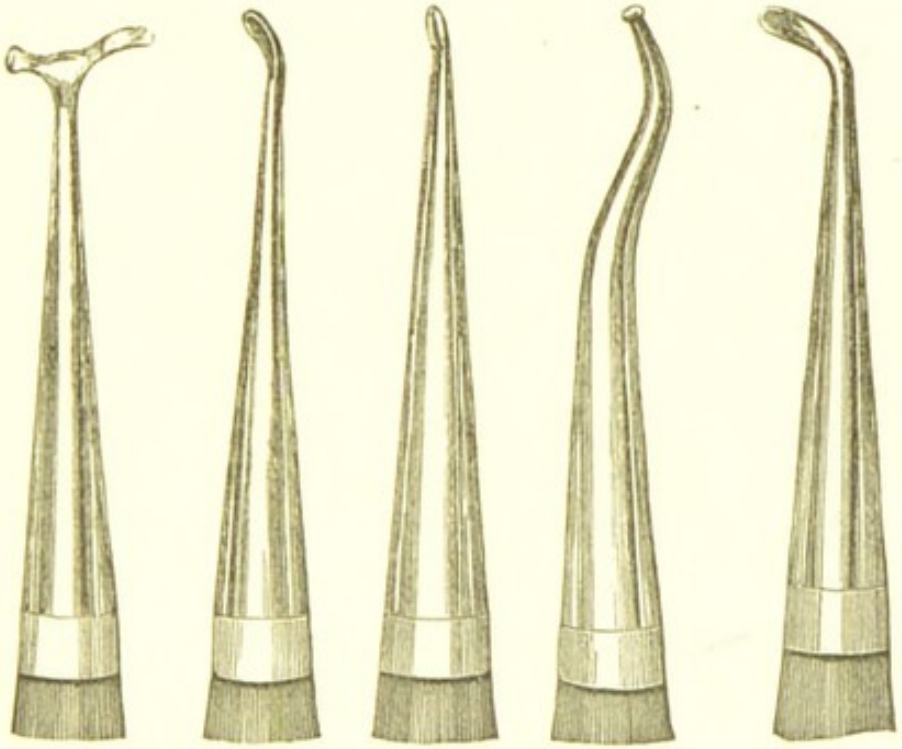
pressure with the wedge-shaped pluggers of Dunning (see page 353). If the cavity be a small one it will be best so to arrange matters, that the space got by their compression shall be in the centre of the gold and not against any of the walls; but if the cavity be large, it will be better to drive all the cylinders up towards one side, and then insert into the space still left a fresh charge. When by the repetition of this proceeding the hole is nearly filled up, the spaces must be formed in the middle of gold, as in the case of the small cavity.

(1) Condensing instruments for crown cavities in upper and lower jaws.

The compression of the gold towards the walls may be effected by driving into the midst of the gold a point shaped like that of a trocar. The effect of this will be to drive the gold outwards against the walls with great force, and it is therefore an unsafe proceeding in a tooth much weakened by caries. The hole thus made may be filled with pellets or strips, or with a little cohesive foil, of which the last is to be preferred.

Now for the first time the ends of the cylinders, which will project a little beyond the level of the edges of the

FIG. 167. (1)



cavity, are to be condensed, and when they can be no more condensed and the solidity of the plug has been tested by trial with a fine point, it is to be burnished.

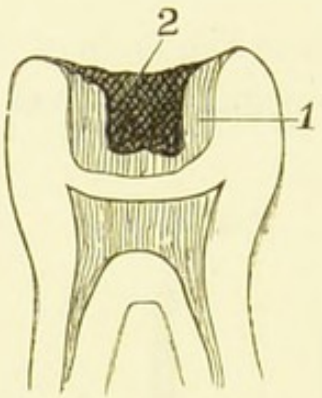
Two useful forms of condensers for large cylinder plugs are given in figures 165, 166 ; for my own part I like the handles of condensers and burnishers to be large

(1) Various forms of burnishers.

and rounded, and those figured on page 403 answer the requirements very well. On the preceding page are a few ordinary forms of burnishers.

After it has been burnished, which may sometimes be advantageously done by an engine burnisher, the surface

Fig. 168. (1)



is cut down to the proper level by a plug finishing bur, then by a corundum point, and lastly finished with pumice.

A plug so executed is likely to preserve the tooth for a very long period. The margins of the cavity are everywhere in contact with soft foil, which is arranged in parallel layers perpendicular to the surface, whereby the greatest resistance to wear is secured, at the same time that the adaptability of soft foil renders it likely that the plug will be water-tight. At the centre of the plug will be a portion of cohesive foil, which will still better resist the attrition of mastication. Moreover, the whole process can be carried through with considerable rapidity.

When the edges of the cavity are formed by soft foil, the free and forcible application of the burnisher will be of great use, but it is of less use where cohesive foil is against the

(1) Diagram of a composite soft and cohesive foil filling in a molar tooth (grinding surface). 1, represents the soft ; 2, the cohesive foil.

edges, as the portions of this being unable to move upon one another, it can effect but little good, and the finish must be wholly got by corundum, pumice, and the like.

A cavity of the class just described may be filled equally well, but with hardly the same rapidity, by using a firmly rolled rope of soft foil, so folding it into the cavity in successive folds that the layers shall for the most part run from the floor to the orifice, or by means of pellets used with sharp-pointed pluggers; but if soft foil is to be used I much prefer cylinders, both for greater rapidity and greater assurance of solidity.

It may also be filled with cohesive foil in strips; in this case the start may be made from a retaining point, from any corner into which the first pieces may be wedged, or sometimes from a mass of crystal gold impacted upon the floor. This last is by no means a bad way of getting a cohesive foundation upon which to build a simple interstitial cavity.

We will suppose that a cavity when excavated extends down to the cervical margin of the tooth, involves the greater part of the interstitial surface, and extends so nearly up to the grinding surface that there is but little besides enamel at this point; it would be very difficult to fill solidly underneath this, and when done it would be likely to give way under mastication, so that it is better to chip this right away with an enamel chisel, and so get a cavity with three walls instead of four, and also get a free and direct access to the whole from the grinding surface.

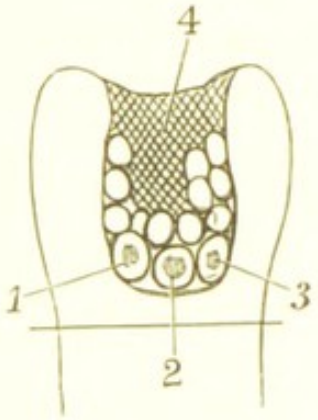
Care should be taken at the cervical margin that if the termination of the enamel be at all nearly reached, the excavation should be carried well down so as to remove it all, as that last thin edge of enamel is very apt to flake off when any pressure is put upon it in packing the gold. The edge of the cavity towards the grinding surface will also require a little attention; if it ends with a thick and fairly level rim of enamel it may be left so, but if it approaches near to the pits of the grinding surface, or any of the

natural fissures of the crown lead up to it, then it will be better to carry it further in this direction, and extend it right into the pit, which must be drilled out to form a good anchorage; or similarly the fissure must be deepened and undercut, the object in view being the utmost smoothness of edge when the filling is completed.

In such a place the action of mastication will be more trying than in a simple crown cavity, as it will have a tendency to drive the filling out of the cavity instead of into it, as in the previous case, and hence a purely soft foil filling is less adapted to the requirements of strength. Still, the filling may be commenced and a large proportion of the gold impacted in the soft form, and with this method we will first deal; at the cervical margin three substantial cylinders may be placed, containing a quantity of gold sufficient to make it hold in place when condensed; and this condensation may advantageously be done with some little method, one side cylinder (1 in Fig. 169) being first a little condensed, then 3, and lastly the central one, 2; then returning to the first, that should be fully condensed, then the second, and lastly the middle one. If this order is followed, it will be found that there will be but trifling difficulty in getting the early portion of the gold condensed without rocking. This sort of procedure may be repeated till about half the height of the cavity has been filled, and then it will be time to commence the use of cohesive foil, which can best be started in the centre by wedging a freshly annealed cylinder or other piece of cohesive gold between two cylinders of soft foil. An anchorage thus obtained, the whole of the rest may be completed with cohesive foil, or the use of the two may be gone on with by building cylinders against the walls, at the same time that the central portion is being carried up with annealed foil, also conveniently applied to such position in the form of cylinders, which will of course contain far less gold than the outer ones; as the grinding surface is approached the use of the soft foil is altogether abandoned.

This mode may of course be varied in many ways. Tin might have been used at the cervical edge on account of its very ready adaptability, or tin and gold mixed, or the help of a matrix might have been sought. For interstitial fillings of large size the matrix is invaluable, both as a time-saver and as rendering quite easy the filling of cavities which otherwise would have been rather difficult. In principle it is the giving to your three-walled cavity a fourth temporary

FIG. 169. (1)



wall, so that in all the earlier stages of the work you are packing into a deep four-walled space.

The simplest form of matrix is a strip of clock-spring passed between the teeth and wedged up against the one which is being operated upon by means of wooden wedges or ordinary pins driven in between it and the next tooth. But Dr. Louis Jack has introduced a form of matrix, which is very far superior to this wherever there is a little space; his matrices, of which a figure is given, are hollowed towards the cavity, and highly polished, their other surface being more rough, so as to give a good grip to the wedges; this hollowing of the matrix renders the filling convex and a little projecting from the cavity, so that a better finish can be given to it.

(1) Diagram representing the position of the cylinders and of the cohesive foil in an interstitial cavity in a bicuspid tooth. The cohesive gold (4) is shaded.

The disadvantage which is urged against the use of the

Fig. 171. (1)

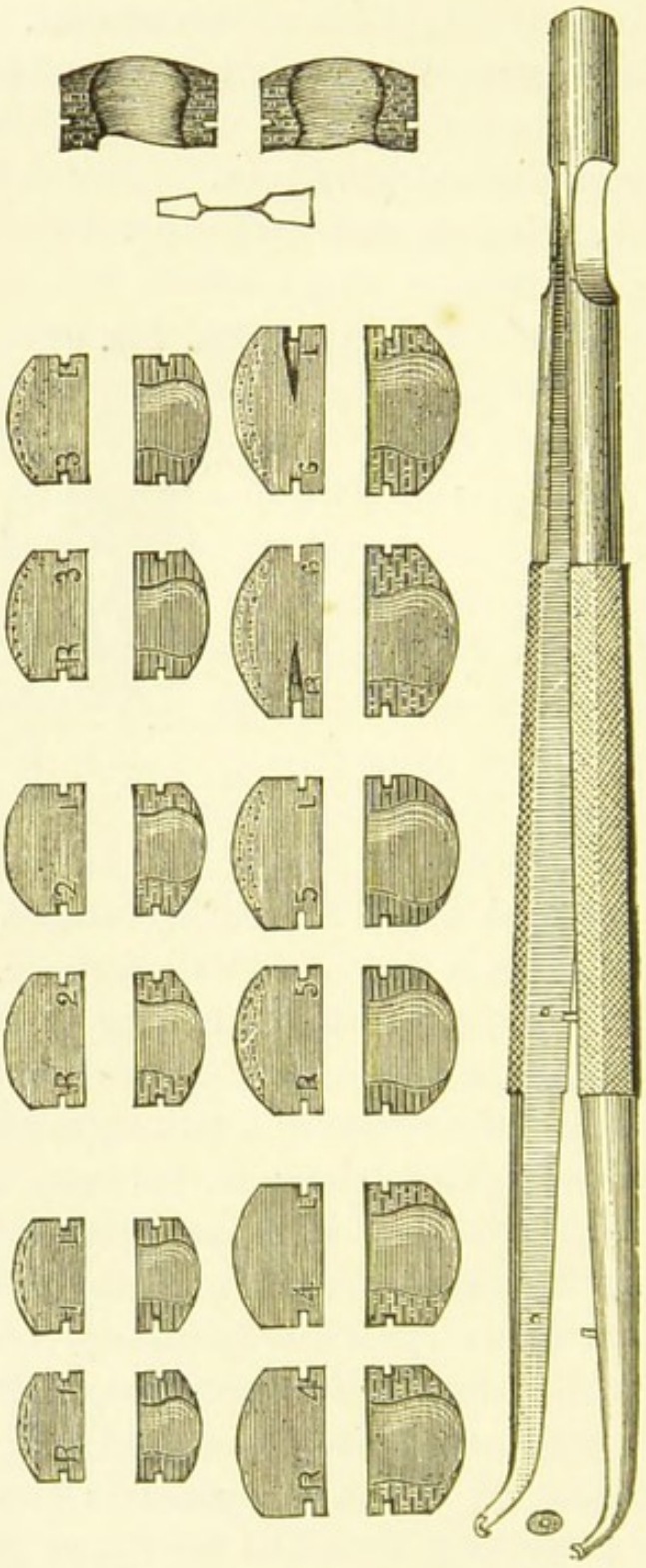
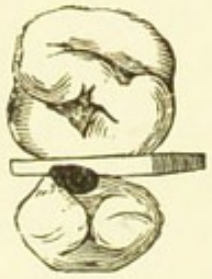


Fig. 170. (1)



matrix is, that the cervical margin, the most vulnerable

(1) Dr. Jack's matrices.

point of the filling, is concealed from view, and this, which is true, has to be met by the adoption of great methodicalness in the introduction of the first pieces of gold. Dr. Jack folds his gold leaf into a long strip, which is a little narrower than the width of the cavity; this long strip he folds again longitudinally upon itself four or five times, the resultant pieces being about four times the depth of his cavity, and each piece containing about a grain of gold.

The strip is taken in the forceps and, sliding it down the

FIG. 172. (1)

FIG. 173. (1)

polished face of the matrix, one end is carried into the retaining groove at the cervical margin towards one side; the rest of it is folded in, keeping it only half condensed; then a similar piece is carried down and worked into the other corner, and a third down the middle. Great care is taken to keep the instrument well against the surface of the matrix, thoroughly condensing the gold here even before it is fully malleted into the tooth groove, for by this means a good margin is secured. It must never be forgotten that in proportion as you lose sight of the cervical edge, so must you substitute a step-by-step method, so as to ensure each portion being solid.

The hand mallet, or the automatic mallets, are well adapted for this stage of the work, and points of a particular bend are almost essential to ensure easily reaching every part of the cavity. When the cavity is half full or more, cohesive foil may be adopted, and if the matrix is at all in the way it can now be removed, but it is usually quite easy to finish without disturbing it. When the matrix is removed there will be only a small amount of

(1) Pluggers suited for use with a matrix.

surplus gold, and that will be pretty smooth, so that a great deal of time will be saved also in finishing the plug.

In the execution of any of these composite plugs, partly soft and partly cohesive, it must be remembered that there is little adhesion between the two portions, and it is therefore quite necessary that the cavity occupied by the cohesive gold, the walls of which will be partly soft foil and partly tooth, shall be of such shape as to firmly retain the gold.

The matrix may be secured by thin wedges of wood, as has already been mentioned, and these will be less likely to slip if they are dipped in gum sandrach, or in copal, prior to being pushed into place; gutta percha or sealing-wax may also be used for this purpose, but it is essential that the matrix should be quite steady during the whole operation. The matrix may be removed towards the close of the operation, if it should be found to be in the way.

It will also be found to be very serviceable in large amalgam fillings, or in other plastic operations, and space for its application may be often obtained by the use of Perry's separators. Another mode of getting space may here be mentioned. If base plate gutta percha be crowded into the cavity and between the teeth, being left a little above the bite, the teeth will in a few days or a week be separated quite painlessly, and if they be left for a much longer period, a very wide space may similarly be gained. For this hint I am indebted to Dr. Bonwill.

An excellent matrix may often be made at the time of use by bending up a thin strip of platinum foil of some thickness, so as to encircle the tooth, its ends overlapping a little, and soldering it together by a little piece of solder in the flame of a Bunsen burner; this is, of course, only available when the tooth stands alone, but it can be made in as little time as it takes to adjust the more complex forms of matrix.

Of these I have not much personal experience, for I have found that the more complicated forms, which have various screw arrangements, &c., are so seldom available as fitting

the tooth in hand; besides which they are one and all open to the objection that they fit up flat against the tooth, so that there is no overplus left when the matrix is removed, wherewith to finish down the surface nicely. Of these Mr. Brunton's appears to be the best.

The advantage of Dr. Jack's form of matrix in this respect is that, while there is left but little overplus, so that time is not lost in filing down a large quantity of gold, yet, owing to the concavity of the surface of the matrix, there is left upon the filling a slightly bulging surface, which enables a good form to be given to it with comparatively little trouble.

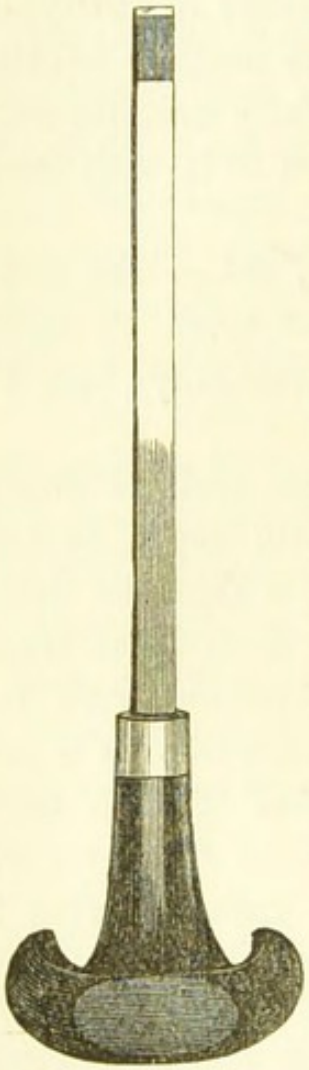
The Treatment of Caries in the Front Teeth.—The most common position for caries in the front teeth is upon the surfaces of contact and therefore these may first be spoken of.

If the surface affected be somewhat large and its depth small, or indeed in any case in which its depth is but slight, the question at once arises whether it shall be dealt with by free excision or by filling, for it is upon these front teeth that the operation of excision is attended with far better results than it is elsewhere; the reason of this is not far to seek, as it is easy to leave the surfaces of such form as to be readily self-cleansing, and there is no tendency for food to become wedged down against the gum, as there is when back teeth have been similarly treated.

Although some practitioners, whose opinion is worthy of every respect, give to this operation a much more extended application, as, for example, Dr. Arthur, I myself only think it to be preferred when it is possible to cut well down to the very deepest affected point without disfiguring the tooth in any material degree, and the cut surfaces must not be left touching, or, indeed, nearly touching one another. It is often possible to shave away the lingual portion so as to avoid all interference with the enamel at the labial aspect, and to leave a V-shaped separation, the apex of the V of course looking forwards.

This may be done by means of enamel chisels, the ends of which should for this purpose be very thin. A chisel of the form here figured serves very well; and its end may sometimes with advantage be ground flat and thin, and its edge be a right angle. When thus formed (I think Dr. Arthur first suggested this form) the steel may be left very hard without fear of its chipping, and it is used to scrape rather than to cut. Or disks and other suitable forms of corundum points may be employed in the engine, but whatever instruments be selected, the operation, when finished, should leave the surfaces highly polished, and the space in the form of a rapidly diverging V, so that the action of the tongue may readily cleanse every part of the cut surface. Instead of leaving the labial edges of the enamel quite intact, a spindle-shaped space is sometimes made, the cutting edges being left in contact as are also the necks, but the cut surfaces being somewhat curved, so that the teeth are in contact nowhere else. This is open to the objection that the teeth do not look very nice, though it is very efficacious in obviating the recurrence of caries. Whenever excision is practised the patient should be kept under pretty close observation for some time afterwards, and the patient directed to pass floss silk and keep the new surfaces very well polished. A combination of filling and excision will sometimes suggest itself as the best for a particular case, the teeth being sliced away from behind so as to leave self-cleansing surfaces, some part of the surface being a gold filling instead of its all being tooth.

FIG. 174. (1)



(1) Enamel chisel.

If it have been decided that it is necessary to fill the tooth, space having been obtained by wedging, or by cutting away the tooth if the cavity be of no great size, there is choice of several methods of filling it.

The cavity having been duly shaped it is to be washed out, dried, and the rubber adjusted, or, if that be deemed unnecessary (which it never is where the gums secrete much viscid mucus), some other means of keeping it dry resorted to.

If the cavity be not very large, foil arranged in the stel-

FIG. 175. (1)

FIG. 176. (2)

late form will be found to work advantageously. Two or three stars may be taken up on the point of the instrument and pressed towards the upper wall of the cavity; one after and within the other. The arms of the stars should then be folded inwards, and the whole compressed thoroughly against the upper part of the cavity. Some little care is

(1) A pair of instruments, right and left, the blades having a slight spiral curve, suitable for introducing foil into cavities in the front teeth.

(2) A pair of instruments, right and left, adapted for compressing plugs in the mesial or distal surface of front teeth, or for adding adhesive foil or sponge gold to the surface of an unfinished plug.

required at this stage of the proceeding, otherwise the gold on becoming condensed will begin to roll. The disposition to move from one part when it is pressed against another part of the cavity is generally produced by neglecting to compress the whole gradually and with uniform force. If the centre of the plug be consolidated while the circumference remains porous, the latter part will turn away from the tooth towards the instrument, and on pressure being applied to any point of the circumference, the mass of gold will turn or roll up from the cavity at the opposite point. Having recognised the manner in which a difficulty may arise, we have to consider how its occurrence may be avoided, or, if present, how it may be overcome. The objectionable condition may be avoided by passing the instrument over the whole surface of the gold with a light hand, repeating the operation with gradually increased force until the whole is equally consolidated. But should the foil show a disposition to roll, we shall do well to remove it and recommence the operation, or to take an instrument in the left hand and hold down one part of the circumference while the other is compressed. The use of two instruments in the manner already alluded to is not unusual where adhesive foil is employed.

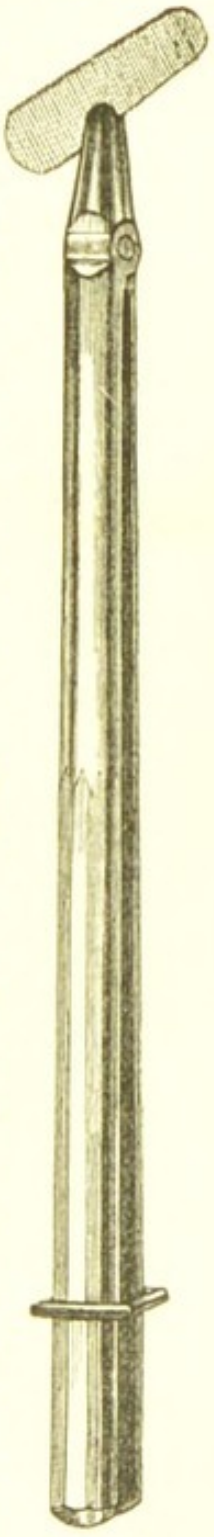
After thoroughly condensing the foil in the upper part of the cavity, the completion of the plug is comparatively easy. If the adhesive foil be used, the operation may be pretty rapidly perfected by adding short strips or soft cylinders one after the other, compressing each consecutive piece upon the gold already introduced, taking care that in making the folds the duplicatures do not fall short of the walls of the cavity, otherwise the plug will be hard in the centre and soft in the circumference.

Should non-cohesive foil be preferred, the same method with respect to filling the upper part of the cavity first, may be adopted; but in the subsequent proceeding it is necessary that the folds of the rope or riband should pass from the bottom to the orifice of the cavity. To effect this,

an instrument with the working extremity terminating like a wedge, will be found the most serviceable form.

The cavity having been filled, a sharp wedge or point, or, what I think is still better, an instrument brought to a point by four chamfers, thus producing a point and four divergent edges like a trocar, should be forced into the centre of the plug. The gold, by this treatment, is forced from the centre towards the circumference of the cavity, and without any tendency to displace the plug. The hole made by the perforator must be filled by the further addition of gold, which may be introduced with instrument in hand. When perforations can no longer be made, unless by using an amount of force that would endanger the walls of the cavity, an instrument with a flat face should be carefully worked over the whole surface of the plug. Recourse must now be had to the file. All gold which projects beyond the margin of the cavity —more especially that which is directed towards the gum, should be cut away, the indentations produced by the filling instrument filed out, leaving the surface of the plug perfectly free from irregularities, and on the same level as the surrounding tooth. The file may be followed by a strip of narrow tape which, after wetting, has been loaded with pumice-powder or finely-powdered silex ; an end being held in each hand, it should be drawn across the surface of the plug with a steady and moderately quick motion, and the friction continued until the file marks are removed from the surface of the plug, when chalk may take the place of

FIG. 177. (1)



(1) Showing a pair of forceps for holding fragments of a dividing file at any angle that may be required for operating upon the median or distal surface of the anterior teeth ; a similar instrument may be used to carry a corundum point.

the pumice. This amount of care in finishing a plug may perhaps be thought unnecessary, and the opinion may appear to receive support from the fact that some roughly-finished plugs last for many years without undergoing deterioration. But on a close examination into the character of the cases it will be found that the disposition to decay was not actively pronounced, and that the walls of the cavities were strong in every part. Had these characters been reversed, it is probable that, in place of finding the plugs, we should have heard that front teeth had been plugged some years ago, but that the fillings fell out in a short time, and that these, with other teeth which were then diseased, gradually decayed away down to the level of the gum.

The immediate object in filling a tooth is to perfectly exclude from the cavity all extraneous matter, fluid or otherwise, and at the same time to leave a surface upon which mucus or minute particles of food cannot readily adhere. If the surface of the gold be left rough, these indications are not fulfilled; food and other matter will collect, and necessitate the frequent use of the toothpick, which falling from time to time into the inequalities of the gold, eventually disturbs the filling. There is another advantage resulting from finishing with care the surface of a plug, and it is this: after the outer part has been filed away, and the surface of the plug and the contiguous surface of the tooth reduced to the same level, we not uncommonly find that the plug is soft at some point, and admits of being perforated. The discovery of a defect having been made, a remedy must be found, even though its application may necessitate the removal of the gold and the recommencement of the operation. For to leave the plug pervious to moisture will be to endanger, if not to ensure, the further injury of the tooth. Unfortunately, the fault is very commonly in the worst possible position, both as regards its effect in exposing the tooth to further disease, and its capabilities of amendment. That part of the cavity nearest the gum is

necessarily the first to receive the gold, which unless it be compressed before the introduction of the foil in the lower portion of the cavity, will, from the difficulty with which the distant part is subsequently reached, remain in a porous condition. But owing to the form of cavity usually produced by caries upon the distal and mesial sides of the teeth, there is some little tact required to perfectly consolidate the upper, prior to the introduction of the lower portion of the plug. And we consequently find that the defects are most commonly situated at the upper margin of the cavity. If there be sufficient space between the teeth to admit an instrument, perforations may be made and additional gold introduced, but if the space be too contracted to allow of the satisfactory completion of the plug, it will be far better to commence anew.

A failure will, however, sometimes depend upon the character of the foil, which, although perfectly good, may be unsuited to the method of manipulation employed.

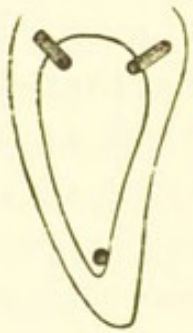
It has been assumed that the teeth have been separated by means of india-rubber, or cut away on the lingual surface, without materially interfering with the part of the tooth exposed to view. But it may happen that the labial has been encroached upon by disease, while the lingual surface is comparatively uninjured. In that case the gold may be introduced from the front, leaving the whole of the back part of the tooth standing. By the adoption of this plan, more even of the front of the tooth may be retained than though the firm, strong lingual wall of the cavity had been reduced. For with the three sides of the cavity strong, the fourth may be preserved, although too weak to stand unsupported by the plug, the firmness and the retention of which will be sufficiently secured by the upper, the lower, and the lingual walls of the cavity. In conducting the operation, however, great care must be taken to avoid injuring the weak part; and it will be found expedient to introduce the foil in small portions, making each piece firm before the succeeding one is added; for should an attempt be made to consolidate the whole plug

by perforating the central part of the mass, the weaker wall of the cavity will give way, and thus frustrate the object of the operation.

Instead of commencing with a star of strips of gold cylinders might have been used, and are nowadays generally preferred, or pellets of soft foil; and it will sometimes be found convenient to condense the first portions of gold against the cervical wall, and then to pack into the lower end of the cavity instead of working steadily down, thus leaving the middle part of the cavity to be filled last.

So far it has been assumed that the walls of the cavity are all fairly strong, but it will very often happen that some or all are weak, and then we must have recourse, wholly or in great part, to the use of cohesive foil.

FIG. 178. (1)



If a tolerably good undercut can be formed in the upper part of the cavity, soft foil may be packed until a third or more of it is filled; but in more difficult cases it is safer to commence at once with cohesive foil. By the use of a second instrument a foundation of cohesive foil may often be built in without the use of retaining points, especially if the beautifully workable cylinders of Wolrab, slightly annealed, be used; but in any really difficult cavity it is safer to begin from retaining pits, necessary evil though they may be thought. One or more should be

(1) Diagram of position of retaining pits in an incisor. They are represented of too great depth in the diagram.

drilled at the cervical margin, their direction being such as to carry them between the pulp and the enamel, approaching neither too closely. A third may or may not be required at the cutting edge of the tooth according to the shape of the hole after the softened part has been fully removed; the accompanying diagram shows, though imperfectly, the position and direction in which the pits should be drilled. A very good instrument with which to fill the retaining pits is made by breaking an excavator or plugger of appropriate size across, and using the fractured surface, which is just rough enough for giving ready cohesion to the pieces of gold; long but very thin strips of No. 20 gold, or of other gold folded to about that, or to 32 in thickness are most suitable, and first one pit should be filled so as to project a little, and then the other, and next the gold should be built across from one to the other; so soon as this is done, a basis of cohesive gold, which is quite immoveable, is there ready to be built upon; and this will be done according to the method in favour with the operator, though some form of mallet is always desirable, and the preference is to be given to those which strike very rapid light blows, such as the electric, Bonwill's engine-mallet, Power's, or the pneumatic mallet. And upon the whole long strips of gold will generally be found to be the most convenient for building upon a retaining point basis; these strips may be made by the operator himself from No. 4 foil, folded to the thickness of 24, 32, or 64, as his own preference may dictate, or heavy foil may be used, such as No. 20, which works very nicely with the electric or with Dr. Bonwill's mallet.

Upon the form in which the gold is used it is not safe to dogmatize, as equally good results may be got with suitable cylinders, or with crystal gold appropriately worked; but this much may be said, that if, after consolidation, the least movement is detected in the gold, it is far safer to take it out and begin again than to attempt to fix it by packing in any additional piece. This can never be safely done with cohesive gold, and but seldom with soft foil,

without the greatest risk of a very imperfect result being obtained.

Although it is always very desirable to have space enough between the teeth for a thin file to pass through, in order to finish the filling satisfactorily, there is another method of obtaining access to it without wedging, which, when the cavity is such as to lend itself to this method, is available; this is to enter the cavity from behind by cutting away its posterior wall very freely, down in fact to the floor of the cavity in almost its whole extent, and then, relying upon the appropriate shaping of the cervical wall and of the opposite portion, to fill with cohesive foil, soft foil being but little suited to a cavity so shaped, as its lingual surface would be with difficulty made perfect without cohesiveness in the foil employed.

A question which will frequently occur in dealing with interstitial cavities in the front teeth is the extent to which the contour of the tooth, when it has been interfered with by disease or by the necessary preparation of the cavity, shall be restored; an exuberant display of gold in the front of the mouth, giving to the patient what may in too literal a sense be described as a golden smile, must, I think, on æsthetic grounds be condemned, though it may be to be preferred to a display of dirty-looking jagged teeth, with worn gutta-percha fillings in them; and though it must be admitted that, if white plastic fillings be employed, the teeth will, unless the patient is exceedingly assiduous in having them renewed, end in a gradual deterioration of the teeth. Much must be left to the judgment of the operator, as well as to the predilections of the patient; though, for my own part, I so dislike the appearance of a glitter of gold every time the mouth is opened, that my tendency in advising my patient would always be against the extensive contouring of front teeth with gold; and it must be recollected that those reasons which render desirable the restoration of contour in the back teeth, which are engaged in the heavy work of mastication, do not apply with equal force to the front teeth

in which there is little tendency for food to be forced down upon the gums, and still less towards its remaining there long.

A difficulty which is frequently met with is the intrusion of the gum into the cervical edge of the cavity, so as to render difficult and very painful the adjustment of the rubber; the excess of gum may be burnt away with a minimum of pain by means of sodium ethylate; or, after two or three paintings with cocaine, violence may be done to it without much if any pain, when it is not desirable to pack it out by means of cotton wool, which would involve the postponement of the operation to another day. If a jaw from which the soft parts have been removed be examined, it will be seen that a triangular space separates the necks of the teeth, the base being formed by the alveolar process, and the apex of the triangle by the convergence of the mesial and distal surfaces of the contiguous teeth. The interval so produced (Fig. 23) is occupied by the gum, and our object is to prevent its bleeding, and at the same time to move it from the margin of the cavity. To accomplish both purposes it is necessary to take a strip of soft wood, such as willow or plane, and cut or file it into a triangular rod. When reduced to a suitable size, introduce it by a steady pressure between the teeth, taking care that the basis of the triangle corresponds to the edge of the alveolar process; by this means the gum will be pressed up against the latter part, the bleeding will be stopped, and the cavity in the tooth fully exposed to view. The introduction of the wood will occasion a little pain at the moment, but it soon gives way to mere uneasiness. When teeth have been gradually separated by caoutchouc, the presence of the wedge tends to keep them steadily fixed, and thereby renders the operation of plugging less painful than it would have been had the teeth remained unsupported. The ends of the wood will, of course, be cut off close to the lingual and labial surfaces of the teeth, and the removal of the carious dentine may then be accomplished without interruption.

If, as will usually be the case, the rubber is to be applied,

the wedge should be forced in after the rubber is in place : sometimes it will be of a little assistance in forming a matrix for the upper third of the cavity.

Owing to the greater size and the very markedly greater irritability of the pulps of the teeth of young people, it is unsafe to put gold fillings into many cavities which in adults might be so treated without any fears as to the result ; and there are many to be met with in adults, especially where the mouth has been somewhat neglected, which are so fragile that they will hardly admit of the application of sufficient force for the introduction of foil, that there is no prospect of introducing a satisfactory gold plug by the methods above mentioned. Either the tooth must be sacrificed, or some soft stopping material must be used. Amalgams will render the tooth dark in colour, and cannot, therefore, be employed. The insertion of gutta percha and silex, known as Hill's or Jacob's stopping, is not open to this objection ; and I do not know that in situations where the material is exempt from any great amount of friction it is less durable than the amalgam. Many cases have occurred in which a gutta percha plug has been perfectly sound at the end of several years, and has presented all the indications of lasting for a much longer period. After all, the preservation of a tooth injured by disease to the extent under consideration is at best but very uncertain. A hard crust, a fragment of bone, or a particle of grit in the food, on striking the tooth during mastication, may break down the walls of the cavity and liberate the plug.

Such cavities may be filled with the zinc oxychloride, or zinc phosphate, and for a time, at least, will be preserved, although the stopping will, sooner or later, fail at the cervical edge. As the failure of the zinc salt almost invariably takes place at this spot, the difficulty might be in some measure obviated, if this part of the filling were made of gold. It is possible to impact gold in the cervical portion of such cavities, even where it is impossible to get sufficient anchorage to ensure the retention of an entire gold filling ;

and by filling the remainder of the cavity with zinc oxychloride it is secured in its place. In several instances I have known such fillings to last much beyond the average duration of osteoplastic fillings, though, of course, they are at best but a "dernier ressort." To finish such a plug effectually the zinc salt must be allowed to set, and the stopping filed and burnished on another day.

Similarly gutta percha may be employed at the vulnerable cervical edge, and the rest of the filling completed with plastic white fillings; and, where its colour does not render it objectionable, that form of gutta percha which is prepared for base plate will be found to endure better than the white gutta percha. It is more troublesome to manipulate, but, although it is softer, it is much less friable, and preserves in the mouth a surface almost polished.

A troublesome form of cavity met with frequently upon the front teeth is that which occurs along the margins of the gums; it usually requires a good deal of alteration of form before it is suited for the retention of a plug, having to be deepened at its two extremities, and a groove formed along its upper and lower edges. In filling such places cohesive gold may be employed from the first and a thoroughly good result obtained, but there is often a good deal of difficulty in keeping them dry, and a more expeditious mode is to be found in the use of cylinders, which for this purpose should be very short, so as not to project far beyond the margins of the hole, but at the same time should be very dense and of considerable circumference relatively to the size of the hole. Such are the 15 B cylinders prepared by Williams, and the reason why large cylinders can be safely employed are several: one that the cavities are always strong walled, another that they are very accessible, and a third that the regularity and curved form of the margins render it easy to force even a very dense cylinder into water-tight contact with all its parts, while the large amount of gold introduced at once removes, after the insertion of two or three cylinders, all disposition to roll.

The plugs may be finished entirely with soft foil, or, after there remains only a small central place to fill in, cohesive gold in any convenient form may be resorted to; very careful finishing and polishing of all the edges is especially necessary in this class of cavity.

When, owing to the loss of back teeth and to peculiarities of bite, the edges of the front teeth have become worn down to an extent that imperils the pulp, it is sometimes desirable to tip them with gold. The operation calls for no special description, save that it is generally desirable to form a slight groove all round the cavity, as well as to form a retaining pit at each extremity: of course cohesive gold is alone suitable for the work.

Closely allied to the form of decay just alluded to is that in which we find a narrow groove at the cervical edge of the enamel, deep in the centre, but cropping out to nothing at either end, with walls which diverge outwards; this may vary, from a slit tolerably obviously produced by the tooth-brush to the wide shallow depression attributed to erosion, a thing which nowadays many authors deem to be but a form of attrition. Putting its origin out of the question for the moment, it may or may not be needful to treat it, according to the rapidity with which we believe it to be advancing, and the imminence of its approaching to the pulp cavity.

It must be remembered that no filling save gold is of much use in such a place, and gold will be very disfiguring; the practice, therefore, of those who cut into shape and fill every spot where this form of mischief is to be detected, as some especially among our American confrères do, does not recommend itself, as it is no uncommon thing for the trouble to be stationary, at all events for a long time. Where, however, it is so deep as to threaten the pulp, or where any softened tissue lines the depression, there is no choice, and it must be filled.

In some few cases teeth may thus be defended, even when each tooth has to be in a measure plated over a large extent

of its surface; but the result is appallingly ugly to look upon.

Bicuspid Teeth.—The treatment of caries in canine teeth, and those upon the grinding surfaces of premolars, may be passed over as not involving any material differences in practice from such as have been already described; but a very large part of the dentist's time will be spent in combating interstitial decay in the premolars, and a few remarks respecting the best methods of procedure are therefore called for. It may be premised that there is much more difficulty in making enduring operations upon these teeth than upon the incisors, partly in that they are more prone to decay, but much more because their shape involves larger surfaces of contact, and their greater function in mastication renders it difficult so to treat them as to get self-cleansing surfaces. To cut them away freely, so as to leave them apart, is not altogether satisfactory; for they are almost sure to close up; whilst to cut the proximal surfaces apart, leaving a shoulder at the gum level, is very apt to leave a dangerous spot at or just beyond the points of contact; so that we are reduced, in a much larger proportion of cases, to the necessity of making contour operations, even though we may not be especially fond of contouring teeth.

And in contouring them it is desirable to leave none of the enamel of the affected tooth in contact with its neighbour, if the cavity be of any considerable size; but so to shape the cavity and the filling that the gold only shall touch the next tooth, or the filling in the next tooth, as the case may be—which will sometimes involve a good deal of alteration in the shape of the natural cavity. It is but seldom, therefore, that it is advisable to enter the cavity from the labial aspect of the tooth, leaving the grinding surface intact, but it will generally be better to cut straight down from the grinding surface.

There is no instrument which answers the purpose better for this stage of the operation than an enamel chisel the

edge of which is formed by grinding off at an appropriate angle the end of a half-round piece of steel of about a quarter of an inch diameter; and the enamel should generally be cut back to the full depth of the cavity, or thereabouts, so that access may be had to all parts of the cavity with a perfectly straight instrument. There will then be a cavity with three walls to deal with; the labial and lingual walls must be cut away till they are quite strong, regard being had to the point already alluded to as to the ultimate points of contact between the tooth and its neighbour; and unless the grinding surface of the tooth be a very smooth one, with the groove across it but feebly pronounced, it will be best, even though caries do not exist in the groove, to cut it out and make a pit in it, so as to get a better form of edge to the finished filling. If this be not done there will be a fissure upon the grinding surface leading to the junction of the filling with the edge of the enamel, and it will form a very likely place for ultimate failure.

The preparation of the cervical edge will need very particular attention, as here also is a vulnerable point: if it extends down so far as to be close to the end of the enamel, it is safer to extend it quite to the end, so as to avoid leaving a small remnant of enamel, which will very likely split off in impacting the gold against it. Even if it does not extend so far, no deep groove should ever be formed or left at this part: it should be cut square, with only the least trace of an undercut, and many of the most careful operators bevel the immediate edge outwards a little. For the shaping of this part of the cavity the spoon-shaped excavator is most useful, as by it there is less danger of an approach to the pulp than would be the case were its end square. The labial and lingual walls may be slightly undercut, remembering always that the minimum of undercut which will retain the filling will leave the walls strongest, will render the operation easiest, and will minimise the danger of failure to consolidate the gold under the edges. Of course the whole cavity must have such a form that the

filling cannot fall out towards the grinding surface of the tooth.

The excavation being complete, we have to make choice of the method of filling to be adopted. Personally, I am very prone to the use of a matrix in these teeth, and therefore to the commencement of the filling with soft foil, or even with tin. Cylinders may also be used, either with or without the matrix; but whatever be done with the filling of the first half or two-thirds of the plug, it will usually, if the hole be of any considerable size, be advisable to complete the operation with cohesive foil. Heavy foil is very convenient for the completion of the fillings in these situations.

FIG. 179. (1)

It is always an advantage for the teeth to have been wedged prior to the insertion of the filling, as this enables the filling to be thoroughly polished, and yet when the teeth close up again, leaves the gold in contact with that in the next tooth. When contiguous cavities have to be filled it is a very good plan to put in gutta-percha plugs, making one filling of the two, and if possible leaving the bite slightly upon the gutta percha. By the end of a few days the teeth will be found to be separated with a minimum of pain and tenderness. Or the requisite separation may be got by the use of Dr. Perry's separators during the excavation of the cavities.

Whatever process be followed in the insertion of the filling, it is of paramount importance to finish the cervical edge very perfectly, and it is even proposed by some to do this when the cavity is only half full, because it is then a little more accessible than it is later on; but this is rather an ultra-refinement, and it can be very efficiently done after the completion of the insertion

(1) Spoon-shaped excavator.

of the gold. If a matrix have been employed, and have been nicely adjusted, the cervical edge will want but little trimming, and if it is composed of soft foil that little can be done with greater facility than would be the case were it cohesively worked from the very first.

So far it has been tacitly assumed that the operator had decided upon restoring the contour of the tooth, at least in considerable degree; but it will sometimes appear to be the best course to leave a space when the operation is finished; and this may be rendered almost necessary by the weakness of the walls rendering it unlikely that they would be able long to withstand the leverage exercised upon them by a filling projecting far out of the mouth of the cavity. It must be borne in mind that this is one of those things where no compromise is to be entertained.

That is to say, if there is not to be restoration of contour, let there be real separation, and no half and half condition. Bicuspids so cut away that their sides are perfectly flat and consist partly of polished dentine forming the immediate surrounding of the filling, will often stand exceedingly well. The teeth may then be left so as to be completely isolated from one another, but it must be remembered that their usefulness in mastication will be materially impaired; for they will have lost a good deal of their masticating surfaces, and, in addition, the gum will not be fully protected against food being packed down upon it. And as food will of necessity get down to the gum, care must be taken that the surfaces are so shaped that it will be easy for the tongue to remove it; and, with this object, the separation should be a little wider on the lingual aspect than it is upon the labial.

Or the alternative form may be preferred, in which there is a shoulder left at the gum level, to serve the double object of preventing the teeth from closing up together, and to protect the gum. This shoulder requires to be shaped with considerable care, so as to leave but a small area of contact; and the patient must be cautioned to pass floss silk through frequently, so as to keep the spot scrupulously clean.

There is not much to be said as to the details of the operation when the insertion of the gold is commenced by the filling of retaining pits, as the proceeding will not differ in any respect from that which would be followed in the case of incisor teeth ; but it may be worth while to say a few words as to the combination of cylinders with a finish of cohesive gold.

It can hardly be too often repeated that, although it is quite possible so to insert highly cohesive foil in such a manner as to be water-tight, yet the difficulties and the pitfalls are such that, in any given case, it is far more likely that success in this direction will attend the use of soft foil, with which it is comparatively easy. Hence the warm advocacy for its use in places where it is not exposed to heavy wear, such a cervical edges ; and cylinders are valuable in this place as being a means of introducing quantities of gold sufficient to steady one another at the same time that the parallelism of their layers ensures the possibility of condensing it uniformly.

Cylinders of such length having been selected that, when placed at the cervical edge with their ends towards the next tooth they shall project slightly, three or four are placed side by side, so as to bridge across from side to side without any material condensation. That which lies against the one side is then slightly condensed, then that which lies against the opposite side, and lastly, that which lies in the middle ; then, returning, condense them fully and mallet them, if the mallet is to be used at all.

By observing such an order in the condensation it will be found that the tendency to roll about is minimised. The mistake into which those little accustomed to the use of cylinders are most likely to fall is the use of cylinders of too small a size, in the fear that they will fail to efficiently condense them. But it is their great merit that they enable us to use large amounts of gold at once, because the gold is all in parallel layers ; and to use very small ones is simply to throw away precisely that advantage which induces us to

select them. Thus, in an average bicuspid cavity, three, or at most four cylinders should, when introduced at the cervical edge, bridge it across and afford a mass of gold amply sufficient to hold firmly in place. A fresh set of cylinders may be placed in the same manner, and the building of the gold carried up to the point where it is thought better to change to cohesive foil.

There is a very easy way of doing this; namely, to place, as before, soft cylinders against the lingual and labial walls, but to put in the centre between them a good large softer-rolled cylinder of freshly annealed gold, such as (in a large cavity) a 36 A William cylinder. These all being condensed down together, the result will be that in the middle there is a region of cohesive gold upon which more may be built, and at the sides, forming the contact with the walls, there is soft foil. Successive additions of cylinders at the sides, and of cohesive gold in the middle, are made; the amount of the latter being gradually increased, as seen in the diagram on page 377, until, as the grinding surface is approached, the whole filling is composed of cohesive gold.

Of course every one will vary the precise method in accordance with his own fancy. Thus, the start with cohesive gold might have been made by digging a hole in the soft foil; but the plan which I have described, of gradually including the annealed gold between cylinders of soft gold, will be found a very convenient one.

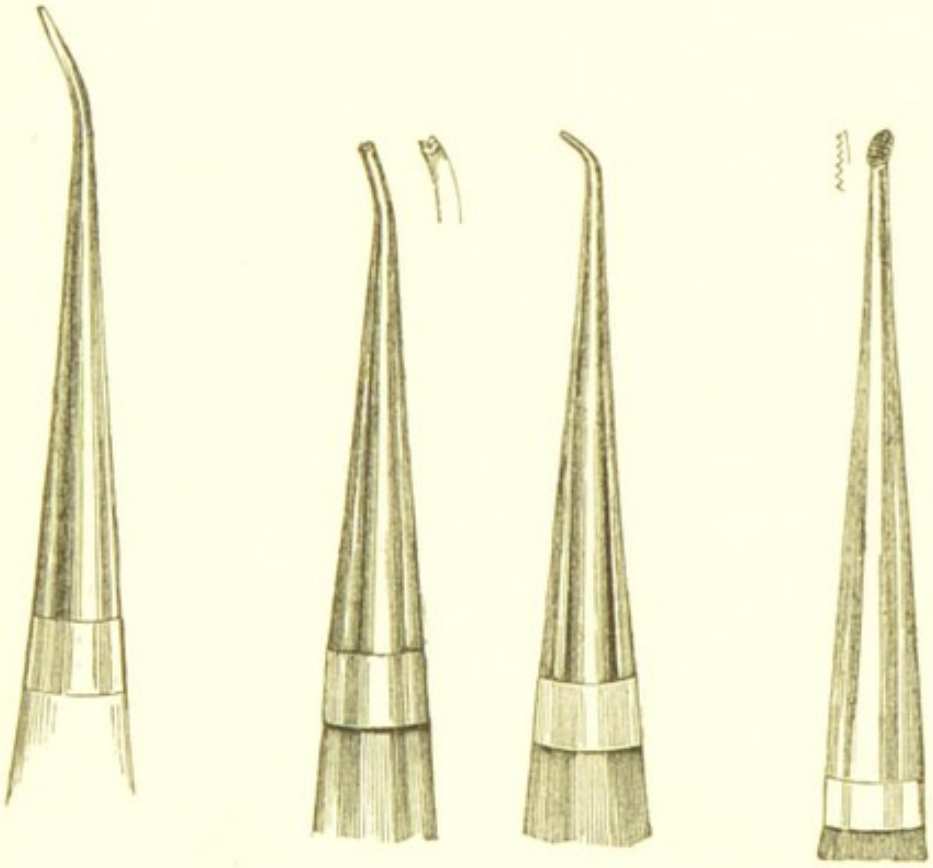
For the condensation of the first portions of cylinder gold, foot-shaped pluggers will be found the best; and their use may often be be continued right through the whole operation; but oftentimes, as the cohesive gold is being introduced, bent pluggers, with square serrated ends, will be advantageous, such as those in Fig. 184.

The cavity having been filled with the gold projecting a little from its mouth, the gold may be gone over with an instrument the round face of which is serrated. This is used with a sort of rolling motion, and will serve to reduce the surface to some degree of evenness; though, of course, it

can have but little effect upon the more purely cohesive portions.

Molar teeth.—In operating upon the upper molar teeth it will be found advantageous to throw the patient's head well back, and for the operator to sit down ; indeed there are but

FIG. 180. (1) FIGS. 181 and 182. (1) FIG. 183. (2)



few filling operations which cannot be performed with far less fatigue in a sitting posture, and the trifling difficulty which will at first be encountered will disappear with a little perseverance, which will be richly rewarded by the relief gained in a day's work.

The use of the mirror should also be assiduously cultivated, as a large number of cavities cannot be directly viewed except by the assumption of a stooping posture, which is exceedingly trying. When seen in the mirror, which for this purpose should be as large as can be intro-

(1) Figs. 180, 181, and 182. Serrated hand-pluggers.
(2) Fig. 183. Broad-faced condensing instrument.

duced without inconvenience, the whole operation can usually be conducted without the assumption of any constrained attitude.

Simple crown cavities of roundish shape can be rapidly and well filled by ropes or strips of annealed foil inserted with a ball-ended plugger, like a very fine-cut engine-finishing bur; in fact, a slightly worn bur makes a capital instrument for the purpose, though a pear-shaped one does best, as the shoulder behind a round one tends to pull the gold out in the early stages.

A perfectly smooth point may be used, like the hand-point supplied for the Herbst method, but I myself prefer slight roughness; but, whichever be chosen, it should be of such size as to easily enter the mouth of the cavity (which should not be materially undercut), but at the same time should be large enough to nearly fill it.

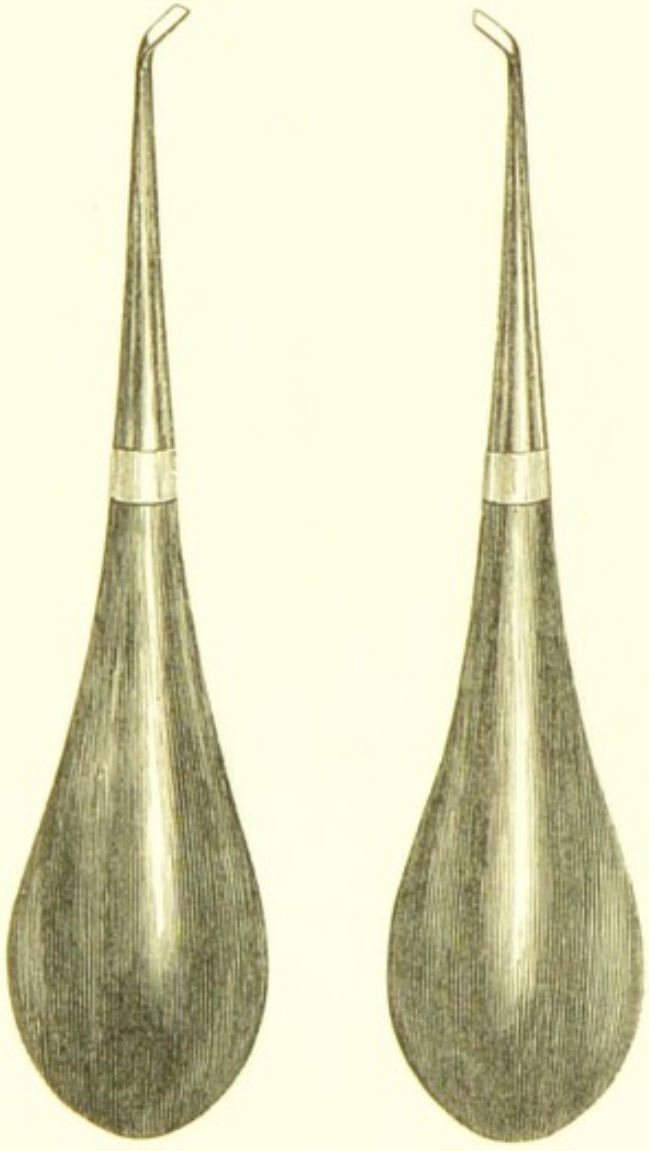
The ball-ended plugger is used with a sort of rocking motion, and the rope or strips of foil rapidly packed in; a smaller similar instrument being taken up to complete the plugging, and to go over all its edges.

These ball-shaped instruments are also very well adapted for filling in the centres of plugs which have been commenced by packing soft foil, whether in the form of cylinders or otherwise, all round the sides of the cavity.

In dealing with interstitial caries in the molars it will be necessary to use the enamel chisel or burs in the engine pretty freely. It is quite impossible to make a good gold filling in a place which cannot be well seen, and in a very large proportion of cases it will be better to cut straight down from the grinding surface than to attempt to work round corners; and tin at the cervical walls will be of more general avail than in the case of teeth further forward in the mouth, as the dark line which it forms will be of no consequence; for the same reason the combination of tin and gold folded up together will come in very usefully, and its hardening property, the exact nature of which is still not understood, renders it valuable where the

strain of heavy mastication has to be met. All that has been said as to matrix filling, cylinder filling, etc., applies equally to the molar teeth : curved pluggers will often be convenient, such as those here figured, which have a slight corkscrew curve not clearly shown in the cut.

FIG. 184. (1)

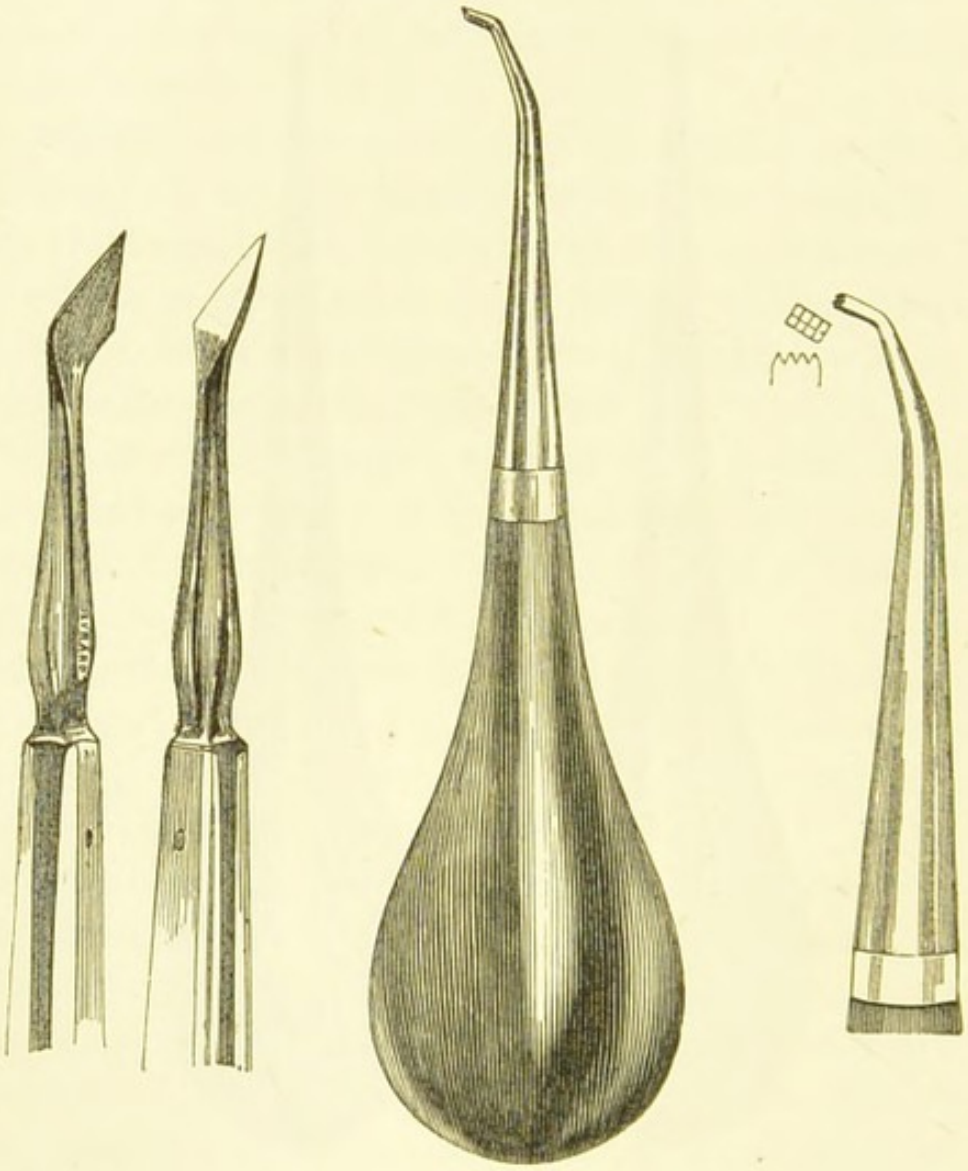


In operating upon the lower teeth there is no general difference of plan required ; but the difficulties of overcoming the flow of saliva are of course much greater, and consequently the number of instances in which the rubber can safely be dispensed with are fewer, and the saliva pump

(1) Fig. 184. Curved hand-pluggers.

will be in very general requisition, both for the patient's and the operator's comfort. In order to reach the mesial or distal surfaces of lower molars and bicuspids, and indeed the grinding surfaces of the molars, enamel cutters will be needed the blades of which are placed at an angle of forty-

Fig. 185. (1) Fig. 186. (2) Fig. 187. (2)



five with the shafts, and the cutting edge formed by a chamfer from the under surface of the blade in the one, and from the upper in the other, and enamel cutters with the blades bent at right angles will also prove very useful; the

(1) Fig. 185. Enamel cutters.
(2) Figs. 186 and 187. Hand-pluggers with a double curve.

instruments represented in the accompanying figures are good in form but are a good deal too large. For hand-pluggers, for operating upon the lower back teeth, a double curve, such as that represented in the accompanying figure, will be found to reach over the other teeth, and down to the distal surface of the one which is being operated upon very conveniently.

For cavities of moderate size in molar teeth or second bicuspids which could only be reached sufficiently freely to insert a good gold filling by a large sacrifice of sound tooth substance, I firmly believe palladium to be quite the best filling that can be used; notwithstanding that, by so saying, I shall probably elicit unfavourable criticism from many here and from a yet larger number of American friends; but then palladium is but little known in America, and not half so much used in this country as it ought to be.

And again, whilst I believe to the full that in moderate cavities a good gold filling will repay all the time, patience, and endurance required for its insertion, I do not think that it will do so in the case of very large molar cavities. It is not as though the result were an assured one; the chances of failure in some direction or other in this class of cavity are by no manner of means remote, and I, setting aside all question of cost, would not care in my own person to sit through the necessarily lengthy operation of building up half or more of a molar for the sake of securing the advantage, supposing all pitfalls avoided, that the gold filling might sometimes have over a carefully inserted amalgam plug.

Plastic Fillings.—In making mention of the various filling materials something has already been incidentally said as to the methods of inserting them, but it will be necessary to add a little upon this subject.

In order to secure the best results with gutta percha great care must be taken to have the cavity dry, and it is a very good plan to wipe it out with chloroform, or a solution of gutta percha in chloroform. It is important to heat the gutta-percha

sufficiently to make it thoroughly plastic, and yet not to burn it, and for this reason some operators heat it over a little water-bath, and others upon a metal plate; either plan is somewhat better than passing each piece through a flame, though, if this be done with sufficient care it is quite possible to get as good a result. The form of instrument employed is not very important, but perhaps the best is a conical point with which the softened gutta percha should be packed until the cavity is somewhat over full: the excess should be trimmed away with a thin sickle-shaped instrument made hot enough to cut it off without dragging, and the surface then finished with a cold burnisher slightly greased. To finish off the edges of the filling with a pledget of wool dipped in chloroform is of doubtful utility, as the surface thus left is perhaps more porous than that left by the burnisher.

The red base-plate gutta percha unquestionably retains a better surface under wear than any of the white preparations, remaining almost polished for a long time. It is, however, much more troublesome to use, as it has a very strong tendency to curl up during packing. This is best met by using it in small pieces made quite hot, and packing it with a sharp conical point.

Osteo-plastic Fillings.—The preparations of zinc oxychlorides deteriorate by exposure to the air, the deterioration taking place mainly, if not wholly, in the powder; to secure uniformity of results, it is therefore a good plan to have it put up in hermetically sealed tubes, each one containing enough for a large filling, as is done with Ash's Rock Cement.

They should all be mixed rather thickly, and this is best done upon a glass plate with a platinum spatula. Dr. Coffin, whose oxychloride fillings were remarkable for their durability, used to pack the paste in successive portions, using strong pressure with pledgets of absorbent paper upon each portion as it was inserted.

In the great majority of cases the rubber dam should be

put on, and the filling thoroughly protected from the saliva by varnishing, the varnish being dried by the hot air syringe before the rubber is removed.

As the cervical edge is by far the most vulnerable point of osteoplastic fillings, it is often good practice to make this portion of the plug of gutta percha, tin, or gold; if this is done the filling cannot be satisfactorily finished down until the cement has become quite hard, when the whole can be cut down and burnished together. In crown cavities the oxyphosphates are not so durable as the oxychlorides; but this is not the case near the margin of the gum. Of the oxyphosphates there are a number in the market, with each of which the makers issue their own instructions. As many of them, and those perhaps the best, set quickly, everything should be in readiness, and the cavity dry before the cement is mixed. This is done with a strong spatula, and the thick paste thus obtained further kneaded and rolled between the fingers, which makes it retain its plasticity a little longer than it does if left at rest. It is quickly and firmly packed in, in difficult cavities a matrix giving much assistance, and the surface smoothed with an agate burnisher slightly greased. It is claimed for fossiline, and for some others, that it is unnecessary to protect the filling from the saliva after it is completed, but this I doubt, as some of the varieties are visibly and obviously injured in this way to a very material extent.

Amalgams.—In the manipulation of amalgams some few points should always be kept in mind, one of the most important of which is that feather edges are rarely or never water-tight, and so in the preparation of the cavity all edges should be left as square as possible; another is, that the amalgam does not absolutely adhere to the walls, and so does not give very good support to frail enamel edges; so that although it can of course easily be packed against them, and there is hence a temptation to leave them, yet this should never be yielded to.

Sullivan's amalgam should be well washed, as it generally

contains some oxydised copper, which can be got rid of by washing in ammonia, in acidulated water, or even in plain water. The more this is got rid of the better will the filling keep its colour; carefully prepared copper amalgam, such as that sold by Stewart, not blackening nearly so much as other forms of the same compound: indeed it in some mouths retains a slight coppery hue instead of deep blackness. It is best used in a thoroughly plastic condition, no advantage attending its use in a very dry state, excepting, perhaps, that of hardness. But Sullivan's amalgam should not be used where great hardness is a desideratum, as it is never capable of standing severe wear.

It is very useful as a filling for milk teeth, and for cavities occurring very early in the first permanent molars, as it appears to be capable of to some extent preserving the dentine around it from liability to caries. There can be little doubt that the black stain in the dentine is due to the formation in it of the sulphide of copper, for the now discarded cadmium amalgam stained it with a characteristic yellow colour, the sulphide of cadmium being the important yellow pigment so largely employed by artists under the name of cadmium yellow.

Palladium is the best of all amalgams when it is quite out of sight, so that its blackness is of no importance, its greatest usefulness being in tolerably strong-walled cavities which could be well filled with gold but for inaccessibility which would render it necessary to cut away the tooth largely, or would render the packing of the gold so difficult that a filling would be unlikely to be made perfect; in the same way it fills a useful place where the difficulty of keeping the cavity dry long is really very great.

But it has one drawback which should be remembered; it tends to expand as it sets, and will often cleave off a weak margin of enamel, so that the caution given as to leaving thin enamel edges applies with extra force to palladium, and it is inapplicable in a good many cavities otherwise well suited for amalgam-filling on this score.

Samples of palladium, reputed to be chemically pure, differ a good deal in their behaviour in amalgamating; some unite very readily with the mercury, others resist it for a time and then unite rapidly, and all give out a good deal of heat as they set; sometimes a sample is met with which, if left at rest for a few moments after being mixed, actually explodes; but what happens in this case is not well understood, for although there is always a good deal of heat set free, it would not be sufficient to volatilise mercury in the middle of the mass with such suddenness; and it has been suggested that the explosion is due to the setting free of occluded hydrogen, of which palladium is greedy.

A special mortar should be kept for palladium only, and it facilitates the mixing if it is not too carefully cleaned, but is left with a little amalgam adhering to the glass or stoneware; it should be mixed with a large excess of mercury, so as to be very fluid, and the excess is squeezed out at the last moment before introducing it into the cavity.

The cavity should be all dried out and absolutely ready before the amalgam is mixed, and no time lost in its introduction, the mass being kept in motion by rolling it between the fingers all the time till it is packed in; it should cease to be plastic in three or four minutes at the longest, so that the filling is hard and can be nicely finished at the time.

No time should be lost in trimming away the overplus, as if there is any delay it will have become so hard as to render this troublesome.

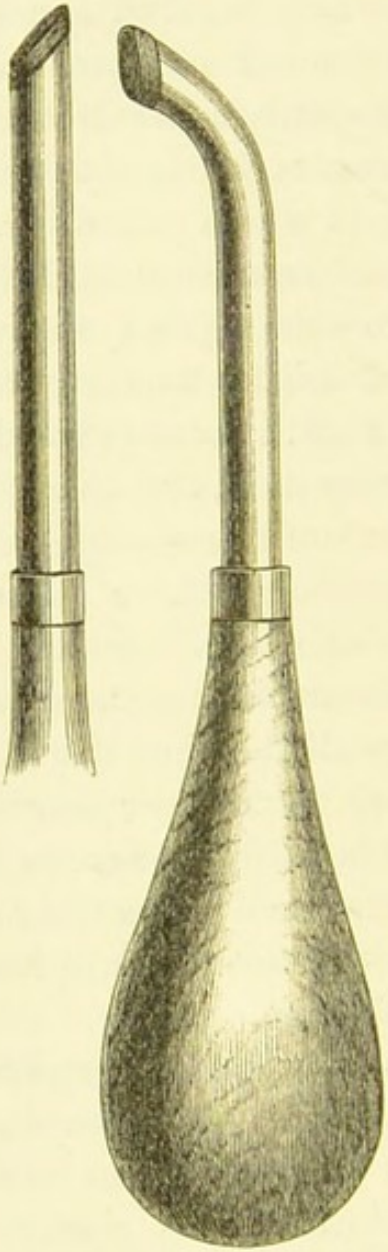
And its rapid setting renders it quite out of the question to use it in any other than a very plastic condition, so that no special directions as to its insertion are called for.

A few years since, partly under the influence of Mr. Fletcher who did much towards the improvement of amalgams, it was thought necessary to use most of the amalgams other than those already mentioned in a very dry form; as has been mentioned before, this at least had one advantage, viz., that this secured the minimum of discoloration; and Mr. Fletcher advised that the mercury

should be weighed out, and little pellets formed from it in its almost pulverulent form by pressing it into little ivory moulds. It being often difficult to convey this very dry amalgam to the cavity, several instruments were devised by

Fig. 188. (1)

Fig. 189. (2)



Mr. Parkinson, Dr. St. George Elliott and others, to meet the difficulty; the one here figured terminating in a short

(1) Amalgam carrier.
(2) Amalgam squeezers, after Dr. Bonwill's pattern.

tube, which is filled with the amalgam; and this is pushed out by a little piston which runs through it when it reaches the cavity.

Very good fillings may be made with appropriate amalgams thus employed; and by the aid of matrices even difficult places may be tolerably expeditiously filled; but after all half the value of an amalgam is gone if it cannot be used in a moderately plastic condition, for it is very troublesome to contour a tooth with a crumbling amalgam.

Dr. Bonwill has shown that an excellent result may be got by using a plastic alloy, and, so to speak, squeezing it in the cavity; and my own experiments prove that, so far as water-tightness goes, at least as good results can be got by this as by any other way of employing amalgams.

The amalgam is mixed not thin, but still thoroughly plastic; it is introduced in successive portions, pads of bibulous paper being forced into it from time to time, by which means the mercury is to a great extent squeezed out at the edges.

These more fluid portions which have thus been squeezed out are removed and more packed in, very strong pressure being employed; and as the filling approaches completion, its surface is gone over with a sort of squeegee, devised by Dr. Bonwill, which consists of a piece of velum rubber contained in and projecting from the end of a metal tube.

By working over the surface with this instrument mercury is squeezed out and the filling becomes hard almost at once.

When Dr. Bonwill is filling two contiguous cavities, he fills them both at once with one mass of amalgam, at the end cutting away the excess and trimming each up to a certain extent, but leaving a point of contact where the two are continuous; through this bridge he cuts with a fine saw on a subsequent day, but there seem to be valid objections to the adoption of this course, for it must be remembered that teeth have a small degree of motion in their sockets, and rub upon one another so as to wear little flat facets where they touch.

Hence, if they be held together by a bridge, some degree of strain will be put upon the walls of the cavities; and this, if it occurs before the plugs are quite hard, will have the effect of making both a little loose, a fact which will become apparent when the file is applied to cut them apart; this has happened to the writer more than once, when the hold in the cavities was but slight.

With the exception of palladium, no amalgam filling can be finished satisfactorily at the same sitting; it should always be polished with sand-paper, disks, &c., after it is hard; upon the fine finish of its edges a good deal of its durability is likely to depend, but, at all events, if so finished it will keep its colour and polish far better than if this is neglected.

After making a large number of experiments out of the mouth, and comparing the results so obtained with the operations performed in the mouth, Dr. Bonwill's method of manipulation appears to have advantages over all of the others. Dr. Coffin had been in the habit of practising something of the same kind by using pledgets of gold or of tin, with considerable pressure, which absorbed the surplus mercury, but Dr. Bonwill has carried it out with a greater thoroughness than any other operator, and obtained in his own practice results with amalgam of exceptional excellence.

For cavities which are not much in sight, Dubois and Eckfeldt's Standard Alloy, manipulated in this way, gives very good results; it sets very rapidly, but does not keep a good colour, being believed to contain copper. Dr. Bonwill's amalgam, also a rapid setting amalgam, makes good fillings, but is not quite in the front rank as regards colour; and Welsh's amalgam is also an excellent one. Fletcher's Extra-plastic or Expanding Amalgam makes good fillings, but the colour is not first-rate, Fletcher's Gold and Platinum Alloy, Davies' Amalgam, and Ash's, being better in this respect.

In order to get over the fact that some of the best amalgams do not keep a good colour, it has been proposed

to form the bulk of the filling with such, and to surface it with thin wafers of an amalgam specially good in respect of keeping its colour, but this has not found much favour in every-day practice.

For an account of this, as well as for much information upon the subject of amalgams, the reader is referred to Dr. Foster Flagg's work on plastic fillings, where a number of formulæ are given. Eckfeldt and Dubois' amalgam is a favourite one with him, where its colour is not a disadvantage.

In the insertion of difficult amalgam fillings all the aids to which we have recourse for gold fillings, such as matrices, gold or platinum posts, or screws, are available, and it is sometimes advisable to leave the matrix, which, in such a case should be a belt of platinum, on till the next day.

Absolute dryness of the cavity is of course desirable, and without it the finest results are not attainable, but fair results may be obtained with care and repeated dryings with bibulous paper even in places from which the absolute exclusion of moisture is hardly practicable.

And in conclusion it may be said that amalgam fillings will repay the operator for all the care and skill which he can bestow upon them. The difference between a good and an indifferent amalgam filling is so great that those who are in the habit of hastily and carelessly inserting it, as a thing upon which much trouble is time wasted, would hardly credit its capabilities when used to the best effect.

TREATMENT OF EXPOSED PULP.

It has thus far been assumed that the cavity to be dealt with has not been of such depth that we have to take the pulp into account at all, and, indeed, it may be said that so soon as we have to do so the really favourable time for filling the tooth has run by. But it will happen sometimes, even in the teeth of those who are careful, and present themselves for examination at regular intervals, that a cavity in a hidden situation will escape notice until it is of considerable depth, and this will be almost the rule amongst the less careful of our patients.

When, after the removal of all the softened dentine (of which, perhaps, we have left a trace at the floor of the cavity rather than go any deeper), the pulp has been somewhat nearly approached, it will be advisable to place some substance which conducts changes of temperature less freely than any metallic filling on the floor of the cavity. If no pain has been felt otherwise than under the provocation of large alternations of temperature, or the access of such substances as sugar, &c., it may be presumed that the pulp is healthy, and so without further treatment we may proceed to protect it; a layer of zinc phosphate, or of zinc oxychloride, may be inserted, and so cut away when partially hardened as to leave the residue of the cavity of good form for filling; if, however, it appears that the dentine remaining between the pulp and the future filling is exceedingly thin, a capping less irritating than either is formed by mixing zinc oxide into a very thick paste with oil of cloves, and then with sufficient zinc chloride solution to make it into a very thin paste. This, which sets rather quickly, is spread over the floor, avoiding any pressure, and

allowed to harden; this mixture seems to be tolerated where the simple salt would cause a severe pain which is not always transient.

Caries with perforation of the pulp-cavity, the pulp being healthy, is a condition that is but seldom seen, excepting as the result of an operation. The dentine in contact with the pulp having been softened by disease, is removed when the cavity is prepared for filling, and the pulp thereby exposed. Perhaps it would be wrong to assume that in such a case the pulp is absolutely sound, but there may be nothing to show that it is diseased, and nothing to warrant the adoption of any other treatment than that which would be pursued if its healthiness were unquestioned.

I am not prepared to say that we never find the pulp of a carious tooth the cavity of which has been laid open by the disintegration of its walls, free from disease; but cases exhibiting such conditions are very rare, whereas the exposure consequent upon the removal of carious dentine is not very uncommon. It is an unfortunate accident which cannot always be avoided—unfortunate, because it would have been better to have retained the softened tissue, the removal of which occasioned the exposure of the pulp, and to have protected it from further decomposition by mopping it freely with oil of cloves, or carbolic acid (full strength), and by plugging the cavity. Had this treatment been adopted, we should, on examination, after the lapse of a few months, have found that the pulp itself had become calcified at the point corresponding to the disorganized dentine. The presence of a plug stays the further progress of the disease, and prevents the fluid of the mouth from penetrating through the defective wall of the pulp-cavity, while the softened tissue retained as a covering to the pulp saves the latter from the effects of sudden changes of temperature, which would have been readily conveyed through a metal plug, but for the intervention of the dentine. When, however, the exposure is produced during an operation the pulp is usually wounded, and bleeds freely. The pain is commonly

acute, but soon subsides; but sometimes no pain is experienced. After the bleeding has ceased the cavity should be syringed out with tepid water, and carefully dried with cotton-wool. The actual state of the walls of the cavity, the size of the perforation into the pulp-cavity, and the condition of the dentine immediately around the hole, can then be examined. If it be found that the whole of the softened dentine had been removed, that the aperture into the pulp-cavity is very minute and surrounded by sound tissue, we may proceed to plug the tooth in the usual manner, adopting the precaution of laying a small piece of sticking plaster over the aperture. But should it appear that the opening into the cavity is of considerable size, or that, though small, it is surrounded by softened tissue, the removal of which would increase its size, a different mode of proceeding must be adopted, as indeed is generally preferable.

As much as possible of the disorganized tissue, short of enlarging the aperture, should be carefully cut away, taking care that the walls of the cavity are reduced to a suitable form; an artificial substitute for the missing portion of the wall must be provided, in the preparation of which two conditions should be observed. Like the dentine, it should be a non-conductor, and also, like it, be capable of protecting the pulp from pressure. To possess the latter quality the material must have a certain degree of strength, and be slightly concave on that surface which is presented towards the pulp.

It is usual to speak of the operation under the title of "capping" the nerve or pulp, and the substance shaped to cover the pulp as the "cap." Gold, ivory, quill, horn, cork, and many other substances have been used.

A piece of suitable size cut from the barrel of a stout quill, being readily produced, was formerly often used. In determining the shape and size of the cap, it must be remembered that there is no objection to the whole of the floor of the cavity being covered; at all events, the cap should be sufficiently large to ensure its edges resting at some little distance

from the margin of the aperture by which the pulp is exposed, otherwise it will fail to protect the latter from pressure during the operation of plugging, and subsequently from that consequent upon the tooth being used in mastication.

While it is necessary that the exposed portion of the pulp should be perfectly protected from pressure, it is perhaps equally desirable that a space should not be left in the concavity of the cap into which the pulp could be received, were it from any cause to protrude through the aperture in its proper cavity. The natural conditions of the part involved should be observed, and as far as possible restored.

These requirements are very well fulfilled by the use of little stamped-up concave disks of platinum which are sold for the purpose, their concavity being filled up with a slight excess of a paste of oil of cloves and zinc oxide ; or a piece of thin card smeared with the same preparation may be used in cavities so shallow that there is but little room for a bulging cap ; but after all, the paste containing both oil of cloves and zinc chloride, which itself sets quite hard enough for the protection needed, is here also about as good as any more elaborate appliance, but it should be mixed so soft that it almost flows over the exposure, and no kind of pressure should be put upon it until it has set quite hard. For it is pressure which is one of the most frequent stumbling-blocks in the way of successful capping of presumably healthy pulps.

But whatever form of capping be adopted the success of the treatment can never be absolutely assured until after the lapse of a considerable time, and so no filling which is put in can be considered as a permanent one ; hence it is better to at once accept this fact and insert a white plastic filling, or in situations where this would soon perish, an amalgam or gutta-percha plug; but this latter I hardly regard as a very perfect protection to a living pulp which has been very nearly exposed, excellent filling as it is from the point of view of resisting caries.

Our object being to promote the formation of a little secondary dentine to repair the damage done at the surface of the pulp, it is not good practice to use any very potent or caustic medicament; thus if we wish to use carbolic acid it must be in very dilute solution, lest by the application of anything of caustic strength we destroy the formative odontoblast layer.

And the patient should be taken into our confidence and made to understand that the tooth must be carefully watched, for a material failure of the temporary plug may undo all that has been gained by the whole capping and filling.

The capping of apparently healthy pulps is a very fairly successful operation; I say very fairly only advisedly, as although a very large proportion seem to do very well and no pain follows the operation, yet a certain number of these teeth examined after the lapse of a year will be found to have dead pulps, even though there has been no discomfort to speak of, or perhaps none at all.[1]

But whatever may be the ultimate issue, there is practically not much uncertainty attending upon the treatment of a healthy exposed pulp for the time being, whatever be the mode of capping preferred, so long as no violence is done to it; the case is far different, however, when we have to deal with an unhealthy pulp, as is far more often the case, even when there has not been any actual visible exposure.

Unfortunately we have not much means of judging of the actual condition of the pulp except by inquiry as to the amount of discomfort which it has caused, and, as this varies not a little in states of the pulp which appear to be identical, our estimate of its degree of departure from health is very often erroneous.

(1) Papers to which the reader may be referred are those of Mr. Thos. Rogers, Trans. Odont. Soc., vol. i., and Dr. Louis Jack, Dental Cosmos, 1873; much has been written since, and will be found scattered through the pages of the dental journals, but the principles of practice remain much as when laid down in these earlier papers.

In a large majority of cases a pulp which has once ached continuously and severely for several hours will, if the opportunity for examination occur, be found to have undergone changes perceptible to the naked eye, and so far as my personal experience goes, such pulps do badly under any form of capping.

Irritation of the Dentinal Pulp.—A diseased condition of the pulp, whatever may be the nature of the disease, is, in the majority of instances, consequent upon the pulp-cavity being laid open, either by the destruction of its walls by caries, or by injury of the crown of the tooth from mechanical violence. But a few cases will be met with in which the tooth becomes painful, and highly sensitive to the effects of sudden changes of temperature induced by the contact of hot or cold fluids, and even to pressure upon the crown or upon the neck of the tooth, while the walls of the pulp-cavity are apparently free from injury. In such cases the patients will complain that the tooth is incapable of bearing with comfort the pressure exercised in mastication. And care must be taken not to be misled by this into the belief that there is periosteal inflammation. Careful examination usually leads to the detection of caries, or to the loss of a portion of the crown of the tooth, either from wear or fracture. A certain degree of pain is produced by pressing a steel instrument upon the injured spots, but the degree of pain will not correspond to the amount of force exercised ; indeed, slight contact seems to give quite as much pain as firm pressure.

But we may fail in detecting any structural change in the indicated teeth. The disordered state may depend upon some other tooth, which, although itself free from pain, may produce sympathetic irritability ; thus pain really due to the wisdom-teeth is often referred to the bicuspids ; or it may depend upon a cause which has a constitutional or general origin. The earlier stages of cold, pregnancy, rheumatism of the jaw, or the presence of mercury in the system, are frequently accompanied by an irritable state of the teeth.

When the foregoing local symptoms are present, it is very difficult to determine whether the sense of pain in the tooth is confined to the dentinal fibrils, or whether it is situated in the pulp, the susceptibility of which has become abnormally heightened. There is no reason for supposing that the fibrils are incapable of assuming a condition of excessive sensibility, and that the morbid state may not for a time be confined to them. But, on the other hand, it is equally possible that the increased susceptibility may originate in and be limited to the pulp itself, which becomes painfully affected by causes which otherwise would not produce uneasy sensations.

That a state of irritation may be assumed by the pulp is sufficiently proved by the fact that the irritable condition of the tooth may be succeeded by inflammation of that organ. Examples of the sequence of the one to the other condition may be seen in teeth, small portions of which have been broken off without injury to the pulp-cavity. When so injured they become gradually sensitive to changes of temperature, and the pain, which at first was transient, at last endures after the exciting cause has been removed. The amount of pain is gradually increased, and eventually terminates in a severe attack of toothache, occasioned by acute inflammation of the pulp. On the aching tooth being removed, it will be found that although the pulp-cavity is entire, the pulp is passing into a state of disorganization. A similar course of symptoms will sometimes follow the operation of plugging a simple cavity in teeth which have been in an irritable condition prior to the operation. For example, in a patient lately under my care, gold fillings were placed in two mesial cavities in the right and left lower molars; the cavities were fully exposed to view, and no indication of exposure of the pulp was to be seen; in fact, the cavities were so shallow that the introduction of a filling was difficult. In the course of a week the gold had to be removed; too late, however, to prevent the spontaneous death of the pulps. In this same patient I had been shortly before that time compelled to remove a crown filling, where the

cavity was both small and shallow, on account of the irritability of the pulp. The susceptibility of the pulp to irritation varies greatly in different persons; it is far greater in youth than in adult life, and there are some few for whom it is next to impossible to successfully perform the operation of filling without setting it up.

No doubt the pulp of a tooth may pass into a state of irritation, independent of injury sustained by the hard and protecting tissues, just as in certain states of the system the susceptibility to disease of any other organ of the body may be increased. But in those cases in which the crown of the tooth has suffered, there appears good reason for supposing that the abnormal state begins in the dentinal fibrils, and extends through them to the pulp. This view is, I think, supported by the results which follow careful treatment. If, in a tooth the crown of which has been injured by caries to a slight depth only, but in which the dentine is highly sensitive, nitrate of silver be applied to the affected part, the susceptibility to pain will in a few minutes be greatly reduced. A similar result will follow the application of other forms of escharotics, unless the walls of the pulp-cavity are sufficiently reduced in thickness to allow the application to pass through to the pulp. The effects with these active agents are rapid, but their use is not free from danger; for it is not always easy to discover how much or how little sound tissue may intervene between the pulp and the sensitive surface. Excepting as a matter of experiment, or when a sufficient length of time cannot be allowed for the application of less active remedies, it will be well to employ vegetable astringents, such as tannin, or solution of gum-resins in alcohol, and to continue the treatment till the tooth regains its normal state.

In a previous page it was stated that the dentine loses sensation on the pulp being destroyed, and it is now shown that a sensitive surface of dentine loses its power of feeling or transmitting pain after treatment with nitrate of silver. The fact that in irritation of the pulp the whole tooth be-

comes hyperæsthetic, so that cold or heat applied to its exterior causes a shock of pain, seems to indicate that the fibrils themselves participate in the change, or at least that their conducting power is exalted.

Irritation, if long continued, is usually, but not constantly, productive of certain changes in the pulp itself,

Fig. 190. (1)

Fig. 191. (2)

Fig. 192. (3)

examples of which may be seen if teeth removed after a long-continued state of uneasiness has been succeeded by active aching, be examined. In some the pulp will be found to contain numerous nodules of dentine; in others, the greater part of the pulp will be found converted into secondary dentine (Fig. 190). Or the calcification of the pulp may be limited to the production of a patch of dentine added to the wall of the pulp-cavity (Fig. 191 and Fig. 192).

In neither of the preceding cases can the calcification have been effected during the day or two of acute suffering in the tooth, consequently it may be inferred that the production of secondary dentine took place when the irritable condition prevailed. It must not on this account be assumed that calcification of the pulp invariably follows upon

(1) Showing the pulp-cavity of a first permanent molar of the upper jaw perfectly filled with a mass of secondary dentine, produced by calcification of the pulp induced by caries of the crown of the tooth.

(2) Section of a tooth, showing the local thickening of the wall of the pulp-cavity, consequent upon irritation produced by advancing caries.

(3) Bicuspid in which a formation of secondary dentine has failed to obviate perforation of the pulp-cavity.—From Tomes's "Lectures on Dental Physiology and Surgery."

irritable conditions of the tooth, for cases will be found in which the presence of secondary dentine cannot be recognised, and others in which a large portion of the pulp has undergone calcification without the precedence of irritability in the tooth. Moreover, it seems probable that the mere presence of these isolated nodules in the pulp is capable of exciting great irritation, instead of being a result of previous excitation of the pulp. On the other hand, it must also be remembered that small isolated calcareous globules are to be found in perfectly healthy developing teeth.

Treatment.—When the irritability of the tooth is consequent upon the presence of simple caries, our aim must be to introduce a temporary plug; some little caution must, however, be used, otherwise the remedy will but serve to increase the disease. The patient may have sufficient endurance to allow the excision of the whole of the affected dentine, and the subsequent introduction of a gold or other metallic filling, but the presence of metal, from the rapidity with which it transmits changes of temperature, serves, when the tooth is highly sensitive, to increase rather than mitigate the evil. The sensitiveness would, however, in many cases, gradually subside; in others, we shall be required to remove the metallic plug, and substitute a non-conducting material. The white plastic fillings will be found extremely useful in the treatment of such cases. Indeed, whenever we find that greatly increased sensibility is established, we shall do well to introduce a temporary plug of this material, taking care to substitute gold when the tooth has recovered its normal condition. In many cases, however, the pain occasioned by the excision of the decayed dentine is perfectly intolerable. The application of chloroform, creosote, or camphorated spirits of wine will lower the sensibility slightly; but no agent is so immediate and complete in its action as a fragment of nitrate of silver introduced into the cavity, and allowed to remain for five or six minutes. Of course, in the front teeth lunar caustic cannot be used, owing to the discoloration which it occasions; but in the back teeth the

dark stain is of less consequence. The natural colour of the tissues, even in the molar teeth, should, if possible, be preserved, but not at the risk of losing them altogether. There is another advantage which attends the use of nitrate of silver; it has a power of arresting the progress of decay.

In connection with a generally heightened sensibility, we sometimes find a ring of decomposing and extremely sensitive tissue encircling the necks of several, or perhaps all, of the front teeth. The operation of plugging is quite out of the question, and the complete destruction of the teeth is therefore reduced to a mere matter of time. Owing to pregnancy or some other cause, it may be desirable to adopt means for allaying the susceptibility of the teeth, and at the same time to preserve them, if possible, for a few months. In the treatment of cases of this description, nitrate of silver has proved very valuable. The author can call to mind many cases in which, by the application of lunar caustic, great discomfort was removed, the presence of hot or cold fluids rendered tolerable, and the teeth, although blackened at the necks, were kept from further deterioration for five or six years.

It may be said that the foregoing treatment bears rather upon an abnormal condition of the dentine than upon an irritable condition of the pulp; and the objection may, in some cases, be valid, but it will be almost impossible to distinguish between pain felt in the dentinal fibrils and in the pulp, and the distinction in respect to the treatment is unimportant, as the conditions run into one another.

Irritation of a pulp which has not been exposed seems most prone to arise in cases where the progress of the caries has been very rapid, and there will often be found in the cavity a large thickness of softened dentine, which has not yet crumbled away, and still preserves a certain degree of consistence. The surmise may be hazarded that, in such cases, the dentinal fibrils have remained alive through a considerable distance in the softened dentine and have not

perished *pari passu* with the progress of the softening; this idea being suggested by the great tenderness of the affected tissue.

It is a safe rule to defer the filling of teeth with irritable pulps until all sign of irritation has subsided; and so it is best to dress the tooth with soothing applications for a while, such as oil of cloves, or creosote, which latter is by many preferred to carbolic acid, though others doubt if carbolic acid diluted till it about corresponds in strength with creosote has not precisely the same effect without the unpleasant taste of the former drug. Strong carbolic acid may itself be used, especially when there appears to be some little thickness of dentine between the cavity and the pulp.

So far it has been assumed that no defined structural lesion has been present, at least no coarse lesion, for it is probable that in all cases of pulp irritation there is structural alteration, were we able to recognise it.

Counter-irritation, in the form of pepper-plaster, applied to the gum over the roots of the tooth, or even strong painting with iodine, will sometimes be successful in quieting pulp irritation, but occasionally all remedies prove futile. One of the most characteristic symptoms of irritation, or of chronic inflammation of the pulp, is the occurrence of sudden darts of severe pain, occurring capriciously, and leaving in the intervals no sensation whatever.

Acute Inflammation of the Dentinal Pulp.—The occurrence of inflammation of the pulp is usually consequent upon its exposure, brought about either by caries or the accidental fracture of the tooth. Not that the pulp is more exempt from the occurrence of inflammation than some other soft tissues, but still the cases of idiopathic disease are not very frequent. In ninety-nine cases out of a hundred the diseased action is consequent upon the perforation of the pulp-cavity. The following is the usual course of events:—A hole is discovered in a tooth, food and other matters collect in it, and are from time to time removed. The presence of foreign bodies at first produces no inconvenience, but after a while

certain substances, such as sugar, or salt, or acid matters, when lodged in the tooth, occasion considerable uneasiness, which is, after a while, exchanged for positive pain. The removal of the irritating matter is soon followed by the restoration of comfort. This state of things may go on for some time, but, sooner or later, the pain, instead of passing off, steadily increases, assumes a throbbing character, becomes still more acute, extends from the faulty tooth to the neighbouring teeth, and to the side of the face, the tooth forming the centre of its intensity. After the lapse of some hours the pain usually subsides, to return again on the slightest provocation, or on the patient assuming the horizontal position. If a tooth be examined subsequent to two or three, or perhaps even after one, severe attack of throbbing pain, the pulp will be found to have lost its vitality, and to have passed, or to be in the process of passing, into a state of decomposition. With the death of the pulp there comes a period of remission of pain, prior to the occurrence of alveolar inflammation and abscess.

Such, then, is the usual course of events, when the pulp of a tooth becomes inflamed. The results of inflammation may, however, be modified by the constitutional condition of the patient; the symptoms may be less severe, or they may be greatly aggravated. In some cases the pain lasts but for a short time, and is comparatively moderate in degree, while in others it is continued for days with great intensity. Again, in one case the alveolar inflammation is absent, and in another the whole mouth becomes affected. Independent of the constitutional state, these differences in effect will no doubt depend upon the condition of the pulp prior to the advent of active disease. The size of the pulp will exercise a very material influence; and the number and size of the globules of secondary dentine within its substance will also tend to modify the severity of the symptoms. Generally, the smaller the amount of vascular tissue involved in the disease, the milder will be the symptoms; it is, consequently, seen that in young people in whom the pulp is

relatively large, and the amount of secondary dentine within its substance comparatively small, the suffering is greater, and the inflammation more extended than in older subjects. The size of the aperture by which the pulp is exposed, will also influence the amount of suffering which attends inflammation of that organ. Local constriction of an inflamed part, under all circumstances, greatly aggravates the pain. In a tooth the pulp is uniformly confined, excepting at the point where the wall of the cavity has been perforated; when the vessels become distended, and the more fluid portions of the blood are effused, the pulp will enlarge at any point where enlargement is possible, and it is consequently protruded through the aperture in the walls of the pulp-cavity. The hole in the substance of the tooth is always much larger than the opening into the pulp-cavity, consequently that part of the pulp which has been protruded through the narrow opening into the larger space may there become enlarged, while the part which connects it with the pulp is constricted.

There are but few of us who do not know something of the pain which results from drawing the air from a carious and aching tooth—or, in other words, sucking it—whereby the atmospheric pressure is taken off the exposed portion of the pulp, leaving the vessels unsupported to withstand the force of the circulation. The immediate result is, that the pulp is forced against or through the opening, and in some cases its vessels are ruptured. The bleeding so produced not uncommonly relieves the distended vessels, and the inflammation is for the time checked. That which we can produce at will occurs, in a greater or less degree, without our intervention; and the amount to which the pulp is protruded, and the degree of strangulation which is induced by the form and size of the exposure, will largely modify the amount of pain.

The dental pulp has but little power of recovery when once it has passed beyond the stage of irritation, and it might almost be laid down as a rule that a pulp which has once

ached very severely is sure to die sooner or later, and most probably at no distant time. It is a bad symptom when cold is found to give relief, and heat or even moderate warmth to aggravate the pain. When we find that a patient holds cold water in the mouth, and will hardly allow of adequate examination, because, as the tooth rises to the temperature of the body the pain increases, we may be sure that the pulp is in a state of acute inflammation and far past any treatment save its speedy destruction. On the other hand, a pulp which is merely irritated will dislike cold as much, or almost as much, as heat.

Merely premising, then, that acutely inflamed throbbing pulps are practically sure to die, their manner of death being probably by plugging of their vessels, and the aching thus oftentimes stopping with singular abruptness, and that therefore it is rarely if ever well to attempt any other treatment than destruction, we may pass to the consideration of the more chronic forms of pulp disease.

During the absorption of the roots of temporary teeth, their pulps undergo a degenerative process by which they are robbed of their extreme tenderness; in advancing age also a somewhat similar change takes place, so that the pulps come to contain oil globules in abundance, and are much less intolerant of irritation.

The discrimination of the various conditions which diseased pulps assume does not at present rest upon any sound and exact knowledge of their pathology, and it therefore happens that for convenience, when we need to make some approach to a classification, we are obliged to divide them up by an arbitrary system based upon symptoms more than anything else.

By a chronic inflammation of the tooth-pulp that which is generally meant might perhaps have been better called a local inflammation rather than one affecting any large area of the pulp; but, on the other hand, in many of the cases which would be called acute, it is not always the whole which is involved, so that this distinction somewhat fails us.

Chronic Inflammation of the Dental Pulp may arise independently of caries, or of the mechanical injury of a tooth, but practically its occurrence may be assumed to be consequent upon, and almost invariably coincident with, the presence of an opening into the pulp-cavity. It differs from the acute form of the disease in the less active character of the symptoms, and also in the results to which it leads. The pain is seldom long continued, or very intense when present. It generally comes on at irregular intervals, a periodical character being observed in exceptional cases only, although these partial inflammations of the dental pulp are specially prone to set up wandering neuralgic pains, the true origin of which may be obscured by the complete absence of local toothache. A sudden change of temperature, the application of an irritating substance, such as salt or sugar, will generally bring on a paroxysm of pain, which may endure but for a few minutes, or may last for several hours.

On carefully examining a tooth which gives rise to the foregoing symptoms, it will be found that the pulp at the exposed point has assumed a deep red colour, is extremely sensitive when touched with an instrument, and bleeds very readily. If the tooth be removed, and the crown broken through so as to expose the pulp, it will then be seen that the inflammation has been limited to that part which was exposed, the remaining portion of the organ having retained the normal pale colour. Had the disease assumed the acute form, the greater part of the pulp would have been injected with blood, the exposed part being distinguished by the greater intensity of its colour.

In tracing the several consequences of chronic inflammation, the first which should attract attention is the change in the character of the exposed portion of pulp. It becomes for the time being a secreting surface; purulent or serous fluid is poured out from its surface, the amount and character of the discharge varying perhaps with the general health of

the patient, but more certainly with the degree of irritation to which the diseased part has been subjected.

Supposing this abnormal condition to be established, the presence of pain is not a necessary consequence; and it is important that the fact should be kept in view, for should it be assumed that the pulp is not exposed because the patient has not suffered from toothache, and a plug be introduced, it is highly probable that the tooth will be lost. The discharge will be blocked in by the plug, and its accumulation will, in the course of a short time, bring on an attack of acute inflammation of the whole pulp. It is therefore of great consequence, before proceeding to treat a carious tooth, to ascertain whether the pulp be exposed or not. The history of the case will not always determine the question, and the position of the tooth, or of the cavity in it, may be such as to render a satisfactory inspection difficult. The presence, however, of that peculiar phosphatic odour, to which allusion has been already made, is a tolerably sure indication that the pulp is exposed, and that a secretion escapes from its surface; and it is, moreover, a sufficient warning to abstain from the immediate introduction of a permanent plug.

A second result of chronic inflammation is the formation of an ulcer, of a very painful and irritable kind, upon the exposed surface; and a third consequence is the development of granulations, which may grow until a mass is formed exceeding the size of the pulp itself, and, in some cases, completely filling up the cavity produced by the destruction of the enamel and dentine. This condition is usually described as polypus of the dental pulp. The morbid growth is not necessarily very sensitive. It bleeds readily, and emits a very offensive secretion.

There are other results which attend chronic inflammation of the pulp. One consists in the gradual disappearance of the pulp by suppuration without pain, and consequently without any symptom which attracts the attention of the patient. The practitioner finds the pulp-cavity empty.

The results of inflammation hitherto mentioned are destructive in their tendencies, but the presence of disease is usually attended by reparative efforts. The development of nodules of dentine in the pulp is almost invariably coincident with the occurrence of caries ; and there is no reason or assuming that the process of formation is arrested in the comparatively healthy portion, although the exposed surface of the pulp is inflamed. But there seemed some reason to doubt whether the exposed surface could undergo calcification. Mr. Arnold Rogers had a preparation which, I think, sets the question at rest. A patient applied to have the roots of a first molar removed, the crown having been broken off many months previously, when, for the relief of pain consequent upon caries, the extraction of the tooth was attempted. The pain ceased after the fracture, and the roots of the tooth were allowed to remain. After the lapse of some months, the remains of the broken tooth caused annoyance, and they were removed. The specimen (Fig. 193) shows that the tooth was broken through about the middle of the pulp-cavity, projecting from which we now find a mass of secondary dentine. It not only projects from the cavity, but hangs over and conceals the sharp edges produced by the fracture. It is obvious that in this case the vitality of the pulp was maintained, that it became enlarged subsequent to unsuccessful operation, and afterwards calcified.

FIG. 193. (1)

There is no evidence to show that secondary dentine can be formed in any other tissue than dentinal pulp. In the

(1) Shows the roots and neck of an upper molar tooth, the crown of which had been broken off in attempting its extraction. Some time afterwards the roots were removed, and it was then found that a mass of secondary dentine projected from and overhung the margins of the remaining portion of the pulp-cavity. A similar specimen is placed by the side of this in the Odontological Society's Museum, the history of which is precisely similar. The gum in this latter case was believed to have healed entirely, or almost entirely, over the fangs and the exposed pulp, thus affording it protection.

case under consideration, the secondary dentine passes over the normal boundary of the pulp-cavity; we are therefore justified in assuming that the pulp itself became enlarged. Now, the tooth had ached before the primary operation was performed, and it may therefore be taken for granted that the pulp was at that time more or less inflamed. These facts, although taken from a single case, warrant the conclusion that there are circumstances under which the dentinal pulp, although it has been diseased and exposed, may be converted into secondary dentine. Having established the fact, the precise nature of the circumstances which favour this reparative action should be determined.

In the case cited the secondary dentine was exposed to view when the patient applied to Mr. Rogers, but the pulp, during the process of calcification, must, I think, have been protected in the first instance by a coagulum of blood, and subsequently by a perfect covering of organized tissue. Had it been otherwise, the pulp would probably have been injured and ultimately destroyed by mastication.

FIG. 194. (1)

I am not acquainted with any cases which can be regarded as strictly parallel to the foregoing, but we may find instances—if a number of teeth are divided—showing that the bulk of the soft tissue had been calcified, although at the point of exposure the conversion remained incomplete. I believe it not uncommonly happens, that the calcification keeps in advance of the progress of caries, and thus protects the pulp from exposure. But such teeth are not removed, and therefore do not come into our hands for examination.

Allusion has already been made to the fact that chronic inflammation of the pulp may not be accompanied by pain in the tooth itself, yet that it may cause severe sympathetic pains in the head and face, and that the pain may extend

(1) A first permanent molar tooth of the upper jaw, the pulp of which was calcified, excepting at its upper part and at the exposed side.

down the neck as far as the shoulder. I remember a case in which the patient suffered severe pain on one side of the head and face at tolerably regular intervals. The pain came on in the evening, and lasted for six or eight hours. It was for some weeks regarded as a case of tic, or hemicrania. After internal remedies had failed, a decayed but painless wisdom tooth of the upper jaw was removed, and from that time the facial pain disappeared. The pulp of the tooth was exposed and inflamed at a point corresponding to an aperture in the pulp-cavity.

The pulp may remain long alive and in a state of chronic inflammation in teeth broken off in the attempt to extract them. For example, a patient applying for an opinion on account of long persistent and severe neuralgia was found to have nothing abnormal in the mouth save a slight papill-form elevation over the site of an upper wisdom tooth which she alleged had been extracted some two years previously ; no opening could be detected in this little elevation, but a sharp probe thrust through it struck against tooth substance, so the gum was divided and the subjacent stump removed, when it was found that the pulp had remained alive in it, and projected slightly from its fractured surface, the protruding portion being of a deep claret colour.

Treatment.—There are some practitioners who claim that a vast majority of unhealthy pulps may be rendered healthy, and subsequently capped, even when suppuration has proceeded to the destruction of a considerable part of the pulp, so that the pulp chamber is only half full ; they hence discard the use of arsenic or other means of destroying the pulp, and adopt in all cases a conservative line of treatment. Dr. Belisario, of Sydney, for some years has discarded the use of arsenic, and finds that he can get on quite well without it, though of course such pulps sometimes die subsequently spontaneously.

Dr. Witzel in his treatise upon the antiseptic treatment of the pulp, retains even small portions of pulp alive, and Mr. Henry (Trans. Odont. Soc.) advocated the same course.

The opposite extreme of practice is represented by those who believe that the power of the tooth-pulp to recover after once it has been seriously diseased, as evidenced by its having ached badly, are so poor that it is morally sure to die, and therefore would prefer to at once destroy it and fill the roots, lest by its spontaneous death at some moment not ascertained, an alveolar abscess supervene and require lengthy treatment to effect a cure.

The safer course probably lies between these two extremes. If on the removal of the soft dentine from a cavity we find that perseverance to the point of the excavation of all that is affected would bring about an exposure of the pulp, and the previous symptoms point only to a moderate degree of pulp irritation, a thin layer of the soft dentine should be left at the deepest part, and dressings applied; it will very likely be found on changing these that there has been a slight oozing through this layer of dentine, and that the wool is a little stained; the repeated application of creosote, of tannin, of oil of cloves, or of camphorated spirit, will after a time result in the dressings remaining clean, and this same result will sometimes be obtained even where there has been a small exposure.

So soon as this result has been obtained, the tooth should be filled without delay, lest the ground gained be lost again by the supervention of some new irritation, and the deep portion must, of course, be given protection by the insertion of a capping; a rigid material like the oxychloride with oil of cloves, is to be preferred to a yielding one such as a layer of gutta-percha.

It is sometimes a matter of difficulty to decide whether there is an actual exposure, without running the risk of making one by our explorations. The occurrence of a phosphatic odour means that there is a discharge from the pulp, and that it is presumably exposed, but it must not be forgotten that an oozing through a thin layer of dentine is quite easy, that structure being tubular; if a jet of suitably warm water thrown into the cavity causes pain, the pulp is

probably actually exposed, and if the pressure of a small pledget of wool has the like effect, the same inference may be pretty safely drawn, but the treatment already indicated will generally suffice if the exposure be so small as to leave its existence in doubt.

If the exposure be larger the tooth should be very carefully cleansed by jets of warm water, and powerful escharotics avoided, the tooth being dressed with dilute carbolic acid, or oil of cloves, or camphorated spirit; thymol also answers well. The exposed pulp having been brought into a healthy state so far as is evidenced by the cessation of discharge, some writers recommend its being flooded first with creosote and then, without wiping this away, with oxychloride mixed very thin; I much prefer, however, the less irritating oxychloride mixed up with at least equal parts of oil of cloves.

As has already been mentioned, this may be done even when a good deal of the pulp is gone, even when all the body of the pulp has been lost and it remains alive in the roots only; but as far as my personal experience goes, teeth so treated are not quite to be trusted, but will sometimes give trouble at no distant date.

When amalgam (in which case it would be well to use an amalgam that hardens imperfectly), gutta-percha, or zinc oxychloride be selected, its removal, and the substitution of a gold plug, should be insisted on so soon as the tooth is in a proper condition to warrant the permanent operation.

It has been assumed that in all cases of exposure of the pulp during an operation, or under circumstances that justify the opinion that it is free from disease, our treatment should be addressed to its preservation.

Such is the general rule. But there are cases in which this rule cannot be acted upon, on account of the impossibility of following out the treatment required for its observance.

From prolonged irritation the pulp may have passed into such a condition that it will continue to ache despite the

application of sedatives; it may be the seat of irregular nodules of calcification, or it may have lost so much of its substances by suppuration that it no longer fills up the pulp-cavity. Again, the walls of the cavity may be so shallow that the retention of a cap with a plug external to it becomes a matter, not only of difficulty, but of impossibility.

When a pulp has ached obstinately, notwithstanding all efforts to soothe it, or is found to be largely exposed and to have lost some part of its substance by suppuration, the ordinary treatment is to anticipate its probable, if not certain death, by destroying it with an escharotic, the only one which has proved reliable being arsenious acid. (Arsenic acid, which is more soluble, has been preferred by some few, but as arsenious acid is quite efficacious, it is at least doubtful whether a greater degree of solubility is to be reckoned an advantage.)

In making an application of arsenic there are three points to be observed; one is to use as little as possible, a sixteenth of a grain being quite sufficient; another is to seal it in so that none shall leak out upon the gum, where it would produce sloughing; and the third is to get it into thorough apposition with the pulp.

Some degree of pain is likely to accompany the destruction of the pulp, but this pain is apt to stand in an inverse ratio to the completeness of the contact of the drug with the pulp, the most severe pain being generally met with when the exposure is imperfect. The addition of a sedative to the arsenic, such as morphia, does not appear to have any definite effect; the drug may be applied upon a tiny pledget of dry wool, or this may be moistened with oil of cloves, so as to pick up the powder better.

The arsenic should be left for one or two days, and the pulp then examined; if its sensitiveness is not nearly abolished a second application will be necessary, but it will usually be possible prior to making this to enlarge the opening, and perhaps to remove some portion of the pulp.

It is an advantage when the sensitiveness is nearly gone to insert a dressing of tannin, and to leave this for several days; this will have the effect of hardening the pulp so that it will be easier to pull it out in one piece.

It would appear that there are a few persons who are especially susceptible to the action of arsenic, just as there are others who are salivated by a single dose of blue pill.

Mr. Harding has placed upon record (Trans. Odont. Soc., 1881, p. 38) the case of a lady who thrice presented the symptoms of arsenical poisoning, slight gastritis, diarrhœa, a rash, &c.; the first time after an arsenical dressing applied to a tooth, the second after a few doses of liq. arsenicalis,

FIG. 195. (1)

the third after a careful application of arsenic to a tooth, there having been no appearance of its having leaked out.

It has been alleged that very disastrous results have in some very few instances followed upon the use of arsenic; the mischief which it will produce if it leaks out upon the gum has already been alluded to, but this will at times go farther, and a small piece of the subjacent bone will exfoliate. This is an accident which will have come within the experience of most practitioners, and it is not usually productive of anything beyond temporary inconvenience,

(1) Molar tooth, in which the bone immediately embracing the roots had exfoliated. The reddish colour of the dentine suggests that arsenic had been applied, but there is no history with the specimen.

but I have been told of an instance of a tooth, a canine, being lost by exfoliation of a thin piece of bone which constituted the whole length of its socket; this was accompanied by very little inflammatory disturbance.

A similar accident also I have known to happen with a molar, but in this latter case the application appeared to have been made with the utmost carelessness, which had not been the case with the canine. And in the American journals some years ago a case was reported in which death resulted from extensive ostitis and suppuration following after the destruction of a nerve by arsenic. It so happens, however, that the account of the case serves to fully disprove the conclusion of its reporters, for the thoroughly characteristically septic inflammation which occurred was obviously, if it was indeed referable to the tooth at all, due to abscess resulting from inappropriate treatment of the roots of the tooth, which was shut up when it ought to have been left open, and left in long after prudence of the most ordinary kind would have dictated its removal. Dr. Arkövy, in a paper read before the International Medical Congress in London, adduced experiments to show that even with all precautions, when arsenic was left in a tooth it travelled very speedily right down to the end of the pulp, and even out at the end of the tooth; but these experiments, looked at in a purely practical bearing, prove too much, for whereas he believed that its reaching to the periosteum, *i. e.* the apex of the root, was a usual thing, we know by clinical experience that its doing any harm at all is an exceedingly rare thing.

The pulp having been devitalised, before any attempt is made to remove it the mouth of the pulp cavity should be very freely opened out so as to give access to the root in nearly or quite a straight line, and a barbed nerved extractor gently passed through by the side of the pulp in the root canal as far as it can be got to go; it is then rotated for a turn or two so as to entangle the pulp; its barbs are then withdrawn, the result being, that if fortunate, the

operator breaks off the pulp at the apical foramen and withdraws it entire. When a pulp is destroyed, and thus got out entire, we do not start with any septic condition, and our great aim is to prevent such contamination arising in the course of manipulation, so that it is a very good plan, where the shape of the cavity renders it possible, to accomplish this part of the operation under a pool of eucalyptus oil, of creosote, or of oil of cloves, these antiseptics running down into the canal as the nerve comes out and leaves it vacant.

Fig. 196. (1)

If this be impossible, a Donaldson's nerve bristle should be ready, carrying a wisp of wool charged with an antiseptic, and this should be instantly inserted and left in the root whilst the other roots are being cleared.

And as we start fair in respect of septic contamination whenever the pulp comes out entire, and the root is of such form and dimensions that there is no uncertainty in reaching to the end of it and in making a thorough root filling, there is not the least object in deferring the operation; on the contrary things will never be in a better state, and they may afterwards be worse, so that the root filling may with advantage be done then and there. When, however, it is not possible to get a barbed nerve extractor up, and the root pulp has to be removed piecemeal with a slightly hooked bristle, or by the repeated rotation of fine watchmaker's broach, then, lest some little fragments have remained behind, it will be safer to leave an antiseptic dressing up the root for some days, and even to repeat it several times.

In the case of single rooted front teeth the pulp may be removed without previously killing it, a nerve extractor or

(1) Nerve extractor.

a broach being boldly thrust up quite to the apex, and given a turn or two so as to cut or break across the pulp at this point; this may often be very advantageously done when front teeth have been broken across their pulp cavities by a blow, but an anæsthetic is desirable in order to spare the patient the very severe though brief pain which the operation would otherwise cause.

FIG. 197. (1)

A hand drill of the form here figured was formerly a favourite instrument for enlarging the orifice of the pulp cavity with a half dead nerve, and it remains in use with some practitioners, though most will prefer a bur in the engine used cautiously.

A difference of practice obtains in respect of enlarging or not interfering with the root canals, some being very averse to drilling them out, and others advocating free enlargement of almost all. In a rough general way it may be said that any root from which the pulp can be pulled out entire can be efficiently filled without enlargement, and *vice versâ;* and some roots, such as the labial roots of upper molars, which are so small as not to admit the finest instruments, may, after antiseptic dressing of their mouths, be left unfilled with a fair degree of safety.

But no root can be held to have been made as safe as possible unless its apex can be pretty easily reached, and the attempt to judge of its length and curvature by means of fine bristles having been made, it should be cautiously reamed out, the safest instrument to commence with being a flexible watchmaker's broach, the temper of which has been lowered, this being followed by a Gates' drill in the engine.

It is useless to attempt to fill roots unless they are accessible, and this will often involve cutting away a good

(1) Drill for enlarging the orifice of exposure.

deal of tooth substance, so that sometimes it will be found easier and better to drill an entirely fresh hole in the axis of the roots through the crown of the tooth; this will be found specially advantageous in the case of distal cavities in the molars through which thorough root filling is all but impossible.

This much premised, a choice has to be made of the various materials available for filling roots.

The condition of a root is sometimes such that it may be filled with a very tolerable certainty that no inflammation will follow, and that there is not the least likelihood that the root filling will ever want to be removed; under such circumstances, and provided that the canals are accessible and of fair calibre, no root filling is better than gold or tin, and the method of introducing these may first be described.

The root having been thoroughly cleansed with dry wool is wiped out with a wisp of wool dipped into creosote or absolute alcohol or camphorated spirit; this done, four or five broaches which have been previously prepared by winding a very small portion of gold or tin foil round them for a short distance from their tips are successively taken and gently passed up to the apex of the root, the foil when there being slid off by rubbing it against the sides of the canal, and then impacted down by pressing with the end of the broach, which, of course, must be blunt-ended. The three or four broaches will have introduced enough foil to plug the immediate apex, and then very small ropes or strips introduced upon any blunt-ended instrument of suitable form and thickness will serve to complete the root-filling.

One of the dangers in filling roots is the occurrence of a piston action, by which any of the contents of the canal might be forced out at the end; but foil introduced in this way minimises this danger, and most thoroughly satisfactory results are attainable in easy roots, though it may be questioned whether it is really better than any other method, for it certainly takes more time, and is hardly applicable to difficult or very minute roots.

And if in spite of due care and apparently favourable conditions inflammation should arise, it is exceedingly difficult to get it out of a root which has become very tender under pressure.

An ideally perfect root-filling should seal the canals absolutely, be easy of introduction, be non-irritant in case a trace gets out at the end, and also be easy of removal; nothing seems to quite fulfil all these requirements.

A favourite material with many is zinc oxychloride mixed very thin, and carried up on small filaments of wool, which, of course, are allowed to remain; but it is difficult to remove, and also difficult to introduce with certainty down a small root. Another material, largely used in America, is a solution of gutta percha in chloroform, which is pumped up the root, and the chloroform allowed to evaporate as much as it will; no harm is done if some filaments of wool are left behind in this, but it is rather easy to get it through the apical foramen, and it is not always well tolerated if this happen. For some time I was in the habit of using a paraffin solid at the temperature of the mouth, but melting only a little above it; this, which was carbolised, was easily got down by the repeated introduction of hot bristles through it, a pool of melted paraffin occupying the pulp chamber during the process, through which bubbles of displaced air passed as the broaches went in and out of the canals.

Excellent results seemed to attend the employment of this process, and irritation was most rare, as nothing approaching to a piston action could occur; but on opening up such teeth after the lapse of months or a year, the pulp canals were sometimes found to be sweet but empty, the semi-solid paraffin having apparently been soaked up by the dentine, and it has therefore been abandoned in favour of wax with a higher melting point.

Dr. Morrison of St. Louis has advocated the use of very soft gold wire, with which he claims that the apical foramen may be very exactly sealed, and I frequently combine the two

processes, pumping in the melted wax and then introducing a suitable wire made very hot and leaving it there. This gives a root-filling at once complete and easy to remove in the event of irritation coming on.

Yet another useful material is shellac, with a small quantity of wax melted with it; this can be drawn out into exceedingly fine threads, of which a number are introduced side by side, till no more will go in, and then they are melted by allowing a drop or two of absolute alcohol to run in, or by repeatedly plunging in hot wire. In this case also, if it is thought fit, a wire may be left in when it is finished; this shellac root-filling is not at all difficult, and the results are very good, but it is not very easy to get out unless a wire be left in, in which case, with the aid of spirit, it can be softened and got out fairly easily.

Unless the root-filling selected is such that it cannot be got out at all, it is good practice to defer the filling of the body of the cavity until a few weeks have elapsed, gutta-percha being introduced meanwhile.

For the filling of flattened roots an instrument made by grinding a piece of watchspring down till it is very narrow will be found handy.

But if a large number of molar and bicuspid teeth be examined out of the mouth it will be seen that there are a not inconsiderable number of teeth in which the roots are of such form and curvature that a perfect root-filling is absolutely impossible, nor could the roots be enlarged to a satisfactory shape; such roots cannot always be recognised while the tooth is still in the patient's head, and there is thus introduced an element of uncertainty against which no care can avail.

It has more than once happened to me to fail in curing an abscess at the end of the roots of a lower molar, and to have to ultimately extract the tooth, then finding to my mortification that the tooth was three-rooted, whereas I had been treating two only of the roots; had it ever got to the stage of root-filling failure would have probably been the

result, though, of course, in many cases, it would be obvious enough that there were three roots, and all could be dealt with. As it may fairly be said that so soon as the pulp has once become involved in the advance of caries, an element of uncertainty has been introduced into the treatment, no matter what care be taken, it is a very usual and a good plan to postpone the insertion of a permanent filling which would involve not only the expenditure of a good deal of time, but also a considerably greater amount of handling to the tooth until the success of the treatment has been assured by the lapse of a material length of time, and so a temporary filling is generally inserted after root-filling; for this purpose gutta-percha answers admirably, and no form of it so well as the red base-plate preparation.

So far those cases only have been taken into consideration in which there has been to start with no irritation of the alveolar periosteum, but this fortunate state of things by no means obtains in the majority of the teeth which require root-filling.

Iodoform has of late attracted some little attention as an antiseptic for the treatment of root-canals, and is in many respects admirably adapted to the purpose. It is a body obtained by the action of iodine on alcohol, solid, crystalline, and of heavy disagreeable odour. It is inimical to, but not absolutely destructive to, all forms of organisms, for micrococci have been found growing in a fluid smelling strongly of iodoform; and it is not quite certain in what way it acts, though it is believed that it is by the setting free of iodine, itself a powerful antiseptic, and probably doubly powerful in a nascent state. It has the advantage of being non-irritant, and of being very lasting in its effects, for wool saturated with it is found to retain its smell, colour, &c., in the root of a tooth for years, while it is in the experience of every one that all trace of creosote or carbolic acid disappears in a comparatively short time.

In this country it has been generally used by being carried on a filament of wool moistened with eucalyptus oil,

but Dr. Bödecker recommends the employment of an etherial solution, about a drachm to the ounce, with which the canals are mopped, and the apices treated, the roots being subsequently filled with gutta-percha solution, to which a little iodoform has been added.

Iodoform is capable of producing poisonous effects, though only when it has been applied in quantities vastly greater in amount than could be introduced into the mouth; a drachm is the smallest quantity which, so far as I have read, has been known to produce any symptoms.

Iodol, a compound which readily sets free iodine, has recently been proposed as a substitute for iodoform; it has no unpleasant odour, but it is as yet doubtful whether it is equally efficacious.

INFLAMMATION OF THE ALVEOLAR PERIOSTEUM.

The inflammatory affections to which the lining membrane of the sockets of the teeth is liable, admit of division into the following groups :—

The first will include (i.) general inflammation of the alveolar membrane affecting the socket of each tooth, or, at all events, the majority of the teeth equally, and dependent for its origin upon a constitutional condition, such as rheumatism, the presence of mercury or some other agent in the system, &c. &c.

(ii.) Local inflammation involving the sockets of one or two teeth, and dependent upon a local cause.

The causes of periostitis about the jaw are various ; thus it may be set up by the inhalation of phosphorous fumes, and ultimately give rise to phosphorous necrosis. Or it may arise in a scrofulous person ; or, again, as a result of syphilis or rheumatism. In any case proliferation of medullary elements takes place in the periosteum ; they may disappear, or soften down into pus, or become organised into bone. It is pointed out by Mr. Wood that the hardening is more common in a rheumatic than in a strumous or syphilitic node, on account of the greater readiness of the fibrine to organise in the former disease, and as a consequence of this necrosis is made less likely to ensue.

Intense toothache is an early symptom of rheumatic periostitis, which is, like other rheumatic ailments, greatly affected by the weather ; there is not much tendency to swelling or to suppuration, whereas in scrofulous periostitis the pain is often slight, and the swelling is usually considerable.

At the outset of general inflammation of the intra-alveolar periosteum, the first indication of the presence of disease is found in the teeth. The uneasiness in the first instance is of that kind which provokes a disposition to grind them forcibly together. For the moment, the pressure of the teeth into their sockets gives relief, but the feelings of discomfort speedily return, and in the course of time they become unpleasantly sensitive to pressure. This is succeeded by a tendency to ache slightly on their temperature being disturbed by a current of cold air passing over them, or by the presence of hot or cold fluids. As the disease progresses, each tooth feels lengthened and loosened, and can no longer be used in mastication without producing a considerable amount of pain. The patient restricts himself to soft food, and takes even that with some degree of caution. If the state of the mouth be examined, we shall find that the disease has extended from the inner to the outer covering of the sockets and to the gums; that the latter are of a dark colour, thickened and vascular, with the free edge more deeply coloured than the surrounding parts. Each tooth may be moved slightly from side to side with the thumb and finger, a condition due to the thickened state of the lining membrane of the socket, and the consequent elevation of the tooth from its proper level. The severity of the symptoms will vary from day to day, as the general condition of health is better or worse. When the disease is essentially rheumatic in character (and it is to the disease when so modified that the foregoing description is more especially applicable), the inflammation seldom advances beyond a congested state of the vessels, with effusion into the surrounding tissues. It is only in extremely severe cases that suppurative action is established, and in them the secretion of pus is limited to that portion of the alveolar membrane which merges into the mucous membrane at the necks of the teeth. The purulent discharge oozes up between the gums and the teeth, and may generally be rendered visible by making pressure upon the former. The state is altogether different from that of

alveolar abscess or gum-boil. In the former the pus is produced at the neck of the tooth, and finds a ready escape; in the latter, it is formed about the root of the tooth, is enclosed within the socket, and has to find its way either by the side of the tooth or through the alveolar wall to the surface of the gum. And it may be doubted whether these suppurative cases really all belong to the same category.

Prolonged inflammation of the alveolar membrane may lead only to the absorption of the alveoli, and this, with the consequent loosening and loss of the teeth, is the more common result; but examples are not wanting to show that the suppurative state may, in enfeebled and strumous subjects, be succeeded by ulceration of the soft parts, and necrosis of the alveolar margin, involving, perhaps, the loss of a considerable portion of the jaw.

I have seen a few cases in which the inflammatory action has ultimately led to the production of large florid granulations. They have sprung up close to the teeth, the crowns of which have been, in great part, overrun and obscured by the morbid growth. The patients complained of pain and tenderness in the teeth, and perfect inability to use them in the mastication of food.

When inflammation of the alveolar periosteum is connected with a rheumatic state of the system, the principal indication of the presence of that disease may at times be confined to the state of the teeth and gums, but the abnormal condition of these parts, when so affected, can scarcely be said to present a specific character. The patient will attribute the visitation of disease to exposure, to a draught, to having taken cold, and will tell you that the feeling of comfort will now, as heretofore, be restored in the course of a few days.

There are, however, cases of inflammation of the alveolar periosteum which present a specific character, have a specific cause, and follow a specific course. One of the effects produced when the system is falling under the influence of mercury, is a congested state of the vessels of the alveolar

periosteum. The teeth become tender, elongated, and loose, and the breath tainted with the mercurial fœtor. Let the exhibition of the metal be continued, and large sloughs will be formed upon the inflamed parts, and portions of the alveoli, with the contained teeth, will be lost. If, on the contrary, the mercury be discontinued when the inflammatory action is, although well marked, moderate in amount, the induced disease will gradually subside.

The following substances are mentioned by Sir Thomas Watson as occasionally producing ptyalism. Preparations of gold, of copper, of antimony, and arsenic; also castor-oil, digitalis, iodide of potassium and opium, croton-oil given internally, and nitro-muriatic acid applied to the surface of the body, have also been mentioned as occasionally productive of similar results.

Moderate salivation, induced once or twice only, may cause but little mischief, but if the ptyalism be kept up for a long time, or if it be frequently induced, a permanent injury will be inflicted upon the organs of mastication. The production of frequent or prolonged inflammation of the alveolar periosteum will be followed by the absorption of the alveoli, the gums will recede, and the teeth, having lost their implantation, fall out long before their destined time.

The degree of mischief will depend upon the length of time the system has been kept under the action of mercury, but the idiosyncrasy of the patient will exercise a still greater influence. There are those in whom a single dose of calomel, or even of blue pill, will produce salivation, and the second or third induce the formation of large sloughs, with necrosis of more or less of the alveolar processes. There are others, again, in whom it is extremely difficult to produce ptyalism.

The destruction from sloughing of the soft parts in the alveolar region of the mouth, consequent upon inflammation commencing in the gums and intra-alveolar periosteum, is sometimes so extensive that the cicatrices which follow drag

down and fix the cheeks firmly to the maxillæ, and limit the motion of the jaw, depriving the patient of the ability to open the mouth sufficiently for the ready introduction of solid food.

The *treatment* in general inflammation of the alveolar periosteum must, in cases dependent upon a bad state of the system, be addressed to the improvement of the general health. If the local disorder depends upon rheumatism, the usual remedies for the relief of that disease should be administered, such as alkalies, abstinence from malt liquors, and fomentations or steaming of the mouth; in some cases iodide of potassium in large doses will have a most marked effect in cutting the disease short; if the malady assumes a strumous type, the remedies best suited for the treatment of struma should be prescribed. If the disease be dependent on an enfeebled state of the body, a generous diet, with quinine, or some other equally active tonic, will prove advantageous.

Cases which partake of the latter character and yield rapidly to generous treatment, prevail towards the end of the London season, and among those who have applied themselves too closely to business.

In aiding the general treatment, local remedies will be found useful. During the stage of congestion, finely-powderd tannin may be rubbed upon the gums night and morning, or even more frequently; or the gums may be painted with tincture of iodine (double strength). If the secretions of the mouth are offensive, or if pus be formed between the teeth and gums, a wash composed of eight or ten grains of chloride of zinc to an ounce of water, will afford relief, if held in the mouth for two or three minutes, at intervals of four or six hours. When the inflammation is slight, a solution of borax in eau-de-cologne forms an agreeable and efficient application; but when suppuration has been established, or when sloughs have formed, the solution of chloride of zinc (the strength of which should be varied to suit the case) will be found to produce a much more rapid

and beneficial effect. The fœtor which attends such cases is at once removed by the zinc, and the parts undergoing suppuration, if the general health be improved, are brought into a more healthy state. A state of inflammation having been established from a general cause, is sometimes kept up by two or three defective teeth. Now, whatever may be the nature of the defect, in the absence of a speedy and complete remedy, the teeth should be removed.

Local Inflammation involving the periosteal investment of the roots of one or two teeth.—It will be convenient to consider this subject under the two heads of active, or acute, and chronic inflammation.

Under the former will be placed cases which terminate in alveolar abscess, as distinguished from those cases of chronic disease in which the periosteum remains in a state of inflammation without proceeding to suppuration, excepting at the point where the gum and the periosteum meet. Such cases will fall under the latter division.

Acute inflammation of the dental periosteum, when confined to the alveoli of one or two teeth, usually arises in connection with, and as a distinct sequence of, pre-existing disease in the involved tooth or teeth. Examples are, however, not wanting to show that this disease may be established in the sockets of teeth perfectly free from caries, and apparently from any other morbid condition; these cases are probably referable to one or other of the causes of general periostitis which have just been enumerated. Whatever may be the exciting cause, the symptoms of the disease present but little variety, excepting as respects their intensity, the rapidity with which the different phases of inflammation succeed each other, and the extent to which the neighbouring parts become involved.

The inflammatory action usually sets in with feelings of slight uneasiness and tension, sensations which excite a strong desire to press by the opposite teeth, or to shake with the fingers, the affected tooth in its socket. Slight, steady pressure of the fang into the jaw gives relief, but the uneasiness

returns on the pressure being withdrawn. The sense of uneasiness is soon followed by a dull, heavy pain, and the tooth feels to be longer than its fellows. The desire to move the tooth in its socket continues, till disease has rendered the parts so tender that pressure can no longer be borne, and even the mouth cannot be firmly closed without pain.

The existence of disease within the socket is soon shown in the gum, which becomes swollen and tender opposite the fangs of the tooth whose periosteum is affected. In addition to this latter symptom, and often prior to its appearance the free edge of the gum assumes a deep red colour, unaccompanied by pain, tenderness, or scarcely any swelling. The neck of the tooth appears encircled with a well-defined red ring. This symptom is usually present in the earlier stage ; but as the disease advances the distinction is lost in the general inflammation of the gum. In health the gums near to the necks of the teeth are pale in colour, whilst opposite to the deeper portions of the root they are darker, and fine vessels are visible in them ; in periostitis this distinction, termed by some American authors the "health line," is lost. The pain becomes more severe, but still preserves its heavy, wearing character, and though not always constant, is seldom absent for many successive hours.

If the progress of the disease be unarrested, the periosteum becomes detached from the cementum, and the point of separation usually commences at, and extends from, the foramen in the root of the tooth. Into the interval thus formed pus is poured from the separated surface of the periosteum. The fang at this part loses its vitality, and is bathed in pus, the quantity of which is gradually increased, space being gained in the alveolus for the dilatation of the abscess at the expense of the bone. The extent to which the alveolus becomes excavated will vary with each case. It may be hollowed out to a very limited extent around the apex of the root, or a large cavity may be formed, exceeding in dimensions that which has been made the subject of the accompanying figure.

The size of the abscess will depend upon the activity of the symptoms, the time the pus is pent up, and the state of health of the patient.

So soon as suppuration is established a process is set up for liberating the secretion. Either the periosteum becomes detached from the neck of the tooth, and the pus finds its way by the side of the socket and passes out at the edge of

FIG. 198. (1)

the gum, or a perforation is made in the wall of the alveolus, through which the contents of the abscess pass into the substance of the gum. At this stage of the disease we have a kind of double abscess—an abscess with a constriction, one division of which is situated in the gum, and the other within the alveolus, the two being connected by a small opening through the alveolar plate. If the disease be left to run its own course, the contents of the abscess will sooner or later find their way to the surface and escape. But the time occupied in the process will depend upon the situation of the disease, upon the condition of the parts prior to the advent of disease, and upon the general condition of the patient. In

(1) An upper jaw in which the effect of alveolar abscess in excavating the bone is shown.

those who are in strong health, the formation of an alveolar abscess is soon succeeded by swelling of the gum and the escape of the pus. But in patients who are in a debilitated condition the disease advances more slowly; the products of suppuration accumulate, and a large abscess is formed, at the expense, perhaps, of the sockets of several adjoining teeth. Considerable mischief may have been produced before the natural relief by the spontaneous bursting of the abscess is obtained. The pus, instead of escaping into the mouth, may find its way to the surface of the face, or into the antrum. The latter result is, of course, only likely to occur when the disease has originated in the bicuspid or molar teeth of the upper jaw; a case, however, came under my notice in which, on the extraction of a central incisor in consequence of alveolar abscess, a perforation into the antrum was found to exist. The previous symptoms of abscess of the antrum had been but little marked. There is no tooth from the socket of which an abscess may not extend to the surface of the face. Instances are sometimes met with of an abscess connected with the root of a lower incisor tooth opening under the chin, and more rarely, opening in front of the chin.

Abscesses resulting from difficult eruption, or caries of the wisdom teeth, occasionally pass forwards inside the mouth, and open near the canines or bicuspids; or they may pass backwards and burst into the fauces (1); they are not uncommonly productive of very considerable constitutional disturbance, and are prone to cause trismus, of which one case is recorded as having lasted as long as nine months, and at the end of that time being cured by the removal of the tooth.

A case of abscess resulting from a first molar is mentioned as having in the first instance burst below the jaw; the pus gravitating down the neck, a second opening lower down resulted, and finally two sinuses opening below the clavicle were established.

(1) Transactions of the Odontological Society, 1858, p. 53.

A somewhat chronic pyæmia has been observed to follow upon an alveolar abscess (Mr. Howse, "Medical Times and Gazette," 1876). Suppuration occurred in the inferior dental canal, and acute periostitis in the posterior half of the lower jaw, which was denuded of its periosteum; the inflammation extended thence through the pterygoid fossa into the orbit, and thence backwards. Ostitis of the vault of the skull followed, and general pyæmia, resulting in the patient's death on the ninth day after the supervention of the acute stage.

The chronic stage had lasted five weeks, and no special history of pain or swelling of the jaws prior to this could be obtained, though the patient's age (four and a half) rendered the history necessarily imperfect; the post-mortem left, however, no doubt as to the sequence of events in the case.

Another disastrous case is related by Dr. Harrison Allen ("Dental Cosmos," Nov. 1874). The roots of a lower wisdom tooth were filled, this operation being followed by ostitis and periostitis in its vicinity. An abscess formed between the mylo-hyoid and the jaw, which gravitated down as far as the hyoid bone, and crept up along the course of the facial artery: the floor of the mouth was pushed up by pus, and severe unilateral glossitis ensued. Death ensued from mechanical suffocation four days after the occurrence of extra-maxillary complications.

In Wedl's "Pathologie de Zähne" (page 173), a case is quoted from M. Leynseele, in which a portion of the lower jaw was splintered in the removal of a tooth; pus burrowed along the side of the jaw, ascending by the ramus to the base of the skull; and gaining access to the cranial cavity by the foramen ovale, rotundum, and spinosum, caused the patient's death from meningitis.

Another case resulted from an unsuccessful attempt to extract an upper molar tooth; suppurative periostitis around the tooth ensued, and rapidly spread to the body of the jaw; after a fortnight the necrosed bone was readily removed, but severe rigors ensued, and the patient died, at the end of a

month, of pyæmia, the immediate cause of death being pleuro-pneumonia (1).

M. Robert (2) also relates a case in which necrosis supervened on an abscess connected with a lower wisdom tooth; what is described as "purulent infiltration" of the side of the neck followed, and the patient rapidly sank.

Mr. Pearce Gould ("British Dental Ass. Journal," March, 1886) has recorded a case of death from alveolar abscess, resulting in thrombosis of the cavernous sinus: on admittance the patient, ætat. 57, presented a sloughy opening in the centre of the right cheek. An incision was made from the outside, and six molar teeth were extracted. The trismus was relieved, but œdema of the right temple appeared, and subsequently an abscess above the external angular processes of the orbit, and another in the posterior triangle of the neck, but the internal jugular was not thrombosed. The respiration became stertorous, pulse 126, small, temp. 103·8, and crops of herpes appeared about the lips. Great œdema of the orbit and chemosis, with some proptosis ensued, and some rigors occurred. Death in a state of coma ensued.

At the post-mortem the outer part of the right side of the lower jaw was sound; some lymph was detected along the basilar process of the occipital bone, and sella turcica; the right cavernous sinus was distended and contained yellowish pus; the right ophthalmic vein was similarly affected. The left cavernous sinus contained a clot. Probably thrombosis had spread through the pterygoid vein on the right side, and thence by the circular sinus to the left side.

Another fatal case is reported by M. Poncet ("Brit. Med. Journal," March 6, 1886), which was admitted to the wards of Val-de-Grâce ten days after general symptoms of septicæmia manifested themselves. There was much swelling at the

(1) Deutsche Vierteljahrschrift, 1872,
(2) Conférences de Clinique Chirurgicale, Paris, 1860.

angle of the jaw, and both forearms were œdematous, and upon one there were serous vesicles. At the necropsy the right masseter muscle was found to contain small abscesses, as did also the sterno-mastoid.

There were no metastatic abscesses in the arm, but the œdema was purulent, and contained quantities of microbes.

In the blood-clots found in the right heart there were also colonies, so that M. Poncet concluded that the patient died of microbe-pyæmia, resulting from dental caries.

Thus extensive alveolar abscess not uncommonly results in partial necrosis of the bone, but to this we shall have to recur under the head of Necrosis.

When the lower molar or bicuspid teeth cause an abscess which finds exit on the face, the opening is usually below the attachment of the bucinator muscle, and collections of matter formed about the wisdom teeth often pass between the muscles and bone, and escape at the angle of the jaw. It will generally be found that, in cases where the abscess bursts externally, the ends of the roots of the teeth pass beyond the level at which the mucous membrane is reflected from the cheek to the gums (Salter). Under certain circumstances the abscess sac may become a serous cyst, as is mentioned by Mr. Salter; this, which may occur in all parts of the body, is sometimes attended with peculiar consequences in the jaw, for the cyst may enlarge between the plates of the alveolus, and thus give origin to cystic disease of the jaw.

Suppuration in the lymphatic glands is a frequent sequence of alveolar abscess, and is especially prone to happen in strumous subjects.

A collection of pus formed in the socket of an upper incisor, will sometimes burrow along between the bone and periosteum of the hard palate, and open upon the surface of the soft palate; in other cases, the periosteum is separated from the one side of the hard palate, and forced downwards to a level with the crowns of the teeth by the accumulated pus. The pressure caused by the abscess, which often be-

comes chronic, may cause absorption of a portion of the palatine process of the superior maxilla, as occurred in a case recently under observation. For some reason not very apparent, abscess on the palate almost invariably proceeds from a lateral incisor. A case has lately been recorded in which pus dripped down behind the velum; it was found to proceed from an alveolar abscess about the fang of a lateral incisor.

The opening of the abscess, whether effected by nature or by the hand of the surgeon, forms an epoch in the complaint. The symptoms from that time gradually subside, the pain dies away, and the swelling rapidly diminishes, leaving a small opening through which pus will continue to be discharged. The coats of the abscess gradually contract, and close upon the root from which they had become separated, but the separation of the two parts is probably permanently maintained. While the inner surface approaches the root of the tooth, the outer surface of the coats of the abscess becomes thickened, and occupies the space which would otherwise be left between the expanded alveolus and the collapsed abscess. In extracting teeth which have been the cause of alveolar abscess, the coats of the abscess are sometimes withdrawn entire, and an opportunity of observing the preceding conditions is afforded.

Such, then, are the events which, in the ordinary course of the disease, mark the progress of alveolar abscess. Exceptional cases now and then occur, in which the local are accompanied by severe constitutional symptoms, amounting perhaps to fever and delirium. Such instances are, however, of comparatively rare occurrence; indeed, it is wonderful how much mischief may be done to the alveolar processes without exciting any great amount of either local or constitutional disturbance. An abscess enclosed in the substance of any other bone, in the manner an alveolar abscess is at its commencement shut up in the jaw, would, instead of producing two or three days of toothache and a swollen face, confine the patient to his room for weeks.

It is not uncommon for an abscess on the hard palate to pass into a chronic condition, and remain almost unnoticed by the patient for months, or even years.

Alveolar periostitis may, however, move more slowly through its various stages. A considerable length of time may intervene between the commencement of inflammatory action and the formation of pus, and in the meanwhile the patient may be the subject of violent intermittent attacks of pain, not, perhaps, confined to the tooth alone, but often extending to the face and head, in which situations the pain may be far more intolerable than in the tooth itself.

In cases answering to the foregoing description, it will frequently be found that dental exostosis, slight in amount perhaps, yet distinguishable, has commenced on the surface covered by, or in close proximity to, the inflamed tissue.

In other cases, again, the suppuration of the inflamed tissues is limited to the apex of the fang, through the canal of which the pus oozes ; but the relief is then only partial, and the periosteum continues to thicken, and the alveolus to enlarge, to make way for the increase in size of the diseased membrane. The pain is intermittent, and often simulates in its character tic-douloureux. The condition I have described is more frequently found associated with stumps than with teeth the crowns of which are but partially decayed ; and it is common to find the extremities of several contiguous stumps similarly involved.

The disease under consideration may assume yet another character: it may begin so gradually, and advance towards suppuration so slowly and painlessly, that the patient is not aware of its existence until he discovers a tumour on the gum, or the contents of an abscess escape into the mouth ; so little inconvenience is felt that the occurrence is forgotten, until, from some cause or other, the canal leading to the alveolus containing the remnants of the disease becomes closed, and pus re-collects. The contents of the abscess again find their way to the surface, and the comfort of the patient is restored. Sooner or later the disease assumes a

more active form, and necessitates the removal of the tooth.

Cases of this passive character are sometimes productive of sympathetic pain, and should not, therefore, be lost sight of. The gum, too, over the affected alveolus, frequently becomes thickened, minutely nodulated on the surface, and assumes a mottled hue.

The fistulous opening of a chronic alveolar abscess is sometimes situated on a long papilla-like process, projected out from the gum to the extent of a quarter or even half an inch. It may be flexible, and lie flattened upon the contiguous gum, or the character of a dense hard granulation may be assumed.

In any description of case, should the inflammation be acute in the first instance or subsequently, and the system in an unfavourable state, the diseased action may extend to the periosteum of the body of the jaw, and if not speedily relieved, occasion thickening of the bone, or, even worse, it may terminate in necrosis of a considerable portion. I have known three-fourths of the under jaw lost from disease commencing in the dental periosteum of one tooth. In more favourable instances, the disease may creep on only to the adjoining teeth, occasion their loss, and then end. In the vast majority of cases, however, the inflammation does not spread: the pus makes its way to the surface, and a fistulous opening in the gum, with slight thickening of the surrounding parts, remains to mark the spot.

Several specimens in my own collection show that active inflammation of the dental periosteum may arise in connection with a tooth without our being able to trace the cause —that a large alveolar cavity may be formed, the involved tooth and the neighbouring parts being, so far as we can see, healthy. In nineteen cases out of twenty, however, the disease follows or results from, or is an extension of, inflammation of the dental pulp, or is consequent on necrosis of the whole or a part of the fang of a defective tooth.

The usual cause of acute alveolar abscess is the escape

from the end of a root of putrid contents of the pulp chamber and of the root canals, thus inoculating with septic material the tissues external to the apex of the root.

The excessively acute inflammatory disturbance which sometimes results from the first interference with a dead tooth, when during a too energetic dressing of the canal, something is pumped out at the end, is an instructive example of this state of things, and necessitates great caution in the first dressings. These should consist of a mere wick of wool dipped in an antiseptic, and the cavity of decay should be only very loosely closed.

A point of the utmost interest, and indeed of very practical importance is whether inflammation and consequent alveolar abscess is in all instances of a septic character. If we were sure that a root once thoroughly disinfected and filled was secure against all chance of abscess it would be a solid ground on which to go ; on the other hand if inflammation can arise *de novo* at the end of such a root without the access of any external influence there is an element of uncertainty which we have no means of eliminating. Fortunately the balance of evidence seems to point to the great majority of inflammations at the ends of roots being septic, that is to say, being due to the introduction of poisonous ferments, and in a very large percentage of cases a properly filled root will remain for an indefinite time healthy ; on the other hand there are indications that it is quite possible for an inflammation to arise independently. Elsewhere in the body suppuration does occur in places which are apparently inaccessible to germs, and the frequent occurrence of gum-boils after exposure to cold, to mechanical irritation, and such causes seems to point to the introduction of germs not being an absolutely essential element in the process.

My own observations have led me to believe that pulps which have died under a capping after being nearly exposed are generally found to be crammed with organisms of many kinds, and that the abscess ensuing is apt to be one of great severity and attended with much pain. But when pulps

have died as a consequence of a blow, with no breach of surface, it is not uncommon for no abscess to ensue, though often a slight swelling is to be felt about the root. When, for purposes of treatment the tooth is opened up, it is not a rare thing for the slumbering abscess to be lighted up into an active, not to say violent, state, perhaps owing to the entrance of germs.

When such a tooth is opened for the first time the pulp will be found sometimes mummified, sometimes moist, white and sodden looking, but of its full size and free from all smell. Now this is just as it should be theoretically, for decomposition ought to be as impossible for it as it is for a piece of tinned meat.

But sometimes the pulp will be found liquified and in a state of stinking decomposition, and, so far, I have failed to find any evidence of the presence of organisms. Here is a dilemma; on the one hand if germs are there how can they have got there; on the other it is pretty generally believed that stinking decompositions do not take place without them, yet here we have one where germs have not only not been found, but where it is difficult to suppose that they can have got access. And further such teeth are capable of setting up the most violent abscess without ever having been opened, so that we have the whole train of events, putrefaction, apical inflammation, and abscess without any communication with the outside. It may be said that germs were there circulating in the blood, and that they only could grow and multiply when the vitality of the pulp was destroyed by the blow; but so far they have, if this be the case, eluded discovery.

Moreover, if they are in the blood, ready to pounce down on any part at their first opportunity, root-filling can never hope to exclude them from the periosteum, but the most that it can do will be to leave them but little pabulum.

Treatment.—Whatever the stage of alveolar inflammation the first thing to be done is to clear out the pulp cavity and the root canals, but a certain amount of caution must

be exercised when an actual abscess has not yet occurred, lest the operations intended to avert it have the effect of inducing an inflammation of very virulent type. The utmost care must be taken lest septic matter be forced out at the end of the roots, and it is therefore best, if time be no object, to be content with freely opening up the pulp cavity, thoroughly syringing it, and sponging it out with antiseptics, without doing more to the root canals than gently cleansing them, and leaving the antiseptic dressing in the general body of the pulp cavity, the whole tooth being closed but lightly, and the root canals left empty; at the next sitting, when the contents of the tooth have been for a time exposed to the action of the antiseptic, the roots may be more thoroughly explored, and dressing left up them. For the first treatment of putrid canals I myself prefer permanganate of potash, or a half per cent. solution of mercuric chloride, which do not coagulate albuminous fluids; and thymol forms a very good dressing to leave in the pulp chamber; for the subsequent root dressings eucalyptus oil and iodoform, or creasote. Camphorated spirit finds much favour with some, and its action would closely resemble that of thymol.

The treatment of inflammation of the alveolus may conveniently be considered under two heads, that in which there is already a fistulous opening on the gum, either spontaneous or obtainable by lancing, and that in which no such agent exists.

In the first state of things a cure is comparatively quick and easy, for potent agents can be employed from the first without any fear of lighting up a violent fresh access of inflammation. As soon as the roots have been well cleansed they should be filled with creasote; this may be done by means of introducing the tube of a hypodermic syringe a little way up them, or by passing up a wick of cotton copiously steeped in the fluid.

Then the endeavour to pump this creasote out through the end of the root should be made; there is so far as I

know no better way of doing this than by placing in the general cavity of decay a piece of ordinary rubber sold for vulcanising, large enough to fill it; pressure is made upon this with a large ended instrument, a tight pledget of paper held in plugging forceps answering the purpose very well, and the pressure being made in a succession of jerks, the piston thus formed will generally succeed in pumping some of the creasote into the abscess and out upon the gum by way of the fistulous opening. If several drops have been successfully forced through, the root can be firmly closed with a creasote dressing on wool; and at the next visit the abscess will be found often to be practically well; some practitioners even fearlessly fill the root at once at the first sitting, if the creasote stream has passed pretty freely.

Failure is rare when the whole track of suppuration is thus pervious, and when no marked improvement follows the treatment it may be suspected that there is considerable roughening or other alteration of the end of the root, and that success is not likely in the long run; a recent abscess almost always yields at once to treatment, but an old one generally is complicated by alteration of the root or of the superjacent bone.

Unless the root canals are large it is always advantageous in case of old abscesses to drill them out freely, whenever their direction can be ascertained to be such as to render this safe; it seems as though the dentine long soaked with decomposing material was not easy to disinfect, and that by drilling away the immediate walls of the canal, we rendered it more easy to cleanse the rest, that which had been most sodden having been got rid of.

Some dentists hold that in all cases of long standing suppuration the enlargement of the root should be carried to the point of enlarging the apical foramen, and drawing blood in so doing; this commends itself as sensible, though most abscesses can be got well without so doing, and the enlarged apical foramen may sometimes introduce a difficulty in the actual filling of the root afterwards; unless, there-

fore, the case prove obstinate, it will suffice to freely enlarge the root down to within a short distance of the end, and to allow plenty of time between the dressings, after the active tendency to discharge has passed by.

When the tooth has become quite comfortable, and the root-dressing comes away clean after remaining in the tooth for some days, the root may be closed with cotton moistened with eucalyptus oil, and charged with as much iodoform as it will pick up; the cavity then having been thoroughly sealed, it should be left for ten days or more, and then the root-dressings again examined.

If they be found clean, and the tooth has remained quite comfortable, a more permanent filling may be introduced, care being taken to select one which can be again removed without much trouble; or, as some prefer, wool root-fillings, with creasote, or iodoform may be retained for some months; this latter plan should be adopted if the operator for any reason has misgivings as to the tooth keeping free from irritation.

Indeed, some consider that these wool-fillings are good as permanent root-fillings; creasote or carbolic acid, however, after a while seems to disappear from the wool, but iodoform I have found in full possession after the lapse of several years, and even after the gutta-percha plug had got to leak badly.

But where there is no fistula, the conditions are much less favourable; the two essentials of antiseptic surgery, drainage and the destruction of all septic agents, are no longer attainable with certainty, for we cannot be certain that our antiseptic will travel freely throughout the interior of the abscess, nor can we easily secure the speedy draining off of pus or exudations; consequently we must go to work very much more cautiously, bearing in mind that every time that the little abscess sac at the end of the root gets distended it is retrogressing.

Pumping operations would be dangerous, and we must be content with root-dressings not too tightly packed in;

camphorated spirit is a very good one, and if there be some little weeping of discharge into the tooth, dry root-dressings are to be preferred, as the wool is then capable of sopping some of it up. For such an application iodoform on a wisp of dry wool, or a few crystals of thymol do very well, or the wisp of wool may be dipped in camphorated spirit and the spirit allowed to evaporate from it.

Local bleeding frequently fails to afford relief in inflammation of the pulp; but when the dental periosteum becomes the seat of disease, the abstraction of blood is a powerful remedy. If adopted at a sufficiently early stage, it seldom fails to produce relief, and frequently cuts short the disease. One or two leeches may be applied, by the help of a leech-tube, to the gum, opposite the end of the root of the affected tooth, and in connection with the local bleeding an aperient may be given.

The gum over the affected tooth should be strongly and repeatedly painted with tincture of iodine, and Fleming's tincture of aconite may be advantageously applied, though caution is required in using so potent a drug in the mouth. If the inflammatory action has gone on for a day or two, it is probable that suppuration cannot be avoided, especially if the affection has spread to the gum.

If we fail to avert suppuration, or to reduce the inflammation, we must then do what we can to relieve the pain and to reduce the disease to a state of passive gumboil. When there is reason to believe that pus has not been formed, a leech may be applied to the gum, and aperients given; but should you find a circumscribed swelling over the tooth, it is pretty certain that pus is making its way outwards, and its progress will be hastened by the use of the gum lancet. The best instrument for this purpose is a short and strong double-edged scalpel, which should be thrust forcibly down to, and, if possible, through, the spongy bone overlying the abscess sac. By thus anticipating the drilling through of the alveolus by the abscess, the patient is saved much suffering, which in the majority of cases ceases with the perforation of bone,

whether this be effected by nature or by art. Wherever there is great general swelling and tenderness, great relief may be given by a free incision, and by drilling through the bone with a large and sharp broach over the apex of the root. It is easy to distinguish by touch when the instrument reaches the root, and the operation gives far less pain than might have been anticipated.

When the more active symptoms have subsided, a small fistulous opening will remain for the exit of the pus, unless the fluid finds it way to the surface through the root. It is quite possible that the coats of an abscess situated in the dilated alveolus may embrace the necrosed extremity of the root, and cease to secrete; in which case the gum would heal perfectly, leaving the end of the tooth in a similar position to that of an encysted foreign body. It does not seem likely, *à priori*, that organic union would again take place between the periosteum and the cementum when they had been long separated by pus.

I think it may be said that as a general rule all acute and recent abscess is amenable to treatment, but that more uncertainty pertains to old and recurrent inflammation, leaving probably a condition short of health in the interval of the attacks.

When the tooth has ceased to be painful there comes the question of the choice of material for filling the roots, and this will partly be determined by the degree of confidence which can be felt in the completeness of the cure; thus a front tooth suffering from its first abscess and cured so completely that a wool dressing left in it for a week is absolutely clean when withdrawn, may be closed up with but little fear that the root filling will have to be withdrawn again, and fragments of wool with fluid zinc oxychloride, gold, tin, slow setting zinc oxyphosphate, or any permanent root filling that the particular operator may select may be employed.

But the case is different with many rooted teeth, the canals of which it may be impossible to completely fill; so

also if the tooth has had several abscesses before, or if it remain a little tender after all discharge has ceased; in such cases the introduction of anything which cannot be got out again will expose the patient to the risk of much pain, and may even involve the loss of the tooth. It will then be safer to fill the roots with wool moistened with creasote, with eucalyptus oil and iodoform, or with paraffin wax, and the rest of the cavity with gutta-percha, till such time as reasonable security of its quiet behaviour has been attained. And it will sometimes happen that it is not feasible to close the roots tightly during the time at disposal for treatment, or even after protracted treatment, and it becomes necessary either to sacrifice the tooth or to have recourse to the confessedly less satisfactory course of leaving a perforation through which a small quantity of discharge can make its escape.

If such teeth were pouring out a material bulk of discharge, so as to taint the breath, they would be better out, but that is by no means necessarily the case, and with the observance of proper precautions they may often do service for years and be perfectly unobjectionable.

But there should not be any large reservoir in the interior of the tooth in which matter can accumulate, and a two-rooted tooth such as a lower molar is best dealt with by filling the body of the pulp cavity and making separate perforations into each root canal just below the edge of the gum. The difficulties which pertain to the management of the particular cavity must be left to the ingenuity of the operator, always bearing in mind that the minimum of space should be left in the interior of the tooth; this operation is termed Rhizodontropy.

I have found it a good plan in the treatment of very tender discharging teeth, irrespective of the question of ultimately filling the roots or not, to leave a perforation in the side of the tooth, the pulp chamber having been filled loosely with crystals of thymol; drainage is then possible at the same time that the interior of the tooth is prevented from ever

becoming foul, as long as the thymol lasts, which from its sparing solubility is a long time.

Mr. Coleman has proposed to treat teeth, the roots of which could not safely be filled, by placing a little distance up the root a small pledget of dry wool, carrying a trace of arsenious acid; it is his belief that owing to the very powerful antiseptic action of this body any weeping into the root would be converted into an innocuous aseptic mass, and that the tooth though tightly sealed will remain comfortable; his own experience he states to be in favour of this method of treatment in a certain class of cases. I have not a sufficient experience of his plan to enable me to say whether the distrust with which one would naturally regard the leaving of so potent a drug for an indefinite time within a tooth is or is not well founded. Mr. McAdam has also made use of arsenic as a medicament for treating roots, but in a somewhat different manner; he employed a dilute solution on cotton wool, but has now abandoned it.

Chronic Inflammation of the Dental Periosteum, limited to the alveolar membrane of one or two teeth, excepting in the extent, and dependence upon a local cause, resembles in character that form of disease which has been described under the head of general inflammation of the alveolar periosteum.

After a case has passed through its earlier stages, there is some difficulty in determining whether the malady originated in the gum or in the periosteum. At the outset the margin of the gum exhibits increased vascularity, becomes slightly thickened, and bleeds readily. If allowed to run its course uninterruptedly, the inflammation passes from the tissues about the neck of the tooth towards those which surround the root. The tooth becomes loose, the edge of the alveolus disappears, and the gum sinks down. By slow degrees the tooth loses its implantation and falls out. Generally the disease is attended with but little pain, excepting such as is produced by force applied to the loosened tooth.

Tooth after tooth may be, and in old people frequently is, lost, till the mouth becomes edentulous.

Or suppuration may occur around the roots of several healthy teeth in strumous or syphilitic persons, as has already been mentioned, and this is especially apt to occur about the incisors.

Among the causes which excite chronic inflammation of the dental periosteum may be enumerated, the collection of tartar, a ligature about the neck of a tooth, or pressure applied in an oblique direction by an antagonistic tooth.

The treatment will depend upon the nature of the exciting cause. If a local cause be detected, its removal must be the first step in the treatment; afterwards astringents, such as tannin applied to the gums, will assist in restoring the part to a more healthy condition. In patients of advanced age treatment produces but temporary relief, more especially if the antagonism of the upper and lower teeth is disturbed by the loss of an important member of either series. But should it be found that an elongated or displaced tooth is unfairly forced upon its antagonist, or upon an adjoining tooth, and is thus inducing disease in the socket of the latter, the offender must be shortened by the file or removed.

In the foregoing section it has been assumed that the inflammatory action has extended over the whole circumference and depth of the socket, and is not usual to find the disease confined to or more highly developed on a portion only of the root of a sound tooth. But there are many cases to which this rule will not apply.

When a part only of the periosteum is affected, the disease presents a somewhat different aspect; it usually occurs in connexion with a stump; the crown of the tooth having been destroyed by caries. The periosteum about the extremity of the tooth becomes thickened and nodulated; the socket widens as the disease advances, until the neighbouring alveolus is laid open. With this state there is occasional and

sometimes severe pain, not necessarily confined to the seat of the disease, often not in the affected alveolus at all, but it is felt in the jaw, or in the cheek-bone, or in the ear. The edge of the alveolus seldom becomes absorbed, so that the fang is held firmly in its place.

When there are three crownless fangs in a row, and the periosteum of one only the subject of chronic inflammation about the end, it is extremely difficult, if not impossible, to detect the offender, unless revealed by tenderness on pressure, or the margin of the gum is encircled with a red line, neither of which symtoms are constant.

This bulbous state of the dental membrane (often termed fungous) is occasionally found in connexion with dental exostosis, and sometimes with necrosis, but in the latter case the disease is disposed to become active, and to end in alveolar abscess.

There is but one method of treatment—the affected tooth should be removed.

When a patient suffering pain in the jaw, or face, or ear, is unable to state the exact seat of pain, but is disposed to ascribe it to the teeth, it will be well to remove any stumps that are found in the mouth ; for the periosteum of one or of all of them may be thickened and diseased, and this will not be known with certainty till they are removed. Very generally the diseased tissue is more firmly connected to the tooth than to the alveolus, and is therefore drawn out with the tooth.

A disease having established itself in the soft tissues subservient to the maintenance of the teeth, the recognition of its origin is at all times attended with difficulty, for no sooner is the periosteum attacked than the contiguous gum becomes affected, and *vice versâ*. This remark applies even to tumours arising in this part of the body. A tumour may originate in the gum, or spring from within the socket of a tooth, or it may commence in the periosteum investing the outer surface of the alveoli ; but in either case the growth is usually described under the head of tumours of the

gums, an arrangement which, for the sake of convenience, will be adhered to in the present instance.

A doubt may sometimes arise in the dentist's mind whether, under certain circumstances, the removal of a tooth is desirable. Thus, it may not be clear that the tooth was the original source of the disease, which may have been due to rheumatism, to struma, or to syphilis; or again, the patient may have already suffered from syphilitic necroses elsewhere, and slight wounds be prone to take on ulcerative action. If the disease can be traced to rheumatism, the teeth should not be extracted, even though they are very loose, as the probability of a favourable termination is great. But if the disease appears to be connected with struma or syphilis, no hesitation need be felt in removing any carious teeth, as they are far more likely to cause extension of the mischief by remaining as sources of irritation, than the operation is likely to do mischief. And even though the involved teeth be sound, when once syphilitic or strumous periostitis has run on to a considerable length, the destruction of the involved teeth by the death of their socket is probable, and the extraction of greatly loosened teeth becomes the best course.

The removal of the involved tooth, however skilfully performed, is not always followed by a cessation of pain; on the contrary, the degree of suffering is sometimes for a while increased, no doubt from the laceration of the inflamed tissues. The duration of the after pain will generally be proportioned to the extent of the inflammation, and to the amount of sympathetic pain previously excited.

In all cases of pain after the operation of extraction, the vacant socket should be sponged out with a loosely-rolled pledget of cotton steeped in phénol sodique, or in the following substitute for that preparation—

℞. Acidi carbolici glacialis, ℥j.
Liquoris potassæ, ℥j.
Aquæ, ad. ℥viij.

This will usually give very great relief, and the wool may be suffered to remain for a day or two, if the pain tends to return on its removal. But it will often be found that one or two applications of the fluid will dispel the severe pain, and that the wool need not be left in the socket. Should this fail, the sufferer should be directed to hold a strong and hot decoction of poppy-heads in the mouth, and to renew the mouthful when it ceases to feel hot. This application should be continued till the pain abates, an event which may be looked for within an hour or two.

Neglected periostitis may lead to serious results: thus Mr. Pollock (Trans. Odont. Soc., 1876), records a case of brawny swelling, extending from the jaw to the clavicle and displacing the larynx; incisions having failed to give relief, it was necessary to perform tracheotomy in order to save life. Another interesting case, related by the same writer, is one in which extensive scrofulous-looking ulcerations on the neck, running right down to the clavicle, were also traced to stumps; they healed shortly after the removal of most of the stumps, and recurred a year afterwards, two or three having been left; the extraction of these at once brought about a cure. Exopthalmos and amaurosis have on many occasions appeared to have arisen from diseased teeth, sometimes with obvious antral mischief to account for it, and sometimes apparently without this cavity having been involved.

The existence of inflammation about the roots of teeth of course at times leads to the enlargement of the lymphatic glands in the neighbourhood of the jaws, though this does not take place with the frequency with which it might be expected. The dentist will often be consulted as to the share taken by diseased teeth in the enlargement of the glands in a particular case, and it will often be impossible to arrive at a conclusion of a definite kind, although it is a good general rule that in all cases in which glands are enlarged all teeth which do not admit of being got into a perfectly healthy condition should be extracted, and that

doubtful teeth should not have any attempt at preservation made, or at least no prolonged attempt. As helps to diagnosis, it may be noted that lymphatic glands somewhat deeply seated in the region of the mastoid process, are often enlarged in consequence of diseases of the external meatus; and in the submaxillary region enlarged lymphatic glands are moveable, whereas the submaxillary gland when inflamed is fixed, being bound down under the fascia.

There is much difference in the degree of toleration which is afforded to dead teeth in different individuals, there being a good many persons in whom dead teeth are never quite comfortable for long at a time, no matter how successfully the roots have been filled. And there are others in whose mouths dead teeth seem to be as serviceable as living ones, or nearly so.

The treatment of an alveolar abscess may occasionally be facilitated by drilling through the alveolus opposite to the end of the root, and so getting free vent for the discharge through the gum; but it is not always possible to exactly hit the right spot, and in the case of multiple-rooted teeth not possible. Cocaine seems to be of some advantage in deadening the pain of such a proceeding, though it does not abolish it.

And after the long continuance of an abscess it will sometimes happen that there remains an opening through the gum of some size, through which the roughened end of the root can be seen and felt, acting as an irritant and keeping up discharge. It is a good plan to cut off the end of the root in this case, and this can easily be done by running a small drill three or four times through it, and then breaking or cutting it off with fine cutting pliers. The end should be smoothed with a burr, and the discharge will often cease and the gum shrink down upon it again.

It has already been mentioned that there are some conditions of the root which preclude the possibility of satisfactory results by the ordinary modes of treatment, and that these conditions cannot always be recognised beforehand, amongst

them being alterations of the end of the root by absorption, or what often goes hand in hand with absorption, irregular depositions upon it of lowly organised cementum. When treatment faithfully carried out for an adequate length of time has failed, there is nothing left save extraction of the tooth, when it will usually be found that in place of the exceedingly thin healthy alveolo-dental periosteum there is a thick spongy membrane, here and there breaking down into pus; but it will very frequently be the case that this unhealthy membrane is almost confined to the neighbourhood of the apex, and to meet this the operation of replantation has been proposed.

It is well-known that a healthy tooth knocked out and immediately replaced will, in a large majority of cases, re-unite, and this even when it has been sometime out of the mouth; but such teeth are liable to subsequent abscesses, owing to the decomposition of their dead nerves. Mr. Coleman (1) and Dr. Magitot met with some considerable success by removing abscessed teeth, scraping off the thickened periosteum from their ends, and sometimes cutting off a little of the apex also, and then replacing them without taking any notice of the pulp-cavities; drainage was in some instances secured by making an opening through the alveolus opposite to the end of the root.

But it is obvious that to give the tooth the best possible chance it is necessary to fill the root, and this can generally be done with great ease through the enlarged apical foramen, care being taken to hold the tooth in a napkin moistened with weak carbolised water, so as to avoid, in so far as it is possible, injury to the adherent portions of the membrane.

The operation is only to be regarded at present as a *dernier ressort*, which may be tried with a valuable tooth near the front of the mouth when the alternative is its entire

(1) Trans. Odont. Soc., 1869; and Trans. International Medical Congress, 1881.

loss; I have, in a few instances, succeeded in thus saving front teeth and bicuspids, the abscesses upon which could not be got to heal otherwise; but it is seldom that milder treatment does fail with such teeth, and in each instance it appeared to be due to the rugged state of the apices, which were cut off before the replantation.

There are a good many pitfalls in the way of success in replantation, one being that a tooth which has been an apparent complete success will, after a few months or a year be found to become loose, and when it is removed its root will be found to have been in great part absorbed.

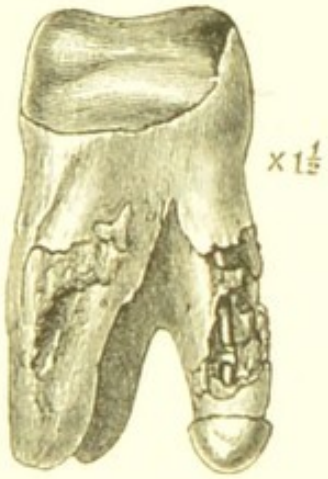
It is often a matter of difficulty to get the tooth back into its socket, and on this account it is sometimes necessary to shorten the root; its replacement will occasionally require a good deal of force, and will give a good deal of pain, so that sometimes an anæsthetic will be as much required for its replacement as for its original extraction.

A refinement of the process was proposed and to some extent practised by Mr. Finlay Thompson, which consisted in the insertion of a minute gold tube passing up through one or more of the roots to the surface of the filling to serve for drainage, this tube being ultimately closed by a gold wire, as soon as it seemed to be safe to do so; to meet the tendency to absorption of the end of the root, this was covered by a cap of thin gold closely burnished down upon it.

All this involved lengthy manipulations out of the mouth, and the results of the operation were not good enough to make it take a place amongst recognised methods of practice. Appended is a figure of a tooth so treated, which was never comfortable, and after a year and a few months was tolerated no longer by the patient. It will be seen that a very considerable amount of absorption had gone on in many places, this being an index of the chronic irritation which had never been long absent after the completion of the operation; thus the capping of the ends of the tooth with gold proved a complete failure so far as preventing absorption went.

All things considered, then, replantation occupies no useful place amongst the resources of the dentist, but there are just a few teeth which may be saved by its means for a time beyond that at which they would otherwise have been lost. And *à fortiori* it is not to be recommended as a frequent line of treatment, as some have proposed; it having even been practised in lieu of devitalising the pulp by ordinary means. A good many teeth were thus treated in London

FIG. 199. (1)



some years ago by an American practitioner, who may have remained under the impression that his success was greater than it really was, as he had left London before these teeth began to loosen again in considerable numbers, which they did within a year or two. A replanted tooth seldom needs any support beyond that which can be obtained by ligaturing it to its neighbours, and often even this is not necessary.

Mitscherlich transplanted a tooth in a dog, and after six weeks' examined it; of the periosteum a good deal was gone, but the tooth had been absorbed in places, and calcification of the osteoclasts had taken place, holding the tooth very firmly, as they were continuous with the bone of the alveolus. The tooth was thus held in

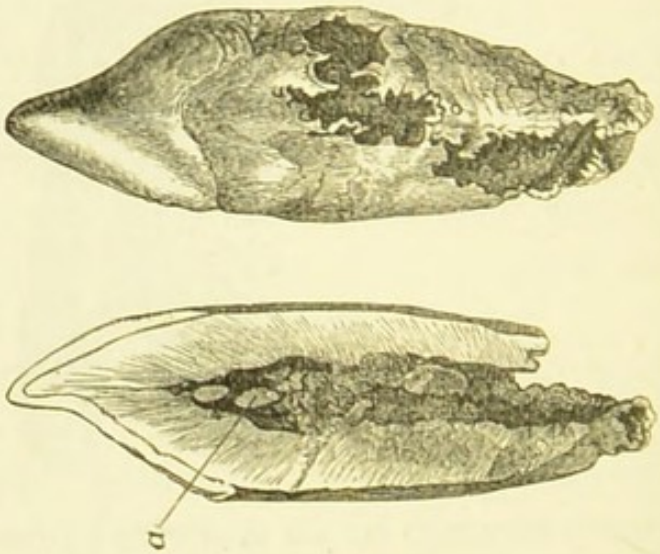
(1) Tooth which had been capped, a tube inserted, and the cavity filled with gold prior to replantation. I am indebted to Mr. N. Stevenson for the loan of this specimen.

largely by bone, with little or no intervening soft tissue, and an ivory peg might be held in in the same way.

It occasionally happens that nature sets up a very energetic process by way of getting rid of a tooth which has become a source of irritation, and its roots are eaten away like those of a temporary tooth. Thus figure 200 represents a tooth the pulp of which had been destroyed with arsenic, and a gold filling inserted without the pulp cavity

Fig. 200. (1)

Fig. 201. (2)



having been cleared of its contents ; the drawing was made from the specimen which was shown to me by Dr. Hawes, of Boston, Mass.

But occasionally the same sort of thing will happen without any obvious provocation, as is exemplified by the specimen here figured, which I found in the Museum of the Odontological Society, with no history attached to it. The crown of the tooth is quite intact, but the root is deeply excavated, and the pulp cavity contains a large mass of secondary dentine which is continuous with the normal dentine where it touches it ; it is impossible to say at what period this mass was formed, whether before or after the root had

(1) Dr. Hawes' specimen.

(2) Specimen from Museum of Odontological Society ; *a*. secondary dentine.

been attacked by absorption from without, though it would seem probable that it was an attempt on the part of the pulp to defend itself, as it exactly corresponds to a deep excavation on the outside of the tooth.

The exterior of the root presents an excellent example of that alternation of absorption and deposition which is so common where irritation has long existed.

A somewhat similar result may follow on the exposure of the pulp by the wearing down of the dentine until the pulp has been quite or nearly exposed. In the human subject relief will have been sought before things have gone on to their ultimate sequel; but in the lower animals instances are now and then met with in which a long time has elapsed without the tooth being shed, as is exemplified in the teeth of a grampus in the Oxford Museum, in which, owing apparently to a twist in the jaws, all the teeth of one side in place of interdigitating came to be exposed to destructive attrition with the result that their implanted portions were enlarged and absorbed in an extraordinary way (1).

An account of replantation which did not mention transplantation would be incomplete, although this latter has not much practical utility. The Odontological Society is fortunate in possessing a caricature executed in 1787 by Rowlandson, which is reproduced in black and white in the Transactions for 1874. It represents a fine lady of fashion seated by the side of a street arab, whose tooth she is to have transplanted into her own mouth; she regards him with disgust, whilst in the background is a gentleman for whom the operation has been completed, and who is looking at his mouth in a glass with much satisfaction; a child is going out of the door with her hand to her face, and a piece of coin in her hand, whilst on the door is the inscription, "most money for living teeth."

The caricature tells the whole tale, whilst more detailed accounts are to be found in the pages of John Hunter. A fierce

(1) For figure see Trans. Odont. Society, 1872–3.

attack was made upon Hunter after his death, and perhaps before, on this ground, it being said that he had communicated syphilis to several persons by means of transplanting teeth, though it is doubtful whether he actually performed the operations himself.

The fact that it fell under the satire of a popular caricaturist, would seem to indicate that for a time at least it was practised with some frequency; but a study of contemporary literature shows that in 1783 it was on the wane, and in 1810 it is spoken of as consigned to oblivion; because, when it succeeded at all, the transplanted tooth remained in only for a few years, and there appeared to be good grounds for the belief that syphilis really was transmitted in some cases; those who are interested in the matter will find some details in the Trans. Odont. Soc. referred to above.

NECROSIS OF THE JAWS.

The death and ultimate separation of portions of the alveolar margins is, in a slight degree, of very common occurrence; the thin edge of the alveoli may exfoliate after an extraction, however skilfully performed, and no ill results attend its doing so, save a prolongation of the healing process. But in place of this very limited death of the bone, the necrosis may be far more extensive, involving the complete destruction of the alveolar portion, and even of the whole depth of the jaw. The causes which bring about necrosis of the jaw are various, and cannot, in every instance, be traced.

Fig. 202. (1)

Thus, in a case formerly under observation, the upper canine of the left side was found to be painful and slightly loose; the pain increased, some little swelling appeared, and pus was found to exude around the tooth. As there seemed to be no hope of saving the tooth, it was extracted, when attached to the apex of the root was found a fragment of necrosed bone, on the upper part of which, as is shown in the figure, was a hollow, smooth surface. This was found

(1) Left upper canine, to the apex of the fang of which is attached a fragment of necrosed bone. The hollowed surface on the upper and right-hand surface of the bone formed a portion of the floor of the nose. On the side of the fang is a smooth, slightly depressed surface, more conspicuous in the figure than in the specimen, which may perhaps have been due to absorption consequent on the pressure of a neighbouring tooth, and there is a slight eroded groove at the front of the neck, but otherwise there is no visible diseased condition to account for the necrosis.

to be a part of the floor of the nose, into which air passed freely; and fluids poured through the nose in drinking.

Since the removal of the tooth some years have elapsed, the aperture being covered by a process from the artificial teeth which are worn by the patient. This remedies the inconveniences of a communication existing between the nose and the mouth; but, although the aperture has greatly contracted, it shows no disposition to entirely close up.

The most remarkable feature of this case is the entire absence of any assignable cause for the mischief; the patient was a healthy man of middle age, with no history of syphilis; the tooth had been only in very slight degree decayed, and had been successfully filled with gold years previously. No blow had been received; in short, nothing whatever could be discovered to account for the lesion.

Another case lately came under my care, at the Dental Hospital, of necrosis occurring without any assignable cause. In this case the sequestrum was much larger, extending from the second lower molar of the right side to the lateral incisor of the same side, and included the mental foramen and a portion of the inferior dental canal. The teeth involved in the dead bone were all sound, and the patient, whose statements appeared perfectly reliable, could not throw any light on the origin of the disease. No history of syphilis could be elicited.

The immediate cause of necrosis is periostitis, resulting in purulent effusion between the bone and the periosteum, and in a large majority of cases the more remote cause of the disease can be traced out.

Thus, in children of strumous diathesis, large portions often necrose, and the disease may be, and I think, very commonly is, set up by a decayed tooth. The tooth-pulp inflames, the inflammation extends to the periosteal lining of the socket, and from thence spreads to the body of the jaw.

A very frequent cause of necrosis is constitutional syphilis, which may lead to the destruction of any part of the jaw,

though its chosen site seems to be the palatine plate of the upper maxilla. A node forms on the hard palate, rapidly degenerates and liquefies, and by separating the periosteum from the bone, leads to necrosis, and consequent perforation into the nares; not uncommonly the morbid action commences on the floor of the nares, and thence penetrates the hard palate.

I have myself met with a case in which extensive necrosis of the lower jaw was the only manifestation of syphilis which had occurred for twenty years, but the diagnosis was put beyond a doubt by the after occurrence of pains in the head and finally of swelling of the testicle. In this case I at successive times removed all the lower teeth, and the extension of the necrosis only ceased with the loss of the last of them, which were the incisors, so that I was driven to the conclusion that it would have been far better for the patient had I adopted a less conservative line of treatment at first.

As has already been stated, necrosis of the alveolar portion, sometimes extending further into the body of the bone, may be set up by a diseased tooth, though this will happen but rarely in a healthy individual. Ulcerative stomatitis not very rarely leads to the exfoliation of small scales of bone; and, in fact, any form of ulceration of the gums may cause this more serious mischief; the ulcerations due to salivation, to scurvy, or cancrum oris being especially prone to lead to necrosis. Very extensive destruction of the bone often follows exanthematous fevers, and exposure to the vapours of phosphorus sets up a severe form of the disease which presents several special characteristics.

Mechanical violence will often cause the death of portions of the maxillæ; thus, large sequestra often come away after gunshot wounds, or after fractures; and the unskilful extraction of teeth is capable of causing extensive mischief. Thus, a patient lately presented himself at the Dental Hospital in whom the alveolar portion of the lower jaw was fractured from the position of the first molar to that of the lateral incisor of the opposite side. The fracture, which was

caused by an ineffectual attempt to extract the first molar, had run horizontally round the jaw, completely separating the alveolar portion from the base of the jaw. I was unable to learn whether the forceps or a key instrument had been used; the treatment adopted was fixation of the fragment by a gutta-percha cap adapted over the crowns of the teeth. The detached piece, however, did not reunite; abscesses formed under the chin, and finally it was removed, in consequence of its becoming necrosed.

Necrosis of a portion of the bone may follow upon the extraction of a tooth, however skilfully this has been performed; and it must not be supposed that the operator is always, or even commonly, to blame for the advent of necrosis after the extraction of a tooth. The conditions leading to necrosis are, in the great majority of cases, developed previously to the removal of the tooth, and are quite independent of its removal; the necrosis would generally have been quite as sure, and perhaps even more extensive, had the tooth been left in. There is not the smallest reason for believing that the removal of a tooth should be deferred because the tissues around it are in a state of acute inflammation or suppuration: if the tooth be the exciting cause of the mischief, there is no excuse for delaying its extraction for a single moment; and the opinion to the contrary, held though it be by a number of medical men, is in no degree shared by dentists, and being based on no evidence whatever, must take rank in the category of popular errors.

Fatal consequences have, in several instances, been known to follow upon necrosis after tooth extraction, some of which have been already alluded to. And from time to time the occurrence of necrosis after the extraction of a tooth has been made the basis of an action for the recovery of damages against the dentist who had operated, but without success; in some instances the actions having been pretty obviously trumped up, and in others no proof existing that any culpability attached to the operator.

It must be remembered that the bone constituting the

alveolus is apparently very intolerant of injury, and seems to have little recuperative power; moreover, things have often gone far towards a necrosis before the operation is performed, and necrosis is not rare without any violence being done to the inflamed tissues.

On the other hand, excessive violence is capable of fracturing portions which subsequently necrose, as was frequently exemplified in the old days of the key instrument, and the writer was recently consulted with reference to a necrosis which had destroyed the whole ascending ramus and a portion of the body of the lower jaw, and which had been attributed not only by the patient, but also by the surgeon who had removed the dead bone, to violence done in the extraction of the wisdom-tooth. But upon a careful consideration of the history of the case it seemed quite as probable that the patient was, so to speak, in for the necrosis before the removal of the tooth.

The disease may arise at any period of life, but it occurs more frequently in children than in adults; and in the former it is, I think, more commonly seen in the lower than in the upper jaw.

In children the sequestrum is generally limited to the sockets of one or two temporary, and the crypts containing the succeeding permanent, teeth; and the situation in which the disease most frequently establishes itself is that occupied by the temporary molars. To this rule many exceptions will be found. The dead bone may be cast off, and leave the forming permanent tooth or teeth behind, injured, perhaps, but not destroyed.

Necrosis, when it occurs in adults, may fall upon any part of the alveolar arch, and may arise at any period of life. I have seen cases in young, middle-aged, and in quite old people.

The indications which attend necrosis are at the outset undistinguishable from inflammation of the alveolar periosteum, but they differ as the disease advances. Instead of the formation of a local and circumscribed swelling, the gum

over the diseased bone becomes generally thickened, tumid, and of a deep red colour; pus oozes up from the edge of the gum. After a time the gum separates from the alveolus, the margin of which becomes exposed. The involved tooth or teeth loosen and fall out. In the course of a few weeks the dead alveoli are detached from the subjacent living bone, and lie loose in the substance of the thickened gum, bathed in pus.

Pain is complained of early in the disease, and is commonly supposed to be toothache; later in the course of the necrosis the face becomes swollen, especially in cases of Phosphorus Necrosis, which disease, being in some respects peculiar, requires a short special description.

If the pus, which is very profusely poured out around the sequestrum, does not find a ready exit into the mouth, it will often point below the chin, or even pass down the neck beneath the fascia, thus sometimes reaching as low as the clavicle. In the case of the upper jaw the pus usually makes its way into the mouth.

Phosphorus Necrosis.—A peculiar form of necrosis affecting the jaws has been repeatedly observed in persons whose duties expose them to the vapours of phosphorus. So numerous are the cases, and so clearly is their history traceable, that no doubt can be entertained that the phosphorus is the actual cause of the disease. There is a prevalent idea that the lower more frequently suffers from the disease than the upper jaw, but this is not borne out by statistics, as out of fifty-one cases collected by Von Bibra, both jaws were affected in five instances, the upper alone in twenty-one, and the lower alone in twenty-five.

One fact connected with the origin of this disease gives it a special interest in the eyes of the dental surgeon; there is a considerable amount of evidence in favour of the view that the poison acts locally, but that in the first instance it cannot attack an unbroken surface. Hence, it usually gains access to the bone through the socket of an extracted tooth, or through the cavity of a carious tooth, exposure of the

pulp being, according to Mr. Salter (1), the only manner in which it gains access.

It is stated that the disease has never been known to occur in a person whose teeth were sound; whilst many who have worked for years with impunity, have only been attacked after teeth had become carious. The experiment of Von Bibra fully confirmed this opinion; he exposed rabbits to phosphorus fumes, and found that they experienced no injury so long as the teeth and jaws were intact, but that if teeth were extracted, or the jaw otherwise exposed, necrosis speedily followed.

The disease very rarely occurs, except in the persons of lucifer-match makers, but Sir James Paget quotes an instance where it was induced by the inhalation of phosphorus fumes as a quack remedy for nervous depression, and a case has lately occurred in which it resulted from a long course of phosphorus pills, taken without medical advice; and Mr. Heath (*op. cit.*, p. 115) quotes Grandidier to the effect that a case has been met with in a child but six weeks old. This case is remarkable inasmuch as the teeth were not yet erupted, so that the poison seems to have obtained access through an unbroken surface.

This form of necrosis is, perhaps, the most severe of any which is met with.

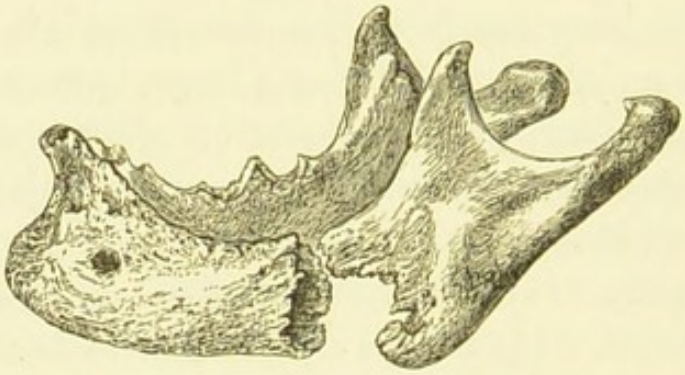
The swelling of the soft parts is very great, and the integument becomes very red and shining; the suppuration, which may give rise to external fistulous openings, though the bulk of the pus is generally discharged into the mouth, is very profuse. The advent of suppuration is marked by rigors and pyrexia, and in severe cases by delirium; after it is fully established the severity of the constitutional symptoms abates, though the patient's health suffers very greatly from inability to take solid food, from swallowing decomposing pus, and from exhaustion. Gangrene of the soft parts or erysipelas may supervene as complications, and ter-

(1) Holmes's Dictionary of Surgery, vol. iv., p. 39.

minate the patient's sufferings. Still, the majority of cases recover with considerable loss of bone. In the case of the lower jaw a very large amount of callus is thrown out around the sequestrum; while in the case of the upper jaw little or none is found.

The bony deposit which is thrown out in phosphorus necrosis is peculiar in appearance, and has been compared to pumice-stone; although usually present in great quantity, it is not invariably to be found, and in the example here

FIG. 203. (1)



figured it was apparently absent. It is also exceptional for a portion of the jaw to be affected in phosphorus necrosis, the destruction more commonly involving the whole body of the jaw, the ascending rami alone remaining intact. It is, of course, impossible to say how far the disease might have extended had the patient lived; but the necrosis in the specimen does not reach far beyond the middle line, though no attempt at separation has as yet been made.

The new bone thrown out seldom surrounds the sequestrum, but generally forms a trough in which the dead bone lies.

The separation of the sequestrum usually takes a very long time, often a year or more; but the surgeon must on no account be tempted to remove it before it is detached. All that can be done is to support the patient's strength by a generous diet, and by tonics; though the duration of the

(1) Jaw from a lucifer-match maker, aged 35, who died whilst suffering from phosphorus necrosis. The bone is diseased from the base of the left ramus to a point slightly beyond the symphysis.

disease renders the avoidance of drugs, as far as possible, desirable. The mouth should be frequently syringed out with lotions of Condy's fluid, or phénol sodique.

Dr. Garretson advises the insertion of pledgets of cotton wool into the sinuses, with a view of hastening the separation of the periosteum, which is already inevitable.

Large quantities of pus will be swallowed, but it is desirable to avoid the formation of any external sinuses, and to induce the discharge of pus into the mouth, as the sinuses would afterwards prove very troublesome.

In the upper jaw there is a greater tendency to recurrence, but the course of the disease is not so violent, and the necrosed portions may be removed much sooner.

It has been stated that in this form of necrosis there is no great tendency to extension of the disease; the whole region affected is attacked at once, from the very first, that is to say, at the period of the first attack of acute inflammation.

Exanthematous Necrosis.—During convalescence of children from the eruptive fevers, and particularly after scarlatina, portions of the alveolar border of the jaw, very commonly including the developing permanent teeth, are found to exfoliate.

The course of the disease is not usually violent, and all that will be required is to remove the fragments as they become loose. Otto Weber (1), however, mentions the occurrence of far more severe cases, which threatened gangrene from the excessive infiltration of the soft parts: in such cases free and deep incisions would be required. The disease is remarkably symmetrical, affecting the two sides of the mouth alike; it is most frequent about the age of five or six years, though it has been met with at a later age. Several examples of jaw necrosis occurring after continued fever are to be found in the different hospital museums.

Treatment is much the same for every form of necrosis.

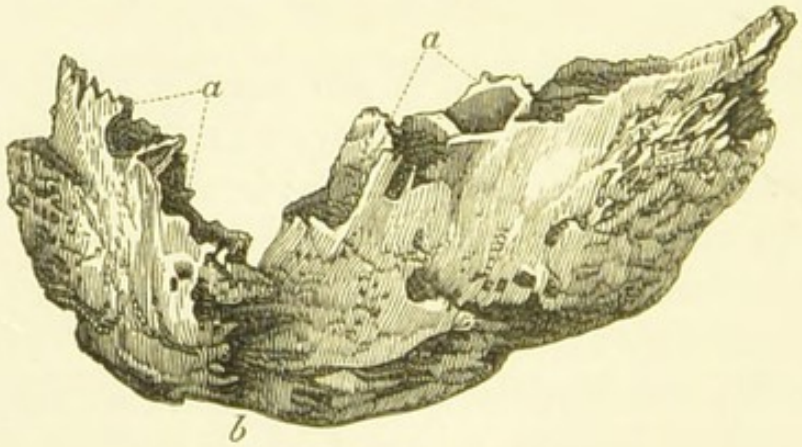
(1) Lehrbuch der allgemeinen und specialen Chirurgie.

Whilst the disease is in the stage of periostitis, threatening to run on to necrosis, free incisions should be made through the inflamed gums, and poppy fomentations assiduously used. Any teeth or stumps which may be causing irritation should be *at once* removed, no matter how violent the inflammation around them may be; and the practitioner who is deterred from so doing by the popular idea that teeth should not be removed until the inflammation has subsided, is likely enough to be waiting for a time that will never come, and is assuredly grievously prejudicing his patient's chances of escape from the more serious ailment.

When the disease has actually reached the stage of necrosis there need be no hesitation in removing a tooth which has caused the disease, but the propriety of at once extracting sound teeth which have become implicated by the extension of the disease may be questioned.

Instances have been recorded of teeth loosened and apparently in a hopeless condition, having, after the removal of the sequestrum, become firmly fixed, either in the remaining portion of the bone or in alveoli subsequently developed.

FIG. 204. (1)



The sequestrum here figured contains (*a*) the sockets of the canines and bicuspids, and the history of the case, related

(1) Sequestrum containing the symphysis (*b*) and the sockets of the bicuspid and canine teeth. From a drawing by Mr. de Morgan. "Lectures on Dental Physiology and Surgery," by J. Tomes, F.R.S.

by Mr. Sharp at the Medico-Chirurgical Society (1), is briefly as follows :—

The disease had commenced with toothache, six months previously, followed by alveolar abscess, and a fistulous opening under the chin. Extensive ulceration of the integuments under the chin had ensued, and after the lapse of two months it was thought that the sequestrum was detached. The existing sinuses under the chin were thrown into one, and the dead bone, amounting to about two-thirds of the lower jaw, easily removed with forceps. The teeth, with the exception of a bicuspid which had been extracted, remained in their places, and became tolerably firm, notwithstanding the entire destruction of their original alveoli.

Mr. Heath (*op. cit.*, p. 123), has collected several other cases in which the teeth remained firm after the removal of sequestra which contained their sockets, and were in a measure useful to the patient; though in other cases they were inconveniently loose, and were subsequently removed. Mr. Heath also relates a case in which the teeth remained firm after very extensive necrosis of the outer plate of the alveolus, the inner having remained to serve as a support.

In the Museum of Bellevue Hospital, New York, there are several very remarkable specimens of reproduction of bone after necrosis, met with in the practice of the late Dr. J. R. Wood.

In one, the entire lower jaw had been subperiosteally resected for phosphorus necrosis, and a complete lower jaw was reproduced, lacking only the condyles, which were represented by thin laminæ of bone laid against the glenoid cavities. Another specimen consists of the symphysis and two-thirds of the ramus; the lower incisors were left *in situ*, being held by the gum alone, and it is stated that they came to be embraced by new bone, and three years afterwards were quite firm. There are several other specimens of

(1) Medico-Chirurgical Transactions, vol. xxvii., p. 432.

similar character, Dr. Wood having given no little attention to the subject.

A case of reproduction of lost tissue is related by Dr. Marshall (Chicago Medical Journal, January, 1884), in which the entire condyloid process, the posterior part of the body and the lower part of the ramus were lost, and a fully formed ramus and an articulation with but little flattening of that side of the face were found less than two years afterwards. There was perfect mobility of the joint. The case was peculiar in that the necrosis of the condyloid region was induced by a large dentigerous cyst, which had cut off this portion from the coronoid process; there was at no time any noteworthy amount of suppuration, and the cyst wall was evacuated and crushed, so that the periosteum was everywhere intact.

The dentigerous cyst was induced by the presence of a wisdom-tooth in the sigmoid notch, with its roots imbedded in the condyloid process.

It has been usually supposed that restoration of bone after necrosis was effected by the periosteum, and in most instances this is certainly the case; Mr. Thomas Smith (1) has, however, met with an example of new formation of bone, which he considers could not have been derived from periosteum.

Mr. Salter (2) points out that the newly formed lower jaw is apt to be absorbed, and to dwindle down to a mere bar; and adds, "How far this loss by absorption of supplemental bone may be prevented by supplying it with a function through the means of artificial teeth, is a question of theoretical interest and of practical importance."

It is a curious fact that there is rarely or never any repair by bone after necrosis of the upper jaw, though in children, and more particularly after exanthematous necrosis, the gap is often filled up by fibrous tissue.

(1) St. Bartholomew's Hospital Reports, vol. i.
(2) Holmes's "Dictionary of Surgery," vol. iv.

Disease in a temporary tooth will sometimes set up inflammation, which in a strumous or enfeebled subject may spread, and ultimately involve a large portion of the jaw, and result in necrosis. The teeth, whether permanent or temporary, implanted in the sequestrum, are usually lost. Mr. Oliver Chalk relates several cases in which portions of the jaw, including the temporary and the crypts of the permanent teeth, were lost. New bone eventually took the place of that which had been removed, and the jaw again became perfect. In several of these cases, permanent teeth most unexpectedly made their appearance, suggesting the idea that the teeth, as well as the bone, had been reproduced. In each instance in which this unusual result occurred, the sequestrum was allowed to become perfectly separated and quite loose, before its withdrawal through the opening which already existed was attempted. The phenomena, as respects the teeth, admit of explanation on other grounds than that of supposing a second series of permanent teeth to have been developed.

Dead is in all cases detached from living bone, by absorption of the layer of the living tissue which connects the two; in addition to which, we commonly find marks of absorption scattered over the whole of that surface of the sequestrum which has been connected with the soft parts. Again, the apertures of the crypts are by the same process greatly enlarged. The connection between the walls of the crypt and the sac of the developing tooth-pulp is in the normal state but a slight one; and this, in the character of cases referred to, may be rendered still more slight by the presence of disease. Now, in the presence of the foregoing conditions, it is not improbable that the pulps of the permanent teeth remained attached to the soft parts, while the crypts included in the sequestrum were removed; and if such were the case, the developing teeth might again be surrounded by newly-formed bone. The truth of this explanation of the manner in which the peculiar results were brought about, is rendered probable by the absence of any well-

authenticated cases of the occurrence of a second set of permanent teeth.

But whatever explanation be adopted, I think all will agree that it is desirable in those cases where necrosis of the jaw occurs during the presence of the temporary teeth, that the sequestrum should be allowed to remain until it is perfectly detached both from the contiguous bone and soft parts, before its withdrawal is attempted; and that its removal should be effected with the least possible injury to the latter, so that the permanent teeth, if not destroyed by the disease, may be placed under the most favourable circumstances for their future growth and evolution.

Before the dead is separated from the living bone a layer of the latter must be absorbed, a process which has already been described in connection with the shedding of the temporary teeth. The separation of the sequestrum must be left to nature. We can render no direct assistance; but it must be the business of the practitioner to see that nature has a fair chance, by attending to the general health of the patient, removing any obvious source of local irritation, and keeping the diseased part in a cleanly state. In effecting the latter purpose, a wash composed of five grains of chloride of zinc to an ounce of distilled water may be used. It will excite healthy action, and greatly diminish, if not entirely overcome, the fœtid smell which attends suppuration associated with dead bone; or dilute solutions of permanganate of potash may be used for the same purpose: the point of a syringe may be inserted into the sinuses, so as to effectually wash them out.

If, after the sequestrum has been separated from the body of the jaw, it is entangled in the soft parts, the scalpel must be used to effect its liberation. With the removal of the dead bone the treatment of the case may be said to terminate. The inflammatory action in the gums and contiguous structures, in the absence of a source of irritation, rapidly subsides, and the mouth is speedily restored to a state of health.

It is important, however, that the sequestrum should be picked out as soon as it has become loose : if this be neglected, burrowing abscesses may be formed. Thus Mr. Cattlin relates a case in which a piece of dead bone from the jaw passed down in abscess cavities, and was finally removed below the clavicle ; and Mr. Wood has forcibly pointed out that it is quite possible to wait too long before removing the dead bone. It has already been mentioned that developing permanent teeth are often lost in the sequestrum thrown off in the so-called "exanthematous necrosis."

Not only, however, may the permanent teeth be exfoliated, but the whole lower jaw has been known to be cast off. Mr. Pollock figured and described such a case (1) ; there was not a vestige of a lower jaw, which, according to the statement of the patient's friends, had been thrown off when she was two years of age. The deformity was less than would have been expected.

(1) Art. "Diseases of the Mouth." "Holmes's "Dictionary of Surgery," 2nd edition.

DENTAL EXOSTOSIS.

THE implanted portions of the teeth, like other parts of the skeleton, are liable to local hypertrophy. In the bones the structure is uniform throughout their substance, and the new tissue does not necessarily differ from that to which it is added. The roots of the teeth present this point of difference: they are composed of dentine clothed with an external layer of cementum, a tissue which offers no striking character by which it can be distinguished from ordinary bone. In exostosis this layer becomes thickened either locally or generally, the dentine in no case participating in the enlargement. The disease may be defined as an addition of tissue, more or less normal in character, but abnormal in amount, to a pre-existing tissue of the same structural character. If, for example, we make a section from a tooth the root of which has been increased in size beyond the natural dimensions, an unnaturally thick layer of cementum will be found, but it will in many instances be difficult to point out a sharp line of demarcation dividing the pre-existing from the recently-added tissue.

FIG. 205. (1)

In respect to the structure of cementum, it scarcely falls within the scope of the present work to enter minutely into its histological characters. For a full description of these the student is referred to Mr. Shelley's paper in the "Transactions of the Odontological Socity," (2) to works on Dental

(1) An upper bicuspid tooth, with exostosis of the cementum of the root.

(2) "On Dental Exostosis." By Herbert Shelley, Esq., M.B. Lond., M.R.C.S. "Transactions of the Odontological Society of London," 1856—57.

Histology, and to Dr. Bödecker's paper (1). But a little space may be given to the consideration of the more prominent features of the tissue.

The structural characters depend in a great degree upon the amount of tissue present. When it is limited to a thin layer, the lacunæ are altogether absent, and even canaliculi do not appear until a certain thickness is attained. If a longitudinal section of a front tooth be taken for examination, the cementum near the neck will present a thin layer of transparent tissue, marked with faint indications of granularity, accompanied in some cases with an obscure linear appearance, suggestive of the idea that the calcification of parallel fibres had contributed to its production. Proceeding in the direction of the root, the cementum thickens, and is traversed here and there by canaliculi, and still further down lacunæ make their appearance, first as a single series, then, with an increased thickness of the cementum, in numbers; the number generally depending upon the thickness of the tissue. The canaliculi of neighbouring lacunæ anastomose freely with each other, and establish a network of communication throughout the whole body of the cementum, and occasionally become connected with the terminal branches of the dentinal tubuli. The communication thus established between the two tissues was formerly doubted, but has now been demonstrated beyond cavil.

The occurrence of vascular canals (Haversian canals) is to a certain extent exceptional, being dependent upon the presence of a larger amount of cementum than is usually found in perfectly healthy teeth. Their presence is not, however, necessarily an indication of disease; for when two contiguous roots are united by the intervention of cementum, a vascular canal will not uncommonly be found to traverse the medium of union. In bone, the vascular canals are distinguished by one or other of the following characters. They are either surrounded by concentric laminæ of osseous tissue, or they

(1) Dental Cosmos, November and December, 1878, and January, 1880.

are enclosed in tissue which has not a well-pronounced concentric arrangement of the laminæ. In the former case the lacunæ partake in the concentric disposition, and direct a large portion of their canaliculi towards the Haversian canal: in the latter their arrangement is less definite, and the canaliculi are directed with less regard to the position of the contiguous vascular canal. In the one instance the characters indicate the presence of secondary bone, or bone which has been developed to supply the place of pre-existing bone removed by absorption; in the other, the presence of primary bone, or that which has been developed in temporary cartilage, or upon the surface of an existing bone. It being to bone developed under the latter circumstances that cementum is most closely allied, the process of its formation may be considered with advantage. In young subjects the shafts of long bones are gradually increased in diameter by additions to the surface. The flat and other bones are increased in thickness by a similar process, and with the femur or humerus, will be found equally convenient for examination and description. If we take either of the latter in a perfectly fresh state, and make transverse sections, either by cutting small fragments with a sharp knife, or even by grinding, taking care to preserve as much of the periosteum as possible, the following appearance will, by means of the microscope, be recognised. Starting up from the general surface of the bone will be seen a series of processes, disposed at more or less regular intervals, producing ridges and furrows, which, for the most part, follow in the length of the bone. Each process is terminated either by a rounded or a dilated extremity. By the increase of the dilatations of contiguous processes, and their ultimate contact and union, the grooves are converted into canals, which are occupied by portions of the cellular layer of the periosteum, which are undergoing conversion into "medulla," and are ultimately permeated by bloodvessels. The new bone has, in fact, been moulded around the portions of the changing periosteum—a process by the repetition of which the shaft

of the bone may be thickened to an indefinite extent. In bone produced under the foregoing circumstances, the indications of lamination are generally indistinct, and when present, follow the general surface of the bone. The arrangement of the lacunæ is subservient to that of the laminæ, consequently in the primary bone the absence of the concentric order in the latter is accompanied by a similar deviation on the part of lacunæ and canaliculi.

It is to this description of primary bone that the cementum of the teeth is most closely allied, and from that it is difficult to point out any distinguishing structural character. There is no doubt whatever that thickening of the cementum is often due to chronic inflammation of the pericementum or peridental membrane; but the roots of teeth are often found to be exostosed, of which we cannot certainly say that any inflammation has ever existed. And it is a process which is peculiarly liable to affect many teeth in the same mouth, quite irrespective of their being decayed or not.

Mr. Shelley, in the paper above quoted, described closely the appearance observed as follows :—

"Upon examining the periosteum of a stump or tooth recently drawn, which has been the subject of long-continued irritation, we find it much more vascular than usual; in some places it is very much thickened and slimy, and very frequently adhering to it are reddish fleshy shreds or masses, which have been called coagulated lymph. These are sometimes of comparatively large bulk, especially where this has been the subject of recent inflammation; and it not only follows that the tooth must be elevated in its socket, but that even the latter must be itself excavated to accommodate the morbid growth. And in order to assist our conception of this fact, I may here remark upon the extraordinary facility with which the jaw-bones change their shape. An alveolar abscess hollows them out, and drills a hole through them in a few days; or two or three double teeth are extracted, and in a few months not a vestige of

their former implantation is visible, and they will slowly expand before a tumour, covering it with a thin papery envelope, rapidly to collapse again after its removal into a firm bony ridge.

"Let us now investigate more closely a mass of this so-called coagulated lymph. It is soft, almost diffluent, on the surface; in the middle it is somewhat denser, and at its union with the fang, which is extremely firm, it is of a gristly cartilaginous texture. The smaller and whiter shreds on the periosteum also partake of the latter character, being tough and less vascular.

"Examined by the miscroscope, the external soft surface is seen to be principally composed of large corpuscles, granular and nucleated, and which in water swell up and burst after a time. The more diffluent parts are entirely composed of these spherical bodies, which agree in character with those corpuscles usually met with in parts recently inflamed, and termed by some exudation corpuscles. In addition to these, small masses of granular blastema are also visible.

"The principal constituent of the next undermost portion is seen to be fibrous tissue in a state of formation. For here may be seen (and in some instances it is most admirably shown) oval corpuscles with fibrous prolongations, some with a short fibre at one end, others lengthened out at both ends, and putting on the characteristic undulation. The corpuscles are light, and generally bi-nucleated, whilst the fibrous extensions are slightly more opaque.

"Still nearer the fang we find the mass tougher, and composed of fibrous tissue, but mingled with it amorphous granules of a gelatinous appearance, and in the meshes, and floating about the margins of the mass, are a number of oval cells.

"At its junction with the fang the substance becomes dense; it is torn with difficulty, and under pressure slips about between the two glasses, and refuses to be flattened out. Under the microscope it appears as a solid, amorphous

yellowish mass, in which, however, may be still distinguished the wavy appearance of the fibrous tissue.

"In this dense gelatinous substance, osseous matter, which has been detached from the fang along with it, may be seen; not, however, shooting out into it in the form of spiculæ-like ossification in the fibrous matrix of the bones of the skull, but as rounded amorphous molecules.

"A more careful examination of the cells found floating freely in the field of the microscope around the margins of preparations made from the two last-described modifications of the so-called coagulable lymph, and which may also be distinguished imbedded in the masses themselves, shows them to be, from their shape and size, identically the same cells, but with different contents, and these contents singularly agree with different modifications of tissue above described. For instance, cells may be seen particularly abundant in the middle of the 'coagulable lymph,' of an oval or elliptical shape, transparent, homogeneous, and furnished usually with two nuclei. Then they may be seen with faintly granular contents and larger nuclei; and lastly, their interior seems stuffed with a more opaque and denser substance, disposed in large granules, among which the nuclei cannot positively be pointed out.

"When a fang to which these masses of so-called coagulated lymph adhere has been allowed to dry, or, still better, if a section be made, it is at once evident that the spots to which they were attached are the seat of a preternatural deposit of cementum; and a thin transparent slice submitted to microscopic examination shows the extra-cemental deposit as I have above described it, and also the fibrous matrix still adherent to its margin, in spite of the rough usage to which it has been subjected in preparing the section."

The account here given differs only in the use of the phraseology of the period when it was written from the more recent writings on the subject, such as those of Dr. Magitot (Sur les Tumeurs de la Périoste Dentaire, 1868) and of Dr. Bödecker.

It may be remembered that bone or cementum is not developed by a direct metamorphosis of the periosteum, but by the calcification of a new growth. Now, the various stages of this new development are to be seen on the inner, or tooth-surface of the periosteum of the socket, and not on its outer or bone surface ; and this may in a measure serve to explain why bony union does not take place.

When a disease consists in the mere increase of a tissue, the presence and position of which are normal, the transition from health to disease is imperceptible, and is usually destitute of symptoms. It is only when the amount of new tissue has attained a considerable thickness, that distinct symptoms are developed, and even then they are in many cases absent. In dental exostosis, a distinction must be drawn between those cases in which the disease is consequent upon pre-existing disease in the tooth, followed by marked irritation of the alveolar membrane, and those in which it is developed independently of any other disease.

FIG. 206. (1)

When the disease arises in connection with caries, it is attended by a thickening of the gums, which assume a deep dull colour, and a disposition to bleed when subject to friction either from the tooth-brush or food. But when the crown of a tooth is free from disease, exostosis of the root may be unattended with any recognisable change in the condition of the contiguous gum. The occurrence of sympathetic pains in the head, face, or neck, may be, and often is, the only indication of disease. In the presence of such pains it is often extremely difficult to determine whether the teeth are in fault, and if so, which tooth or teeth have occasioned the suffering. Sooner or later local symptoms may arise by which the offender can be recognised. The tooth will become tender on pressure, or sensitive to the effect of hot

(1) A molar tooth of the upper jaw, the roots of which are thickened by the addition of cementum, the crown being free from disease.

or cold fluids, or the gum may become absorbed, and leave exposed the neck of the tooth, which eventually becomes loose. Such obvious symptoms, however, commonly appear only after the patient has undergone great suffering from assumed idiopathic tic-douloureux, a complaint for the relief of which patients have often submitted to have tooth after tooth extracted, although the relief afforded after each operation was but questionable.

There are cases, however, in which the presence of exostosis, even of slight amount, produces great misery: a certain tooth is pointed to by the patient as the cause. Its removal brings relief. The complaint returns, another tooth is fixed upon, and removed with a similar result. Another and another follow; and it is only after all the teeth in the upper or lower jaw have been removed that the patient gains permanent immunity from pain, as is exemplified in the following case which came under the writer's treatment some years ago. The crowns of the teeth were sound, but the roots had become slightly enlarged by exostosis. The patient, when she first consulted me, stated that she had suffered from tic-douloureux for several years, and had submitted to the usual treatment without advantage. Two teeth had been extracted, and the operation was followed by a remission of the symptoms. The pain, however, soon returned with full severity, and at the time she came under my charge two upper bicuspid teeth were regarded as being connected with the production of the disease. She stated that the pain came on gradually at irregular intervals, lasting sometimes for twelve or fourteen hours, or until, exhausted by suffering or narcotized by opium, she fell asleep. The suspected teeth appeared quite healthy, but the patient stated, that though they did not ache, yet that they were seldom free from an uneasy sensation. She always felt that they were there, and prior to an attack of facial pain they became hot and felt full. Leeches were applied to the gums, and internal remedies administered, but without producing any mitigation

of the symptoms. After a time the teeth became sensitive to the effects of changes of temperature, and a current of cold water or air not only produced pain in the two teeth, but also brought on an attack of pain in the face. The teeth were extracted, and for several months the patient was comparatively free from pain. Other teeth became similarly affected, and were removed with similar results; but it was only after the whole of the teeth of the upper jaw had been extracted that the patient became perfectly free from the recurrence of the disease. In another case the patient had suffered for several years from intermittent pain in the head and face. For a long time the cause of the disease appeared to have a constitutional rather than a local cause, but the usual remedies failed to afford relief. After a time a feeling of uneasiness attracted attention to the only remaining molar tooth, the second molar of the upper jaw, situated on the side in which the pain was felt. On removal the crown was found to be sound, but the roots of the tooth were enlarged. In this, as in the preceding case, the liability to pain in the face ceased after the operation.

In the two cases cited the relief was complete, although by no means instantaneous. The pain became gradually less severe, and the attacks less frequent, and shortly ceased to recur.

It may be stated generally, that the removal of a tooth which has been the cause of sympathetic pain, usually produces a severe attack, the paroxysm bearing some relation in its duration and in intensity to the previous attacks, and to the length of time during which the disease has existed.

The sympathetic affection may, however, in a few rare examples, extend to a derangement of the whole nervous system. Two cases have occurred under my own observation, in which epilepsy appeared to be consequent upon diseased teeth, the most prominent feature being exostosis of the roots.

The abnormal growth of the cementum is, as compared to

exostosis of bones, confined within very narrow limits. The size of the root of a tooth may be doubled, and two contiguous teeth may become united by the development of cementum about their roots, but we never see a great mass of new tissue produced.

I am indebted to my friend Mr. Spence Bate for the following illustration, and for the loan of the specimen from

FIG. 207. (1)

FIG. 208. (2)

which it was taken. The amount of hypertrophy is here very considerable, and has not only connected the two roots of the tooth, but also the remaining stump of a contiguous tooth, the crown of which had been previously lost.

Through the kindness of the late Mr. Martin, of Portsmouth, I am enabled to add an example in which the second and third upper molars are united by the abnormal development of cementum.

Although numerous instances may be found where two teeth have become united by cementum developed under circumstances which constitute its formation a disease, yet in no well-authenticated instance has the cementum become continuous with the bone of the socket. In reptiles the anchylosis of the teeth to the jaw is a normal character, but

(1) Showing exostosis in a lower molar tooth, uniting the two roots and the stump of a contiguous tooth. From a specimen in the collection of Mr. Spence Bate.

(2) Showing the second and third molar teeth of the upper jaw united by the abnormal development of cementum. I am indebted to the late Mr. Martin for the use of this rare specimen.

in the human subject a case is yet wanting to show that anchylosis between the teeth and the jaw is under any circumstances possible. In two tissues so similar to each other in structure that their distinction is often attended with difficulty, we should be able to point out why their separation in the presence of disease is always preserved when contiguous bones placed under similar circumstances become so readily united.

If we examine a case of local disease in a bone—a phalanx, for example, in which the vitality is at one point lost—we shall find an opening through the integuments from which pus is discharged ; extending from this point, the skin and periosteum will be inflamed to a certain distance, the diseased gradually merging into the healthy tissues. If an opportunity of a careful examination be afforded, it will be found that where the dead joins the living bone, the latter is undergoing absorption, and that beyond this point new osseous tissue is becoming developed upon the surface of the pre-existing bone, the latter part corresponding to the junction of the healthy and the diseased soft tissues, and the former to the part where the skin exhibited all the indication of chronic inflammation. In a tooth the periosteal investment of which has become inflamed, conditions in many respects similar to those which take place in bone may be observed. Thus the end of the tooth will be denuded of periosteum, and in some cases diminished in bulk by absorption. Higher up the membrane will be adherent and thickened, and beneath this the cementum also will be increased by recent additions of new tissue. In order to allow of the increased bulk, the alveolus is necessarily enlarged. Still, the interval which separates the wall of the socket from the contained root is small, and might readily become the seat of bone uniting the tooth to the jaw, but for the existence of some cause which prevents the union of the tooth to the jaw while it allows two bones, when similarly placed, to become connected by ossification.

It is not unusual to see microscopic evidence of an alter-

nation of absorption and deposition of cementum, and this is especially apt to be found where a stump has for a long time been a source of slight irritation.

The absorption which later takes place may go as far as to eat into the dentine, after removing the whole thickness of the cement; examples of absorption and subsequent deposition of osseous material in the cavities so formed have lately been described by Mr. Henry(2) under the name of Inostosis. The absorption is effected by the agency of polynucleated cells, which are derived from the osteoblasts or formative bone cells. Whether they themselves become calcified, or in turn give place to fresh osteoblasts, has not, so far as I know, been determined by actual observation; but, seeing that calcified cartilage matrix is drilled with the utmost rapidity by the advance through it of th osteogenous tissue, it seems most probable that the same osteoblast cells are capable of effecting the absorption and subsequently becoming calcified.

FIG. 209. (1)

(1) Lower molar, the fang of which has been affected by exostosis, and also by absorption.

(2) "Transactions of the Odontological Society," December, 1871, and April, 1872.

DISEASES OF THE ANTRUM.

The maxillary sinus is liable to become the site of various new growths, the consideration of which does not fall within the province of this volume: but the malady with which it is most frequently affected being generally traceable to the influence of diseased teeth, it is indispensable that the dental surgeon should be well acquainted with at least this affection of the cavity. It is quite possible that the development of fibrous, enchondromatous, or malignant tumours of the antrum may have been in some way influenced by the irritation produced in the antral cavity by diseased teeth; nevertheless, the dental surgeon is not called upon to deal with such affections, so that any description of their characters would be superfluous in this place.

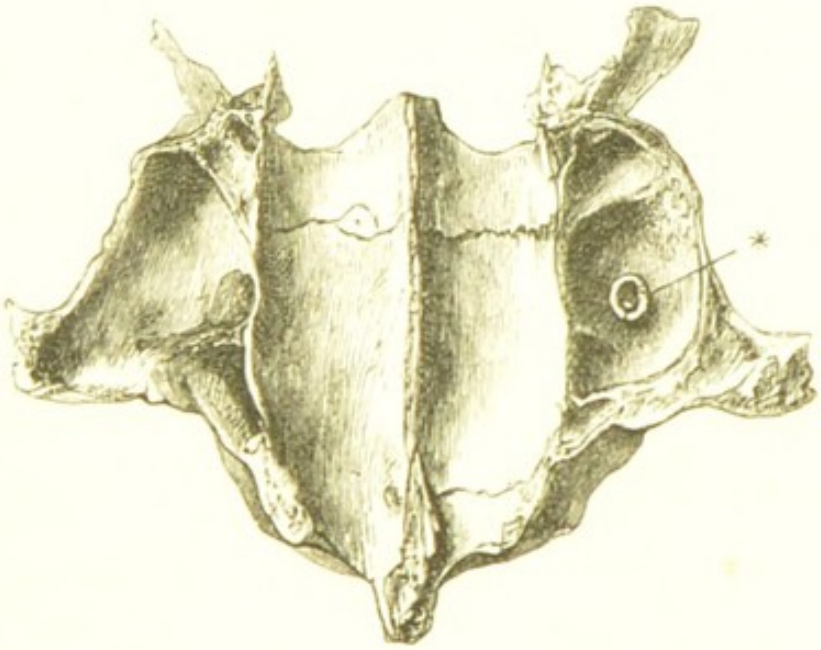
Suppuration in the antrum—sometimes termed abscess, and sometimes empyema of the antrum—is almost always traceable to the influence of diseased teeth: which is not to be wondered at, seeing that the roots of the second and first molars often pierce its bony wall, and are therefore covered only by the periosteum. The teeth which most commonly come into close relation with the floor of the antrum are the canines, bicuspids, and first and second molars, the fangs of which may pass through its floor; or alveolar abscesses attached to their roots may perforate and burst into the antral cavity, as is exemplified by two specimens, one of which was in my father's collection, and is here figured.

This alveolar abscess was connected with the stump of the first molar, and has opened the antrum above the socket of the palatine fang. The manner of perforation is very peculiar, there being, as is seen in the figure, a regular bony

tube standing up into the antrum from its floor. It is noteworthy that the abscess has found exit through the bone elsewhere, as there are large openings through both labial and palatine walls of the alveolar process.

By the burrowing of an alveolar abscess through the substance of the bone, teeth which do not ordinarily come into

FIG. 210. (1)



very close relation with its floor may cause abscess in the antrum; thus, amongst the out-patients of the Middlesex Hospital I some years ago saw a case where extraction of a loose and painful central incisor gave exit to a quanity of exceedingly offensive pus; a probe passed through the vacant socket entered the antrum through a canal as large as a goose-quill; and Dr. Latimer, in the "Dental Cosmos" for January, 1870, records a case where abscess of both antra had followed on filling the two lateral incisors over exposed pulps.

(1) Superior maxillary bones viewed from above. A horizontal section has been carried across the antral cavities, which are seen to be partially divided by septa rising up from the floor. On the left side is seen the perforation (*) caused by an alveolar abscess. The specimen is now in the Museum of the Odontological Society, among a series of antra which have been lent by Mr. Cattlin.

It must therefore be borne in mind that any tooth is capable of causing abscess of the antrum; but, although diseased teeth are the cause of the great majority of cases, yet some few have arisen from other influences. Dr. G. A. Rees records a case occurring in a new-born infant ("Medical Gazette," vol. iv., new series) which seems to have resulted from pressure of the face on the arch of the pubis during parturition, and it has also been attributed to the passage of food up through the socket of an extracted tooth. Otto Weber states that it sometimes arises after chronic nasal catarrh, or obstruction of the nares by nasal polypus.

I have myself met with several cases of antral suppuration which were not attributed to diseased teeth, and one in particular was so striking as to deserve more than passing notice. The patient, a gentleman aged about forty-five, presented himself with all the usual symptoms of pus in the antrum of the right side which discharged pretty freely into the mouth: several teeth had been previously lost, and those which remained presented no sign of alveolar inflammation, nor had any of them dead pulps.

The patient had suffered from primary syphilis some years previously, and was at this time much troubled by headache, and slight iritis, for which he was undergoing mercurial fumigation. A bicuspid was extracted, its alveolus enlarged, and the antrum, after a longish period of treatment, brought into a healthy state again.

However, after a few months the patient returned, saying that he recognised all the old symptoms, and was convinced that the other antrum was full of pus. Here again there was no tooth capable of setting up irritation, so a practically sound bicuspid was extracted, and the patient's diagnosis found to be quite correct. In each instance the pus was horribly fœtid.

In the normal condition the antrum is lined by a thin mucous membrane, continuous, through an orifice in the middle meatus, with the mucous membrane of the nose;

this delicate mucous membrane is attached to a thick, dense periosteum covering the bone. It was formerly supposed that distension of the antrum was often produced by an accumulation of mucus secreted from its membrane, owing to closure of the orifice; but the existence of this mucus is purely hypothetical, according to Otto Weber, none having been seen in the dead body on opening the antrum. According to Otto Weber suppuration in the antrum may take place in two situations; the entire lining of the cavity may be inflamed, as, for example, by the spread of catarrhal inflammation from the nasal cavities, in which case the discharge of pus will flow out through the natural opening into the middle meatus of the nose. But what very much more commonly happens is that the suppuration, when excited by the root of a tooth, takes place beneath the periosteum, which is then lifted from the bone, and separates the accumulated pus from the true cavity of the antrum. Hence it is that pus so frequently fails to escape by the natural orifice into the nose. When the antrum becomes distended by suppuration, the bone is often sensitive to the touch, and the teeth appear lengthened; as the accumulation of fluid progresses, a swelling appears in the sulcus between the teeth and the cheek, from the canine backwards as far as the third molar. Occasionally the concavity of the palate becomes obliterated on that side, and in extreme cases the floor of the orbit becomes pushed up, displacing the eyeball.

In most cases of antral abscess some little tenderness and swelling of the cheek and fulness about the zygoma are noticed; but the lachrymal ducts are not closed, as would generally be the case with the growth of solid tumours.

The symptoms attendant upon inflammation of the lining of the antrum are, in addition to those already mentioned, dull, deep-seated pain, occasionally of a lancinating character, œdema and tenderness of the cheek, and a varying amount of pyrexia. The formation of matter is sometimes, but by no means invariably, indicated by the occurrence of slight

rigors. In a more advanced stage an offensive discharge may flow from the corresponding nostril, or drip into the throat at night, so as to be expectorated in lumps in the morning. As far as my own experience goes—and I speak from limited experience—the discharge from the nostril which occurs in the earlier stages of malignant disease is not usually so offensive or so thick as that which proceeds from simple inflammatory affections of the maxillary sinus. There is also another point by which simple inflammation may be distinguished from certain of the more formidable diseases causing enlargement in that region. The teeth, though somewhat lengthened, are seldom or never disturbed in position by the former malady, but where a morbid growth, originating in the antrum, has progressed to a considerable extent, the teeth often become separated from one another, and diverted from their natural directions. In one case which terminated fatally, the discharge which flowed from the nostril was for some months thin and watery, and destitute of offensive odour; but, as it is more common for the matter to find no exit in cases of empyema of the antrum, the discharge is often not present to afford any guide to a correct diagnosis.

Symptoms of a closely similar character may be associated with the earlier stages of malignant disease, though malignant growths seldom remain long confined within the antrum, but pass out and invade surrounding parts; and it is very necessary that the practitioner should be aware of this, for should he, under the impression that the case is a simple one, remove a carious tooth, he may get the credit in the mind of the patient of having induced a fatal disease by his injudicious interference.

The affections which are most likely to be confounded with empyema of the antrum are mucous polypi and dentigerous or other cysts in its cavity; and in some instances slowly-growing solid tumours may be confounded with chronic abscess of the antrum. Careful inquiry into the history of the case will often very materially aid a correct diagnosis,

but in a certain number of cases it is impossible to be perfectly certain of the true nature of the enlargement; and it has more than once happened that surgeons have commenced an operation for the extirpation of a jaw that proved to be enlarged by nothing more formidable than an antral empyema.

With care, acute inflammation of the antrum may generally be correctly diagnosed, but chronic suppuration, especially when leading to considerable thickening of the bone, may very closely simulate the solid growths.

This thickening of the bone around a chronic abscess may be so considerable as to produce marked deformity after the cure of the empyema, and may even necessitate an operation for its removal.

When there is any doubt, an exploratory puncture should be made; it is not in the least likely to lead to any bad results, and may prevent the surgeon from falling into a very important blunder. A small perforation may with perfect safety be made with a spear-headed drill in the engine, and will at once close if it is not needed; if this is insufficient a trocar or a scalpel should be used, as the indications afforded by the insertion of a grooved needle are uncertain. In some instances patients have been conscious of a sensation of fluid washing about in the cavity when the head is suddenly moved, but of course this can only happen when the cavity is incompletely filled with fluid.

If left to itself the pus is sometimes evacuated into the nose by the natural orifice, or finds an outlet through a vacant alveolus. But this fortunate result is rare, and the neglect of antral abscess not uncommonly leads to serious consequences: the pus sometimes finding an exit through the cheek and leaving considerable deformity, but more commonly finding its way into the orbit, causing great protrusion of the eyeball, temporary or permanent blindness, and finally making its exit at the inner or outer canthus. In a case recorded by Dr. Latimer, the discharge was so profuse as to necessitate a cloth being constantly kept upon

the patient's face, and the skin in the neighbourhood of the eye had become excoriated by the discharge to such an extent that it had all the aspect of malignant disease.

A most remarkable case of death from intra-cranial suppuration, consequent on neglected antral abscess, is recorded by Dr. Mair, and quoted in full by Mr. Heath in one of the appendices to his work.

Necrosis of a portion of the walls of the cavity, or even caries of the bone, occasionally ensue, and sometimes, when the disease is acute, it is accompanied by erysipelatous inflammation of the face, with very great constitutional disturbance.

Mr. Salter has pointed out that permanent amaurosis may result from the displacement of the eye; indeed, he also gives an example of amaurosis following inflammation without abscess. Dr. Latimer also alludes to cases of impaired vision, the result of antral abscess.

In the first case, the history of the disease was briefly this—violent toothache around the first upper molar, enormous swelling of side of face, infiltration of the lower eyelid so as to close the eye, protrusion of the malar bone, and frightful pain in the eye, which became protruded later and became blind. Pus escaped near to the outer and inner canthus of the eye, and in this condition the patient remained for two or three weeks, with occasional discharges of matter by the nose.

The hard palate was convex within the mouth. Mr. Salter removed the fangs of the first molar, and a wisdom-tooth; the pressure of the instrument caused pus to pour from the openings below the eye, and there was a sensation of bagginess and yielding about the whole bone. After the extraction blood also poured out from the fistulous openings. The eye was sightless, the globe prominent, the pupil fixed; there was general inflammation of the fibrous textures of the eye, and extreme conjunctivitis. Eventually a large sequestrum came away, and the inflammatory condition passed off, but the sight of the eye never returned. On ophthalmoscopic

examination, the only abnormal appearance observed was extreme anæmia of the optic nerve, a condition constantly associated with suspension of the function of vision when dependent upon causes external to the globe.

The result is not always so disastrous as in the last case; thus Stellwag quotes a very interesting case reported by Galezowski, in which, after blindness of one eye for thirteen months, complete recovery ensued. The first thing noticed was the sudden advent of exceedingly severe neuralgia, recurring from time to time; the eye became painful, protruded, and sight was lost.

After six months, great swelling came on, and several drachms of pus were discharged from the lower eyelid; the pain then subsided, but the sight did not improve. Eventually the pain recurred with increased intensity, but although the eye remained blind and the pupil dilated, no structural change could be discerned. The first upper molar was carious, and on its removal a splinter of wood was found at the end of the fang, which was probably the end of a toothpick. The antrum was opened by the extraction, and on the same evening the eye was sensible of light; by the next day it had completely recovered. It is remarked that the toothache, seldom present, was not coincident in point of time with the neuralgic pains and pains in the eye.

In a case of Mr. Pollock's there was no actual empyema of the antrum, but there was deep-seated active inflammation of the superior maxillary region, and the eye was much congested. On the removal of the first bicuspid and first molar, about which there was much irritation, the inflammatory symptoms rapidly subsided; but the eye remained blind, although the pupil subsequently contracted in response with that of the sound eye.

In the blind eye no structural change could be detected.

It is pointed out by Mr. Salter that in most of the cases recorded no permanent mischief could be detected in the structures of the eye, even when sight was never recovered, save anæmia of the optic disk, thus suggesting the idea that

some irreparable damage had been inflicted on the optic nerve external to the eyeball.

The case of a girl of sixteen has recently come under the observation of several ophthalmic and dental surgeons, in which there was orbital cellulitis with but slight constitutional disturbance, great protrusion of the eyeball, and loss of sight. The teeth were remarkable for their very imperfect development and tardy eruption; several carious teeth were removed, but the antrum was not explored, so that it is not possible to say whether the removal of the teeth did or did not aid in curing the cellulitis, which entirely subsided, and has left the sight of the eye fairly good. The patient did not come under my own observation till after the subsidence of the ophthalmic trouble.

The treatment of empyema of the antrum consists in giving free exit to the pent-up matter, and this may be effected in several ways; the most usual and the best course is to extract all the dead teeth on that side of the mouth, when it will probably be found that matter makes its escape through one of the alveoli. Should this be the case, the orifice should always be enlarged by using a *large* trocar —which would also be the proper course if the matter did not appear—the socket of the first molar being usually selected as the most suitable point for puncture. In forcing the trocar into the antrum the thumb should be supported against the jaw, so as to obviate the risk of the instrument suddenly entering and wounding the floor of the orbit from below.

Most surgeons use either a gouge or a trocar for opening the antrum. An opening commenced with a trocar may be enlarged with a gouge; but the operation may be done with far less disturbance, and consequently with far less after-discomfort to the patient, by a large spear-head in the dental engine. But if the case be an obstinate one the gouge is best suited for the making of a very large opening.

In this connection it may be mentioned that a moderate opening is sufficient if the antrum can be thoroughly

washed out through it; and it is not generally known that, if the opening into the nose be patent, this can be very efficiently done without any syringe. If the patient holds that side of the mouth full of water, after a very little practice he will be able by the pressure of the cheeks to send it in a full stream through the nose, and in this way a large bulk of water can be forced through, though, of course, no very strong medicament can be thus used.

In case there are no diseased teeth, a sound first molar may be extracted, or the puncture made near the malar process, or backwards from the canine fossa; one of these situations must be selected in the rare case of empyema of the antrum occurring in an aged and edentulous person. O. Weber recommends that the hole should be made large enough for the little finger to enter the cavity; this is rather unnecessarily large, except for an obstinate chronic case, but there is no doubt that, in all cases where we have to open up a cavity, the safer course is to make a large opening. It is a great and important error, though one often committed, to be content with a small opening into the antrum; and many cases are greatly and needlessly prolonged by the accumulation of morbid secretions in consequence of such treatment. It has been pointed out by Mr. Cattlin (*loc. cit.*) that the floor of the antrum is often divided by a transverse septum of bone, which conformation would render it quite impracticable to thoroughly and efficiently wash out the cavity through any small opening.

Having made a free opening, the cavity should be thoroughly washed with warm water thrown in with a large syringe: a piece of gum-elastic catheter, placed on the nozzle of the syringe, will often aid in doing this effectually.

After the cavity has been thoroughly cleared out, astringent and disinfectant lotions should be used daily. A weak solution of permanganate of potash answers the purpose excellently; but should the mucous membrane take long to recover a healthy condition, a stimulating injection composed

of a weak solution of chloride or sulphate of zinc, or nitrate of silver may be used; weak boracic acid lotions also being useful, and in obstinate cases tincture of iodine has been advantageously applied. And Mr. Smale has found packing the cavity with strips of lint dipped in a 1:40 solution of carbolic acid successful after the failure of other remedies.

The opening should be kept closed lest the accidental access of food excite fresh irritation. It has been recommended that a gold tube with a stopper be fitted to the opening, and secured to the neighbouring teeth; but in most cases a plug of soft wax will be found to answer the purpose, unless it be thought necessary to keep the opening permanently patent.

Dentigerous and other cysts of the antrum will be noticed in another chapter, and need not be referred to here.

Occasionally the root of a tooth passes into the antrum during an attempt to extract it, and this accident may occur in the hands of the most careful and skilled operators.

As has already been noticed, the root of an upper molar not uncommonly passes through the floor of the antrum, and may even become enlarged within that cavity. When an attempt to remove such a root is made, one of two things happens: either a portion of the antrum is brought away with the tooth (Mr. Cattlin, *loc. cit.*), or the root slips up into the cavity. Such an event occurred in the practice of Mr. Cattlin; and as the patient's father had died from malignant disease of the jaw, it was deemed prudent, not only by Mr. Cattlin, but by Mr. Stanley and other surgeons of eminence, to remove the stump, lest it should become a source of local irritation. A trephine was applied to the labial plate of the alveolus, and the cavity of the antrum laid open. For some time the missing root could not be found, and it was only by employing a cup formed of gutta-percha, mounted on a piece of bent wire, that it was ultimately removed. In most cases the employment of a strong current of water will suffice for the dislodgment of a stump, but in

this instance the floor was divided into two compartments by a transverse septum of bone.

In one instance a canine tooth was driven into the antrum by a fall, and its presence only discovered after some time, when empyema of the cavity had resulted. In such a case its removal should be at once effected.

ABSORPTION OF THE ROOTS OF PERMANENT TEETH.

The removal by absorption of more or less of the root in teeth the crowns of which have been injured by disease, has been already mentioned; but cases from time to time arise in which, while the crown of a tooth is perfectly sound, the root is attacked by absorption. It is to absorption, when it occurs under the latter circumstances, that attention will be directed.

Although the processes of absorption will be the same under whatever circumstances they may be set in action, yet we may arrange the cases under two divisions, in accordance with the character of the exciting cause. In the first may be placed those examples in which the whole or part of the root of a sound permanent tooth is absorbed without reference to the growth of an adjoining tooth; and in the second, those cases where a portion of a permanent tooth is absorbed to make way for the eruption of a neighbouring tooth.

I have seen many cases of absorption in permanent teeth, where the waste has so far reduced the roots that they became loose and painful; but I am indebted to Mr. Canton and to Mr. Brookhouse for specimens showing complete absorption of the root. In the one case the incisors, one after another, became loose, and fell out, the patient being on the younger side of forty, just as though they were temporary teeth making way for their successors. In the other, a permanent lateral incisor was lost under similar circumstances. In neither patient was

Fig. 211. (1)

(1) Permanent central incisor, the root of which has been absorbed: from a specimen placed at my disposal by Mr. Alfred Canton.

there any indication of the presence of disease, either in the gum or in the alveolar process. The attention was attracted by no other symptom than the gradually increasing looseness of the tooth. In a patient of my own, aged fifty, an upper central became rather suddenly loose and painful. It was subsequently found that the one side of the root had been removed by absorption, the process having been arrested when the walls of the pulp-cavity were reached, leaving the pulp perfectly encased in a thin tube of dentine. But for the supervention of inflammation,

FIG. 212. (1)

FIG. 213. (2)

followed by the secretion of pus, it is probable that in this, as in the preceding cases, the whole of the root would have been removed.

The fact that the walls of the pulp-cavity resisted the absorbent action with greater success than any other part of the dentine, accords with what we may observe taking place in a limited degree in temporary teeth. It is probable that the presence of the pulp gives this power of resistance; for in pivoted teeth the root is commonly reduced by absorption, and perforations are sometimes made, by which the metal pin is exposed. In a specimen in the museum of the Odontological Society, the root of a tooth has been in great part absorbed in consequence of the irritation produced in its

(1) A permanent incisor, one side of the root being removed by absorption. A thin case of dentine enclosing the pulp has been preserved.

(2) A pivoted tooth, with the root reduced in size by absorption, and gold pin exposed at one point by a perforation, also produced by absorption.

socket by a bristle which had made its way up the empty pulp-canal.

The six upper front teeth of a young person were shown some years ago to the writer subsequently to their removal on account of looseness. There was no assignable cause for their destruction, and the patient's general health was quite good; yet the roots of all these teeth had been shortened with singular uniformity until not more than half the root remained.

The cases which fall under the second heading are usually dependent upon the malposition, and consequent retarded eruption, of a permanent tooth. The extent to which the absorption of tissue is carried is usually limited to the production of a slight depression in the neck or root of the tooth, but in a few cases the process is continued until the pulp-cavity is laid open and the pulp exposed.

The canines of the upper jaw being more frequently malplaced than any other teeth, except the wisdom-teeth, we should expect to find instances of absorption in the lateral incisors and first bicuspid teeth. But in these we seldom see more than a simple depression, towards which the advancing crown of the coming tooth has been directed, though instances of the exposure of the pulps of lateral incisors have been placed on record. It is upon the second molars that the greatest extent of injury is inflicted. When the crown of a wisdom-tooth is directed forwards, it leads to absorption at the neck of the obstructing tooth; and the process, though generally arrested before the second molar is permanently injured, will, in some cases, lay open its pulp-cavity. I have seen several cases in which the injury has been followed by inflammation of the pulp, necessitating the immediate removal of the tooth. In a case which occurred recently, the patient complained of severe pain in a second molar of the upper jaw. The tooth appeared in every respect sound; directions were therefore given that a leech should be applied to the gum. On the following day the patient returned, complaining that the abstraction of

blood had failed to produce relief, and strongly urged that the tooth should be removed. The tooth had become slightly movable, and the crown had lost a little of the natural brilliancy of colour. After removal, the cause of the suffering was manifest. The pulp-cavity had been laid open, the pulp became inflamed, lost its vitality, and at the time of the operation was in a state of decomposition. In this instance there was not the slightest evidence of caries; but in others which have come under my notice, the cavity produced by absorption subsequently became the seat of caries.

The exact mechanism of the absorption which takes place when one tooth impinges upon another below the level of the gum is not fully understood: when the contact takes place above the edge of the gum no harm is done, unless the crowding induces caries at that point; but when it is at a lower level, absorption is set up, whether by the periosteum being irritated by being squeezed between the crown of the advancing tooth and the cementum of the other, or by some other process. But as a practical matter it must be remembered that there may be absolutely nothing to show for it, save pain and tenderness, for the spot at which absorption is taking place may be far beyond the reach of a probe: this has been observed both with lateral incisors and with second molars.

In a case recently under observation pain was complained of in a second molar, which was found to be eaten into at the gum-level, where a short wisdom-tooth impinged upon it. It was grasped with forceps, and, though previously apparently fairly firm, the crown came away instantly: on examination it was found to have entirely lost its roots, save the shortened remains of the anterior labial roots, and yet its pulp had remained, in part at least, alive.

Necrosis of the Teeth.—After the death of the tooth-pulp the tooth may long retain an organic connection with the part outside it by means of the cementum, and usage has led us to speak of such a tooth as a dead tooth, though, in fact, it is not really wholly dead. But usage has likewise

limited the term "necrosed," which really means just the same thing, to that more complete death in which the cementum likewise is involved.

A perfectly dead tooth is soon thrown off by nature as an extraneous body, its expulsion being attended with more or less local inflammation of the surrounding soft parts. The amount will to a considerable extent depend upon the relations of the several parts involved at the time the death of the tooth takes place, and upon the cause which produced it.

If, for instance, the alveolus and the gums have receded, the inflammation excited by the dead tooth will not be great, unless the death of the tooth has been consequent upon recent inflammation of the pulp and of the dental periosteum. Even then the symptoms will be less severe than they would have been had the alveolus and gum risen to the usual level. But we see many discoloured teeth which have remained for years firmly implanted in the jaw, and their presence has been unattended with serious inconvenience, yet they may be described correctly as necrosed teeth. In such cases the disease has not, however, involved the whole of the tooth; some part has retained its vitality, through which the connection with the soft tissue has been maintained, and consequently the tooth has been enabled to hold its place. The circumstance that a tooth, the crown of which presents all the external characters peculiar to a dead tooth, retains its position, and in certain cases fails to produce considerable local disturbance in the jaw, while in other instances great irritation is set up, indicates that the disease is subject to important modifications, which at first sight are not very apparent. On investigating a series of cases, it will, however, be found that the modifications which they present are consequent upon the extent to which the tooth has become involved, rather than to any special difference in the disease. Thus the dentine may lose its vitality in consequence of the pulp having been destroyed, and the tooth assume the peculiar brownish-red colour which arises from the decom-

position and diffusion of the blood contained in the pulp through the dentine, and yet the cementum may retain its connection with the periosteum. This connection affords the means by which the tooth may retain its place for an indefinite period. Examples are often seen in which the pulp has been suddenly destroyed by a blow received many years previously, and the injury has been followed by discoloration of the crown of the tooth. The patient will state that the tooth is dead, but this is not strictly correct; the death has been limited to the dentine: the cementum has retained its vitality, although its normal state may not be perfectly preserved.

Again, in pivoting a tooth, we reduce the root to a similar condition. The vitality of the dentine is sacrificed when the pulp is destroyed; but if the operation is attended with success, the life of the cementum will be maintained.

The time during which a tooth so circumstanced will retain its position without undergoing further change, is not unlimited, for the cementum is apt to become the seat of an increased, if not a morbid action, so soon as the vitality of the dentine is lost. In some cases great additions are made to its surface, and through the new tissue the connection with the periosteum is preserved. In others, again, absorption is set up, and the root becomes reduced in bulk, is gradually detached from the periosteum, loosens, and falls out. In the former case the living portion of the tooth appears to be very limited in amount, its extent being often confined to the newly-added tissue; for the appearance presented by some specimens would justify the conclusion that the cementum which existed at the time the dentine lost its connection with the soft parts, though not deprived of life concurrently with the dentine, yet subsequently lost its vitality; but not, however, before new cementum had been added upon the surface of the older tissue in parts.

If we remove a tooth which has been the subject of the foregoing changes and allow it to become dry, those portions of cementum which are of comparatively recent formation,

will present the opaque white aspect of healthy bone; while the other parts of the tooth, including the older cementum, exhibit more or less discoloration. Now, it is possible that the whole of the tooth became necrosed at the same time, but it is more probable that the death of the cementum was subsequent to the death of the dentine, and also to the development of a new layer of cementum. Otherwise, it must be admitted that the living tissue was developed upon, and united to, and continuous with, the dead structure.

Necrosis may, however, be confined in the first instance to the cementum, the dentine and dentinal pulp retaining their normal relations. In cases which present this character the tooth becomes loose, and the gum usually, although not necessarily, recedes. The surface of the cementum is detached from the periosteum, excepting perhaps at and about the extremity of the root where the nerves and blood-vessels pass into the pulp-cavity.

The patient complains of intermittent pain in the tooth, excitable at any time by the application of hot or cold water; very commonly pus will escape from between the tooth and the gum when the latter is pressed. The crown of the tooth does not assume the dark slate colour which follows after the death of the pulp. In this form of the disease additions are not made to the cementum, unless in small and isolated spots. Sometimes the cementum is greatly reduced by absorption, and even the dentine in many cases suffers also, though necrosed tissue is usually a source of so much irritation that it comes to be bathed in pus, and so is to be removed from the action of osteoclasts.

There is yet another form of partial necrosis. One root of the double-rooted teeth, or one or two of the treble-rooted teeth, may become dead and perfectly detached from the lining membrane of the alveolus, while the remaining root or roots preserve their vitality. Teeth when in this condition are apt to be at times very troublesome. When they are used in mastication pain is experienced from the dead

root being pressed into the socket, the lining membrane of which is injured by the rough surface usually presented by the dead root. The continued irritation arising from this cause is productive of thickening of the alveolar covering, accompanied by the development of a high degree of sensitiveness in the hypertrophied parts, the susceptibility to pain in which is consequently increased. Hot or cold fluids taken into the mouth also excite pain in the tooth itself, or in the irritated alveolus (it is very difficult to say in which). The alveolus and gum of the dead root may or may not become absorbed.

Such teeth may sometimes be restored to usefulness by cutting off the necrosed portion, which is usually not at all difficult of accomplishment with the aid of the engine. An upper molar, one labial root of which has thus been cut off, will preserve a considerable degree of firmness if its other two roots are fairly healthy.

In one case we may see the whole of the root, even to its extreme point, laid bare by the removal of the investing parts, and in another case the gum will nearly maintain its normal height. Of the two, the former condition is preferable, on account of the greater degree of irritation and pain which usually attend the latter.

The thickened periosteum, if adherent at any point to the cementum, may be, and sometimes is, withdrawn from the socket on the tooth being extracted. It is usually light in colour, of considerable thickness, and almost as dense as fibro-cartilage.

It is probable that the success sometimes attendant upon replantation, after all other treatment has failed, depends upon the possibility of thus removing any necrosed cementum or much thickened periosteum before restoring the tooth to its socket.

EROSION OF THE TEETH.

It occasionally happens that the enamel and the subjacent dentine become eaten away, without any of the ordinary appearances of dental caries being manifest. The cavities, if such they may be called, are in general regular in form, and saucer-shaped, the removal of the enamel having taken place more widely than that of the dentine. The surface is perfectly hard and polished, and often absolutely free from discoloration.

This affection, which was described by Hunter under the name of "decay by denudation," most commonly attacks the necks of the teeth, forming a smooth horizontal groove close to the edge of the gum: it is more frequently met with in the upper than in the lower jaw, and closely simulates the appearance produced by mechanical abrasion caused by the friction of a tooth-brush.

Now and then, however, teeth are attacked in positions inaccessible to the tooth-brush; thus, in the canine tooth here figured, the groove was not only upon the anterior surface, but extended back on both sides of the neck of the tooth; moreover, it was distinctly undercut.

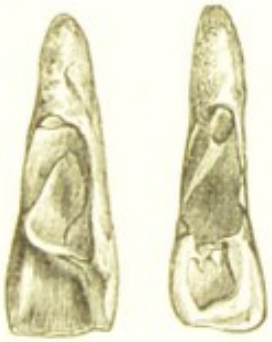
This erosion may go on till the pulp-cavity is opened and even passed, so the tooth is fairly cut through by it. An instance of a lower bicuspid, with its crown thus undermined, has recently presented itself, which, from its position, was thoroughly protected from the ordinarily recognized sources of friction. Although the labial surfaces of the teeth are usually attacked, the lingual surfaces may in some few instances be eaten away; in the two incisors here figured this has taken place, the gum having at the same time receded. In the right-hand figure an island of enamel

has been thus removed from the lingual surface of the crown.

Sometimes the enamel is attacked at several points on the labial surfaces of the crown of the front teeth. In a patient lately under my care, the enamel had been removed in irregular-shaped patches from the upper incisors and canines,

Fig. 214. (1)

Fig. 215. (2)



and to a less extent from the bicuspids. The subjacent dentine, which had been but little eroded, was perfectly hard and polished, but the edges of the enamel, which were sharp and angular, were partially disintegrated, chalky-looking, and crumbly. The patient had been confined to her room, and for the greater part of the time to her bed, by a severe attack of rheumatic fever and its sequelæ, for upwards of nine months; and during this time she had taken much medicine, and had been incapable of giving any attention to her teeth.

Occasionally this disappearance of the enamel, &c., may be traced to peculiarities of diet, such as sucking lemons, and in one case the patient, a hysterical girl, subsisted mainly upon grapes, which she sucked in such a manner as to bring them largely in contact with the labial surface of her front teeth.

In other cases the mucous membrane of the lip is found to be thickened and altered in appearance where it lies upon

(1) Canine, of which the front and sides of the neck are deeply grooved.

(2) Incisors, the backs of which are eroded.

the surface of the teeth, but it has yet to be shown whether this is cause or effect.

A somewhat similar case is figured in Harris's "Dental Surgery" (tenth edition, p. 261); and Dr. Parmly mentions a case in which a natural tooth, set upon an artificial piece, was similarly grooved; this last observation I can confirm, and may add that I observed it in a case where the patient rarely or never resorted to the use of a tooth-brush; a similar observation was recorded by Mr. Harrison in the "Transactions of the Odontological Society," May, 1870.

But a yet more cogent argument for the existence of this "erosion" of the teeth, as distinct from mere mechanical abrasion, is furnished by an observation of Dr. Murie (1), who found that the teeth of a sea-lion (*Otaria jubata*) had been thus wasted. The excellent figure given (*loc. cit.*) is too large for reproduction in these pages, but it is at once evident, on inspection of the drawing, that the circumferential grooving of these teeth cannot be accounted for by friction, as in most instances, and notably in the great canines, the places most affected are situated on the sides of the teeth most protected from wear, and the crowns are merely worn down in the ordinary way.

This condition, at least in this extreme degree, is not common among the seals, but I have seen an approach to it in the teeth of other specimens of Otaria, and in the proboscis seal.

In the museum of the Royal College of Surgeons there is a skeleton of *Otaria stelleri*, in which this form of wasting of the teeth is well exemplified. In it the teeth are much worn down by mastication, but in addition to this, some of them are deeply grooved in positions not at all exposed to ordinary wear. The third left upper incisor is thus deeply notched on its outer and anterior aspect, close to the edge of the gum, whilst other teeth present a similar condition, though less markedly.

(1) Transactions of the Odontological Society, June, 1870.

Mr. Coleman (Trans. Internat. Med. Congress, 1881), discussing these teeth of Otaria, points out that some seals are known to take stones into their mouths, and very probably take more or less sand also: moreover, hard fish-scales are very frequently in their mouths, and their long and very flexible tongues are capable of sweeping all round these eroded teeth. Whilst admitting that it is difficult to account for, and that some uncertainty still rests upon the subject, he does not think that we can fairly rule out mechanical attrition as not being amongst the possible causes in these cases.

Mr. Bland Sutton, in one of his most valuable papers on comparative dental pathology (Trans. Odont. Soc., Jan., 1884, and April, 1885), has touched upon this condition of erosion in seals, and draws attention to the reduced dentition of the elephant seal (*Macrorhinus leoninus*), whose peg-shaped molars present a circumferential grooving perhaps due to erosion, and also to a skull of *Otaria jubata*, the property of Mr. C. Bartlett.

In the latter the skull and jaws are affected with a sort of porous soft hyperostosis like that seen in the skull of rickety animals about puberty. A racoon-like dog (*Nycter-eutes procyonides*), is also quoted as having the characters of mollities ossium, and the teeth as having undergone erosion. Hence he thinks that in face of these instances of erosion occurring with constitutional bone disease, and with comparatively functionless, imperfectly developed teeth, there would seem to be an association between erosion and defective development.

And beyond this, it is easy to suppose that the secretions of the gum overlying the diseased bone might well be altered, and possibly might be such as to soften the teeth round their necks.

An appearance similar to erosion has been met with on the functionless tusks of the female Indian elephant: upon one of these a mass of eggs, apparently of a dipterous insect, were found, and it is stated by sportsmen this is no

uncommon occurrence, and that the larvæ or pupæ are often found in the margin of the gum and attached to the tusk. Mr. Sutton, however, disposes of the idea that these parasites play any part in the erosion, if such we are to term it, for the excavation took place for three inches below the exserted portion of a rudimentary tusk, which was examined *in situ* in an elephant which died in the Zoological Gardens. This, then, is a true case of absorption, and not of erosion, and Mr. Sutton comments upon it thus: "Pathologists have long been aware that morbid changes are more prone to attack undeveloped, functionless or imperfectly acting organs; hence I imagine that the tusks of female elephants are more prone to inflammation than the fully developed representatives in the male."

There is yet another form of wasting of the teeth, which is more rare than those already described. In it, not isolated spots, but the whole exposed portion of the tooth is attacked; as the morbid action goes on, the enamel is slowly removed from the crown, so that the teeth become shorter and thinner, and assume a peculiar yellowish, translucent appearance, the position of the pulp cavity being strongly marked by a difference of colour. In the only case which has come under my own observation, the wasting of the teeth was established beyond all doubt by taking models from time to time. The patient, an anæmic girl, was reduced to a state of great prostration by acute dyspepsia, and was for a considerable time confined to her bed; she was, however, so hysterical that it was exceedingly difficult to rightly estimate her condition. At one time there was great tenderness of the teeth, and general periostitis in the front of the mouth, which, judging by colour alone, appears to have resulted in the death of one of the upper central incisors. The use of alkaline applications seemed to have no effect whatever; but the patient's condition has now greatly improved, and the disease appears to be no longer progressing. It is remarkable that during her prolonged

illness, while the teeth were being rapidly eroded, no caries occurred in the mouth.

A case of wasting of the front teeth, by which a separation of three-eighths of an inch was brought about between the incisors in the course of two years, is related in Harris's "Dental Surgery" (p. 264); and Mr. Bell has given figures of a case in which this wasting, affecting mainly the edges of the teeth, effected a wide separation between the upper and lower central incisors, and attacked also, though in a less degree, the laterals and canines, which could not be brought into contact with one another.

The cause of these various forms of erosion has been from time to time, the subject of great discussion; though some hypotheses, such for instance as that which attributes it to disease inherent in the dentine, may be at once dismissed.

It has already been shown that mechanical abrasion will with difficulty be made to account for all the cases, though Dr. Bonwill has recently pointed out that the elastic flexible hairs of a tooth-brush could make grooves of forms not at first sight readily explicable.

Absorption cannot always be called in to account for the removal of the tooth substance, for it often takes place at spots remote from any structure capable of developing an absorbent organ, and it seems that we must fall back upon the idea that it is an example of chemical solution. But whence the solvent comes, and why the affected surfaces are not the site of ordinary caries, are questions which remain unsolved, though it seems probable that mucus, by fermenting or affording a midus for fermentation, may provide the acid solvent.

Dr. Magitot ([1]) regards the grooving of the necks of the teeth as the result of caries, which has tended to spontaneous

([1]) Recherches sur la Carie des Dents. Paris, 1871, p. 523:—"La cavité offre alors l'aspect singulier qui la fait comparer à un trait de scie transversal à parois lisses, polies, dures et résistantes. Ce sont ces cavités que Duval et divers autres auteurs désignaient sous le nom de

cure by the obliteration of the dentinal tubes; but this view does not differ from that which ascribes it to chemical solution, as Dr. Magitot holds that caries itself is the result of a chemical solvent.

When the cavities produced are of suitable form, the further progress of the malady may be arrested by filling them; and for this purpose gutta-percha is often found exceedingly efficient for a time. But where the surfaces attacked do not admit of protection by a filling, treatment does not yield satisfactory results. The use of soft tooth-brushes should be enjoined, and alkaline dentifrices prescribed, as being the most likely to prevent solvent action on the teeth.

The cavities produced by erosion of the teeth are often excessively sensitive to the touch of an instrument, or to alternations of temperature. This sensitiveness may be cured by applications of nitrate of silver, or, where a black stain would be objectionable, by chloride of zinc.

'caries simulant l'usure,' et dont le mode de production n'était pas expliqué. Elles ont, en effet, toutes les apparences de l'usure véritable, mais nos observations sur la succession des diverses périodes de la maladie nous ont démontré que ces sillons nets et polis ne sont autre chose que des caries du collet passés à l'état de guérison spontanée ou caries sèches."

ODONTALGIA OR NEURALGIA.

When pain is distinctly referred to a tooth or teeth we speak of it as Odontalgia, but when the tooth is free from pain or the suffering in other parts is so great as to distract attention from it we speak of it as Neuralgia.

Although toothache is not in itself a disease, but is rather the symptom of many other diseases, it may be convenient to group together the various causes which may give rise to it; referring the reader, for the more minute description of such causes, to the various parts of the book in which they are to be found.

As a matter of fact, the enumeration of the causes of toothache is little else than a list of each and all the morbid conditions to which the teeth are liable; though, inasmuch as the pain is often the chief thing which has to be cured, it is useful to consider the diseases collectively from this point of view.

Like all other pain, toothache is more or less intermittent; it is seldom that it is perfectly continuous, or if it be, it will vary greatly in intensity at different times. The character of the pain, as well as its severity, is greatly affected by the condition of the patient; a low condition of bodily vigour, whether produced by over-fatigue, prolonged abstinence, or exhaustion of the system by other causes, will tend to produce pain of a diffused, rather than a distinctly localised character, and will markedly increase its severity.

The ordinary causes of toothache may be grouped under the following heads:—

1. Morbid conditions of the tooth-pulp.
2. Morbid conditions of the alveolar periosteum and exostosis.

3. Morbid conditions of the periosteum of the jaws.

4. Irritation of the dental nerves by causes not productive of visible local lesions.

5. Ulcerations and inflammation of the mucous membrane and submucous tissue ;

though, of course, such a classification is merely approximate, and serves only to give some method and arrangement in dealing with the subject.

Under the first head would be included irritation, acute and chronic inflammation of the pulp, pressure from confined matter in the pulp-cavity, and deposit of secondary dentine in its substance. Probably, also, the exposure of sensitive dentine gives pain by setting up irritation of the pulp, as may also caries in its early stages.

Under the second head would come inflammation of the periosteum, acute and chronic alveolar abscess in its various forms, and those lesions which are mainly manifested by alterations of the fangs of the teeth, such as roughening by absorption, or increase by exostosis.

Under the third head, traumatic, rheumatic, strumous or syphilitic periostitis.

Under the fourth, cases of malposition of wisdom teeth, retarded eruption of wisdom teeth, pressure due to insufficient space, &c.

Under the fifth, the severe inflammation consequent upon difficult eruption of wisdom teeth, severe salivation, sloughing from access of arsenious acid to the gum, &c.

Pain that is due to irritation, or to chronic inflammation of the pulp, is rarely continuous, and partakes more or less of a neuralgic character, so that the patient is often quite unable to point out the affected tooth. It is, more often than not, periodic in its access, and is generally absent at the periods of full vigour, as for instance, after dinner or after breakfast. The same may be said of the irritation due to secondary dentine.

The suffering induced by acute inflammation of the pulp is excessive, particularly if it be in a closely-confined space :

it ceases more or less abruptly, from the consequent death of the pulp. When, therefore, a patient states that he has suffered for some few hours from a terribly severe attack of toothache, which has departed as suddenly as it came, the inference is that a pulp has violently inflamed and died; and a careful examination must be made to prevent the occurrence of alveolar abscess, as a consequence of the passage of decomposing matters through the pulp canal.

The pain is almost always of a violently throbbing character, and it is often attended by extreme tenderness of the whole tooth, which appears raised in its socket; whether this is really so, is a matter of doubt, as the almost instant relief given by remedies which can only affect the pulp itself would seem to point rather to a sympathetic hyperæsthesia of the nerves of the periosteum, than to actual inflammatory changes. The recumbent posture or active exercise serves to aggravate the pain by increasing the vascular supply.

An inflamed or irritated pulp is almost always hyperæsthetic when tested by alterations of temperature, so that much reliance is usually placed upon the evidence afforded by the application of heat and cold to the tooth. Heat is best applied by contact with a hot instrument, which should be of some size, and in the event of no immediate response being elicited, it should be re-applied and kept upon the tooth till, upon its removal, the tooth feels quite hot to the finger; cold by contact with a pledget of wool dipped in cold water, or, this failing, a jet of cold water thrown upon it from a syringe.

When relief from pain is obtained by cooling the tooth down below the ordinary temperature of the mouth, and pain returns the moment it gets warm, a violently inflamed pulp with pus formed or about to form at its surface is almost invariably present. But valuable as the test of temperature is, and it is the best we have, it is possible to be somewhat misled, as it sometimes happens that a tooth with an inflamed periosteum will be rendered painful by sudden alterations of temperature, such as that produced by drink-

ing a cup of hot coffee, and there is no doubt that an equable temperature is that which is most comfortable to a slightly inflamed periosteum. But this will be comparatively little affected by heat or cold, applied strictly to the tooth, and so contrived that its effect is not widely extended.

The pain which is dependent on inflammation of the alveolar periosteum is usually not so violent as that last described; it is seldom entirely absent, and is much less influenced by the temporary condition of the patient.

As it proceeds to suppuration it becomes more severe, and in the place of a dull aching, assumes a throbbing character; so soon as the matter has drilled through the bone, the pain is greatly ameliorated, general swelling of the surrounding tissues often being coincident with this amelioration.

The affected tooth or teeth are raised in the socket, and there is a marked tenderness on pressure, or, at all events, on percussion. Slight feverishness, a furred tongue, and headache may be also present.

The diagnosis of exostosis before the extraction of the tooth is very uncertain, and is often, when arrived at at all, the result of a process of exclusion; though sometimes rather forcible manipulation of the suspected tooth will bring on pain in these cases.

For the diagnosis of the various forms of periostitis, the reader must be referred to the chapter on this subject; it need only be mentioned here that rheumatic periostitis may be suspected when the pain is widely spread along the jaw, severe out of all proportion to the local mischief visible to the eye, and capable of being brought on by changes of temperature, exposure to draught, or damp weather.

With regard to malposition of wisdom teeth, it may be noted that the mere fact of the tooth being in an abnormal position will sometimes cause severe pain, without giving rise to any signs of local inflammation; and the mere slow eruption of these teeth will not rarely cause great suffering, even where there appears to be ample room for them to take their place.

Why such teeth should be productive of so great suffering is not very readily explicable, but it is very possible that by the gradual elongation of their roots, as these are formed, they press upon and displace the nerves going to the other teeth.

Pain which is really due to the wisdom teeth is very often referred to a spot much farther forward in the mouth, and the patient will often point to a bicuspid tooth as the seat of his sufferings.

A source of great pain, which often escapes detection for

FIG. 216. (1)

a lengthened period, is exposure of the pulp of the second molar, by the pressure of a wisdom tooth impinging upon it below the level of the gum. The accompanying illustration, borrowed from a paper by Mr. Cattlin, will serve to exemplify this state of things.

The treatment of toothache is, obviously, when possible, to remedy the cause.

Acute inflammation of the nerve frequently does not come into the hands of the dental surgeon for treatment, as it has often eventuated in the death of the nerve before the patient has the opportunity of seeking relief.

In chronic inflammation, the application of chloroform, carbolic acid, creosote, or thymol to the exposed spot usually gives relief, but in most cases the tooth cannot be saved

(1) Wisdom tooth lying below the level of the gum, which has impinged upon the fangs of the second molar, and, by causing absorption, has laid open its pulp-cavity. From the Odontological Society's Transactions.

without destruction of the nerve; so that it is best to apply arsenious acid at once. Curiously enough, this application to a nerve which is already painful seldom increases the pain; in fact, it often gives relief, even before the nerve is thoroughly destroyed; and this it probably does by speedily cauterising the limited spot which is the seat of inflammation.

When irritation of the pulp seems dependent on exposure of sensitive dentine, a few applications of nitrate of silver to the surface will usually effect a cure.

Toothache which is due to alveolar periostitis may be relieved by free lancing, and the application of hot fomentations; though in some cases cold gives more relief. The application of stimulants to the gum over the roots is sometimes useful, especially in the case of single-rooted teeth: tincture of capsicum or tincture of iodine may be used for this purpose, and repeated applications of tincture of aconite occasionally prove serviceable.

But the extraction of the tooth will very often become necessary, especially when the roots have been previously filled with some material not readily removable.

Pain caused by difficult eruption of wisdom teeth will seldom be cured by any other measure than the extraction of the tooth; but relief may be temporarily given by free incisions, cutting away, if possible, the tough overlying gum; and the excessive tenderness of the ulcerated surfaces may be very greatly relieved by very lightly touching them with nitric acid, and afterwards using repeated applications of phénol sodique.

Pain resulting from a diseased condition of a part, is by no means invariably referred to the spot whence it really originates, but is felt in some distinct and often remote place. A familiar example of this is afforded by the pain resulting from hip-joint disease, which is referred to the knee, or that from various hepatic disorders referred to the right shoulder. In many cases it is possible to in some measure account for this change of locality by the known

distribution of the sensory nerves, but in others it is quite impossible.

From a pathological point of view, the disease neuralgia probably has no existence: it is but a symptom indicative of a lesion at some point, which may be discoverable, or may be hidden from our view; and it is not indicative of any one particular lesion, but of a great variety of morbid conditions. Nor, from a pathological point of view, are we justified in separating odontalgia and neuralgia from one another, seeing that the two arise oftentimes from precisely the same cause.

In neuralgia pain is the prominent, indeed, often the only symptom; but it must be recollected that, after all, it is only a symptom, and not a disease *per se*. On this point Trousseau (1) says, "Whether the neuralgia be due to chlorosis or to a carious tooth, it is still a symptom, in the first case, of chlorotic cachexia; in the second, of the caries of a tooth. As we shall see presently, there is a great difference between these two forms of neuralgia, as regards their obstinacy and their degree of curability, but not as regards *pain*. All neuralgias, regarded as painful affections, resemble one another—with the exception, however, of that neuralgia which I have called epileptiform. It is certainly true that the cause of the neuralgia most frequently possesses a manifest influence on the recurrence, the duration, and the period of invasion of the paroxysms of pain, as well as on the seat of the pain; but the pain itself exhibits very nearly identical characters."

To take a recent definition of neuralgia, it may be described as, "a disease of the nervous system, manifesting itself by pains which, in the great majority of cases, are unilateral, and which appear to follow accurately the course of particular nerves, and ramify, sometimes into a few, sometimes into all the terminal branches of those nerves. These

(1) Trousseau, "Clinical Medicine," vol. i. "On Neuralgia." New Sydenham Society's Translation.

pains are usually sudden in their onset, and of a darting, stabbing, boring, or burning character; they are at first unattended with any local change, or any general febrile excitement. They are always markedly intermittent—at any rate, at first; the intermissions are sometimes regular, and sometimes irregular; the attacks commonly go on increasing in severity on each successive occasion. The intermissions are distinguished by complete, or almost complete, freedom from suffering, and in recent cases the patient appears to be quite well at these times; except that for some short time after the attack, the parts through which the painful nerves ramify remain sore and tender to the touch. In old-standing cases, however, persistent tenderness, and other signs of local mischief, are apt to be developed in the tissues around the peripheral twigs. Severe neuralgias are usually complicated with secondary affections of other nerves which are intimately connected with those that are the original seat of pain; and in this way congestion of blood-vessels, hypersecretion, or arrested secretion from glands, inflammation and ulceration of tissues, &c., are sometimes brought about." (1)

To this Trousseau (*loc. cit.*) would add that there is invariably—or, at all events, so constantly that the character is available for diagnosis—tenderness over some of the spinous processes; in the case of the fifth nerve over the first two cervical vertebræ; though this statement is challenged by Dr. Anstie (*op. cit.*, p. 10), who says that these tender points "are not *characteristic* of neuralgia" (the italics being his), and that they may be present in a variety of other affections. Trousseau goes on to say, "I will give another illustration: in toothache, arising from the presence of a false tooth with a pivot, the spinous processes are not tender on pressure, however acute the pain may be; but if this pain, which is at first limited to the locality of the tooth—in the lower jaw, for instance—extends to the inferior

(1) "Neuralgia and its Counterfeits." F. E. Anstie, M.D.

maxillary division of the fifth, then to the superior maxillary branch, and lastly to the ophthalmic, the spinous processes then become tender on pressure, and the case is one of neuralgia."

My own experience does not enable me to speak very positively as to the constancy, or the contrary, of this tenderness over the first two cervical vertebræ in cases of neuralgia distinctly dependent on the teeth, though I have more than once met with it.

It is a character of neuralgia, proceeding from any cause, to particularly affect certain spots, which were first pointed out under the name of "foci" of pain by Valleix. In the case of the fifth nerve these are rather numerous; namely, one at the supra-orbital notch, one in the upper eyelid, one at the emergence of the nasal branch at the junction of the nasal bone and cartilage, one within the eye, and one at the inner angle of the orbit; these all belong to the ophthalmic division of the nerve, which is perhaps the one least often affected in dental neuralgia. In the superior maxillary division the following are the usual foci: infra-orbital, where the nerve emerges from its bony canal; the malar, on the front surface of the malar bone; the palatine, where the anterior palatine nerve emerges; and, lastly, the whole alveolar border.

In the inferior maxillary division of the fifth nerve we have the temporal, a point a little in front of the ear on the course of the auriculo-temporal nerve; the inferior dental, the lingual and the labial, which are more rarely seats of pain.

But the focus most commonly affected in neuralgia, due to any cause, is a point where a number of nerves inosculate, near to the parietal eminence which is known as the parietal focus. A case in which this last focus was affected has lately been under my care: the cause of the neuralgia was irritation of an exposed pulp in a second upper molar, which however was so far protected by the position of the cavity that it was rarely touched in mastication. When, in the course

of examining the tooth, the exposed nerve was touched, a paroxysm of intense pain in the parietal focus was instantly felt, for the relief of which the patient, applying both his thumbs to the spot, made pressure with his whole strength. Pressure was the only thing that gave any relief; and, according to the patient's own account, it prevented the spread of the pain from this limited spot over the whole side of his head, which was otherwise apt to occur as the paroxysm was passing off. No pain was felt in the tooth, save just at the moment when the instrument touched the pulp.

Besides manifestations of pain at various foci, congestion of neighbouring parts and hypersecretion are met with from time to time: thus I have lately seen a patient in whom, by touching an exposed nerve in a first upper molar tooth, I could at will produce injection of the conjunctiva, a profuse flow of tears, and an outpouring of saliva. With reference to the latter effect, the patient's spontaneous statement was that he had applied to another practitioner for relief from the pain he was suffering, and this gentleman had put something into his tooth which had aggravated the pain and had salivated him.

Sometimes the pain felt is referred to a perfectly innocent tooth, often the corresponding tooth in the other jaw; this perverted sensation is occasionally so definite, that it is a matter of difficulty to persuade the patient that the source of his troubles is not where he feels the pain. Thus a gentleman lately requested me to extract a perfectly sound second upper molar, the tooth affected being the corresponding lower molar, of which the pulp was exposed. Nitrous oxide was administered to him, and the lower tooth extracted; but, so soon as he recovered, he exclaimed, "You have taken out the upper tooth after all;" nor could he be persuaded, until he had felt the vacant space with his fingers, that such was not the case, thus affording a striking evidence of the correctness of the inference that the lower tooth had been the real cause of the pain.

Although in most cases of dental neuralgia, pain is con-

fined to the various branches of the fifth nerve, in any of which it is common, it may extend to the side of the neck, to the shoulder, and even the arm of the affected side, which may be subject to a sense of lassitude and weariness almost amounting to slight paralysis (Salter).

There is good reason for supposing that transient amaurotic symptoms are sometimes produced by the irritation of diseased teeth; in fact, it is probable that any or all of those curious secondary affections noted in cases of neuralgia of the fifth nerve, may occur when it is produced by the irritation of diseased teeth, as well as when it is the result of occult causes.

A remarkable form of neuralgia has been described by the late Dr. Gross, Professor of Surgery at Philadelphia, as occurring in edentulous jaws, or in spaces from whence teeth have been removed.

In these cases the pain is generally distinctly localised, its seat being the wasted alveoli and the gum which overlies them. It occurs exclusively in elderly persons, and comes on gradually, proceeding, however, from bad to worse, until the patient's health is worn out by constant suffering. Like other forms of neuralgia, it is most severe at periods of depression, and is often temporarily relieved by the administration of quinine.

The explanation of the pathology of the affection offered by Professor Gross is, that the minute nerves distributed through the wasted alveolar border have undergone compression from the deposition of osseous matter in the canals; and some support is lent to this view by the fact that the bone was found to have a dense, ivory-like consistence, when cut down upon at the affected spots, and the overlying gum was dense and unusually adherent.

In each case recorded, Professor Gross, after the failure of other remedies, resorted to the excision of the affected portion of alveolus, which in most cases effected a permanent cure, and in all produced great alleviation of the symptoms.

There is a form of neuralgia, named by Trousseau, *epi-*

leptiform neuralgia, which, so far as I know, has never been traced to the irritation set up by diseased teeth (1). In it the pain is frightfully intense, exceedingly sudden in its access, and brief in its duration, passing off as suddenly as it came. In a large number of cases the attack is accompanied by severe convulsion of the facial muscles, causing the patient to make frightful grimaces. This form of the disease is met with during the decline of life, and is quite incurable, though periods of temporary relief may occur. It is not uncommon for the movements of the jaw in mastication to bring on the attacks, so that nutrition is seriously interfered with; and as the disease progresses, the neuralgic foci before described become exquisitely tender. Trousseau remarks on points of similarity between this disease and epilepsy, more particularly "petit mal," and convulsions limited to a single limb; and again on a resemblance between it and angina pectoris; while Dr. Anstie states that it is sometimes associated with a strong family taint of insanity, and often with melancholia in the individual.

The periodicity of neuralgic attacks has been already alluded to: Dr. Cayley (2) divides facial neuralgia into two classes—the periodic and irregular. Of the former he mentions that the attacks are usually daily—when the disease is due to malaria they are prone to come on in the morning, and when due to other causes, in the evening. It may be here mentioned that the attacks, when it is dependent on diseased teeth, almost always come on in the evening.

As Trousseau ("Clin. Med.") points out, diseases of the nervous system, such as epilepsy, catalepsy, certain kinds of chorea, and many other convulsive affections, frequently assume not only an intermittent, but a periodic type; and

(1) As a caution to the dental surgeon, it may be mentioned that Trousseau records a case in which the paroxysms were brought on by speaking, eating, or drinking, or *by touching with the tip of his finger his few remaining teeth.* These teeth were extracted without affording the least relief.

(2) "Archives of Dentistry," vol. i.

there seems to be some little connection between these various neuroses—in so far, at all events, as the tendency to inheritance goes—for it will often be found that different members of the same family will suffer from various forms of nervous disorders.

It is very generally supposed that no morbid changes in the nerve can be recognised in the majority of cases of neuralgia; this may perhaps be due to the imperfection of our methods of investigation, but in some few cases distinct lesions have been made out. Thus Wedl ("Pathologie der Zähne," p. 345), in examining several nerves which had been resected by Schuh, found that the neurilemma, the medulla, aud the axis cylinder were alike occupied by granular deposits in patches; and in one case he distinctly made out that the axis cylinder was in a measure obliterated by strongly refractive calcareous masses.

Pigmentation and increased vascularity of the neurilemma were likewise observed in some few cases. Hence Professor Wedl concludes that in inveterate cases of neuralgia, neuritis, and consequent degeneration of the nerve structure, are apt to ensue: but he regards this as distinctly secondary, and as resulting from peripheral irritation.

Central lesions have also been observed in some few cases; thus Schuh ("Gesichtsneuralgien," § 19) records a case of severe neuralgia, in which calcareous deposits existed in *both* gasserian ganglia: on the affected side there was enlargement of the ganglion from increased vascularity and exudation. In other cases lesions at the point of origin of the nerve have been detected. Still, in the majority of cases, the most minute examination reveals nothing whatever, and the rapidity with which a perfect cure may be effected in some instances is a strong reason for regarding the derangement as more frequently functional than structural.

But the various authorities are not by any means agreed on the subject of the pathology of neuralgia; thus Trousseau says in cases "in which a local pain gives rise to a neuralgia, the spinal cord is influenced, and then, through reflex

action, excites neuralgia, in which it appears to be always involved."

Dr. Anstie (*op. cit.*, p. 110) regards the posterior roots of the spinal nerves as the real seat of neuralgia, and holds that the essential condition is *atrophy, which is usually non-inflammatory in its origin.* But the instantaneous cure of a neuralgia which we not uncommonly meet with after the extraction of a tooth, or even after the destruction of the nerve by arsenious acid, appears to me to clearly indicate that all the phenomena are possible without central degenerative change; or, at all events, that the central change is not enough to produce the neuralgia after the cessation of the peripheral irritation.

Amongst the causes of neuralgia the following may be enumerated: chronic inflammation of the pulp; difficult eruption of wisdom teeth; secondary dentine in the pulp-cavity; decomposition of a dead pulp in a confined space; exostosis; alveolar periostitis, which may depend on the escape of decomposing matter through the pulp canal, or on roughening of the fang by absorption; exposure of sensitive dentine (rarely); and, in fact, almost every diseased condition which affects the teeth. Besides these, facial neuralgia may be due to periostitis in any of the bony canals through which the nerve trunks pass, or to osteophytes diverting them from their course. Inflammation of the mucous membrane, or the periosteum of the antrum, may involve the superior dental nerves which pass along the antrum in open grooves, and not in bony canals, and so give rise to neuralgia.

With reference to the influence of the teeth, the late Dr. Anstie says, "It is an undoubted fact that they may cause neuralgia even of a very serious type, and attended with extensive complications; as in Mr. Salter's cases, already mentioned, of reflex cervico-brachial neuralgia from carious teeth. Looking to the extreme frequency of caries, however, as compared with the rarity of true *neuralgia* (not mere *toothache*), as a consequence of it, it is impossible not

to suppose that the share of the carious teeth in the production of such neuralgia must be very small, compared with that of other influences." Whilst every one must admit the rarity of neuralgia as compared with dental caries, I think that few dental surgeons would endorse the concluding passage of the sentence.

But an explanation of such being the opinion of one who has had such extensive experience as the late Dr. Anstie, is not, I think, difficult to find; and it rests in this, that the most typical cases of neuralgia produced by teeth, are just those in which—partly from the absence of all local pain, and partly from the prevalence of a mistaken notion on the subject—the teeth are never suspected. Thus, Dr. Anstie says that the pain in these cases (*op. cit.*) is far less affected by variations in bodily health, and far less amenable to relief from remedies, than in other forms of the disease; and Trousseau, apparently, holds the same opinion. Now, although this is perfectly true where there is any considerable amount of local inflammatory action, it most certainly does not hold good of the commonest cause of all in dental neuralgia, namely, a very limited chronic inflammation of the tooth pulp, which will be more minutely described hereafter. Patients suffering from this are eminently susceptible to various causes tending to depress their bodily vigour; thus a too prolonged abstinence from food, over-fatigue, exposure to cold, &c., will bring on or greatly aggravate the paroxysms; and, on the other hand, they are eminently susceptible to the action of remedies such as quinine. A full dose of quinine will almost always give relief in these cases; and if taken nightly, an hour or two before the time of recurrence, will often avert the paroxysm.

With the exception that diseases of the teeth very rarely set up neuralgia of the most extreme severity, I do not know of any character by which the malady thus set up differs from that due to more recondite causes; and nothing save a most minute examination of the teeth will enable the

practitioner to form a correct diagnosis. There is no more fertile source of error than to suppose that amelioration, or even temporary cure, indicates that the cause is not a tooth. In fact, it often happens that the question whether a tooth shall give rise to slight local pain, which may even be altogether absent, or to neuralgia, is determined by the condition of the patient at the moment. The conditions which seem most often to predispose to neuralgia are the exhaustion of overwork: women are also specially subject to neuralgia, as opposed to toothache, in the early months of pregnancy.

In such cases, the administration of a full dose of quinine, or a few extra glasses of wine, will almost always effect a temporary cure.

But the preceding observations apply mainly to the neuralgia which is set up by chronic local inflammations of the tooth pulp—conditions which are not necessarily productive of pain at all; with regard to those cases in which more extensive inflammatory mischief exists—as, for instance, round unhealthy stumps—the remarks of Dr. Anstie and of Trousseau, as to their obstinacy under general treatment, hold good.

Seeing, then, that there is no character by which neuralgia dependent on the teeth can be distinguished from the other forms of the disease, it becomes necessary to examine somewhat minutely the various morbid conditions of the teeth which are capable of setting it up.

Although these disorders of the teeth have been described elsewhere in this work, there are some few points in connection with them which call for further mention here. By far the most common cause is chronic inflammation of the pulp; and with regard to exposure of the pulp, it may be remarked that violent local toothache and well-marked neuralgia do not commonly co-exist; the local pain and the diffused pains seeming to stand, in a measure, in a complementary relation to one another. An examination of teeth which have set up neuralgia serves to account for this fact, for the pulp is

generally found to be healthy save at one spot, where there will be a limited patch of chronic inflammation, superficial and of small extent. These local inflammations of the tooth-pulp, which are to be found where the situation of the cavity is such that the exposed nerve is but little subject to irritation from the chance contact of food, &c., by no means always give rise to local toothache, even though they be capable of causing excessive neuralgia.

So long as the exposed nerve escapes acute inflammatory attacks, no pain may be felt in the tooth ; the patient finds that he gets relief from the use of a generous diet, from change of air and the administration of tonics, and hence wrongly concludes that there is no discoverable local lesion. At the risk of recapitulation, let me once more insist that perfect freedom from local odontalgia, periodicity in the paroxysms of pain, amelioration, and even absolute temporary cure of the symptom under the use of quinine and the like remedies, must not be taken as indications that the disease has no local cause, and that this local cause is not likely to be a tooth.

When an exposed nerve has been the cause of such pain, it very commonly happens that a paroxysm may be brought on by the touch of an instrument, though this is not invariably the case, and it may sometimes happen that, from the partial obliteration of the pulp-cavity by calcification, it is very difficult, or even impossible, to reach the remnant of the nerve. And although a nerve which has become in great part obliterated by progressive calcification does not often give rise to pain having a diffused character, still instances of its doing so are now and then met with. A patient lately presented himself for examination, who had suffered from pain extending over the whole side of the face and head for upwards of a month, to such an extent that he had not obtained a single night's rest without the administration of sedatives ; he had not the smallest abnormal sensation in any of his teeth, and he only came to me at the very urgent request of his medical attendant, being himself convinced

that the teeth had no share in producing his ailment. The only tooth which presented any sign of decay was a bicuspid which stood alone in the mouth; the carious cavity was fully visible on its mesial surface, but had become hard and polished by the effect of mastication, so that caries was not progressing in the tooth. No pulp-cavity was apparently left, the space which it had occupied being filled up with secondary dentine, and being perfectly insensible to the touch of an instrument, or a jet of ice-cold water.

Nevertheless, as no other cause could be found, and as pressing an instrument firmly over the situation of the pulp-cavity caused an uneasy feeling, I suspected this tooth, and accordingiy drilled in the direction of the pulp-canal; and having opened it up, passed in a very fine nerve-extracting instrument. This did not at the time cause more than a momentary sensation, but after the lapse of several minutes a most acute paroxysm of neuralgia came on. Seeing that, from the flattened form of a bicuspid, there was little chance of extirpating the remains of the nerve with an instrument, a very small quantity of arsenious acid was passed up the fang and allowed to remain there. From that time the patient had no recurrence of pain, and after a few weeks the tooth was filled; a matter of some importance to him, as it served to support some artificial teeth. It may be thought that in this instance the neuralgia was due, not to the exposure of the pulp, but to the presence of osteo-dentine in the canal: this may have been the true cause; but, as a general rule, the pain due to osteo-dentine is of gradual development, whereas in this instance the pain began in nearly its full intensity; moreover, it is usual for pain due to partial calcification to be more distinctly localised, so that the patient is enabled to point out the affected tooth.

The occurrence of pain during the eruption of the wisdom teeth has already been alluded to, and the explanation that it may in some instances be due to the gradual elongation of the fangs of the wisdom tooth pressing upon, and diverting from their course, the nerve trunks, has been mentioned.

The following case, which is only explicable on some such assumption, will serve to illustrate the neuralgias dependent on eruption of wisdom teeth.

A gentleman, æt. 28, had suffered for about six months from agonising neuralgic pain in the left eye-ball. The attacks were strictly periodic, occurring about seven in the evening, and again about three o'clock in the morning, the latter attacks being the most severe. His health had suffered greatly from the long-continued pain and deprivation of rest, and he had ceased to gain much relief from tonics. On the left side all the teeth were perfect; but the upper wisdom tooth, instead of occupying its proper position, where there was plenty of room for it, lay horizontally, with its crown directed outwards towards the cheek. As it was a source of irritation to the cheek, it was removed, though without much expectation of its relieving the neuralgia. However, the patient never from that moment had another attack; and on examining his mouth some nine months afterwards, to my great surprise, I found that another tooth had come down, and was partly erupted in the normal position for the wisdom tooth. That the extracted tooth lay in close relation with this second wisdom tooth, is indicated by its fangs bending nearly at a right angle close to their ends.

A case of neuralgia dependent on exposure of a nerve in the second molar, brought about by the pressure of a wisdom tooth, has already been mentioned in the section relating to toothache.

Various alterations in the fangs of teeth may give rise to neuralgia: Figs. 217 and 218 represent teeth which were extracted on account of neuralgia, and were brought before the notice of the Odontological Society (by the kindness of the Council of which they are reproduced here) by Mr. Cattlin (1). In the one case there is a nodular exostosis (Fig. 217); and in the other (Fig. 218), the end of the fang has been partially absorbed, and left roughened and

(1) Transactions of the Odontological Society, vol. iii.

irregular. In the same paper is recorded a case dependent on the fang of a canine tooth being prolonged to a fine point, almost as sharp as a needle : in this instance the source of irritation was detected by making the patient bite upon a hard substance with each tooth in succession (Fig. 219).

A fang which is a source of great irritation may become covered over with healthy gum, and so effectually concealed

Fig. 217.

Fig. 218.

Fig. 219.

that its presence can only be detected by the use of a sharp steel probe. If such an instrument be pressed firmly through an edentulous gum, so as to reach the bone, it will readily enter it, and be slightly held by it, so that there is some sense of resistance in withdrawing it ; but if it come upon the hard surface of a tooth-fang, it will not enter it at all. This affords a ready means of detecting a buried tooth-fang ; as, if the surface of the fang be softened to such an extent as to be penetrable by an instrument, it rarely becomes completely buried and covered by healthy gum. I have lately seen an instance of occasional slight neuralgia kept up by a very small fragment of the end of the palatal fang of an upper molar, broken off in extraction some six or seven years previously. Occasionally a minute pustule would form on the gum over it, which leads down into a narrow track only large enough to admit a fine nerve-canal instrument, but nothing hard could be felt at the end of the track. However, as the patient recollected the extreme end of the palatal fang having been broken off, I enlarged the track by passing into it silk threads, carrying a paste made of potassa

cum calce moistened with glycerine. By the use of this agent such a purpose can be effected, in successive applications, with surprisingly little irritation to the surrounding parts, and no pain worth consideration. In this particular instance the tooth-fang descended towards the surface when room had been made for it to do so, and was easily picked out by fine forceps.

The fragment was found to have undergone partial absorption, and was much in the same condition as the tooth represented in Fig. 218.

In those cases of neuralgia in which the cause of the pain is not tolerably apparent after a careful examination of the teeth, the situation of the pain will often throw some light on the matter; though it must be recollected that irritation applied at any part of the fifth nerve may give rise to pain at any other.

With this reservation, the following situations of pain may be taken as indicative of the points of lesion. When the pain is most severe in the parietal region, or at the upper part of the temple, the affected tooth is generally in the upper jaw, and far back in the mouth. When it is referred to the eye, which is rather rare, the tooth may be found in any part of the upper jaw.

Pain referred to the ear, or the region of the temporo-maxillary articulation, is almost diagnostic of a lesion in the lower teeth, generally towards the back of the mouth.

The sacrifice of the tooth is not always necessary in cases of facial neuralgia: for example, when it is due to chronic inflammation of the pulp, it may almost always be cured by the destruction of the pulp by arsenious acid; but when it is due to affections of the alveolar periosteum, or difficult eruption of wisdom teeth, &c., the teeth should be promptly removed. And, indeed, when it is the wisdom tooth which is the source of trouble, it should almost always be sacrificed.

Wherever there is distinct reason for connecting one or more teeth with the origin of the pain, no dental surgeon

will hesitate for one moment at removing the teeth, unless he sees his way clearly to curing the morbid condition without sacrificing the tooth.

There are, however, many cases of neuralgia, really dependent on the teeth, in which it is almost impossible to be certain of this before their removal. For instance, there may be many stumps in the mouth, any one, or all of which are perfectly capable of setting up the irritation, but there may be no symptoms to identify any particular one with the disease. Where there is the least sign of inflammation about the stumps, I should not hesitate to advise the removal of every one; and even where there is not, in a confirmed case of neuralgia, useless stumps, which may perhaps be exostosed, are far better away.

With reference to the extraction of teeth in neuralgia, some difference of opinion appears to exist. Thus Dr. Anstie says, "I admit also, though with much greater qualification, that carious teeth may need to be extracted before we can cure a neuralgia; but even here I should put in the decided *caveat* that we must consider whether the system is in a state to bear the shock; and that, in any case we probably ought to mitigate the effects of the operation by performing it under chloroform. And I need hardly tell any one who is familiar, either practically or from reading, with the subject, that thousands of carious teeth have been extracted from the mouths of neuralgic patients, not only without benefit, but with the effect of distinctly aggravating the disease."

It is possible that in some of the cases where distinct aggravation of the pain has followed the removal of the teeth, the patient may have been suffering from so-called epileptiform neuralgia, or under that form of neuralgia described by Professor Gross as effecting edentulous jaws; but it must not be forgotten that a large number of neuralgic patients are nervous, more or less hysterical, women; and every one at all familiar with either hospital or private practice, will know only too well the strong tendency to ascribe to an operation which has brought no relief, not

only the aggravation, but even the original causation of the condition which it was intended to remedy. So that the patient's own statements on the matter of the disease being aggravated by a dental or other operation, must, in the absence of corroborative evidence by which the medical man can form his own opinion, be accepted with great reserve.

Schuh (1) considers that it is possible, though unusual, for neuralgia to be induced by the extraction of teeth; and Wedl, seeking to account for it, does so on the assumption that the pathological changes which have been observed in some few cases are the real sources of neuralgia. He points out that in caries, inflammation of the tooth-pulp leads to degeneration of whole bundles of the nerve-fibres, whereas in the neuritis of neuralgia only a few nerve-tubes are thus affected; and that in this difference between the two conditions, a real distinction is implied.

But, in the first place, neuralgia is more often produced by a local than by a general inflammation of the tooth-pulp; so that it is likely that, even in the tooth itself, only a few nerve-fibres would be involved: again, if the injury inflicted on the nerves in the jaw so readily effect their degeneration, how is it that neuralgia after tooth-extraction is not an every-day occurrence?

But a yet more formidable objection to this explanation of the difference between toothache and neuralgia, is to be found in the fact that the two are interchangeable: what is toothache one day, may be, owing to a change in the patient's condition, neuralgia on the next, and so continue to change about from time to time, as the bodily health of the patient varies; though this only happens with mild cases of neuralgia.

Wedl also (*loc. cit.*) suggests that the occurrence of neuralgia after tooth-extraction may be due to the two ends of the nerve becoming enlarged and painful, as often happens

(1) Wedl. "Pathology of the Teeth" (Trans. by Dr. Hitchcock, 1872), p. 432.

in amputation stumps; and that this, through some peculiar diathesis, may take place successively in the case of all the teeth which have been extracted. To meet this suppositious condition, Döbbelin has proposed and put into practice a course of procedure which, to me at least, sounds very strange: he drills into the pulp of all the molar and bicuspid teeth alike, whether they be carious or perfectly sound, and destroys the nerves. By this procedure he claims to have effected a perfect cure of a case, for the relief of which a portion of the infra-orbital nerve had been previously removed without any benefit.

Nevertheless, I am not inclined to fully endorse the great caution with which Dr. Anstie speaks of the extraction of teeth—the less so as I think he somewhat underrates the influence of teeth in producing neuralgía. Whenever teeth can be found, on the same side as the neuralgia, which are obviously in one of the conditions which have been described as likely to set it up, the dental surgeon should, in my opinion, have not a moment's hesitation in extracting them. His course becomes rather less plain when there are only carious teeth, with no exposure, or near approximation to exposure of the nerve, or where there are numerous apparently healthy stumps.

Still, where no other cause is apparent, I would advise the removal of everything which can possibly act as an irritant; for the chances of our effecting a cure are so infinitely greater than the probability or possibility of doing mischief, as to outweigh the latter altogether; and I think that every one who will take the trouble to search out and carefully read all the well-recorded cases, will come to the same conclusion.

It sometimes happens that the pain of extraction will be entirely referred to the seat of the neuralgia, and not felt at all at the place itself.

The removal of the exciting cause is often followed by a severe paroxysm of pain, which I have sometimes been able to relieve by sponging out the socket with phénol sodique;

and these paroxysms may recur from time to time, with lessening intensity, for some days, so that it is advisable to warn the patient not to expect an immediate cure.

It has already been mentioned that the paroxysms have a tendency to periodicity, often recurring with great regularity: the coming attack may often, and indeed generally, be warded off by a full dose of quinine. But when quinine is given with this object, it must be given in large doses—from five to eight grains for an adult; small doses, frequently repeated, are often perfectly ineffective in a patient who is at once relieved by a full dose. The large dose is better tolerated if a saline purgative be given some two or three hours before taking the quinine, which should itself be administered about an hour and a half before the time at which the recurrence of the pain is expected.

In order to arrive at an opinion as to whether a neuralgia has a dental origin, it is best to be methodical in the making of an examination, somewhat after the following manner:—

First search carefully for cavities; failing to find any, sharply tap each of the teeth in succession, and press them forcibly home into their sockets by making the patient bite upon slips of thick visiting card.

Next try them with hot and cold water, in case of doubt isolating any suspected tooth by means of the rubber clam: then thoroughly heat up any large fillings by prolonged contact with a hot instrument of some size.

Enquire into the existence of exostosis upon the roots of teeth previously extracted.

And failing any decided response to the tests applied, remember that it is always possible that you have hit upon the time between the death of a nerve and the supervention of alveolar inflammation.

Dr. Lauder Brunton is disposed to refer a large number of cases of neuralgia, even of a migraine type, to the influence of carious teeth (see "Disorders of Digestion," p. 100), but whilst naturally as a specialist he is inclined to refer many things to the disease of the special organs on which

attention is so much concentrated, I am hardly inclined to go with him to the full length. Thus, in some of his cases the dental lesion was hardly of a kind which we are accustomed to see associated with remote nervous disturbance.

Neuralgias of the migraine type are not likely to be frequently referred to the dental practitioner, as the long periods of remission and the conspicuous headache renders their character tolerably obvious. Yet in persons subject to "sick headache" it is very common to get a neuralgic condition in many branches of the fifth nerve, so that dead teeth or roots may have unusual sensations in them at the outset of an attack, just as vision is apt to be disturbed at this same period.

All dental causes having been eliminated, it remains to briefly mention what else in the way of treatment remains, and here the capricious nature of neuralgias is very strongly shown, as remedies, which the subsequent course of events prove to have failed to reach the source of trouble, are often nevertheless perfectly efficacious for the time. The electric current, constant or intermittent, usually fails to give any relief, but once in a way it will do so: thus, a gentleman who suffered from intense neuralgia of the left inferior dental nerve, brought on oftentimes by the mere movement of the lips in speaking, was advised to have the nerve divided, but meantime, first of all, to try the effects of galvanism. To my great surprise this effected a cure of a neuralgia of several years duration; or at all events cured it for six months, the patient having been subsequently lost sight of.

Where particular branches of the fifth nerve are affected, the operation of nerve stretching, which has come into great vogue within the last few years, may be resorted to.

Trousseau mentions a case of thirty years duration, in which repeated operations (division of nerves) were performed, so that the man became to be well known to all the Parisian surgeons, and his face was scarred all over; he got

relief almost always for a time, but it might be months or only days. Dr. Grainger Stewart relates another in which the pain was so agonising that the patient lost all self control: the paroxysms could be induced by pulling the hair, or touching the gums, tongue, or skin, so that only liquid food could be taken. The infra-orbital nerve was stretched, with the result of giving a month's respite from pain, after which the pain reappeared, transferred however to the region of the mental foramen; the nerve was stretched there, and a perfect cure resulted, the patient having remained under observation for a year.

The general history of these nerve-stretching operations is one of temporary cure, and repeated operations at shorter and shorter intervals, but completely successful cases are not wanting to encourage the surgeon to undertake the operation.

The following case is instructive as illustrating several points common to many cases. The patient, a young man, was incapacitated from steady work by agonising paroxysms of pain in the inferior dental nerve: at times he did not dare speak nor eat for fear of provoking them, and all the teeth had been extracted from the lower jaw on that side. The writer exposed and stretched the nerve as it issues from the mental foramen, through a small incision at the reflection of the mucous membrane from the jaw on to the cheek, but this gave only partial relief, and that only for a few days, and so about half an inch of the nerve was resected. This enabled him to talk and eat and shave without provoking paroxysms, but the pain, which was never quite cured, soon recurred with all its former intensity. The inferior dental nerve was then divided at a point a little behind the site of the wisdom-tooth by the method originated by Dr. Hodgson of St. Louis. This consists in entering the bone with a spear-head drill about $\frac{1}{8}$ inch diameter upon the summit of the alveolar ridge, its point being directed towards the angle of the jaw. The drill, which is worked in the dental engine, can be felt to crush into the cancellous tissue after it cuts through the denser bone of the shell of the jaw, and,

keeping it carefully in the middle line of the jaw, it can be felt to meet with increased resistance and again to crush into the inferior dental canal. This is thoroughly broken up and its contents destroyed by working the drill about a little, and it is then withdrawn; the wound being practically almost subcutaneous, does not give the least trouble, and there is no bleeding to matter: generally there is not a quarter as much as would follow an ordinary extraction.

In this particular case there was absolute cure for six months; then the pain began to return, and the patient expressed himself as ready to shoot himself. Though advised by Sir James Paget, and the writer, that another operation would probably do no good, he begged and entreated that it might at once be done, even for the chance of but a few days' relief. The relief given was very transient, and subsequently he consulted Mr. Durham, who exposed the nerve where about to enter the canal at the inner side of the jaw and stretched it severely. This gave temporary relief, but the patient has been entirely lost sight of both by Mr. Durham and the writer.

It is pretty clear from the sequel that in this case neither the first, the second, nor the third operation could have attained to the site of mischief, yet we gave relief for a greater or less time, and this is a common story in operations undertaken for the relief of neuralgia.

It would almost seem as if violence done to the nerve, even at the wrong place, corrected for the time being its vicious habit, whether by altering its nutrition, or by depriving it of its ordinary functions of transmitting centripetal impressions and so giving it rest; or else by transmitting a severe shock to the centres where it originates.

A patient at the Dental Hospital under the care of Mr. Canton suffered from intense neuralgia in an edentulous alveolar border: it being in the upper jaw, the division of the nerve could not be practised otherwise than by a comparatively severe surgical operation, so at the writer's suggestion Mr. Canton drilled four or five large holes into

the bone at the region which appeared to be the focus of the pain. This simple measure effected, so far as is known, a complete cure: nine months afterwards the patient was perfectly free from neuralgia.

It does not seem likely that the drill, except by the merest chance, reached and removed any definite local trouble, and it seems far more probable that it succeeded in some such way as that suggested above.

Mr. Victor Horsley has recently removed Meckel's ganglion for neuralgia of extreme severity affecting all the branches of the fifth, and up to the present time (six months after the operation) with complete success; and the operation, or a similar one, has been performed with success on a few other occasions. ("Dental Record," 1882.)

SECONDARY AFFECTIONS DUE TO THE IRRITATION OF DISEASED TEETH.

The resemblance, not to say relationship, which appears to exist between the various neuroses, such as epilepsy, chorea, neuralgia, and the like, has been already alluded to, and, having in view the frequent association of neuralgia with all sorts of secondary disorders, it is a question whether these might not have been advantageously considered under the head of neuralgia. Still, it perhaps conduces to greater convenience of reference to group them together, and hence a separate section has been devoted to their consideration (1).

The reflex disturbances productive of a sense of pain have already been mentioned, and, incidentally, their influence on motor and secretory apparatus has been alluded to. Besides this, the nutritive processes may be profoundly modified, as not very uncommonly happens in the eye.

The close connection of the fifth nerve with the sympathetic through the ciliary, otic, spheno-palatine, and submaxillary ganglia, serves to show in some measure the course through which these influences might travel so as to modify nutrition.

It has already been mentioned that in cases of neuralgia, tonic or clonic spasm of the facial muscles, sometimes affecting one or two muscles only, sometimes the whole side of the face, is not very uncommon; these may graduate almost imperceptibly into typical epileptiform seizures.

(1) In writing this section of the book much assistance, which I take this opportunity of acknowledging, has been received from the very complete list of cases drawn up by Professor Wedl ("Pathologie der Zähne," p. 353 *et seq.*); from cases related in the "Lancet" (1859 and 1861) by Mr. Hilton and Mr. Hancock; from an article contributed by Mr. Salter to Guy's Hospital Reports (Third Series, vol. xiii., 1867); and from a paper by Mr. Henry Power (Trans. Odont. Soc., 1883).

Thus, Mr. Coleman ("Brit. Journ. Dental Science," 1863) has reported four cases in which convulsions were relieved by the extraction of carious teeth: the convulsions were slight, and in some instances confined to the face and arm; tingling sensations and a variable degree of paralysis of the arm are also noted. In the same place may be found a reference to a case of Dr. Baly's, in which epilepsy was apparently cured by the removal of a carious tooth.

Epilepsy.—It is remarked by Dr. Brown Séquard, in describing his experiments on epilepsy artificially produced in lower animals, that after various injuries had been inflicted on the spinal cord of guinea-pigs, very slight irritation of the branches of the fifth nerve was sufficient to bring on an epileptiform convulsion, in some instances mere tickling of the skin producing this effect. Bearing in mind also the fact that epilepsy has been in several instances due to the irritation resultant on tumours pressing on nerves, and has been cured by section of the affected nerves, we shall be less surprised to find that in some few cases it has been almost indubitably connected with diseased teeth. The connection between the convulsions arising at the period of the first dentition, and the process of cutting the teeth, is most clearly shown by a great number of cases (*cf.* page 46); and Portal (1) mentions that the extraction of sound teeth at this period had, after all other means had failed, at once arrested the convulsions.

Convulsions arising at the period of second dentition are very rare; cases have, however, I believe, been met with in which epileptiform attacks have accompanied the eruption of the second set of teeth in a child previously healthy, and ceased with the completion of that process (2). But difficult eruption of the wisdom-teeth has, in several instances, been clearly traced to be the exciting cause of epileptiform con-

(1) Portal, "Observations sur l'Epilepsie," p. 333.
(2) Ashburner, on "Dentition;" Dr. West, on "Nervous Disorders of Childhood;" Wedl, "Pathologie der Zähne."

vulsion. In one case, related by Portal (*op. cit.*, p. 206), these convulsions were limited to one side of the face; they were very violent, and were accompanied by extremely severe pain; in this instance the tooth was not removed, but the attacks, which had commenced coincidently with the commencement of the eruption of the tooth, entirely ceased when this was completed.

Portal (*op. cit.*) mentions a second case, in which the convulsions were general; the disease, which was accompanied by severe facial neuralgia, was completely cured by the extraction of the second molar, it having been found impossible to remove the wisdom-tooth itself.

Dr. West (*op. cit.*) relates an instance of convulsions (with temporary delirium after one attack) of frequent repetition, which were clearly traced to difficult eruption of permanent teeth; in this instance, not the least derangement of health was produced, the boy at once resuming his occupation when the spasmodic movement ceased.

Dr. Ramskill ("Med. Times and Gazette," 1862) relates the following case:—

"A boy, æt. 13, has had frequent attacks of epilepsy for the last eighteen months. Latterly his mother has noticed that some days he rubs his left cheek, complaining of face-ache, after which the fit follows. On examining the mouth there is to be seen a molar tooth considerably decayed, with a swollen gum around it, and partly growing into the cavity; it is not very tender to the touch, and the examination does not give rise to toothache. On questioning, I find the sensation which the boy experiences before a fit does not seem to be one of pain, but rather of an indefinite uneasiness. He always has a fit the night this comes on. Has never felt it during the day; it is always about seven or eight o'clock. I desired the mother to have the tooth extracted, and ordered a simple saline with a quarter of a grain of belladonna, to be taken twice daily. This was in June. The tooth was extracted next day. I saw this boy once a fortnight from

that time for four months, but he has had no recurrence of the fit.

"In this case, I believe, an unfelt aura commenced about the gum, surrounding the tooth, and was not recognised till some degree of inflammation arose; thus a modification of pain became associated with the aura, and directed attention to it."

Two cases have occurred under the author's own observation, in which epilepsy was consequent upon diseased teeth, the most prominent feature being exostosis of the roots.

A lad, a farm labourer, from Windsor, was admitted into the Middlesex Hospital for epilepsy. The usual remedies were tried for six weeks without effect. His mouth was then examined, and the molar teeth of the lower jaw found to be much decayed, the fangs of some alone remaining. Although he did not complain of pain in the teeth or in the jaw, the decayed teeth were removed, and the fangs of each were found to be enlarged and bulbous from exostosis. During the eighteen months that succeeded the removal of the diseased teeth, he had not suffered from a single fit, though for many weeks previous to the operation he had two or three per day. This is a case of singular interest, inasmuch as there was no complication of maladies, and hence there could be no doubt as to the cause of the disease, seeing that it immediately subsided after the removal of the teeth; and it is further instructive, as showing that local irritation sufficient to produce grave functional derangement may exist without pain being felt in the seat of mischief.

A similar, though less marked case, occurred shortly afterwards in the person of a policeman; he had fits which were greatly relieved by the removal of a lower wisdom-tooth, the subject of caries and of exostosis.

In looking over the records of such cases, it is noticeable that local pain is not often mentioned, but that the presence

of neuralgic pains is very frequently and pointedly recorded.

The reflex affections of the nervous system may manifest themselves in other ways than by epileptiform seizures.

Thus, Remak (1) has seen a case in which disease affecting the wisdom-tooth gave rise to violent palpitation and cardiac distress; whilst Lederer gives cases of vomiting and cardiac pain, and Dr. Anstie of alarming stoppage of the heart's action, consequent upon the operation of pivoting a tooth.

This last-mentioned operation has even been followed by death from tetanus, as in the following case (2):—

"———, æt. 25, tall and thin, but apparently in very good health. On his marriage trip he visited Paris, and there had the misfortune to break off a front tooth. Wishing to conceal the accident from his wife, he went immediately to a dentist. The tooth was pivoted (and, I have no doubt, carefully, for the dentist was one with a great and just reputation), and the necessary concealment seemed ensured. From the time of the operation, however, he had severe pain in the stump, which pain increased for four or five days, when he left Paris for Rouen. Upon arriving there the pain had become excessively severe; he consulted a medical man, but it was too late: trismus came on within twenty-four hours, and was soon followed by tetanus and death."

A case of tetanus has also been recorded by Döbbelin (3), which came on immediately upon the extraction of a tooth.

Hysterical attacks, delirium, and even temporary insanity (Esquirol) have been traced to the irritation caused by the eruption of the wisdom-teeth; and, although such cases are extremely rare, the authorities by whom they are quoted are such as to preclude the probability of the observers having been deceived.

Dr. Tyler Smith believes that certain cases of sympathetic

(1) Sydenham Society's Year-book, 1868, p. 120.
(2) "Lectures on Dental Surgery and Physiology," by John Tomes, 1848, p. 321.
(3) "Pathologie der Zähne," by Professor Wedl, 1870, p. 353.

pain in the uterus, and even of actual abortion, have been brought about by dental irritation; and that such should be the case is hardly more remarkable than that strangury should be caused in children during first dentition.

Mr. Sercombe ("British Journal of Dental Science," vol. iii., p. 221) has recorded a very interesting case of obstinate leucorrhea, and uterine pain, cured by the extraction of a tooth; touching the tooth with a probe, and its subsequent extraction, brought on most acute paroxysms of uterine pain.

Deafness during attacks of neuralgia has been elsewhere noticed; and limited space precludes the relation of more cases of functional reflex disorders, though many more interesting examples might be collected from the pages of current medical literature.

Affections of the Muscular System.—Various reflex affections of the muscular system are from time to time met with; thus, in the section devoted to the consideration of neuralgia, mention is made of its frequent association with a sense of lassitude, and even paralysis of the arm of the affected side.

In a case of Mr. Salter's (*op. cit.*) there was total inability to raise the arm, or grasp with the hand, which could not be used to hold a fork at dinner, or for dressing; there was continuous pain in the limb. The extraction of a carious impacted wisdom-tooth gave immediate relief. In a second case, likewise accompanied by constant aching pain in the arm as well as in the side of the face, the symptom disappeared within a few hours of the extraction of the wisdom-tooth.

Spasmodic closure of the jaws resulting from the eruption of the wisdom-teeth in an already crowded jaw is, in a slight degree, of very frequent occurrence; and cases where the fixation of the jaws is almost complete are not very uncommon; thus Mr. Hancock relates an instance of severe pain in the ear and closure of the jaws being cured by extraction of the first lower molar.

In one of Mr. Salter's cases, the trismus, of four months' duration, passed away within twenty-four hours of the extraction of the second molar, which was removed in consequence of the impossibility of reaching the wisdom-tooth. The posterior fang of the second molar was much eroded by the pressure of the wisdom-tooth.

The continued application of steady force will generally cause the muscles to yield at least sufficiently to enable an examination of the mouth to be made; and even in the event of considerable inflammation and ulceration having taken place, the difficulty in opening the mouth is still generally in great part due to muscular spasm, and will be found to yield to prolonged traction on the administration of chloroform.

Amongst the most interesting examples of disordered muscular action is one related by Mr. Hancock in the "Lancet" (1); the patient, a young woman, had suffered for upwards of six months from spasmodic wry-neck, and had submitted, without avail, to the usual treatment of counter-irritants and various internal remedies. No evidence of any diseased condition being found, Mr. Hancock advised the removal of a stump and a carious tooth on that side of the mouth, these being the only discoverable sources of irritation; after a few days she was entirely cured of the wry-neck. In this case the teeth had caused no pain to the patient. It is noted by Dr. Anstie, in his recent work, that these peculiar spasmodic affections are not frequently directly associated with trigeminal neuralgia; but that they are met with only in highly neuralgic families.

Dr. Ormond has also placed upon record (2) a case of spasm of the sternomastoid, which was apparently due to the irritation set up by diseased teeth: after their removal the spasms entirely ceased.

An unusual form of spasm, which for want of a more

(1) "Lancet," Jan. 22, 1859. Transac. Odont. Soc., 1869.
(2) Trans. Odont. Soc., 1869.

appropriate place may be introduced here, has been met with by the writer. The patient was suffering from difficult eruption of a wisdom-tooth, with much swelling and ulceration of the adjacent gums; whenever in closure of the mouth the upper wisdom-tooth touched these inflamed tissues, the mouth was violently dragged open. This spasm was of so painful a nature that the patient went about with a cork between his teeth, so as to prevent any contact, and in this way he could obtain sleep which was otherwise impossible. It seems probable that the spasm was rendered the more distressing by the fact that the comparatively weak muscles which open the mouth were violently tugging against the powerful closers of the jaws.

Disordered Nutrition.—The nutritive functions do not always escape participation in the disturbance set up in neuralgia of the fifth nerve, which is probably transmitted through the medium of the ganglia in connection with it; the frequent occurrence of an excessive outpour of saliva, or of tears, has been already noted, but to these may be added some yet more curious manifestations of the disease.

The late Mr. Hilton (1) had several times remarked a tongue furred on one side only, to be dependent on structural or functional disorders of the fifth nerve. In the first case related, the disease was tubercle affecting the gasserian ganglion; in the other, the unilateral furred tongue seemed to depend on the presence of carious *upper* molars, seeing that the peculiarity in each instance disappeared shortly after the extraction of the tooth. Mr. Hilton remarks that these phenomena, of the existence of which he is satisfied, would be more easily explicable if dependent on carious lower teeth, seeing that the tongue derives its nerve supply from the third or inferior maxillary division of the fifth nerve; nevertheless, the varied seats of neuralgic pains show how closely the whole nerve is connected, and how easily irritation is transmitted from one part of its course to another.

(1) Lectures delivered at the Royal College of Surgeons. "Lancet," 1861.

A curious instance of disordered nutrition, due to the same cause, is given in this lecture, in which the hair covering one temple became perfectly white in a patient suffering from dental neuralgia. In the person of the late Dr. Addison, this reflex disturbance of the nutritive function went so far as to cause an offensive purulent discharge from one ear, proceeding from a slight ulceration in the auditory canal.

This condition of things was entirely and speedily remedied by the extraction of a carious lower molar.

Rumbling sounds or neuralgic pains in the ears, may be caused by diseased teeth. Harvey saw an instance of severe pain and offensive discharge from the outer ear proceeding from the presence of a carious wisdom-tooth.

Secondary Affections of the Eye.—A very large number of well-authenticated cases have been recorded, in which not only functional, but organic disease of the eye has been distinctly traced to be due to the presence of diseased teeth.

In the opinion of V. Stellwag, the irritation is transmitted through the ciliary ganglion, and by inducing hyperæmia and hyperæsthesia, may lay the foundation of serious organic mischief.

Mention has already been made of congestion of the conjunctiva caused by irritation of the fifth nerve, and if this irritation be kept up for some time, a condition of chronic inflammation may result.

The most complete account of the relation between dental lesions and diseases of the eye is to be found in a paper by Mr. Power ("Trans. Odont. Soc.," 1883), in which there are many suggestions as to the probable mode of causation; thus it is laid down as well known that injuries affecting the branches of the first division of the fifth pair are prone to affect the eye of the same side, and there are good reasons for believing that affections of other branches of the fifth pair may be the cause of ophthalmic troubles.

After mentioning that wounds of the supra-orbital nerve are occasionally followed by amaurosis, he quotes later on in the paper the experiments of Von Hippel and Grunhagen,

who found that compression of the aorta caused increased intraocular pressure, and if now the fifth nerve were stimulated the pressure was greatly augmented, and well-marked pulsations were observed. Whatever the exact chain of events may be, it is sufficient for our purpose to note that stimulation of the fifth is capable of disturbing the tension of the eyeball. This being proven, it ceases to be wonderful that dental irritation should be able to disturb the eye.

Mr. Hancock gives a case of strabismus of three years', and of ptosis of two weeks' duration, which were found to depend on carious upper molars, and were cured by their removal ; the patient was an adult. And Fox, in his "Dental Surgery," relates a case of excessively severe neuralgia, in which only fluids could be taken because any touch upon the teeth brought on a paroxysm. Profuse salivation and ptosis were present, and the ptosis disappeared after the extraction of a carious upper molar, though the case was not cured till after the extraction of all the remaining teeth, the roots of which were all affected by exostosis.

One of the most common forms of reflex disturbance of the muscles of the eye seems to be a partial paralysis, this condition occurring more frequently than that of spasm.

Thus Mr. Power enumerates paresis of the ciliary muscle bringing about want of accommodation, paresis of the iris causing a dilated and motionless pupil (mydriasis) ; paresis of one or other of the ocular muscles leading to squints, or paresis of the orbicularis, in which case the eye is widely open (lagophthalmos) or of the levator palpebræ (ptosis).

Mr. Sewill ("Trans. Odont. Soc.," 1883), in conjunction with Dr. Ferrier, records a case of neuralgia, local hyperæsthesia, and muscular spasm of the right side of the face. The spasm of the orbicularis was so great that the right eye could only be opened by great effort, and the lens was nearly opaque. Dr. Ferrier was inclined to attribute all these symptoms, even the cataract, to the neglected state of his teeth, and Mr. Sewill found numerous roots much inflamed,

a vulcanite plate which had not been removed for years much encrusted with tartar, and an enormous mass of tartar in the lower jaw.

After extraction of the upper teeth and treatment of the lower, the neuralgia and the muscular spasm disappeared; but there was no improvement in the state of the eye—indeed there hardly could be.

A somewhat unusual form of disturbance has been placed upon record by Mr. Hutchinson ("Trans. Odont. Soc.," 1885). The patient had suffered for some months from spasm of the left eyelid, which was drawn up by constant contraction of the levator palpebræ to such an extent as to expose the white of the eye all round the iris. Four carious molars were extracted, which cured a neuralgia but did not relieve the lagophthalmos.

For a year things remained thus, and then Mr. Hutchinson removed a large amalgam filling, beneath which was found a minute pulp exposure. The tooth was extracted, and the patient's appearance at once began to improve; at the end of six months no casual observer would have noticed any difference between the two eyes. "Thus in this case reflex irritation of the third nerve had been caused by irritation of a branch of the fifth, and this in the absence of any symptoms referable to the tooth."

Mr. Coleman ("Trans. Odont. Soc.," 1875) recorded a case of temporary loss of sight in one eye following upon the pivoting of a tooth. Mr. Lawson, who saw the patient, did not think that it was due to this cause, attributing it to constitutional causes; but the patient herself was exceedingly positive upon the point, having noticed the exact coincidence of the dates, and Mr. Coleman shared her convictions fully.

Somewhat sudden amaurosis has in a good many cases been apparently due to dental irritation, as is illustrated by the following case, now almost classical, related by Professor Galezowski: "F. P——, thirty years of age, possessing a good constitution and enjoying good health,

with the exception of pains in the head and limbs, which never lasted long, suddenly experienced in the autumn of 1825 a violent pain, shooting from the left temple to the eye and the side of the face. He ascribed it to cold. This pain lasted several days, then lessened and re-appeared from time to time, without being sufficiently severe to induce the patient to seek medical aid. In about two months it suddenly increased in intensity,—occupying the eye particularly,—with a feeling as if it would pass out of the orbit. F. P—— now discovered that he was blind with that eye, and applied to a neighbouring physician, whose treatment, although continued for two months, did no good. The pain, however, was no longer continual; it assumed a somewhat periodical character, leaving the patient easy for some hours of the day. At the end of the following six months the pain increased, the cheek swelled, some spoonfuls of bloody matter were discharged by a spontaneous opening in the lower eye-lid, after which the swelling subsided and the pains nearly disappeared, although the blindness remained complete. The discharge was renewed from time to time during the following six months, and there was no great suffering. But in the autumn and winter (1826) the pain, particularly in the eye, became so violent, that F. P—— came to Wilna in the beginning of 1827, determined to have the organ extirpated, if no other remedy could be found. Professor Galezowski found the left eye totally insensible to light, with the pupil dilated, and no other visible alteration. The pain, not then so severe, consisted in violent occasional pricking and darting sensations in the left temple and parts round the eye. There was discharge from the lower eyelid. The first molar tooth of the left side was carious. It had not caused much uneasiness, and the toothache, when it existed, had not coincided with the pains in the temple and eye. The Professor determined on removing the tooth, and having done so, was surprised to see a small foreign body at the extremity of the fang. When drawn out, it proved to be a

small splinter of wood, about three lines in length, which had traversed the centre of the tooth, and had probably been introduced in picking the teeth. A probe was passed from the socket into the antrum, from which a few drops of thin purulent fluid escaped. The pain ceased almost entirely, and on the same evening the eye was sensible to light. Vision gradually improved, so that on the ninth day the patient could see as well with the left eye as with the right, after a blindness of thirteen months. On the eleventh day he left Wilna to return to his family."

Numerous other cases might be quoted, but the following will suffice to give an idea of their general character.

A patient of Mr. Hancock's (*loc. cit.*) became suddenly blind; when examined the pupils were seen to be fixed and dilated: the entire absence of premonitory symptoms and of structural lesions having led to the conclusion that the disease was of reflex origin, the mouth was examined, and great crowding of the teeth discovered. Six teeth were removed, and on the same evening the patient, having been totally blind for upwards of a month, was able to distinguish light from darkness, and in the course of a week was entirely cured; no other treatment, save two doses of aperient medicine, having been resorted to.

A similar condition of functional amaurosis has been known to follow the extraction of a tooth, the effect speedily passing off under the influence of sedative applications to the socket.

In a second case of amaurosis, of eight months' duration, with entire fixity of the pupil, and inability to distinguish light from darkness, a carious second upper molar tooth was found. After the extraction of the tooth, the sight gradually improved, and was entirely restored in a few days.

It is the opinion of Mr. Hancock that a purely functional disorder of the eye may, if allowed to continue unchecked, lead to a permanent structural lesion. Such attacks differ from the advent of true amaurosis in their sudden access, in not having been preceded by dimness of vision, muscæ

volitantes, flashes of light, pain, and the like symptoms; entire absence of local pain in the teeth seems to be the rule, and not the exception; indeed, it often seems as though manifestations of local pain stood, in some measure, in a complementary relation to one another, so frequently is the disappearance in the one place coincident with the access in the other.

Teirlink (1) found that extreme photophobia, pain in the eye, dimness of sight, and contraction with immobility of the pupil, were dependent on a splinter of tooth stuck in the upper jaw, but he does not mention where it was.

Hay (1) also met with an instance of photophobia and pain in the eye, together with severe darting pains in the face, which were provoked by tapping or touching an incisor tooth. On the removal of the tooth these symptoms disappeared; at the root was found an abscess.

Sir Thomas Watson ("Lectures on Physic," 4th edition), mentions a case in which blindness, confined to one eye, recurred three or four times, always being cured by the extraction of carious teeth.

Mr. Salter has seen an instance of change in the colour of iris dependent apparently on prolonged neuralgia; no other nutritional change had occurred.

De Witt found vision to return in an eye which had been totally blind for twelve years, after the removal of an amalgam filling, beneath which was pent up some decomposing pus. Pain returned at the place, and coincidently the sight again deteriorated, but after the extraction of the tooth the blindness wholly disappeared, though the patient could not distinguish what very small objects were.

Another patient suffered for fourteen years from congestion and lachrymation from one eye, and photophobia, these symptoms being aggravated by unsuitable diet; the symtoms began to amend and soon disappeared after the extraction of a carious tooth.

(1) Wedl. "Pathologie der Zähne," p. 355.

A patient under the care of Mr. Salter and Dr. Hyde Salter suffered from dimness of vision and aching pain in the eye, and likewise from facial paralysis, which rapidly became complete.

This latter was clearly due to the portio dura being involved in plastic inflammatory products in the parotid region, due to a carious upper wisdom-tooth; the eye affection may, more probably, have been reflex, as it recurred afterwards when a lower tooth was in fault, and was accompanied by painful paralysis of the arm, which was unquestionably reflex.

Amaurosis may also be produced by carious teeth in a more direct manner; namely, by displacement of the ball of the eye by accumulation of pus; but these cases may be more appropriately mentioned in connection with diseases of the antrum.

One case of exophthalmia has been recorded (Mr. Power, *loc. cit.*), which appears to have had a dental origin; there was much pain, the eye was red, the tension + 1, and there was marked exophthalmia. The cornea was hazy, the retina injected, and a few hemorrhagic spots near the macula; heart, lungs, and urine normal. Ten days later acute chemosis supervened, with much periorbital pain: and two carious teeth and a stump were removed, with the result that in three days there was marked improvement, the chemosis had disappeared, as had also the injection of the conjunctiva and the exophthalmos. Possibly the explanation of such a case as this may be found to be in an inhibitory action upon the vaso-motor system, set up by the irritation of the fifth nerve, leading to an engorgement of all the parts supplied.

Occasionally cases occur of a very puzzling nature: thus recently a patient has been seen by several ophthalmic and dental surgeons, who had almost lost the sight of one eye—there was some retinitis and great protrusion of the eyeball, but no suppuration occurred, and the mischief quieted down without any certainty as to the diagnosis being

attained. One or two carious teeth were removed, but the patient had few teeth, some apparently never having been cut, and those that were present were exceedingly imperfect, stunted teeth, with soft brown enamel, so that it is possible that she may have buried teeth in some wholly abnormal position.

Mr. Power thinks that it is not at all improbable that dental disease may be the starting point of glaucoma, seeing that experiment has shown that irritation of the fifth nerve can alter the vascular tension of the eyeball, and that disturbance of tension is the first and most conspicuous phenomenon in glaucoma, of which disease pain in some of the branches of the fifth nerve is a very frequent precursor: on the other hand, Priestley Smith has investigated the tension in a large number of cases of toothache in young persons at the dental hospital, without finding any really definite alteration of tension.

Mr. Power sums up "that in all cases of threatening glaucoma, especially when this is associated with ciliary neurosis and obscure pain in the temples and maxillary orbital regions: in all cases of mydriasis and probably of myosis, originating without apparent causes: in all cases of sudden paralysis of either of the orbital muscles, or of loss of sensation in the absence of cerebral symptoms: in all cases of phlyctenular disease of the conjunctiva: in all cases of ulcers of the cornea resisting ordinary treatment: in all cases of sudden failure of the accomodation, especially in young children: and finally in all cases of exophthalmos, the condition of the teeth should at least be examined, and if faulty conditions present themselves, these should be at once rectified, and then one at least of the possible causes of each of these diseases will be removed."

FRACTURE OF TEETH.

When the loss of substance is trifling in amount and does not materially interfere with the personal appearance of the patient, nothing further than the removal of any sharp or projecting edge, by the use of the file or strip of stone, need be attempted. But should the fracture extend into or even within a very short distance of the pulp-cavity, a more decided course of treatment will be called for. The nature of that treatment will be determined by the direction which the fracture has taken, by the amount of injury the root of the tooth sustained at the time the injury was inflicted, and by the age of the patient.

The incisors, from their position, are more frequently fractured than the bicuspid or molar teeth. The latter are not, however, exempt from accident. When the jaws are violently driven together by a blow or a fall, a back tooth may give way. A cusp may break off, or the fracture may extend through the pulp-cavity, and detach one or other of the roots, with its corresponding portion of crown. I have seen in a bicuspid tooth the fissure extend from the crown through a greater portion of the root.

Molar teeth may thus occasionally be broken by a blow without the integuments being cut, their fracture being due, not to the direct force, but to the impact of the teeth of the opposite jaw.

The fracture so caused may run through the pulp cavity, and yet the fragments remain in such exact apposition that even on careful examination it may escape observation.

A medical man, happening to be leaning forward in his carriage at the moment when it was suddenly pulled up, pitched upon his head and was stunned: for upwards of a

year he suffered from occasional neuralgic pains, which were ultimately found to be due to a sound upper molar which had been split right through, the palatine being separated from the buccal roots. The pulp had remained alive, and the fracture was long overlooked, it having followed the natural fissures of the crown.

The force employed in mastication is sometimes sufficient to split a tooth, and in one instance which came under my notice the bicuspid was fractured across the upper third of its root by biting suddenly upon a fish bone. Although the tooth was rather loose, and the patient was positive he had broken it, it was tolerably free from pain, and so was left for a time, as I doubted the possibility of its being fractured so high up by such a cause. However, it became so loose that after the lapse of three weeks it had to be removed : on microscopic examination no signs either of absorption or of deposition on the fractured surface were seen.

And it will sometimes happen that a tooth is fractured without the patient having been aware of any blow or shock, and this should be borne in mind when a tooth is found unaccountably loose and tender : it is often possible when moving such a tooth between the fingers to feel that it is moving upon an unduly short implanted portion.

It may be stated generally, that when the fracture extends through the pulp-cavity in the direction of the length of the tooth, the root will have been injured, and should in most cases be extracted ; and the rule will be almost absolute when the pulp cavity of a tooth, the root of which is incomplete, has been opened, whatever may be the direction or the extent of the fracture. If, on the other hand, the crown of a tooth be broken off transversely external to the edge of the gum, there is a fair chance of preserving the implanted portion, and of rendering it subservient to the support of a new crown by the operation of pivoting, should such a course appear desirable.

It is, however, only in teeth with single roots that the

operation can be performed with uniform success. Even in the bicuspids of the upper jaw, and more especially in the first bicuspid, the application of a pivot is not always feasible. The roots of these teeth are not only subject to great lateral compression, but also to actual division into two or into three distinct fangs. In either case, the drill, in preparing a hole for the reception of a pivot, may pass through the tooth into the socket, or no individual root may be of size adequate for the insertion of a pivot pin: such cases may be occasionally treated by the application of one or other of the forms of gold crowns, if such a course seem preferable to the extraction of the root.

But in young persons the gap will generally fill up; if, for instance, a lateral incisor be broken off at or before the age of thirteen, and the root be immediately removed, the canine will come forward, and in a few years fill up the space; or if the accident occurs at a later period, in a mouth crowded with teeth, a similar result would follow the operation. A like course may sometimes be pursued in a young patient, when, with the lateral incisors large, a small central tooth is injured. Pivoted teeth may last twenty years, or even for a longer period, but such durability must be regarded as exceptional. From seven to ten years would more correctly express the period which will intervene between the insertion of a pivoted and the substitution of an artificial tooth, the use of which must, for the sake of appearance and articulation, be ever afterwards continued. If, then, the space occasioned by the loss of a fractured tooth can be filled up by the gradual approximation of the contiguous teeth without seriously interfering with the personal appearance of the patient, it will be better to remove the root of the injured tooth.

It is not, however, impossible so to bind together the fragments, when the fracture has run down through the root, as to restore the tooth to usefulness, just as may occasionally be done when the roots have separated as a consequence of caries. Screws may be inserted into the

several roots, which are then united by being imbedded in a common mass of amalgam, or an arched wire with its ends imbedded in each root, and then fixed by cement, may be employed: or a gold band may even encircle the tooth outside, but whether any of these operations offer a reasonable prospect of success must be decided upon the indications of the individual case.

The occurrence of fracture without apparent injury has led to speculations upon the possibility of its having been occasioned by force from within, it having been even suggested that the evolution of gas from a decomposed pulp might have done it.

Another and more reasonable explanation, which has, however, not much to commend it, is that if the pulp has been converted into secondary dentine this is unyielding, and a distorting force coming upon the tooth it is split, as it were, by a wedge from within. Only a very small percentage of split teeth, however, contain the solid mass of secondary dentine postulated.

The union of a fractured root within the socket, unlikely as it might seem, does sometimes occur.

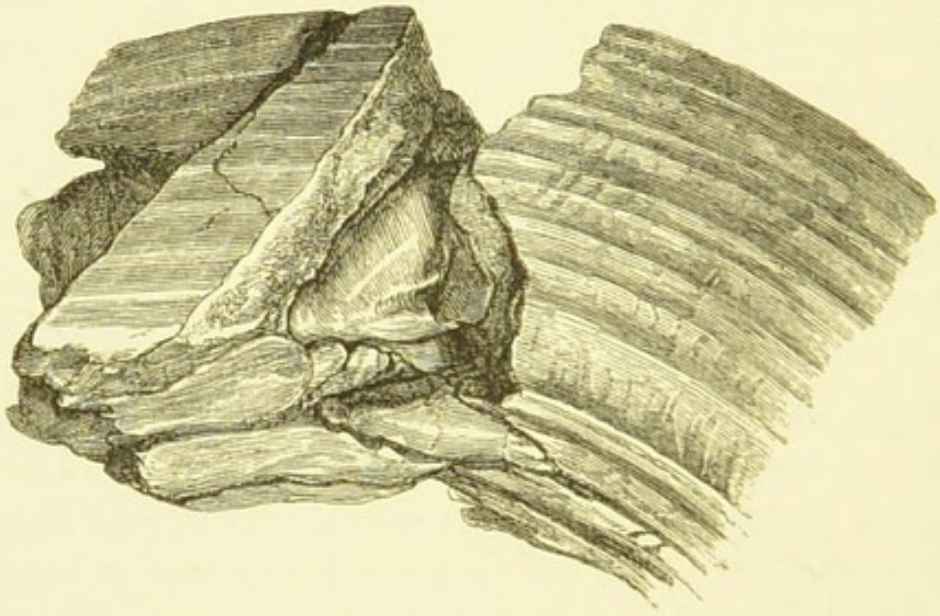
Sir E. Saunders has in his collection an incisor which shows the marks of a reunited fracture extending across the root near the junction of its terminal and middle third. A description, with a figure of this tooth, has been published (1). And Dr. Belisario has met with a case in which reunion has apparently taken place. Professor Owen has described and figured an instance of reunited fracture in the tusk of a hippopotamus (2). The preparation in my own collection, from which the following illustration is taken, is of great interest, as it at once proves that in the tusk of the hippopotamus, at all events, union may take place after a severely comminuted fracture, with considerable displacement of the fractured parts. In this specimen—and I believe in the two preceding examples—the union is effected by the development of cementum. These

(1) "Lecture on Dental Physiology and Surgery."
(2) "Odontography."

facts go to show that when a tooth is fractured within the socket, it may, under favourable circumstances, be reunited. To recognise and bring about these circumstances may in individual cases be difficult, but the knowledge that a fracture may be united should lead to a course of treatment favourable to its occurrence in cases where fracture of the root of a tooth is suspected.

In a case which came under my own notice, a front tooth was broken across and a molar tooth loosened by a severe fall in a patient under twenty years of age. The latter tooth was allowed to remain, in the chance of its regaining

FIG. 220. (1)



its original firmness of implantation. After the lapse of many months the molar tooth was still a little loose, and now and then became the seat of pain. The degree of looseness appeared to vary; at one time the tooth seemed to be rapidly recovering its usefulness as an organ of mastication, at another it appeared to be getting from bad

(1) Shows a perfectly united fracture in the tusk of a hippopotamus. The tooth had been broken with the socket, with considerable separation of the fractured surfaces. The union has been effected by the development of cementum.

to worse. At last the patient determined to submit to no further inconvenience, and the tooth was extracted. The nature of the accident was then for the first time recognised. The root of the tooth had been fractured transversely some distance within the socket, and the fractured surface had been subsequently coated over with cementum. The production of new tissue upon the broken surface must be regarded as a reparative effort, and had the tooth been by any mechanical means kept for a time in a state of rest, it is probable that an union of the fractured surfaces would have been effected.

The dentinal pulp may, however, take some share in uniting the fragment of a tooth broken within the socket;

FIG. 221. (1)

thus, Professor Wedl, in his "Atlas" (*op. cit.*), figures two reunited fragments in which a fresh development of dentine took place; indeed, it is not to be wondered at that this should sometimes happen, for when displacement takes place during the development period, a very complete union is formed, as is exemplified in the accompanying figure; and it is no uncommon occurrence for the pulp to resume its formative functions long after the cessation of regular calcification.

And that an injured pulp may be stimulated into undergoing calcification is well seen in the specimen which has been figured on page 431.

(1) Union of portion of root displaced during formation.

DISLOCATION OF TEETH.

In consequence of a blow or a fall, one or more teeth may be entirely forced from their sockets, the alveoli in some cases receiving considerable injury, and in others little or none. But violence which falls short of dislodging a tooth may cause the death of the pulp, and this should be always watched for after the infliction of a blow; or it may merely loosen the tooth, which, when allowed to remain at rest for a time, becomes firmly refixed.

Occasionally, where great violence has been used—as, for example, in machinery accidents—large portions of alveolus come away with the teeth; and the roots of the front teeth have been known to be driven through the floor of the nose. In one case an incisor was supposed to have been knocked out, which had really been driven into the antrum, where it made its presence known by causing an empyema of that cavity after the lapse of some weeks.

A patient lately presented himself asking to have a lateral incisor pivoted, he having, as he supposed, broken it off by a fall when hunting. It was not, however, broken at all, but had been driven right home like a nail into a board, till its cutting edge was a little below the margin of the gum.

The patient being placed under an anæsthetic, and a vulcanite splint being in readiness, the tooth was grasped with forceps with a view to drawing it down. It required, however, far more force than does an ordinary extraction to stir it at all, and then it came straight out: it was at once replaced, but appeared to have no bone in front of its root. However, after a few days it became independent of the splint, and in a week was less tender than its neighbours

which had been only shaken. Six weeks afterwards, its edge, which had been chipped, was ground smooth with a corundum point, and it is now as firm as any of his teeth. In this case the destruction of the original socket must have been pretty complete, but it has apparently been reformed.

It is now a well-established fact, not only that a tooth which has been forcibly loosened in its socket will, if allowed to remain at rest, become firmly refixed, but also that teeth which have been removed may, on being returned, even after an interval of several hours, become attached, and remain firm and useful for many years. A patient of my own fell upon a cog-wheel, and knocked out the central incisor of the upper jaw. He returned the tooth to its socket in the course of half-an-hour, and, according to his own statement, it gradually became firm, and remained so for upwards of twelve years; at the expiration of that time it became loose and troublesome, and was extracted. When the accident occurred, the tooth had the usual length of root, but at the time of its removal the latter part had been reduced to less than half its normal length by absorption. Many similar cases, as respects the reunion of the natural connection of completely dislocated teeth, were brought forward at a meeting of the Odontological Society held in 1858; and many instances are known where patients having had a wrong tooth extracted, at once replaced it, and retained it for several years. Hence, when a tooth has been dislodged, it should at once be thoroughly cleansed, and the socket cleared of all coagula, before its replacement is attempted. It should then be secured in its place by ligatures, or, what is much better, by a cap of gutta-percha adapted to it and the neighbouring teeth. A cap of gutta-percha should also always be placed over teeth which have been loosened by a blow, or by the operation of torsion; it keeps them steady in their position, and protects them from the bite of the antagonistic teeth.

If much swelling and inflammation of the gums ensue,

this must be combated by leeching or free incisions through the whole thickness of the gums.

Dr. Rollins, of Boston, sent the writer a microphotograph of the root of a lower molar which had been replanted and worn for four years; a little irregular absorption had taken place near the end of the root, and also new cementum had been deposited in great abundance. The alternation of these processes indicated long continuance of the irritation which resulted in its ultimate removal.

The tolerably ready union of a freshly extracted tooth has been made available in a few regulation cases: Dr. Beers, of Montreal, successfully transposed two misplaced teeth, and Mr. Spence Bate and Mr. Coleman have both transplanted teeth from one mouth to another for regulation purposes.

There is abundant evidence to show that a tooth thus replaced will acquire a membranous connection with the socket; this is, indeed, exemplified by the operation of torsion, by the old operation of transplantation of teeth known in the time of John Hunter, and by those cases in which, more recently, teeth have been extracted, the diseased periosteum scraped off, and the teeth then replaced.

The late Mr. Sercombe placed in the museum of the Odontological Society a pivoted tooth, which had been extracted on account of prolonged irritation in the socket, and afterwards replaced. It became tolerably firm, but after some little time became so loose that it had to be removed, when the root was found to have almost disappeared. Such seems to be a not unusual termination of cases of replantation.

When a tooth is extracted it carries with it a certain amount of adherent periosteum, and of course there is living protoplasm in its canaliculi and lacunæ: this is capable of ready reunion, as is well exemplified by recent successful cases of bone grafting operations.

It is said that the protoplasm of bone will retain its vitality for several hours, and that this is the case with

cementum is indicated by the success, temporary at all events, of the operation of extracting teeth, filling them out of the mouth, and replanting them.

In the writer's own practice, an incisor, which a boy had carried all day in his pocket, was successfully replanted, after a thorough scrub with carbolic acid, $\frac{1}{2}$ per cent. solution: in this case the pulp-chamber was cleared and filled from the apical foramen, and now, after the lapse of five years, the tooth is perfectly firm.

And another yet more remarkable case has occurred within the last year: a boy, whose parents were on the continent, knocked out his left upper canine and lateral: he was not brought to be seen for five days, and then healing had taken place to such an extent that the teeth could not be returned to their own sockets. But the mouth was crowded, and the smaller lateral would go home into the socket of the canine, so it was inserted there, and the canine left out. So far this has been completely successful, and it has become firm.

In view of these facts, which seem to indicate that no harm would be done by a short delay, it is probably safer in all cases to enlarge the apical foramen, withdraw the pulp, and fill the pulp cavity.

If this is done the tooth should be handled as little as possible, the cementum being protected from damage by wrapping it round with bibulous paper moistened with a very dilute solution of carbolic acid; the tooth may be held by the enamelled crown so as to interfere still less with the cementum and any soft tissue that may be adherent to it.

In cases of replantation of diseased teeth it is sometimes practical to leave the pulp cavity unfilled and open through the crown as a means of drainage, filling it subsequently when all irritability has passed off; this, if it appeared desirable, could also be done in replanting a dislodged tooth, though it would seldom appear to be necessary, as there will not have been any antecedent suppuration.

In the management of the case it will be necessary to urge upon the patient the necessity of keeping the tooth in a state of perfect rest, and of resisting the tendency to pull the tooth about in consequence of the uneasiness felt around it.

A Hammond's splint, modified as circumstances may dictate, answers well for steadying the teeth; but it is often desirable to prop the bite to ensure rest.

But the union is liable to be an imperfect one, and the tooth will be extremely likely to become sore to the touch from the slightest cold or derangement of the digestive organs, and in a large number of cases is soon lost owing to absorption of its root setting in.

This result is the more intelligible if we recall the famous experiment of Mischterlich, in which it was found that the replanted tooth, which was very firmly held in, was really largely fixed by the excavation of absorption spaces in its cementum, these being occupied by the large cells and other tissues characteristic of the absorption process; there is thus the train laid, so to speak, for the resumption of the destructive process at any time.

THE OPERATION OF EXTRACTION.

In extracting a tooth, the following conditions should be fulfilled :—First, the whole of the offending organ should be removed.

Secondly, it should be removed with as little injury as possible to the structures in which it is implanted.

Thirdly, the patient should be spared all unnecessary pain in the operation.

That method by which a tooth, or the remains of one, can be removed most certainly, quickly, and at the same time with the least amount of injury to the adjoining parts, will also remove it with the least pain. To meet these requirements, recourse must be had to an instrument so formed that it shall grasp the tooth alone, and on the application of the required force effect its removal. Such instruments are forceps ; forceps so constructed that they will accurately fit the tooth to be extracted, and so fashioned at the jaws, nibs, or blades, that they shall readily pass within the gum and separate it from the neck of the tooth.

In the construction of tooth-forceps, certain general principles may be laid down, the observance of which cannot be neglected without prejudicing the general effectiveness of the instrument. The terminal edge of the jaws should fit with accuracy to the neck of the tooth for the removal of which it is designed. The whole of the circumference of the neck cannot be embraced, but a large portion of the lingual and labial surface of that part of the tooth can be reached by the instrument. The greater the surface over which the pressure is diffused, the less will be the risk of breaking the tooth by the force employed to effect its removal. Assuming the tooth to be grasped by the instrument, the jaws should

diverge from the terminal edges sufficiently to clear the crown, but the divergence must not be greater than is necessary to effect that object, otherwise the form of a cutting instrument will be approached.

In forming the terminal edge some little care is necessary, as it must be sufficiently thin to pass under the gum and separate it from the neck of the tooth, and, in some cases, even to pass a short distance within the alveolus. At the same time a sufficient amount of metal must be preserved to ensure the requisite strength. If a section were made of a well-constructed pair of forceps for the incisor teeth, each jaw of the instrument would present the outline of a sharp wedge, which when applied to a tooth, would be in close apposition to the neck of the tooth, leaving the crown untouched. The length of the jaws should be sufficient to clear the crown: any further increase would diminish the power of the instrument, or necessitate an inconvenient length of handle.

Size and Curve of Handle.—In respect to the length of the handle there is great difference of opinion, the size of the hand of the operator by no means determining his selection of the length of handle most convenient to him. Perhaps there is a tendency to use forceps with handles both longer and larger than is consistent with the utmost attainable delicacy of manipulation; but hardly any two people think alike on the matter. Forceps for extracting the front teeth will necessarily be straight, but those used for the removal of the molars must be more or less curved; and the direction and degree of the curvature are questions of some importance. The straighter the instrument, the more readily will its action be controlled. On this account it is desirable to limit the curve at the joint, and, in the case of forceps for the upper teeth, to antagonize it by an opposite curvature in the handles.

Many American dentists, however, seem to prefer forceps for the extraction of lower molars which have a very considerable curve in the handles, and a crook at the end of

one handle for the reception of the little finger; but, for my own part, I do not think this form of forceps is at all equal to the usual English patterns. The jaws of the forceps must, however, form some angle with the handles at the joint, in order to enable the latter to clear the other teeth in the mouth, when used for removing the back teeth.

As the teeth are variously shaped, so will it be necessary to have forceps of different forms; in fact, a pair fitted to each kind of tooth. In order to secure perfect adaptation of each instrument to its allotted purpose, average teeth should be selected and given to the forceps maker, who should be instructed to make the jaws fit accurately around the neck, whilst they diverge enough, and only enough, to secure the crown of the tooth from pressure.

The roots of all teeth having a general conical form, forceps, when well made and applied, should be but as a lengthening of the cone in the direction of its base. Instruments for extracting stumps should be made altogether lighter, and the jaws should be thin and sharp at their edges, so that they may be made to cut rather than to tear the structures connecting the root with the adjoining tissues.

When forceps are used for the extraction of teeth, the operation is divided into three stages:—First, the seizure of the tooth; second, the destruction of its membranous connection with the socket; third, the removal of the tooth from the socket. It will be of great service to the student, and advantage to those operated on, that he should pay strict attention to these stages, and that each should be well and efficiently executed before he proceeds to its successor; for should the tooth be unskilfully seized, the crown will be broken off in the attempt to detach the tooth from the periosteum of the socket; and until this is effected, the roots cannot be removed from their bony cells. A tooth will resist a great force applied in a line with its axis, or, in other words, if an attempt is made to pull a tooth straight from its socket; and some most disastrous results have been known

to follow such attempts made by persons unacquainted with the form of the molar teeth which they attempted to extract: three or four teeth and the alveolus inclosing them have been brought away, and the greater part of the floor of the antrum was actually torn away in one case. It must be remembered that, if single rooted teeth be excepted, no tooth could be extracted from a rigid perfectly unyielding bone, and that it hence is important to study in which direction the bone of the socket is most yielding. In seizing a tooth, the jaws should be closed lightly upon it, and inserted under the free edge of the gum, and then *forcibly* driven down to the edge of the alveoli, or even a short distance within them. I say forcibly, because all beginners, and even some practised in the use of forceps, are liable to failure because they do not use sufficient force: they seize the tooth at the edge of the gum, instead of at the edge of the alveolus. The beginner should be impressed with the necessity of laying hold of the tooth as far down towards the fangs as the instrument can be passed.

An old and successful operator, when instructing another in the use of forceps, said, "Push the jaws of your forceps into the sockets as though you intended they should come out at the top of the head, or under the chin."

I find that even in recent American works it is said that the use of the gum-lancet should generally precede the application of either the forceps or the key, and its employment is strongly advocated. Nevertheless, I do not think its use either necessary or even advantageous, save in those very few instances where the gum is unusually adherent; and the only position in which this adherence of the gum to the tooth is likely to be productive of trouble or injury is the posterior surface of wisdom teeth. It will occasionally happen that the gum may be unnecessarily lacerated when firmly adherent to this part of the wisdom tooth, so that it is, perhaps, safer to ascertain whether it is or is not closely attached to the tooth before attempting its removal. But, with this somewhat rare exception, I am unable to see what

is to be gained by lancing the gum, if the edges of the jaws of the forceps be in proper condition.

American forceps, as a rule, appear to have the blades much thicker, and to approach less to a cutting edge, than those of English make, and it is probably on this account that lancing of the gum is still advocated by some transatlantic writers.

When the forceps have been pressed well up, the student must be on his guard lest he crush the tooth by squeezing the handles of the forceps too tightly. To guard against this, some operators pass the little finger between the two handles ; but a preferable plan is to regulate the pressure exerted by partly introducing the fleshy part of the thumb between the handles. No more pressure should be put upon the tooth than will suffice to prevent the forceps from slipping.

The manner of effecting the second stage will depend on the shape of the tooth to be removed ; as will also the third. But it is quite impossible for any person to extract teeth properly, whatever instrument may be used, especially if the forceps be chosen, unless the operator is perfectly acquainted with the form of each tooth, with the relative position and size of the roots, with their direction in the alveoli, with the general form of the alveoli themselves, and with the directions in which they offer the greatest and the least resistance. And the difference between a good and a bad operator lies largely in the quick, almost instinctive recognition by the sense of touch of the direction in which yielding is taking place, and the abandonment of force in directions where rigid resistance is encountered. An educated hand will thus often successfully remove teeth with abnormal roots, which would assuredly be broken by less skilled manipulation.

In describing the manner in which the operation of extraction should be performed on the different teeth, the incisors, canines, and bicuspid teeth will be first considered, and afterwards the molars.

A section through the neck of an incisor of the upper jaw will show that the anterior is larger, and forms part of a greater circle, than the posterior surface. Now, the end to be attained in the application of forceps, is to apply them over as large a surface as possible, so that the pressure may be diffused, and the chance of fracturing the tooth by the pressure of the instrument avoided. To extract these teeth, therefore, the jaw to be applied to the posterior surface must have a smaller curve than that for the anterior. When the forceps are closed upon the tooth, they should embrace, not only the anterior and posterior surfaces, but a part of the lateral surface also. A cylindrical tube of thin metal, when pressed upon equally in every direction, will resist enormous force; but if the pressure be confined to one or two points, a comparatively trifling power will crush it: so it is with a tooth.

FIG. 222. (1)

The lateral incisors require forceps made upon the same principles as the central teeth, but somewhat less in size. These are liable to greater variation in external dimensions than any other teeth, sometimes being very small indeed, and at other times almost as large as the central incisors.

The forceps having been well pushed up towards the alveoli, and the tooth firmly grasped, then, by a firm and steady turn of the wrist, twist the tooth in its socket, and so soon as it is felt to yield to the force, it may be drawn from its socket with little effort.

The incisors of the lower are smaller than those of the

(1) Forceps adapted for the removal of the incisor teeth of the upper jaw.

upper maxilla, and much more compressed laterally. Forceps for the extraction of these teeth will require to have the jaw which is to be applied to the posterior smaller than that for the anterior surface of the neck. The jaws of the instrument should be straight; but it will be found convenient to have the handles curved, so as to avoid the upper teeth. When the tooth is grasped it must be forced outwards, and, when it is felt to yield, draw it upwards and outwards.

The canines of the upper and lower jaws require for each a pair of forceps made upon the same plan as those for the removal of the incisors, except that they must be larger and rather stronger. Those for the cuspidati of the lower maxilla should, like forceps for the incisors of the lower jaw, have the handles slightly bent. Sometimes these teeth are very small, in which case forceps adapted to the adjoining teeth may serve for their removal. The canine teeth, in the upper, may be detached from their membranous connection with the jaw by a rotatory movement, and will then leave the socket readily; in the lower jaw the rotation movement is often impracticable.

The bicuspids will be extracted with instruments similar to those already described, except that there will be a little difference in the jaws, which must be accurately fitted to the neck of the tooth. These teeth are not very frequently liable to much variety in size, so that an instrument which is well adapted to an ordinary bicuspid tooth will apply itself to almost all. I have forceps in which the jaws are bent at right angles with the handles, and open laterally, for the extraction of bicuspids of the inferior maxilla. But they do not answer so well either as instruments which are nearly straight, or those in which the handles are constructed in the manner shown in the illustration, it being less convenient to apply the necessary force, and more difficult to regulate its direction, with the former than with the latter forceps. In extracting teeth which have their roots laterally compressed, and are placed in an unbroken line with other

teeth of like-shaped roots, the only available movement

Fig. 223. (1)

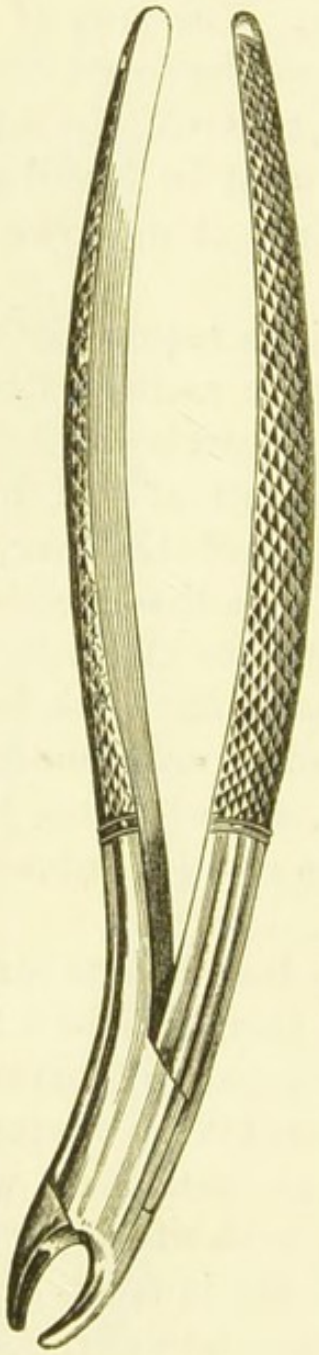
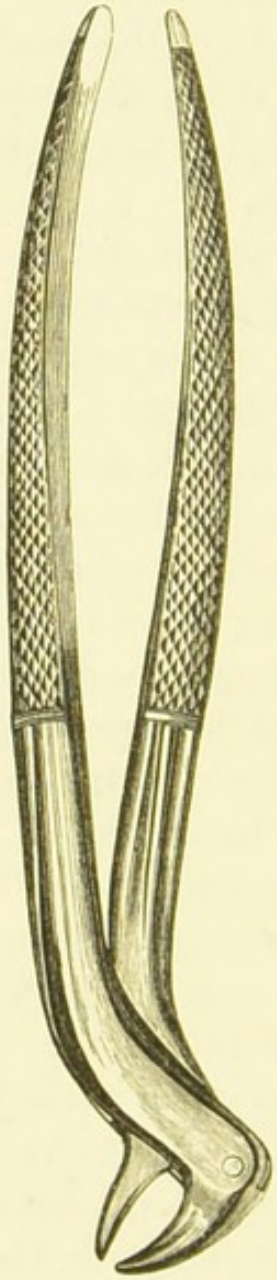


Fig. 224. (2)



will be at right angles with the line of the alveoli, and in the direction of the greatest diameter of the roots.

(1) Forceps adapted for the removal of the lower incisor teeth, with the handle curved to enable the operator to avoid the teeth of the upper jaw.

(2) Forceps suitable for removing the bicuspids of the lower jaw. The joint is placed in an unusual position, and the handles bent in order to allow the hand of the operator to avoid the teeth of the upper jaw. The merit of inventing this useful instrument is due to Mr. Evrard.

The bicuspids of the upper jaw have the necks compressed laterally. In removing them, whatever be the form of the instrument used, the force must be mainly applied in a direction outwards and at an angle to the dental arch. After the forceps are thrust up, and made to grasp the neck of the tooth, a very slight inward motion may be made, but it is outwards that the tooth will mainly yield, as may be seen in looking at a vertical section of the bone and teeth *in situ*, when it will be noticed that there is a far greater thickness of bone on its inner than on its outer side. But it must be borne in mind that in forcing it outwards or inwards we desire only to break its connections with the socket; and that if the force be too completely in this direction in removing the tooth, the outer alveolar plate will be needlessly injured, so that it should be finally drawn downwards.

The bicuspids of the lower jaw have more conical roots than those of the upper, and hence may be detached by rotation, and then lifted out of the socket.

When I say rotation, I do not mean that the tooth shall be twisted a half or even a quarter turn, but that it shall be twisted till its attachments are felt to give way. If, in order to effect this, more force is required than can be judiciously employed, then the direction may be changed, or the rotatory movement abandoned. There are some teeth that vary so much from the usual form of root that they cannot be turned in the socket. The degree of force that it is necessary to employ, in this and in all other cases of like operations, can be learned only in practice.

On Extraction of the Molars.—Normal molars of the superior maxilla have three roots—two external, one internal. Of the two external roots the anterior is the largest, and is placed in a plane slightly external to the posterior root, which is both shorter and smaller. The third, the internal root, is thicker and of greater length than either of the others, and is situated opposite to the posterior external root, and to the space between that and the anterior external

root. The divergence of the roots takes place at the point where the tooth becomes concealed in the alveolus, leaving the neck with a form such as would result from the agglutination of the roots, having the described relative position. At this point the forceps should be applied for the removal of the tooth. Instruments—for it will require two, one for each side, right and left—must be made upon the same general principles as those already described. The jaw for the labial surface of the tooth must have two grooves—the anterior the larger; the posterior smaller, and upon a plane internal to the anterior groove. The jaw for the lingual surface must have but one groove, and that fitted to the base of the internal root. From the position of the molars of the superior maxilla, the jaws of the instrument for their extraction must necessarily be bent at an angle with the handles. This angle should not be more than is absolutely necessary, for the more curved the instrument the greater is the loss of precision. The handles should have a general curve in the opposite direction to the jaws.

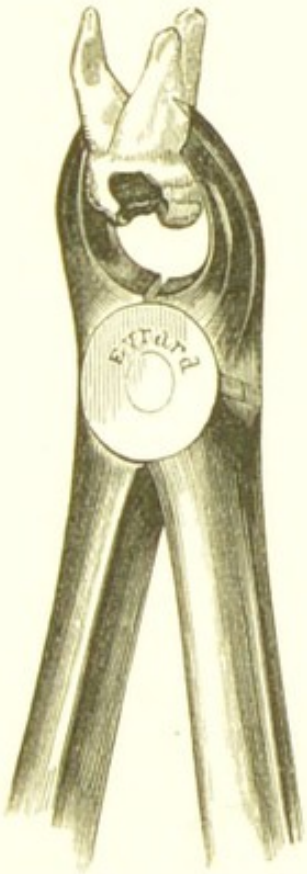
The internal root, which is not only the largest, but the longest also, diverges from the two external, and passes upwards and inwards towards the internal wall of the antrum, and is enclosed in tolerably dense bone. The external alveoli are composed of thin and porous bone.

In removing these teeth, then, the tooth being firmly grasped at its neck, the first motion should be very slightly inwards, to disengage the fangs from the external alveoli, but this movement should be through a very small distance: in fact only just perceptible, for the nature of the parts precludes the possibility of its being carried far, and perseverance in this direction will lead to disaster. The force should then be directed downwards and outwards in the axis of the internal root. If these precautions be observed, no difficulty will be found in removing the superior molars. The first and second molars of the superior maxilla are so nearly alike in size and shape, that

an instrument well fitted to one will serve equally well for the removal of the other.

The first molar, however, if isolated by the previous

FIGS. 225 and 226. (1)



removal of the second molar and the second bicuspid, will, when their vacated alveoli have been filled with solid bone, offer great resistance to extraction, and is sometimes broken off in the attempt. Indeed, a solitary tooth surrounded by firm bone is always more difficult to extract, and requires more care, than one situated in a continuous row of teeth.

(1) Forceps for removing the superior molar on the right side of the mouth. In the second figure a left side instrument is shown embracing a tooth.

In the third molars, or dentes sapientiæ, of the upper jaw, though the roots are often united into one conical mass, yet the shape of the neck of the tooth is so like those of the preceding teeth, that an instrument which is suited for the removal of the anterior molars is often sufficiently well adapted for the removal of the wisdom teeth. The dentes sapientiæ are, however, sometimes much smaller than the other molars ; in which case a smaller instrument might be required, but that, when of small size, the upper wisdom teeth are for the most part removed by the application of so slight a force that any instrument by which they can be embraced will serve for their removal. A useful form of forceps for the extraction of upper wisdom teeth is made with two nearly rectangular curves, like those of the plugging instrument represented in Fig. 165 : the same forceps will answer equally well on both sides of the mouth.

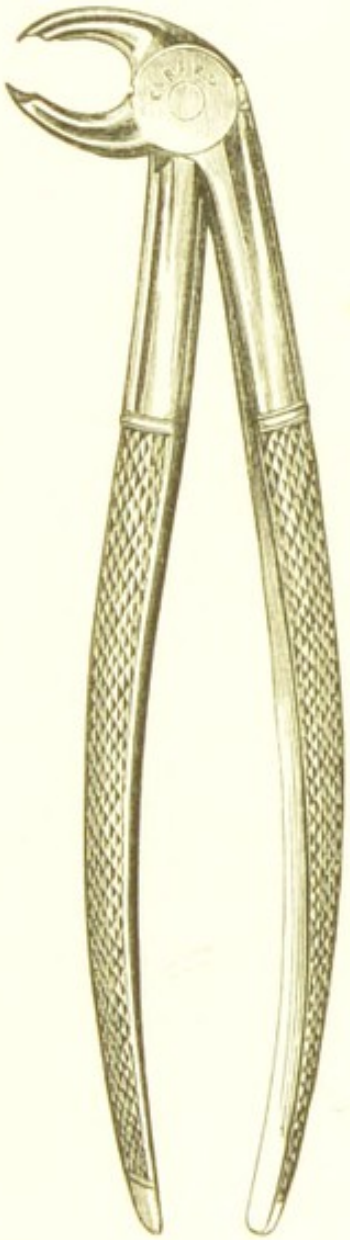
The molars of the lower jaw have two roots, a distal and a mesial root, which at their union form the neck of the tooth, and leave upon it a depression or groove on the lingual and labial surfaces. A transverse section through the neck of a lower molar, in outline, resembles a rude figure of 8, and it is to the surface so formed that the jaws of the forceps must be adapted.

The two roots are not equal in size, neither are they strictly parallel in position. The mesial or anterior is both broader and thicker than the posterior or distal root. Their position as regards each other is slightly oblique, giving at the point of confluence at the neck of the tooth a slightly greater breadth to the labial than the lingual surface. The position of the tooth in the jaw is also a little oblique. A line passed from the centre of the labial across to the centre of the lingual surface of the neck would, if continued, proceed over the tongue, with a slightly diagonal direction backwards. Owing to these peculiarities in the form of a lower molar tooth, it becomes desirable to possess forceps destined to effect their removal fitted to the teeth on each side of the mouth—an instrument for the right, and one

for the left teeth. One pair may be made to answer the

Fig. 227. (1)

Fig. 228. (2)



purpose, perhaps, but the obliquities of position and conformation render it quite impossible to adapt the jaws of one

(1) Forceps for the removal of molar teeth of the lower jaw.
(2) Hawk's bill forceps, the jaws of which are placed at a right angle.

instrument to fit with accuracy to the necks of both right and left lower molar teeth. The handles must necessarily be placed at an angle with the jaws of the instrument, and the angle will be determined by the plane in which the jaws are bent.

For extracting the first lower permanent molars of young people, where the alveolus is likely to be tolerably yielding, I prefer small forceps nearly of the form represented in Fig. 227, but with the handles curved to fit the hand; but in older people, and in all, young or old, for the removal of the second molars, forceps with the jaws bent at right angles are preferable (Fig. 228).

When, however, the whole tooth has an inclination inwards, the handles of forceps of this last form would, in the place of being nearly horizontal, be directed upwards to an extent that would render their application a matter of difficulty. Hence with teeth which incline inwards, forceps of the form represented in Fig. 227 are found to be more convenient.

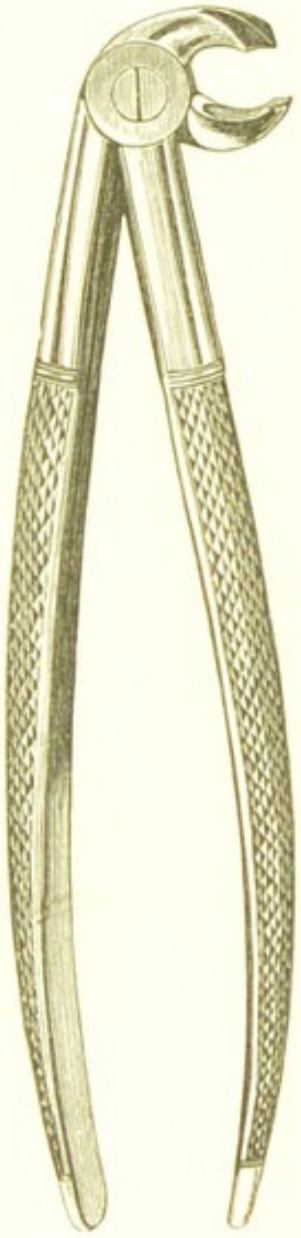
In some instances these same forceps may be used for the extraction of the third molars. Generally, however, these teeth are situated so far back in the mouth, and are separated from the corresponding members of the upper series, when the mouth is opened to its fullest extent, by so small an interval, that although a modified instrument may not in all cases be absolutely necessary, it is, at all events, more convenient. An instrument, the jaws of which, in addition to standing at a right angle to the handle, are also themselves curved forward (Fig. 229), I have found particularly serviceable, not only in extracting the third, but also the second molar teeth. A right and a left pair will, of course, be required.

A deviation from the normal form is exceptional in any member of the dental series, saving in the dentes sapientiæ. In these teeth the converse holds good, the typical form is more frequently lost than retained, and it is on this account that the operator should be prepared with

suitable means for meeting such exigencies as may arise. The question of irregularities of form will, however, be subsequently referred to.

In removing molars of the lower jaw, the blades of the instrument, whatever may be its form, should be lightly closed and carefully thrust down to the free edge of the alveoli, which part of the operation is easily effected, in consequence of the decreasing size of the teeth from the crown to the fangs. Having obtained firm hold of the neck of the tooth, the first motion should be inwards, by which the tooth is detached from the external plate of the alveoli : afterwards the tooth should be drawn outwards and upwards, and so removed. The roots of these teeth, however, not unfrequently take a curve backwards ; if, therefore, a lower molar offers considerable resistance when its extraction is attempted, the movement after the tooth has been forced laterally should not be in a straight line, but in a curved direction, corresponding to the course taken by the roots.

Fig. 229. (1)



When an instrument having blades in the same straight line with its handle is used, the operator must stand in front of the patient, and the power will be exercised by rotation of the wrist ; but if a hawk's-bill instrument be selected, the dentist in removing the tooth from the right side of the

(1) Forceps for the removal of second or third lower molars situated in the right side of the mouth.

The jaws of the instrument are placed at a right angle. The jaws themselves are curved in a manner which allows the instrument to be passed to the back part of the mouth, without necessitating a wide separation between the upper and lower teeth.

mouth will stand behind, and in operating upon the left side of the jaw, in front of the patient, or rather on the right, and slightly in advance of the patient. As in this case the handles of the instrument will project horizontally outwards from the left corner of the patient's mouth, the operator must reach across the patient with his arm, and is then, to some slight extent, in a disadvantageous position. Hence some operators, whilst almost invariably using this form of forceps for extracting lower molars on the right side, do not use them on the left side of the mouth. But a very little practice will overcome the difficulty of reaching across the patient, and the position is a far less awkward one than that adopted by some operators, who stand on the left of the chair to remove lower teeth with this form of forceps. This is indeed a disadvantageous position : it is difficult to see where the blades of the forceps are, and the operator is encumbered by his own body being between his operating hand and the patient's mouth. The same remarks apply to the use of the elevator in the lower jaw, it being the constant habit of some operators to stand on the patient's left to remove a left lower tooth. As the handles of the instrument project from the side of the mouth, the power employed in the removal of the tooth will be exercised by raising and depressing the hand ; but the operator should endeavour to lift the tooth from its socket, and not to simply depress the handle, using the alveolus as his fulcrum to the very last. It is to these rectangular instruments that I generally give the preference. One point in the extraction of lower teeth which is too often neglected is to place the patient low enough relatively to the operator. Another point of great importance is to securely fix the patient's lower jaw ; if the tooth to be removed be upon the patient's left, the jaw should be seized by the operator's left hand, the thumb being placed upon the crowns of the teeth immediately in front of the tooth to be removed, and the fingers, covered by a napkin, supporting the jaw from below. In operating upon patients when under the influ-

ence of nitrous oxide, the tongue often rises up and obscures the view of the teeth; hence it will often be better to reverse the position of the hand just described, and place the thumb below the jaw, so as to have one or two fingers free, for the purpose of depressing the tongue.

But, whatever position be selected, the lower jaw must be absolutely under the control of the operator.

In the foregoing description it has been assumed that a considerable portion of the crown remained, and that the condemned tooth, therefore, could be readily grasped at its neck. It often happens, however, that the tooth has decayed away, or been broken off to a level with or below the edge of the gum; in either case the instruments at present described are inapplicable. Stump-forceps, or the elevator, must be employed to effect the removal of such teeth.

There are two forms of stumps, single and double, or triple. Single-rooted teeth necessarily leave only a single stump, but in molar teeth a sufficient portion of the neck may remain to preserve the connection of the roots. For the extraction of single stumps we require one kind of instrument, for double another, and for triple-rooted stumps a third.

In forceps for removing single stumps the jaws should be grooved to fit the stump, made very sharp at the edge, and of well-tempered cast steel, so that the edge may be renewed from time to time on the oil-stone. When the instrument is closed, they hold the stump, and fit to a material part of its whole length.

In the construction of these instruments, care should be taken to allow a sufficient interval between the upper part of the blades, otherwise they will close upon and crush the exposed and fragile portion of the stump, before the terminal portion of the blades bears upon the part capable of resisting the required pressure.

Although little variety will be required either in the size or in the form of the jaws, the relations they hold to the

handles will require variation, in order to admit of their

Fig. 230. (1)

Fig. 231. (2)

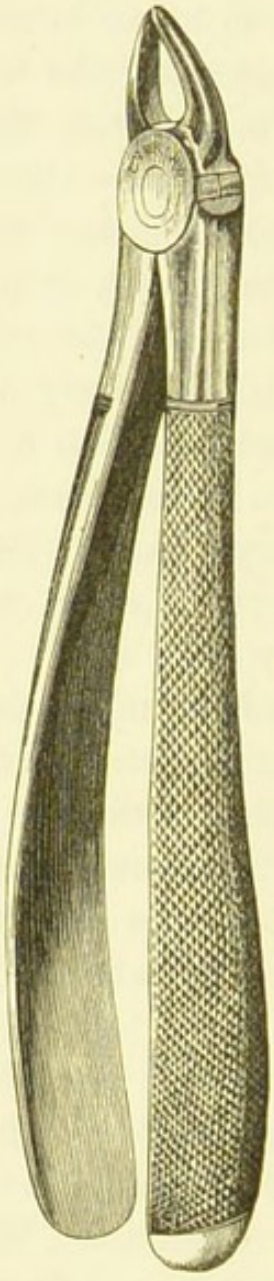
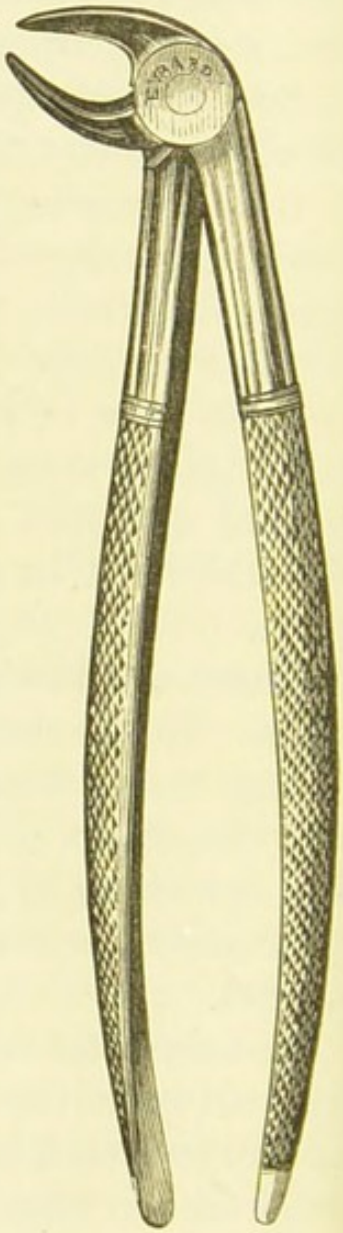


Fig. 232. (3)



application to stumps situated in different parts of the

(1) Forceps for removing the roots of single-fanged teeth situated in the front part of the upper jaw.

(2) Forceps for removing the detached roots of the upper molar or bicuspid teeth. The jaws of the instrument are slightly curved upwards, and the handles in an opposite direction, in order to enable the operator to reach the back part of the mouth.

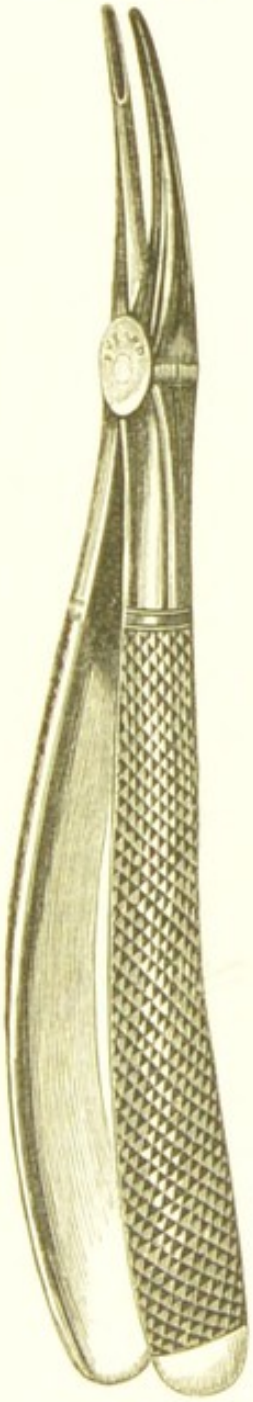
(3) Forceps with the jaws bent at right angles, for the removal of the roots of the lower bicuspid teeth. For the extraction of stumps of the lower molar teeth, a considerable advantage will be gained by a slight curve in the blades below the joint, as shown in Fig. 229.

mouth. Of these varieties the succeeding illustrations will afford examples.

The edges of the blades having been rendered moderately

Fig. 233. (1)

Fig. 234. (2).



(1) Forceps with blades bent at an angle in the same plane as the handles, for the removal of the stumps in the lower jaw.

(2) Forceps with long slender blades for picking out of the alveoli the loose roots of teeth, the crowns of which have previously been removed; somewhat stronger instruments of this form, or having the blades bent twice, are very valuable for removing upper stumps.

sharp, they should be closed lightly upon the stump and then forced between it and the edge of the alveolus. In many cases simple pressure will carry the instrument to a sufficient depth, but in others a slight amount of rotation will be found necessary. The root, when embraced at a point capable of resisting pressure, is readily removed. The direction in which the force should be employed in effecting its extraction will be regulated by the shape of the root under operation—a point already discussed in a previous page. Occasionally the margin of the alveolus is so unusually strong that it becomes extremely difficult to introduce ordinary stump-forceps, and the difficulty in operating is still further increased when the stump requiring removal has been broken off on a level or a little below the terminal edge of the socket. To meet the difficulty, Mr. Cattlin devised an instrument, shown in the accompanying illustration, but the writer has never found occasion to use it.

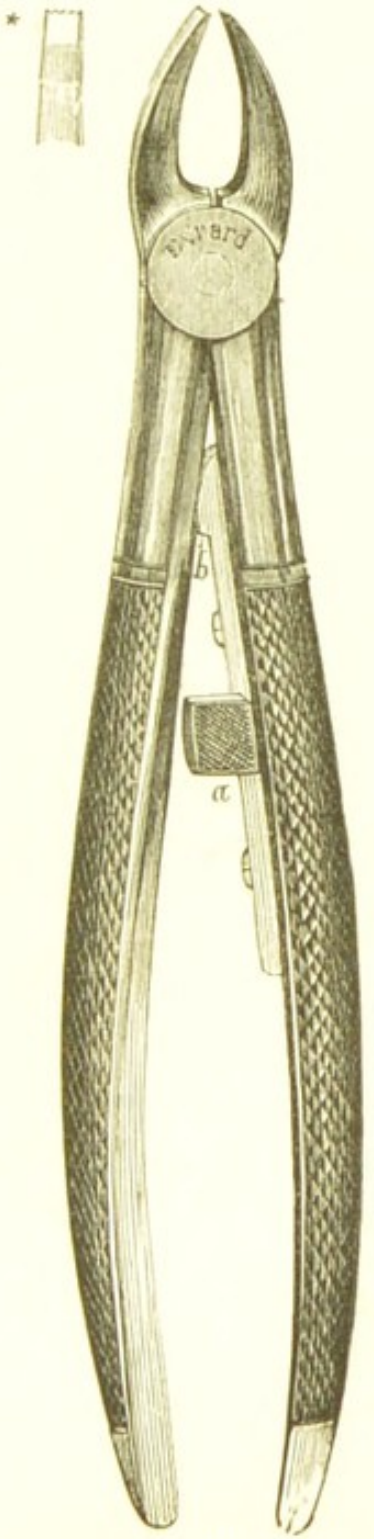
If, instead of simple or single, we find compound roots—the roots of molar teeth united by the presence of a portion of the neck of the tooth—an advantage will be gained by adopting a different form of instrument to any at present described. For removing the compound roots of an upper molar, an instrument will be required similar, as respects its general form, to that which would be used for the extraction of the tooth, but with the outer or labial blade prolonged into a sharp point.

The palatine blade has, at the suggestion of Mr. Coleman, undergone a slight modification. The terminal portion is somewhat reduced in thickness, and turned a little outwards in a direction corresponding to the course taken by the root of the tooth as it enters the alveolus. Instruments constructed on this principle were shown to me many years since by Mr. Rogers, and to him I am indebted for patterns from which many have since been made.

In operating, the palatal blade must be pressed into the alveolus of the corresponding root, and the point of the labial blade placed over the interval which separates the two

labial roots. This position having been gained, the point must be driven through the gum and alveolus into the space which separates the labial roots by closing the handles of the instrument. By this procedure a firm hold upon the triple root is obtained, and its removal is readily effected, unless the connecting portion of the tooth gives way. In that event the roots become separated from each other, loosened in their socket, and are then readily removed by a more simple form of stump-forceps. Before applying the instrument, it is desirable to make an inverted V-shaped incision over the labial roots of the tooth, to receive the point of the labial blade of the forceps. If this precaution be neglected, the gum may be torn needlessly.

FIG. 235. (1)



(1) Forceps, the edges of the blades of which are cut into teeth like a saw, for the purpose of operating upon roots presenting a conical surface. The instrument is provided with a stop between the handles. The thumb-piece (*a*) is pressed upon and forces the wedge (*b*) forward, and prevents the blades from closing, the sharp edges of which, by rotation, are made to cut their way into the stump, or between the stump and alveolus. When a sufficient depth has been reached to enable the blades of the instrument to take a firm hold, the wedge is withdrawn by the thumb, and the instrument used as an ordinary pair of stump-forceps. I am indebted to Mr. Cattlin, the inventor of the instrument, for this illustration. But these forceps have not proved so useful as was anticipated; there are few teeth which cannot be removed without resorting to such a process.

* Shows the surface of the wedge, which rests against a similarly grooved surface on the handle of the instrument.

But although such forceps, as well as the corresponding pattern which is made for lower teeth, and which cuts its way through gum and alveolus on both sides, are perfectly

Fig. 236. (1)

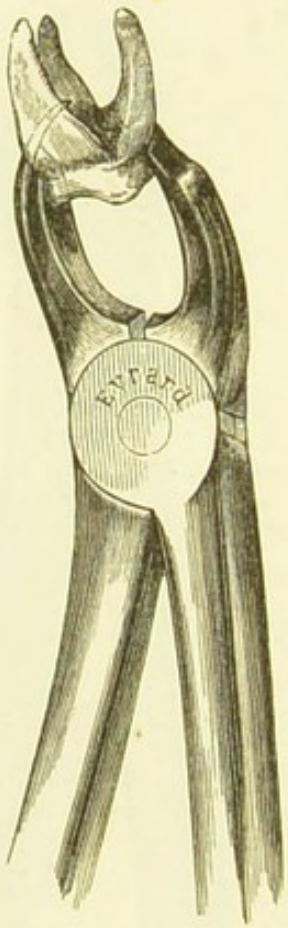
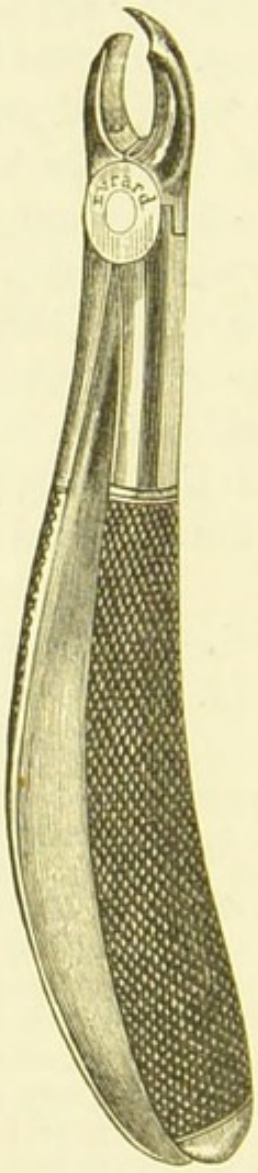


Fig. 237. (1)



efficient in getting the tooth out, their use is to be deprecated except in cases of most extreme difficulty. For the

(1) Forceps for removing upper molar teeth, the crowns of which have been broken off, while the connection between the three roots has been preserved. The peculiarity of the instrument consists in the production of a tapered prolongation of the outer jaw, capable of passing between the labial roots of the tooth. In the first figure the jaws are shown embracing a crownless tooth, in the second the instrument only is shown.

FIG. 238. (1)

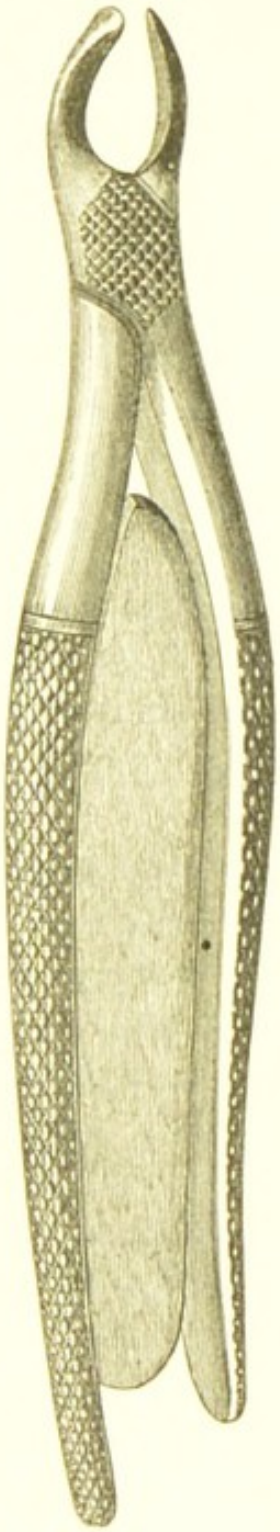
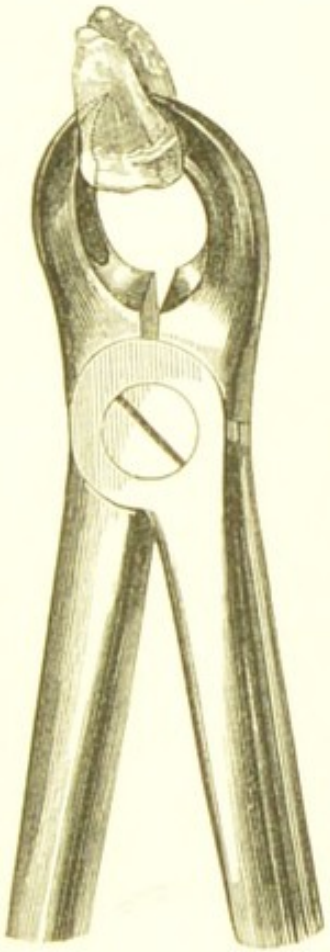


FIG. 239. (2)



(1) Stump forceps, the outer blade of which terminates in a sharp point, like the elevator figured on page 618.

(2) Forceps for removing lower molar teeth, the crowns of which have been broken off through the lower portion of the neck, leaving the two roots firmly connected. The blades are lengthened into points, which converge and pass between the roots of the tooth.

bone and the gum, more crushed than really cut, do not heal readily, and the patient is likely to have much subsequent pain ; the alveolar bone is not at all tolerant of this sort of injury, and is apt to inflame when subjected to it.

The forceps which I myself greatly prefer to any others are represented in the accompanying figure; the outer blade ends in a point like that of a spear-pointed elevator, and is kept thoroughly sharp ; it was the intention when the forceps were constructed to use this blade as an elevator to split the roots, but in practice it is found to be so efficient used otherwise, that I never now use one blade alone.

The sharp point is placed at the middle of the labial margin of the root, and when forced up, which it always can be, it passes somewhat between the labial roots. If the roots are so far separated that they cannot be brought out together, it separates them very completely, but more commonly it brings out two, or all three, and it very rarely fails to bring out any at all.

Other methods of extracting an upper molar stump may be resorted to ; one, which is very often successful in bringing away all three roots together, is to apply forceps of the form represented in Fig. 231 to the palatine and anterior buccal roots, with a view to extracting these together, and leaving the posterior buccal to be dealt with separately. Another method is to separate the three roots by forcing a sharp spear-pointed elevator (see Fig. 240) into the centre of the stump, and thus splitting it, when the separated roots can be individually removed without difficulty. A pair of cutting-forceps intended to effect this object has been designed by Mr. Harding, in which the external blade is replaced by a vertical cutting edge, and quite a variety of forms have been devised to meet the difficulty of dealing with broken down upper molar teeth. But the nerve in such teeth is almost invariably dead ; and the operation may generally, if it appears unlikely that the roots can be extracted together, be done far more neatly by employing a sharp spear head in the engine to cut the roots

apart. It is not necessary to absolutely complete their severance, as the stump forceps, with which the several roots are grasped, will do this if the union between them be greatly weakened.

The double root which remains after the crown of a first or second molar of the lower jaw has been reduced to the level of the gum, may be removed by an instrument constructed upon similar principles to that which is used in extracting the triple fangs of the corresponding upper teeth, differing, however, in having each blade terminated by a point. The points are destined to pass between the roots of the stumps, and when a sufficient portion of the neck of the tooth remains to act as a guide, they may be forced into that position without passing through the labial and lingual plates of the alveolus. The occasional irregularity in the disposition of the roots, more especially of the second molar, must in this, as in all operations upon the teeth, be borne in mind.

The most generally useful instrument for extracting the roots of teeth has yet to be mentioned. There is scarcely a root, or even a tooth, which cannot be removed by the elevator. The instrument consists of a blade terminated by a spear head, or other selected form, and a stout shaft mounted in a strong handle. The minor modifications to which this instrument has been subjected in order to meet the exigencies of a particular case or the views of the operator are endless. Fig. 240 shows one of the more useful forms of the instrument. Independent of the form, the following conditions should be observed in constructing the instrument. The blade and shaft must be made of good steel, and reduced to a spring temper. The handle should be full and strong, and the whole instrument sufficiently stout to bear, without bending or springing, any force the operator may employ.

In operating, an elevator may be employed as a simple lever. The edge of the blade having been made sharp, it is thrust down between the root of the tooth and its alveolus ;

the handle is then depressed with a slight rotary movement, and if the motion be judiciously directed, the round part or back of the blade will rest upon the margin of the socket, while the edge of the blade cuts into and takes a hold in the surface of the root. It cannot be too strongly insisted upon that the edges of the elevator should be sharp : as sharp as an enamel chisel, so that it fairly cuts into the root and gets a good grip of it. The instrument becomes a lever of the most simple kind, the short end of which takes its bearing on the tooth ; the alveolar processes, or perhaps the neck of a contiguous tooth, form the fulcrum, and the long end of the lever is in the hand of the operator. By the depression of the handle the tooth is raised in its socket; but simple depression will not in all cases be sufficient to secure the full effect. A slight degree of rotation is generally necessary, otherwise the edge of the instrument, instead of entering, may slip over the surface of the tooth. Many teeth, more especially the wisdom teeth, may be forced or prized out of their sockets by a single effort, but the second or even the third application of the instrument may be required. A tooth may be so placed with respect to the jaw or the neighbouring teeth, that after it has been moved in its socket, a change in the direction of the force becomes necessary in order to complete the operation without inflicting needless injury on the adjoining parts.

An elevator may, however, be used otherwise than as a lever. A root, the implantation of which is not very firm, may be forced out by pressing the point of the instrument against it, the direction of the force being such as will favour its escape from the socket. If, for example, the root of a bicuspid on the right side of the upper jaw requires removal, the operation may be performed in the following manner :—Let the patient's head be well thrown back, and placed immediately in front of the operator. The upper lip may be raised by the forefinger of the left hand. The point of the elevator should be passed upwards between the gum and the tooth until a sound portion of the root is reached.

At this point the extremity of the instrument should be pressed into the root sufficiently to take a firm bearing, and the handle of the elevator at the same time brought up to the side of the cheek. When this position is gained the offending root may be pushed out of its socket.

Although the instrument under consideration admits of being used upon either of the foregoing principles, it would be found very inconvenient in the treatment of a case to insist upon the adoption of one method to the exclusion of the other. Not uncommonly the operation may with advantage be commenced by using the elevator as a simple lever, and completed by using it for pushing the loosened tooth out of its socket.

Whenever the elevator is employed, the forefinger of the operator's hand should lie along the shaft, and the point of the elevator should not reach more than three-quarters of an inch beyond the top of the forefinger. If any slip should occur, the instrument is well under control, and those lacerations of the gum, or even the cheeks and tongue, that happen when this precaution is neglected are obviated.

It is undesirable to use the elevator for the extraction of upper wisdom teeth which occupy their normal position, as from the direction in which the force is applied the tuberosity may readily be broken off. Teeth may often be advantageously removed by combining the use of the elevator and the forceps, using the first-named instrument for raising up and loosening the roots, and forceps to complete the extraction.

The roots of lower molars may often be removed by inserting the point of an elevator behind the posterior root and prizing it up from its socket : the removal of the anterior root will then be easy ; or if the anterior root be first removed, the posterior may be very easily reached by inserting the elevator into the vacant anterior socket and thrusting it boldly through the septum, so that its point catches the posterior root quite low down.

Elevators as generally sold by the instrument makers are

far too large and clumsy: the great size of the points renders very great force necessary to make the instrument enter the socket, and needless pain is inflicted on the patient.

Fig. 240.

The spear-pointed elevator represented in the accompanying figure is by far the most generally useful form, and is quite large enough for any purpose. Sometimes, however, owing to the inability of the patient to open the mouth widely, it may be difficult or impossible to reach a lower wisdom tooth with a straight instrument. For such cases a very useful form is sold, the blade of which is shaped like a single jaw of a pair of thin and sharp stump-forceps; this blade is inclined to the shaft at an angle somewhat greater than a right angle, so that it can be applied without necessitating the mouth being very widely opened.

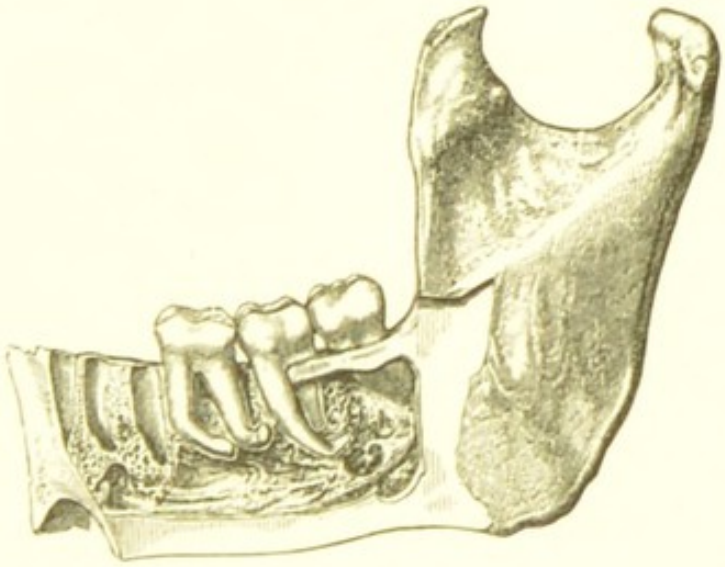
Somehow or other a great clumsy elevator, such as has never been used either by my father or myself, has come to pass under the name of "Tomes' elevator," within the last five or six years. I have rarely had occasion to use any other form than the one here figured.

The practitioner, it is presumed, will be well acquainted with the normal forms of each member of the dental series, but the normal character of the crown does not necessitate a similar condition of the root of a tooth, and the irregularity is discovered only when the operation of extraction is attempted. It is not unusual for the roots of the inferior molars to be curved backwards, and now and then the curve is produced into a positive hook (Fig. 241).

Had the extraction of either the first or second molars shown in the accompanying illustration been attempted, either the ends of the roots would have been left in the jaw or a large piece of the alveolus brought away with the tooth. The former accident would probably have occurred; the tooth, to use a patient's words, would have been broken in the jaw.

The question as to what shall be done with the roots of such a tooth when broken in the jaw is at once raised. In my own practice I invariably allow the extremity or even the lower third to remain, unless it is clearly the subject of disease. If it be loose, its removal is readily effected, and

FIG. 241. (1)



should it have been connected with an alveolar abscess, its removal will not be attended with difficulty. The digging out—if the expression be allowed—of the terminal third of a sound and firmly-attached root is productive of great pain and a considerable amount of injury to the alveolus ; but the presence of the root, if undisturbed, is very rarely indeed followed by any inconvenience.

In the example figured, the roots of the teeth, though curved, are comparatively small, and might probably give way under a force which would not strike the operator as being greater than that required to effect the dislocation of firmly-implanted teeth. But it occasionally happens, from some unseen cause, that a tooth for a time remains unmoved, although a force more than sufficient to remove an ordinary tooth has been employed.

(1) A lower jaw, the external portion of which has been removed, so as to show the position of the roots of the molar teeth, which in this example are curved backwards, with the points turned upwards.

It is when placed under this difficulty that the knowledge and skill of the operator are put to the test. The roots of the tooth may be curved, or they may be unusual in size or number, and the tact to recognise the direction in which the resistance lies, and the knowledge of the irregularities of form to which the several roots of the teeth are liable, become highly valuable.

In the following illustration three forms of irregularity are shown; the tooth with the convergent, and that with the

FIG. 242. (1)

A B C

four divergent roots, would be removed by force employed in the usual direction. In the one case the operation would result in the fracture of one or both roots, or the withdrawal of the portion of the alveolus enclosed by their convergence; in the other, in the fracture of one or more roots, or perhaps in the removal of a portion of the labial or lingual wall of the alveolus. But if a similar course were pursued with the wisdom tooth, it would break off at the neck, or the tooth would effectually resist the efforts of the operator. With the forceps, it would be very difficult to extract such a tooth, but by adopting the elevator, the tooth could be gradually prized out of its socket without difficulty.

In operating upon teeth in the upper jaw, similar difficulties may arise. An unusual size of the one, or the occur-

(1) A and C show a first permanent molar of the lower jaw, with roots convergent, and a corresponding tooth with four divergent roots.

B, a wisdom tooth, with the roots curved backwards, and thickened by hypertrophy of the cementum.

rence of several roots, even in a bicuspid tooth, will sometimes embarrass the operator, by raising a doubt as to whether the tooth will give way under the force he is employing. Similar difficulties, consequent upon similar causes, will arise with respect to the molar teeth of the upper jaw. The application of the usual force is not attended with the usual result.

FIG. 243. (1

The remedy will consist in steadily increasing the force and varying its direction, feeling our way, as it were, until the tooth is separated from its socket.

The wisdom teeth of the upper jaw, though frequently the subjects of irregularity, being implanted in comparatively porous bone, very seldom resist the efforts of the operator.

The irregularities of form to which the teeth are liable, having been described in a preceding part of the volume, need not be again particularised.

Owing to an unusual thickness and strength in the alveolus, the removal of a tooth is sometimes attended with

FIG. 244.

unusual difficulty, and the operator is still further embarrassed when the crown of the tooth so circumstanced is broken off on a level with the alveolar margin. Generally the stump-forceps or the elevator may be made to enter the alveolus, but exceptional cases may arise. To meet these,

(1) Shows a first bicuspid of the upper jaw, with three distinct roots.

Mr. Cattlin proposes to cut away with a small trephine a portion of the outer plate of the alveolus. The root is then readily dislodged, but I have never had need of such a proceeding.

Mention has already been made of a case in which the greater part of the floor of the antrum was torn away by a blacksmith, in the endeavour to extract an upper molar, and of another in which a large portion of the external alveolar plate was broken off the lower jaw with a key instrument, the fragment descending the neck in a series of sinuses, and finally being removed below the clavicle. But even in the hands of the most careful and skilled operators a variety of accidents may occur. A molar tooth of which the fangs are divergent can obviously only be extracted by the bending or the fracture of some portion of the alveolar walls.

A limited fracture of the alveolus, or the bringing away of a fragment of alveolar wall with the tooth, is of very small moment in a healthy subject, seeing that this alveolar border has to be subsequently removed by absorption. In some instances, however, the adhesion of the tooth to the bone is so firm, that a large portion of that surrounding the fangs is torn away. I lately saw the tuberosity of the upper maxilla brought away in the extraction (with forceps) of the wisdom tooth ; on examining it afterwards, it was found that the bone was so strongly adherent to the fangs, that it could only be detached in small fragments : it was to this cause, and not to the shape of the fangs, that this mishap was due.

Mr. Salter (1) records a case where, in the endeavour to extract an upper central incisor, the bone was fractured along a line corresponding to that which separates the intermaxillary from the maxillary bones in the palate, and along a horizontal line at the base of the nose. There was a wound in the palate from which there was some little hæmorrhage. Happily, however, no untoward result followed ; the fractured bone speedily united, and the tooth

(1) "British Journal of Dental Science," vol. xiv., p. 160.

was cut off level with the gum so as to enable the patient to wear an artificial substitute.

Mr. Salter also mentions an instance of the horizontal ramus being entirely broken through by an operator of skill and experience.

A patient lately under treatment at the Dental Hospital presented a very extensive fracture of the alveolar portion of the jaw ; he had applied to a chemist to have the first lower molar on the right side removed, in an unsuccessful attempt to remove which tooth with forceps the fracture occurred. The line of fracture had run forwards at a level corresponding to the apices of the roots of the teeth, so that the portion of bone containing the bicuspids, the canine, and the central and lateral incisors was detached, and only held in position by the soft parts.

A gutta-percha cap was adapted to the crowns of the teeth all round the lower jaw, so as to keep the fractured bone in its place, and every attention was paid to the thorough cleansing of the wounds with injections of diluted Condy's fluid (the fracture being—as is usual in fracture of the jaw—compound in the mouth). Nevertheless, extensive necrosis supervened, and abscesses formed beneath the jaw, so that there seemed but little hope of saving the teeth. The patient was eventually lost sight of, and I do not know what was the termination of the case.

But the most severe accident is recorded by Mr. Cattlin [1] in the following words : "The gentleman who operated in this case had the misfortune to break off the crown of the tooth, and in endeavouring to extract the root with the elevator, the instrument slipped and broke away the tuberosity of the maxilla, with a part of the floor of the antrum, and a portion of the sphenoid bone. In the efforts which were afterwards made to remove the fractured portion of the bone with a pair of stump-forceps, the tooth and the hamular process were also separated, and fibres of the external and

[1] Transactions of the Odontological Society, New Series, vol. iii., p. 138.

internal pterygoid muscles were torn away, and may be seen in the specimen attached to the pterygoid plates. The ultimate results of this accident were that the patient, after suffering in health for some time, became perfectly deaf on the injured side, and the movements of the jaw were permanently restricted. The inflammation had undoubtedly extended into the eustachian tube, and had also involved the ligaments and muscles attached to the inferior maxilla."

It has not been deemed necessary to enter specially upon the extraction of temporary teeth, but a complication sometimes arises to which attention may with advantage be directed. It has happened on two occasions which have come to my knowledge, that in extracting a second temporary molar of the lower jaw, the permanent successor has come away, embraced by the roots of the temporary tooth. In each instance the gum has been inflamed as a result of disease set up in the pulp of the temporary tooth, and it is probable that the alveolar processes had in each case also been greatly reduced, if not altogether removed, by absorption. It is well to bear in mind that such an untoward accident may happen when the gum and alveolar periosteum have been for some time inflamed, but I do not know that any precautionary measures can be adopted.

FIG. 245.

Temporary teeth are, as noted by Mr. Salter (*loc. cit.*), sometimes united to one another by fibrous tissue around their necks, but the removal of more than one tooth in this way is a matter of no practical moment, as it could only occur where the roots were for the most part already absorbed.

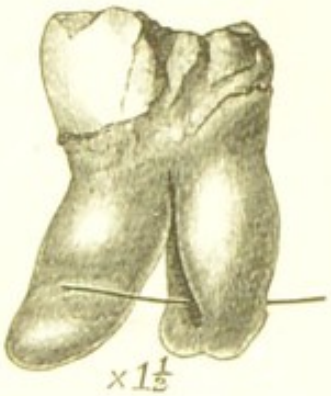
It often happens when the crown of a tooth has been long lost, that the teeth on either side of it overhang the space, and numerous instances have occurred of a sound tooth (most generally a bicuspid) being unintentionally forced out of its socket during the removal of the stump. Where this seems likely to happen, the finger or thumb should

be firmly pressed on the imperilled tooth, and the stump withdrawn from whichever side affords the best prospect of avoiding the other tooth.

The passage of a tooth-fang into the antrum, during an attempt at its extraction, has already been noticed (see Diseases of the Antrum); a precisely similar accident, where, however, the tooth-fang escaped into an abscess-cavity in the bone, instead of into the antrum, has been recorded by Mr. Salter in the paper already several times alluded to. In the event of either of these accidents happening, the root should be sought for and removed, bearing in mind, however, that if the opening be large, it is likely to gravitate towards the opening of itself, so that its removal becomes easy.

In the "Dental Cosmos" (1877), is related a case of disappearance of a lower wisdom tooth during an attempt at extraction: it is probable that it tore up the mucous membrane, which is loose on the inner side of the jaw in this region, and lay between it and the bone. At all events, eleven months later, it was removed from this region, having set up profuse and long continued suppuration between the jaw and the base of the tongue; in this article reference is given to a similar case reported in the "Detroit Review of Medicine" (1876).

FIG. 246. (1)



×1½

Mr. Salter also gives examples of loss of sensation in the regions supplied by the inferior maxillary nerve, consequent on the bruising of this nerve in difficult extractions of the wisdom teeth. Ordinarily this numbness passes off in a few days, but in one of his cases normal sensation has never been quite restored to the lip and chin.

(1) Lower wisdom tooth (Mr. Sewill's case). The bristle passes through a hole in the anterior and a groove in the posterior root, occupied by the inferior dental nerve and vessels.

Mr. Sewill presented to the Museum of the Odontological Society a lower wisdom tooth, one root of which is actually perforated, whilst the other presents a groove upon its side. The extraction of this tooth resulted in paralysis of the area supplied by the mental nerve, which is a pretty conclusive proof that the inferior dental nerve passed through the hole.

I have myself met with deep grooves in a similar position in a tooth, the extraction of which gave rise to marked numbness. It would appear that the normal procedure for a lower molar root, which is approaching the roof of the inferior dental canal, is to turn horizontally backwards, thus avoiding it (see Fig. 241), but that it sometimes may go on growing till it passes it on one side, or may even come to embrace it as in Mr. Sewill's case. As a rule, sensation slowly returns to the area affected, as indeed it often does where the nerve has been intentionally divided in cases of neuralgia.

A remarkable case of dilatation of the pupil and impairment of vision, following the extraction of an upper bicuspid, has been recorded by Tierlink: the symptoms disappeared after application of extract of opium in the socket.

Fatal syncope has been known to follow upon the extraction of a tooth: at Marseilles, in 1881, the extraction of a woman's tooth was attempted, but desisted from on account of alarming syncope; a second attempt was made, or more strictly was about to be made, as fatal syncope ensued before it was actually touched. The necropsy revealed nothing, save a slight degree of cerebral congestion.

In conclusion it must be added that some degree of ostitis may follow upon an extraction however skilfully performed, and it is, as has already been mentioned, much more likely to happen when much injury is done to the alveolar bone, which appears to have very little recuperative power.

When teeth have to be extracted, there is very commonly some degree of inflammation existing about them, and instead of quieting down, this may run on to the exfoliation of small fragments.

There is not much to be done in the way of treatment: opiate fomentations to relieve the pain, antiseptic washes, such as Condy's fluid, thrown well into the socket with a syringe, and iodoform in powder, as a local application, seem to be of service in shortening the duration of the inflammation.

HÆMORRHAGE FOLLOWING EXTRACTION.

Hæmorrhage from the Alveoli.—Prolonged bleeding from the gums has been alluded to in connection with diseases of that portion of the dental system. It is hæmorrhage occurring after the extraction of teeth which has yet to be described. Ordinarily blood ceases to escape from the socket within half an hour of the removal of the tooth ; but isolated instances, in which the bleeding has ceased only with the life of the patient, have been at long intervals recorded ; and cases in which the flow of blood has been checked with considerable difficulty, and only after the patient has been greatly reduced, though not common, are by no means rare.

Before proceeding further in the description, it may be useful to inquire under what condition these untoward consequences follow upon a very simple and, under ordinary circumstances, a very safe operation.

When from an insignificant wound the blood flows for a longer time and in a larger stream than the nature of the injury would lead the surgeon to expect, a state of system is denoted which may be a permanent character peculiar to the individual, or may arise from a temporary condition of the circulating fluids, or from the condition of the blood-vessels themselves. The pathology of the hæmorrhagic diathesis is, however, far from being understood (1) ; want of coagulability in the blood and want of contractility in the vessels being almost all that we can predicate of it. There are those who have at all times difficulty in arresting bleeding even from

(1) See Mr. F. Mason, in "Monthly Review of Dental Surgery," August, 1872.

a slight wound, and in them prolonged hæmorrhage usually follows the extraction of a tooth. A patient of my own suffered considerable inconvenience from a very loose lower bicuspid tooth, but dreaded its removal, in consequence of the difficulty he suffered in controlling the hæmorrhage which had on previous occasions followed the extraction of teeth. The loose bicuspid was, however, removed, and the blood ceased to flow from the socket within half an hour. The patient returned home, but before he had reached the end of a short railway journey, bleeding from the socket had recommenced, and many hours elapsed before the hæmorrhage was perfectly arrested. The hæmorrhagic diathesis was in this case fully pronounced, and was independent of the general health. The condition of the vessels or of the blood must have been different from that which usually exists in a perfectly healthy individual, but the difference was not sufficient to interfere with the general health of the patient.

In some persons the disposition to profuse bleeding occurs only at a comparatively advanced period of life ; the fault then lies in the vessels themselves, the coats of which become stiffened by the presence of a deposit within their substance, and they consequently lose the power of contraction. In other examples the hæmorrhagic tendency depends upon an abnormal state of the blood—upon the presence of blood disease, as certain maladies are called.

Sea scurvy and purpura afford the most striking examples of such diseases, one peculiar feature of which is the loss of coagulating power in the blood.

In such cases hæmorrhage may occur without there being any wound at all, blood being poured out from a mucous surface, *i.e.*, from the lungs, the bowels, the fauces, the tongue, or the gums. Dr. Hyde Salter met with a case in which the patient's life was greatly imperilled by loss of blood, the chief point of hæmorrhage being the gums between the lower bicuspids, from which place blood had welled up almost without cessation for upwards of a month. After the failure of other remedies, it was finally arrested

by the application of a spring clip, which had to be removed after about twelve hours on account of the pain which it caused; however, the inflammatory swelling which it had set up seemed so to have altered the vascular condition of the parts that the bleeding did not recur.

In a healthy subject the division of blood-vessels of moderate size is followed by contraction of their divided ends, and by the coagulation of the blood upon the surface of the wound. By the concurrence of these changes, the escape of blood is arrested. But when the vessels have lost the normal power of contraction, or the blood its capability of coagulation, the bleeding, even from the removal of a tooth, may seriously endanger the life of the patient.

In patients of hæmorrhagic diathesis, the extraction of teeth, and, indeed, other operations which involve the injury of soft parts, should be avoided, unless the circumstances of the case render them absolutely necessary. But in the practice of dental surgery the existence of this state of system sometimes is learnt only by the occurrence of prolonged bleeding from the alveolus, or from the statement of the patient after the tooth has been extracted.

Treatment.—In the cases of alveolar hæmorrhage which have come under my own care, the bleeding has been speedily arrested by matico. After clearing away the coagulated blood, a leaf of that plant, previously softened with hot water and rolled up, has been placed loosely within or fitted closely into the socket. A few folds of lint laid upon the gum, and held in position by closing the mouth, have been sufficient to retain the matico in the alveolus until the bleeding entirely ceased. On examining the mouth on the following day, I have often found the leaf held in the socket by the blood which had coagulated about its surface and within its folds.

The degree of success attendant on the use of the matico leaf will greatly depend on the care with which it is applied. The leaf having been thoroughly softened, should be cut into strips as wide as the vacant alveolus is deep; they should be

rolled up into a form resembling that of a cigar, and of such a size as to fit the alveolus. In rolling up the leaf the rough side should be kept outwards. The rolls are taken up in plugging-forceps, and passed firmly down to the bottom of the alveolus, the somewhat pointed end being introduced first. In the case of upper bicuspids, the operator should somewhat flatten the roll of matico leaf, and before introducing it carefully ascertain whether the root is bifurcated; should it be so, two small rolls should be first passed up, one into each opening. If the matico leaf be carefully applied, it acts as a plug, as well as being an astringent; and I have never known it to fail in a single case where its application was satisfactorily made. But, should it fail, a carefully constructed plug should be tried. The socket having been cleared of blood, a little matico may be introduced, and then small pieces of lint added and carefully packed one after another, so as to completely fill the alveolus. Upon the surface of the gum, folds of lint should be placed in sufficient number to allow the teeth of the opposite jaw, or the jaw itself in the absence of teeth, on closing the mouth, to produce firm pressure upon the surface of the bleeding socket. To keep up the pressure, the volition of the patient should not be trusted. It will be better to pass a bandage under the jaw and over the head sufficiently tightly to prevent the mouth from being opened. The use of escharotics in the treatment of hæmorrhage is attended with this immense disadvantage: the parts with which they come in contact are destroyed, and as their action cannot be limited to the interior of the bleeding alveolus, the surface of the wound may become extended, and should the caustic fail to produce the contemplated effect, the difficulties of treatment are enhanced by the increased size of the bleeding surface.

In the case of a child who suffered from hæmorrhage after the extraction of a temporary molar in the lower jaw, lunar caustic, and afterwards spirits of turpentine were applied without success. At the time I saw the patient, blood was oozing both from the alveolus and the surrounding gum, the

surface of which had been made raw by the caustic. This case yielded to the matico leaf carefully applied in the manner already described.

For the reason given above, perchloride of iron is an objectionable application. I was called in consultation to see a case in which extensive sloughs about the fauces had been caused by its injudicious application, and the whole sloughy surface was oozing ; and I may add that in dental cases I have never seen it succeed in cases which had resisted other and less objectionable styptics.

In obstinate cases the socket should be firmly plugged, and nothing does this better than the extracted tooth if that is obtainable, its root being wrapped round with a very small amount of wool impregnated either with dry tannin or with a solution of tannin.

Pressure may sometimes be more effectually made by the help of a plate of shellac moulded over the gums, or of metal, if there be time to make one ; various elaborate apparatus have been devised with this object, something like the appliances used for retaining the portions of a fractured jaw in position, but these would be sure not to be at hand when required.

Failing these remedies, the actual cautery might be used, and in any severe case, ergot in free doses should be given, while in a person in whom hæmophilia is known or suspected, ergot and sulphuric acid may be administered for a few days beforehand ; this plan of treatment was successfully carried out by Mr. Turner (" Brit. Assoc. Jour.," February, 1886). In any suspected person, the socket of the extracted tooth should be at once plugged without waiting for bleeding to occur, and in this way I have extracted several teeth for a youth with marked hæmophilia, with no further trouble than that the administration of gas brought on profuse epistaxis, which we had great trouble in checking.

But in spite of every effort an occasional fatal case occurs ; in one of those recorded it is noted that there was

oozing from a large surface, but perchloride of iron had been used, and it appeared to have greatly intensified the peril; in this case the common carotid was tied with no good result and the patient died.

A fatal case occurred in St. George's Hospital under the care of Mr. Dent in a patient, aged 22, who had lost his father from epistaxis; he had had a lower molar extracted without any difficulty; bleeding occurred, and the socket was plugged a first and a second time with beeswax, then ergot with turpentine and perchloride of iron were tried, then matico leaf, then a wooden plug. Later on the anterior wall of the alveolus was broken down, and a compress of cork dipped in perchloride of iron inserted. The bleeding having again recommenced, the lower jaw was divided, and the inferior dental canal plugged with wood. Shortly after the operation a fresh hæmorrhage set in from the wound, which was temporarily controlled by a styptic, but in the evening of this, the fourth day, bleeding came on again, and the patient died.

Were I to have the misfortune to meet with such a case in the lower jaw, I should be inclined to try the division of the inferior dental canal by means of a drill in the dental engine, just as is sometimes done in cases of neuralgia; the cylindrical hole thus produced could be easily plugged with a wooden peg, and the operation produces no laceration of the surface to speak of, so that the patient's condition could in no way be made more risky even if it failed in its object.

ANÆSTHESIA.

For dental operations, nitrous oxide is to be preferred to all other anæsthetics, inasmuch as it is far safer than any other: this, which is a matter now of clinical experience, drawn from a vast number of administrations, was clearly indicated by experiments upon animals in the early days of the introduction of the gas as an anæsthetic. For it was found that the arterial tension was but little lowered when an animal was under its full influence, it in this respect markedly contrasting with chloroform; and that even when the gas was pushed to the extent of stopping respiration, the heart continued to beat, and the animal could be revived by artificial respiration.

When a longer insensibility is desired, it can be obtained by the administration of a small quantity of ether just as the point of insensibility is about to be reached with the gas; and if it is desired, a full ether anæsthesia can be obtained by commencing with gas, but more speedily changing to ether. But chloroform should never be employed for dental operations: whether it be that the upright position adds a danger when the heart's action is lowered, or whether there be some other cause, it is certain that quite a considerable number, one quite disproportionate to the number of administrations, of patients have lost their lives under chloroform administered for dental operations.

The writer has, in the course of his practice, only once operated upon a patient under the influence of chloroform, and habitually absolutely refuses to do so: it is conceivable that in the event of long anæsthesia being required for a very young or a very aged person, these taking ether badly,

its use might be justifiable, but such cases must be rare indeed.

From chloroform, healthy adults have repeatedly died: to emphasize the opinions here expressed, it may be men tioned that quite lately a girl died under chloroform administered for a dental operation, who had less then a fortnight before in the house of another dentist taken gas with perfect safety and success.

A few deaths have taken place under nitrous oxide, but as yet no case in which the patient was a vigorous healthy person: one took place at Exeter, but this case is open to doubt as to whether a foreign body (part of the gag) may not have got into the larynx, and the patient was an invalid. Another took place in Manchester, but here the patient (a medical man) suffered from heart and lung disease, and it was administered a second time at a short interval. A third case occurred in the Dental Hospital, the patient suffering in this case from extensive cancer of the tongue, which may well have embarrassed respiration; and a case occurred in Paris where an enormously stout elderly man succumbed.

So far as is known to the writer, no other cases of death at all due to the anæsthetic have occurred, and the record is such as to leave nitrous oxide by far the best and safest for dental purposes.

But in operating under any anæsthetic there is a source of danger which must be carefully kept in view, and that is the passage of foreign bodies into the air passages. This might happen even in a conscious patient, but it is very unlikely to do so, and if it did the body would probably be coughed away at once.

A fatal case occurred in the hands of the late Mr. Clover from the breakage of the gag (a spring gag made in two pieces, which broke apart). In this case the cylindrical gag passed through the vocal cords and lodged below them in the larynx, which it almost fitted. After about an hour tracheotomy was performed by Mr. Lawson, and the child did well for a few days but ultimately sank from bronchitis.

M. Poulet ("Brit. Med. Jour.," Aug., 1879), records two fatal cases from teeth slipping into the larynx, and mentions others which were not fatal; he recounts a fatal case which occurred to M. Rigaud whilst operating for harelip: a milk tooth came out and lodged in the rima glottidis, the nature of the asphyxia not being guessed at the moment.

In the "American Med. Record," Nov., 1881, a case is recorded in which a patient, after the extraction of thirteen teeth under nitrous oxide, suffered from slight epigastric pain, cough, dyspnœa, and nausea, and after four days, marked pneumonia set in. Six days after the extraction a tooth was coughed up, with immediate relief to all urgent symptoms, but a month afterwards moist râles were abundant, and it was six weeks before the patient was well.

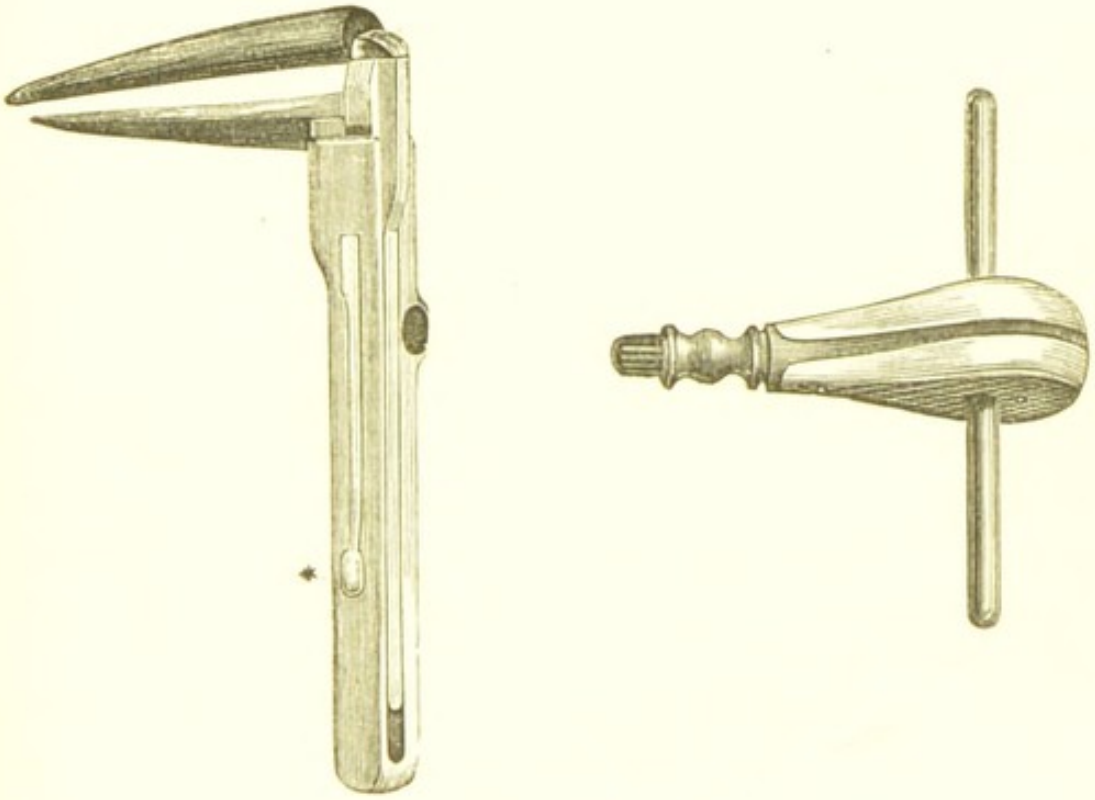
But the most remarkable case of all is that which came under the care of Sir William MacCormac ("Trans. Odont. Soc.," 1885). In this, a pair of bicuspid forceps broke, and one blade, measuring about an inch, passed down to the bifurcation of the bronchi. Sir William MacCormac was able, after performing a tracheotomy, which involved a large wound and the laying open of a good many rings of the trachea, to grasp it and get it out, and the patient made a good recovery.

The administration of anæsthetics does not fall within the province of the dental surgeon as such, and hence any lengthy discussion is beyond the scope of the present volume. There are, nevertheless, some few points with which he is directly concerned, such as the means of propping open the mouth, &c.

The accompanying useful form of speculum for opening the mouth when the lower jaw is forcibly closed, and so a prop cannot be introduced prior to commencing the inhalation, may be brought before the attention of the reader. It consists of two flattened blades, which close together like a bird's bill, the lower passing into a concavity within the upper blade. Upon the steel, which gives strength to each blade, a covering of horn is riveted, and a small piece of

gutta-percha is let into the surface against which the teeth are destined to rest. From the jaws or blades of the instrument two steel rectangular stems are continued, the one passing within the other and rendered movable, the one within the other, by a rack and pinion motion. The separation of the blades is effected by a removable handle, and they are allowed to again approach each other by releasing

Fig. 247. (1)



the spring catch. The construction of the instrument will be readily seen on referring to the figure (Fig. 247).

For ordinary cases the solid gags, manufactured in vulcanite, answer the purpose admirably, but sometimes it is difficult or impossible to find a place in the mouth in which

(1) An instrument devised by Mr. Cattlin for opening the mouth, when from any cause the jaws become rigidly closed. It consists of two sliding bars, or stems, moved by a rack and pinion, and held in position by a spring catch shown at *. The blades, or jaws, are continued in steel from the two portions of the stem, and are covered with horn. The handle, or pinion, is shown detached from the body of the instrument.

they will rest securely, and yet be out of the operator's way.

A valuable gag designed by Mr. Hutchinson presents the additional advantage of holding the tongue down; but unless the front teeth are firm, there is a chance of their being forced out by spasmodic closure of the jaws. Indeed, this accident once happened in my own hands, though, fortunately, I had intended to remove these teeth at a future administration of the gas, so that the patient was quite unaware that their removal had not been intentional.

Some difficulty may be experienced in arranging the gag in mouths which are nearly edentulous; in this event large fine-textured corks, in each of which a groove has been filed, will often prove serviceable.

To these matters, however, the administrator of the anæsthetic will ordinarily attend; the one point, on which the operator cannot be too careful, is to withdraw every stump or detached piece of tooth from the mouth. With the forceps this is easy, and the operator must never loose his hold of a stump or tooth until it is safely outside the mouth; but with the elevator there is an additional risk of the fragments falling back into the larynx; and such an accident is the more likely to escape notice at the moment, on account of the lividity and asphyxiated aspect so often presented by patients under the influence of the gas.

As the great danger is the passage backwards of foreign bodies, the operator must be careful not to lose sight for a moment of the tooth which he is extracting; and should he be using the elevator, the stump should be seized by the left hand the instant it is lifted out of its socket.

It is, of course, undesirable that one person should administer the anæsthetic and operate, as the unconscious patient requires all the attention of the administrator, without his being distracted by having anything else to do.

And in the interest of the operator it is very undesirable to administer gas to females alone, delusions upon the

subject of indecent assault, which cannot be dispelled by the strongest evidence of relatives present in the room, are not of great rarity, and it may perhaps be of service to give here a reference to a summary of a good many such cases collected in the "Dental Register," Cincinnati March, 1882.

The salts of cocaine have been lately proposed as local obtundents, but so far the results have fallen far short of the expectations formed.

Cocaine is thoroughly efficient in slight operations upon the eye, where it renders the conjunctiva insensitive: in the same way it will render the surface of the gum insensitive, and enable the operator to force it out of the way or to cut it away without pain. But for sensitive dentine it is little or no use, and for extractions it is of doubtful utility.

Mr. Hunt of Yeovil has great faith in it; and he employs it by injecting freshly made solution into the neighbourhood of the tooth to be extracted: happening to have a somewhat tender stump in my own mouth, I experimented upon it by injecting at intervals two grains of hydrochlorate of cocaine. This had the effect of making an area of the size of half a crown on the gums and mucous membrane of the cheek absolutely insensitive, but the stump remained all the time slightly tender to firm pressure, so that it would have been decidedly painful had it been removed.

But the two grains had a most unpleasant constitutional effect: I was unable to walk straight, felt very giddy, and, in fact, very much as though I had been smoking my first pipe, and it was two hours before the effect passed off.

The point of the observation, for the sake of which I relate it, is that complete local anæsthesia was not produced even when a very unpleasant constitutional effect had been arrived at. Unpleasant faintness has occurred in several cases, and recently there has been a death from cocaine in St. Petersburg: in this case, however, no less than twenty-four grains were injected into the rectum. But so far as dental purposes are concerned, it is not likely that any really dangerous amount could be administered.

ODONTOMES.

Irregularities in the form of individual teeth have already been noticed at a previous page; these irregular teeth, however, are linked, by insensible gradations, with those masses of dental tissues which bear no external resemblance to the form of teeth.

The name "odontomes" is applied to those masses of dental tissues which result from morbid conditions of the formative pulp; these may consist in hypertrophies, local or general, or various degenerations. It is hardly possible to strictly define what is meant by an "odontome," in the usual acceptation of the term; for it is not usual so to designate, for example, the teeth with enamel-coated nodules, near their necks; and yet these excrescences differ only in degree from those which equal or exceed the whole tooth in size, and would, by most writers, be called "odontomes." Professor Broca has described these malformations, taking as the basis of his classification the periods of development at which they arise; and although something may be said against this sharply-defined discrimination of the one form from the other (1), yet it has obtained currency and must be described here.

In order to understand the origin of these pathological products, it is necessary to clearly keep in view the normal process of tooth formation. At an early stage, a future tooth is represented by a mass of submucous tissue (meso-

(1) Prof. Wedl ("Pathologie der Zähne," p. 116) objects to Prof. Broca's classification, on the ground that it is not based on histological investigations, nor is it in exact accordance with the history of tooth development. Nevertheless, as any classification is better than none, in the absence of a better it has been adopted in these pages.

blastic), which has, as it were, risen up to meet the inflected process of oral epithelium (epiblastic), which is to form the enamel organ. This papilliform mass, assuming the form and dimensions of the crown of the tooth, becomes covered on its surface by a layer of cells, known as the "membrana eboris," whose special office is the formation of dentine; very shortly it becomes covered over with a cap of formed dentine, which when once formed is unalterable.

Professor Broca (1) classifies odontomes according to the period at which they arise, dividing them into four groups:

I. Those which arise before the development of the membrana eboris (odontomes embryoplastiques).

II. Those which arise shortly before the formation of the cap of dentine (odontomes odontoplastiques).

III. Those which arise during the formation of the crown of the tooth (odontomes coronaires).

IV. Those which arise during the formation of the root, after the completion of the crown (odontomes radiculaires).

The first class, those which arise before the formation of odontoblast cells, need not detain us long, as, even if we admit the correctness of Professor Broca's views as to their origin, they bear no semblance to teeth, and fall within the province of the general surgeon rather than that of the dentist. At the period of their origin the dental germs contain no histological structures special to tooth germs: and the result of their hypertrophy would contain no calcified tissue, but only a structure identical with that of fibrous or fibro-plastic tumours arising elsewhere. But an ordinary fibroid tumour, arising in the jaw, springs from, and is widely connected with the bone, so that its enucleation is an impossibility; whereas the fibroid tumours, by Broca claimed as odontomes, are encysted, and may be shelled out by the use of the fingers, or of a spatula; unless, being of long standing, they happen to have contracted adhesions to the cyst wall; even then they do not show any continuity

(1) "Traité des Tumeurs," p. 300. Paris, 1869.

of structure with the surrounding bone. Such a tumour is one which occurred in the practice of Mr. C. Heath: a fibroid tumour was removed from the jaw of a lady, which shelled out in this way, and was, in fact, completely encysted; on microscopic examination it was pronounced to be a fibro-plastic tumour, and its recurrence was confidently predicted. Two years afterwards, however, no sign of recurrence had been seen.

In one instance M. Robin met with a tumour, situated in the lower jaw of a child aged two and a half years, which was apparently fibrous, but it was studded with papillæ, on which distinct dentine and enamel were found; and Professor Wedl (1) quotes Virchow's description of a tumour, which he designated a "myxomatous proliferation of the dental germ," occurring in a calf. It appeared as a free polypoid tumour, three inches in length, and seven and a half in breadth; on its surface were papillæ, here and there coated with firm enamel and dentine.

It is also suggested by Professor Wedl (*op. cit.*, p. 275) that a case of sarcoma, occurring in a man aged thirty-five, may have had some connection with an enamel germ, inasmuch as in its fibrillated stroma were numerous cavities and tubes lined with epithelium, calling to mind an utricular gland, the terminal vesicles of which had become in places pinched off from the rest.

Mr. Eve ("Trans. Odont. Soc.," 1885) calls attention to this class of tumours, and inclines to the view that they may have their origin in tooth germs; it is interesting to note that he figures the process of colloid degeneration going on in them, resulting in the formation from an epithelium of masses of stellate cells with their interspaces filled with colloid material, exactly like what we see in an enamel organ. And in the poison canal of a viperine tooth we may see the enamel cells, here become useless, undergoing this very degeneration.

(1) "Pathologie der Zähne," 1870.

But here again Broca's classification fails to be quite satisfactory: granted that these tumours are uncalcified odontomes, calcified odontomes with largely proliferated enamel organs occur, and it is not logical to widely separate the calcified from the uncalcified simply because of the deposition of lime salts in them, if so be that their genesis is in other respects the same.

Mr. Sutton ("An Introduction to General Pathology," 1886), attacks Broca's classification, and proposes an alternative one, but he underrates in my opinion the share taken by enamel in their composition, and its significance.

He would divide them thus:

1. Cementomata.
2. Dentomata.
3. Osteo-dentomata.
4. Mixed dentomata,

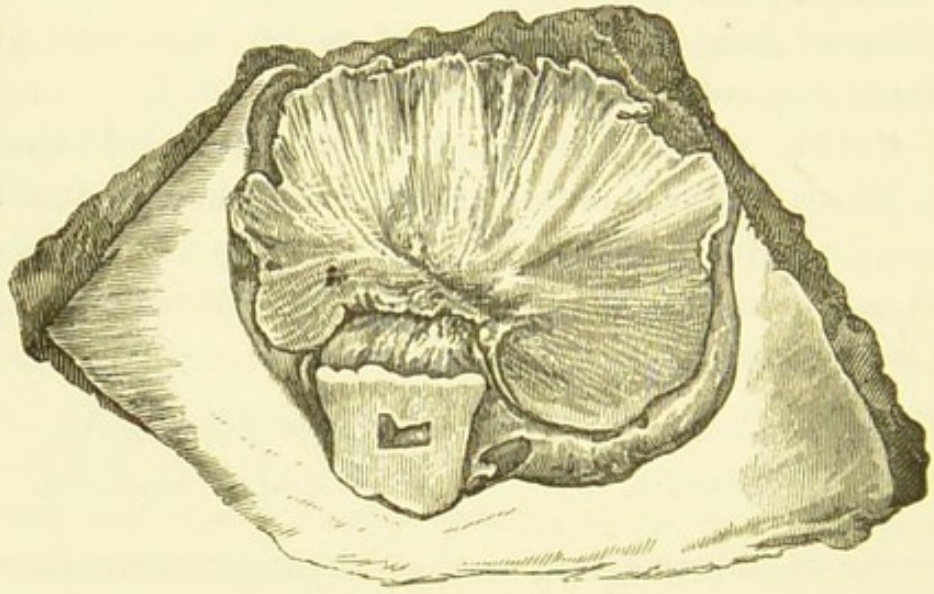
classifying them according to the prevalent tissue present.

Odontomes of Broca's second class (odontomes odontoplastiques) require somewhat more detailed notice; at the date of their origin the dentine germ is covered by a layer of odontoblasts, more or less completed, but dentine has not yet been formed. Consequently, when the bulb has become the seat of an irregular outgrowth, a mass is produced containing dentine from the calcification of the odontoblasts, and perhaps also enamel, the enamel organ having followed, as it tends to do, the wanderings of the dentine germ; but as no part of a tooth had as yet been formed, the mass may be a confused heap of dental tissues, not bearing the most remote external resemblance to a tooth.

It will be well to note, before proceeding further, that the product of the calcification of a dentine-pulp is by no means always true dentine: so long as the layer of odontoblasts coats its surface, true dentine is produced; but this layer is easily displaced and destroyed, and, once destroyed, is probably never formed afresh. Any calcification which may take place after the destruction of the odontoblasts will assume the form of secondary dentine, or of confused bone-like tissue, but no more true dentine can be formed.

The foregoing description may serve to explain the manner in which the mass here figured arose.

Fig. 248. (1)



In this case the second molar of the lower jaw was represented by an irregularly flattened mass, composed of enamel, dentine, and a bony tissue thrown together without any apparent regularity. The wisdom tooth was held down beneath this most extraordinary mass. The nature of the case not having been rightly understood, a portion of the jaw including it was removed; the figure showing the appearance presented by the excised portion after a longitudinal section had been made through it. The mass when removed from its receptacle in the bone, presented no resemblance to a tooth. From its surface little beads of enamel here and there projected, whilst the woodcut fairly represents the naked-eye appearance of the section through its middle. The radiate appearance is due to the alternation of the

(1) Shows the appearance presented by a vertical section through a portion of the lower jaw, in which was enclosed an irregular mass of dental tissues representing the second permanent molar, beneath which the wisdom tooth was confined. The prominence at the lower part of the figure shows the angle, and the part to the left a portion of the ascending ramus of the jaw.

structures which compose it: these are mainly dentine and a bone-like tissue, which in some places occupies a position relatively to the dentine which would lead to the inference that it is cementum, whilst in others it is obviously the result of the calcification of portions of the dentine pulp which had lost their layer of odontoblasts, and had, therefore, ceased to produce true dentine by their calcification. There is no single definite pulp-cavity, but the dentinal tubes radiate from numerous small canals, and become lost in the confused irregular structures which abound around them. In places the dentinal tubes radiate with considerable regularity from these central canals, whilst in others they are very confused and irregular in their course.

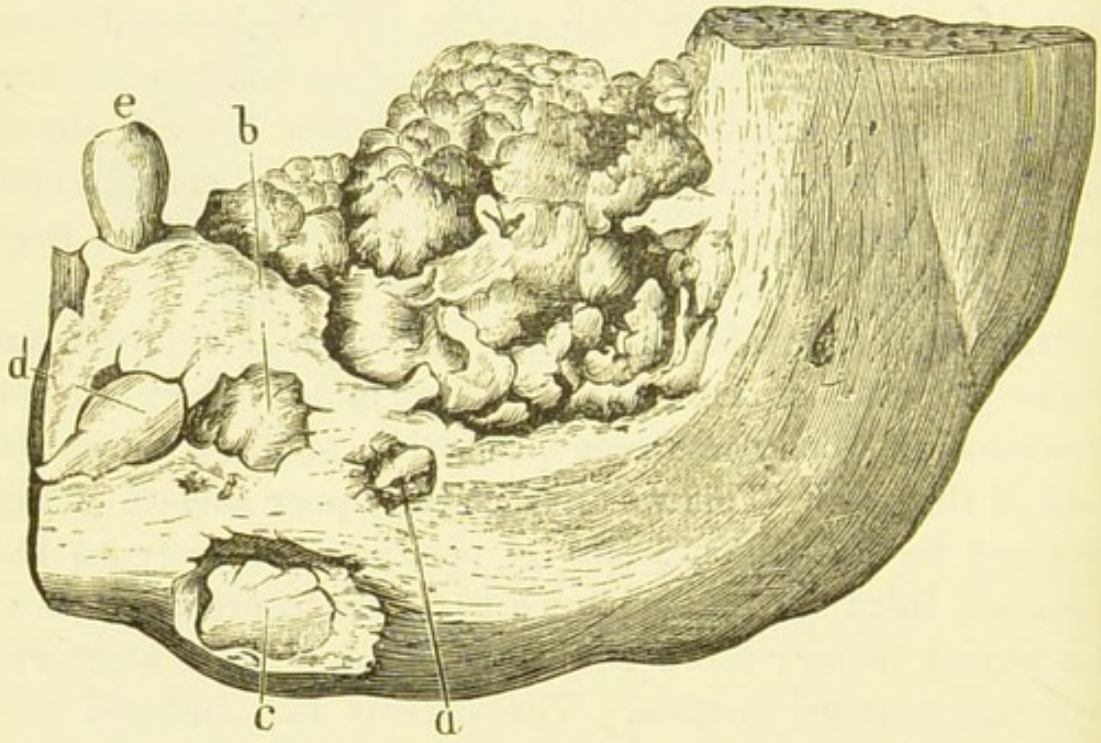
Prior to the operation there was considerable enlargement of the jaw behind the first permanent molar, where a hard, brown-looking body was seen projecting slightly above the level of the gum. This was in fact the upper surface of this aberrant tooth, which, from its position relatively to the first and third molars, is shown to be the representative of the second molar: a few nodules of enamel were scattered over this exposed surface. The patient had suffered considerable pain in the situation of the enlargement: and the case having been regarded as one of disease of the bone, which was likely to proceed from bad to worse, the portion of jaw figured was excised by Sir W. Fergusson.

Dr. Forget records a somewhat similar case: the mass in this instance occupied the whole space between the first bicuspid and the ascending ramus of the jaw, and was by him regarded as the representative of the second and third molars of that side, the crown of one molar and the second bicuspid having been found held down beneath it. For the use of this figure, which is copied from Dr. Forget's memoir, "Des Anomalies dentaires et de leur influence sur les Maladies des Os maxillaires," I am indebted to the kindness of Mr. Christopher Heath.

The patient in whom this odontome occurred was aged twenty, but disease of the jaw had first been remarked at the

age of five years. Behind the first bicuspid no teeth were to be seen, but the jaw, as far back as the ramus, was the seat of a smooth, unyielding tumour. This was removed by a vertical saw cut in front of the bicuspid, and a horizontal cut at the level of the inferior dental foramen. After removal

Fig. 249. (1)



the jaw was found to be expanded over an uneven, tuberculated oval mass, of the size of an egg. Beneath it at one spot (*e*) was found the crown of a molar tooth, whilst between it and the bone was a thick, more or less fibrous membrane. On microscopic examination it was found to be mainly composed of dentine, the surface of which was in places covered with enamel, this latter dipping down into the crevices, at the bottom of which cementum was found.

In this case resection of nearly half the jaw was practised, but in a case related by Mr. W. A. Harrison, before the Odontological Society (2), a mass occupying the whole space

(1) *e*, first bicuspid; *d*, second bicuspid; *c*, first molar; *a* and *b*, portions of the mass which protrude through the bone.

(2) Prof. C. Wedl. "Pathologie der Zähne," 1870, p. 125.

between the incisor and molar teeth came away spontaneously, leaving a groove large enough to receive the last joint of the thumb; this speedily filled up by granulation.

A similar case, in which the mass lying above the wisdom tooth was removed by operation, is quoted by Wedl (1), and figures taken from models of jaws are given, showing the rapid contraction and filling-up of the cavity left.

The odontome represented in the accompanying figure is convex on its upper, and concave on its lower surface; it was placed like a cap over a lower molar tooth, the impressions left by the cusps of which may be traced on its inner surface.

The upper surface, represented in the figure, is partly smooth, and partly studded with enamel nodules, like those met with in Sir W. Fergusson's case. It was made up of irregular tracts of dentine, amongst which folds of enamel dipped down; no well-marked cementum was found.

The section represented in Fig. 250 was made from a very similar odontome, and will serve to exemplify the usual structural characteristics of these growths. It is traversed by parallel vascular tracts (*a*), which here and there dilate

Fig. 250. (2)

into pouches, or branch out into several divisions; from these vascular tracts the dentinal tubes radiate with considerable regularity.

(1) "British Journal of Dental Science," 1862.

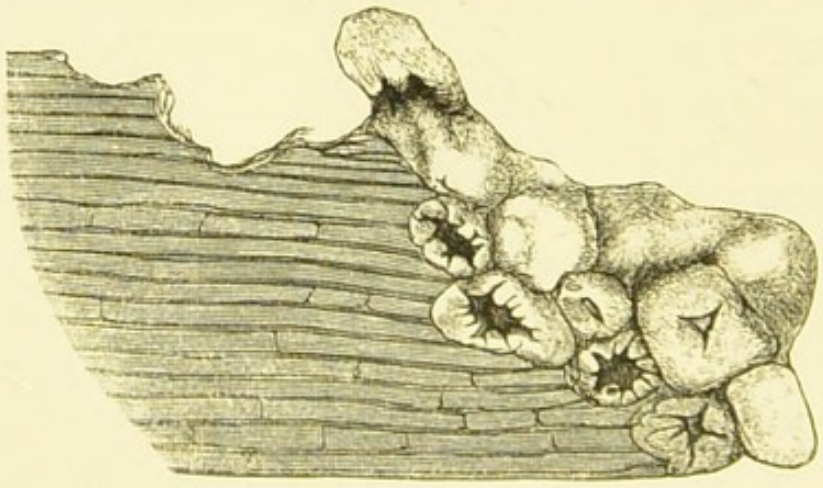
(2) From Heider and Wedl's "Atlas zur Pathologie der Zähne." *a*, Smooth enamel-coated surfaces; *b*, nodules of enamel.

Globular masses are in places very abundant, and at the

Fig. 251. (1)

peripheries of the several systems of dentinal tubes irregular spaces abound. In some parts enamel is continued far down

Fig. 252. (2)



into clefts and fissures, so that on section it is seen lining cylindrical spaces, as is seen at the point *b*. There is no distinct investing layer of cementum, though here and there the clefts are occupied by lacunæ with numerous canaliculi.

(1) From an odontome. From Heider and Wedl's Atlas.
(2) Section of an odontome.

In microscopic examination of odontomes, it is very common to find those marks of alternations of absorption and deposition which we commonly regard as evidences of inflammation: the accompanying figure of calcified osteoclasts bedded in excavations of dentine shows this character.

As will be inferred from the recital of the above cases, there is a danger of operations of needless severity being performed through a failure to recognise the true nature of the disease. Indeed, a surgeon so experienced as Mr. Christopher Heath, has put upon record that he had a narrow escape of doing this himself, but the operation having been postponed for a time, the nature of the disease became evident during an operation undertaken for supposed necrosis.

The case is so instructive that it may be quoted in full (Heath's "Injuries and Diseases of the Jaws," 3rd edition, p. 221):—

"Miss C., aged eighteen, the daughter of a dental surgeon, was brought to me in July, 1881, with a considerable swelling of the right side of the lower jaw, some of which was evidently inflammatory, and partly the result of previous treatment; but there was, I thought, sufficient evidence of expansion of the jaw to warrant the opinion that a tumour was present, and I therefore recommended the removal of a portion of the jaw. Suppuration was then present, and with the finger a rough surface of apparently exposed bone could be felt, but this I regarded as the result of inflammatory action excited by the injudicious irritation of a periosteal growth, since partial necrosis of a jaw involved by cartilaginous or malignant growths, which have been irritated by exploratory measures, is in my experience by no means uncommon. The patient had the advantage of the opinion of Sir James Paget, who was not perfectly satisfied as to the existence of a tumour, and expressed a hope that the case might prove to be one of necrosis. Under these circumstances the operation was postponed.

"On my return to town in September I found the patient improved in health, and the swelling diminished by the sub-

sidence of the inflammation, but a considerable enlargement of the lower jaw still present, with a sinus opening externally.

"From the mouth a white mass was visible, which, appearing among granulations, looked like necrosis, and I agreed that an attempt should be made to remove this, although I could not think it accounted for the expansion of the jaw. On September the 8th, with the assistance of Dr. Snow, the patient was put under chloroform, and I proceeded to examine the mouth with my finger. I soon found that the white mass was not bone but tooth, and thus was unable to make out its outline. I was unable to make any impression with chisel or gouge, but at last with an elevator succeeded in lifting out of its bed a mass of dental structures forming the odontome shown in the figures.

"The mass measured $1\frac{1}{2}$ inches antero-posteriorly, 1 inch transversely, and $1\frac{1}{4}$ inches from above downwards. It weighed 315 grains.

"A section of the odontome has been made, and it has been submitted to Mr. Charles Tomes, who has kindly furnished the following report:—

"The whole surface of the odontoma is nodulated and roughened by stalactitic excrescences, and there is at no point any form recalling the character of a tooth crown.

"The surface of a section presents a complicated marbled pattern, due to the admixture of several dental tissues, and it bears a general resemblance to that form of dentine known as 'plici-dentine,' or 'labyrintho-dentine.' On the whole the mass is of tolerably uniform structure throughout, though there is an area of somewhat simpler structure in its upper and central portion, from which folds of dentine appear to radiate. So far as it goes, this would seem to point to the whole mass being the product of a single tooth germ, rather than that of several fused together, a matter which was left in some doubt by the absence of an accurate history of the case.

"The excrescences of the surface, as well as the greater part of the interior, are made up of folds of dentine, in

which dentinal tubes are very abundant, and which surround flattened remnants of pulp chambers; between and intimately blended with this comparatively well-formed dentine, is a more coarsely calcified material, containing numerous lacunæ, and permeated by vascular channels,—in fact, osteo-dentine.

"Enamel is present upon some of the nodules of the surface, but it does not by any means form a complete investment; where present it dips in folds, following the convolutions of the dentine, and it is to be met with in the very centre of the mass, though not very abundantly. It is nowhere well formed, being brownish and opaque.

"This odontoma is the product of the formative dentine pulp of a tooth (or teeth), which has, in place of remaining simple, budded out innumerable processes on all sides, and finally has calcified; its enamel pulp has in parts followed the complexities of its surface, and in parts failed to do so, or, at all events, has failed to perpetuate itself by calcification."

These irregularities in the form and size of the dentine pulp may, as development goes on, give place to a more normal process, so that we occasionally find that at the bottom of a warty-looking irregular mass are tolerably normal roots. Such teeth have been described as "warty teeth" by Mr. Salter, but it seems objectionable to multiply names, and they have, therefore, here been included under the same heading as those in which the abnormal development continues till the last.

The tendency towards the assumption of the normal form in the fangs is well illustrated by the accompanying figure. The crown is perfectly colossal, though it retains in a measure the typical form of four cusps; the investment of enamel is imperfect, but the cement is continued from the fangs over the crown, on the sides and top of which it attains to a great thickness.

Passing on to the next class, the "odontomes coronaires" of Broca, we no longer have a shapeless mass in which little or no resemblance to a tooth can be traced. As these

originate after the commencement of calcification, at a time when there is a cap of dentine over the pulp, this crown is always to be found bearing a tolerably close resemblance to that of a normal tooth, however much the aspect of the

FIG. 253. (1)

whole mass may be altered by subsequent outgrowths of the pulp. This form of odontome is far more common than

FIG. 254. (2)

that last described, and is exemplified by the specimen here figured, which is taken from my father's collection. Here the outgrowth is limited to the anterior surface of the tooth.

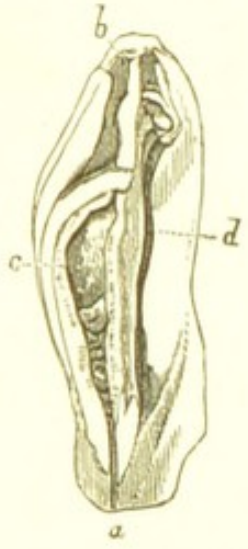
A similar specimen has been figured by Mr. Salter, in his

(1) Natural size. From Heider and Wedl's "Atlas zur Pathologie der Zähne."

(2) Small odontome, from the incisor region.

article in Holmes's "Dictionary of Surgery," in which there has been a localised hypertrophy of the formative pulp. In some instances the defective tooth is not the subject of any very obvious deformity, though it is usually somewhat irregular in shape and enlarged at some point. The enamel investing the crown may be, and often is, perfectly well-developed; but we shall find at some point a slight depression, in the centre of which is a small dark spot. If

FIG. 255. (1)



the tooth be divided through its long axis, we shall find that the dark centre of the depression is in fact the choked-up orifice of a cavity situated within the substance of the tooth, external, however, and perfectly unconnected with the pulp-cavity. If the section be a fortunate one, we shall be able to trace the enamel as it is continued from the exterior of the tooth through the orifice into the cavity, the surface of which is lined more or less completely with this tissue.

But besides these cavities, which are in reality outside the tooth, we shall also very generally discover, on microscopic examination, that there are other cavities, which are con-

(1) Shows a section of an upper tooth in which a cavity, *c*, is formed external to the pulp-cavity, *d*. It is lined with a thin layer of somewhat imperfectly-developed enamel, and communicates with the surface of the tooth at *a*.

tinuous with the main pulp-cavity, and these by the direction of the dentinal tubes radiating from them will generally serve to explain the manner in which the abnormality has originated.

Deep fissures are in some cases formed upon the lingual surfaces of the incisors, near their bases, leaving a basal ridge. Now, if we imagine one of these ridges, sufficiently thick to contain in its centre a process of the pulp-cavity, to rise up still higher and approximate itself at the top to the surface of the tooth, the orifice leading to the space between it and the back of the tooth would become contracted, and we should have a condition of things not very dissimilar to that presented by the specimens here described.

A tooth presenting this sort of deformity was presented to the Odontological Society by Mr. Margetson: the appended figure is borrowed from the Transactions of the Society.

Fig. 256. (1)

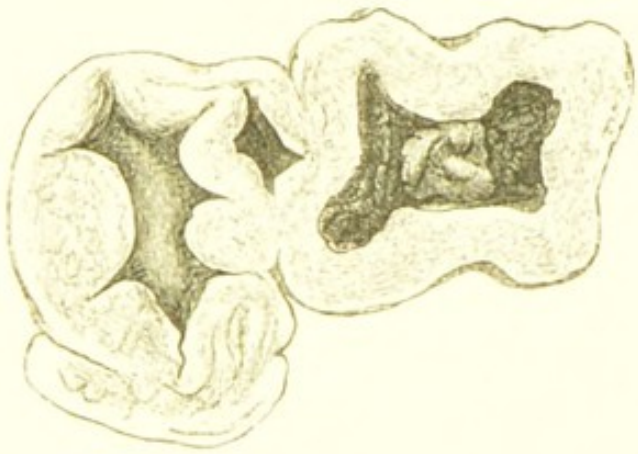
Sometimes, however, the malformation commences after the crown of the tooth has been completed, and whilst the roots are in process of formation. These "odontomes radiculaires" are rare, only a few cases having been recorded, though Mr. Sutton has found them to be comparatively common in lower animals. Of these one is in

(1) Mr. Margetson's specimen.

the museum of the College of Surgeons (1), one is recorded by Dr. Forget (2), and another by Heider and Wedl (3) in their Atlas; a fourth was presented to the Odontological Society by Mr. Hare, of Limerick, and described and figured in the Transactions of the Society (4), in whose museum the specimen now is.

In these cases the growth is due to a hypertrophy of the formative tooth pulp arising after the development of the tooth is nearly complete; hence in those two cases which have been thoroughly examined, the tooth and its fangs were found but little altered, although the latter lay imbedded in the mass which had grown around them.

Fig. 257. (5)



This is the case in the specimen here figured from a slight sketch made some years ago in Boston: on the right-hand side is the comparatively normal tooth, seen in section, and on the left is the new outgrowth, which is of very irregular form.

(1) Specimen 1022, Pathological Series. Guy's Hospital Reports, series iii., vol. xiv., and Art. "Diseases of the Teeth," by S. J. Salter, in Holmes's "Dictionary of Surgery," 2nd edition.

(2) "Des Anomalies dentaires et de leur Influence sur la Production des Maladies des Os maxillaires." Par A. Forget. Paris, 1860. Plate ii. Figs. 1 and 2.

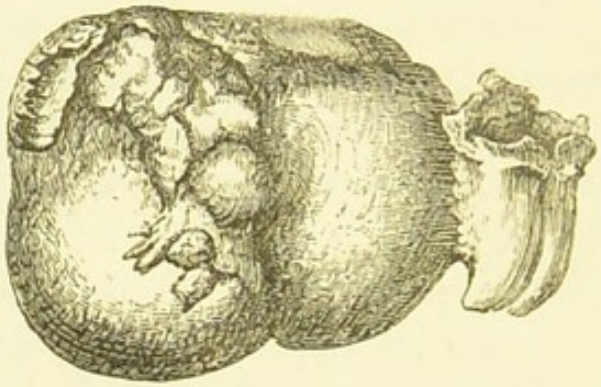
(3) "Atlas zur Pathologie der Zähne," von Prof. Heider und Prof. C. Wedl. Leipzig, 1868. Taf. ii., Figs. 28 and 29.

(4) Transactions of the Odontological Society, vol. iii., p. 335, J. Tomes; and 2nd series, vol. iv., p. 81, Charles S. Tomes.

(5) Section of an odontome in the Boston Medical Museum.

Dr. Forget's case, of which a figure is here given, was further examined by Professor Broca, who satisfied himself that its origin was in an outgrowth of the dentinal pulp, though no actual dentine was found in the mass, which was of indistinct bony structure. For the use of the annexed woodcut I am indebted to the kindness of Mr. C. Heath.

Fig. 258.



The whole mass came away on an attempt being made to extract the decayed tooth which formed the anterior portion of the growth.

Mr. Moon has recorded a case occurring in a female aged 38 ; there had been swelling of eight years' duration, with closure of the jaws, increasing at times : sometimes there was immense swelling, extending upwards so as to pass behind the tuberosity of the upper jaw. On examination a bony mass was found to lie behind the lower wisdom tooth to which it was attached, and after removal was seen to belong to the class of radicular odontomes.

Another very remarkable specimen was placed in my hands for examination by Dr. Barrett, of Buffalo, which at first sight would have been regarded as an odontome ; a molar tooth, perfectly normal as regards its crown and two-thirds of its roots, had the ends of its roots merged in a rounded, rough-surfaced mass, nearly as large as the tooth itself. Not being at liberty to interfere with the specimen, I was not able to investigate it quite fully, but it appeared to me that the roots had been pretty completely formed, and that they had been subsequently embraced by a soft growth

originating at their ends, and that this had subsequently calcified.

But by far the largest specimen which has been met with in the human subject is that now in the museum of the Odontological Society, from whose Transactions the subjoined figures are borrowed (*loc. cit.*). The mass, which is

Fig. 259.

represented of its natural size, is seen to be attached to and to surround the root of an upper molar tooth.

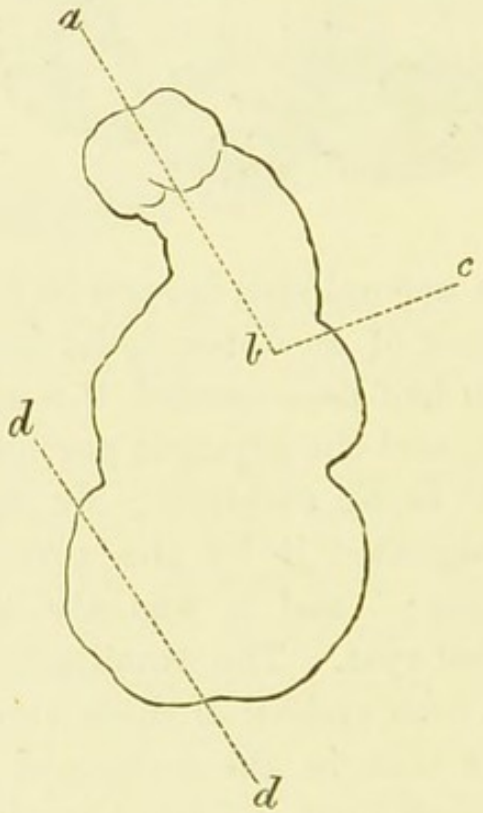
Before a section had been carried through the crown and roots of the tooth, and the adjacent portions of the tumour, it was supposed to be an exostosis ; Mr. Salter (1), objecting to this view, designated it by the term "dilated hypertrophied tooth-fang;" and it was also suggested that it might be a calcified cyst. The examination of the section, however, renders each and all of these views as to its nature untenable. As is seen in the subjoined figure (Fig. 261), the fangs of the tooth are not dilated nor hypertrophied, but are of rather small size: at some point, not seen in the section, there has sprung from the dentinal pulp an outgrowth, which has completely enveloped the fangs, and grown out into a great lobulated mass.

The examination of the sections made along the lines *a b*, *b c*, and *d d*, revealed the following structures. At the top were the fangs of the tooth, bedded in the mass ; an investment of cementum of varying thickness completely encased the whole, following all the irregularities of its outline.

(1) Holmes's "Dictionary of Surgery" (*loc. cit.*).

Inside these layers of cementum, came a shell of dentine, seen at the right-hand lower corner of the figure; the tubes in this layer of dentine radiated outwards, and were disposed with considerable regularity: the inner surface of this dentine shell was, however, far less regular in its outline than its outer surface, the interior being filled up with an ill-defined osseous structure. At the part marked *d d* the dentine shell was entirely absent.

Fig. 260. (1)



In the specimen at the College of Surgeons the only section which has been made is at a part of the mass nearly corresponding to the line *d d* in the specimen here described: so that its relation with the tooth-fang is purely a matter of conjecture; and in the one figured by Heider and Wedl nothing of its relation to the fangs is shown. For this and other reasons (2) the proposed name "hyper-

(1) Diagram showing portion of the sections made.
(2) See Odontological Society's Transactions, vol. iv., pp. 81 and 103.

trophied dilated tooth-fang" seems inapplicable. The manner of origin of the tumour is tolerably clear: at a certain period in the development of the dentine pulp, an outgrowth takes place; which, though often connected by only a very small pedicle with the rest of the normal pulp (see description of an odontome in Transactions of Odontological Society, Feb. 1872), grows up around and embraces a considerable portion of the tooth or its fangs. Being contained within the tooth capsule it receives an investment of cementum on its surface, within which the pulp has become calcified into dentine or bony tissue. The incomplete calcification, or death of portions of the pulp, may lead to the existence of cavities in the interior; or it may

Fig. 261. (1)

become absolutely solid, as appears to be the case in the specimen in the Museum of the College of Surgeons. The

(1) Section made along the line *a b*. The upper edge of the dentine shell is at the right-hand lower corner of the figure.

result of calcification of the outgrowth of the dentinal pulp is true dentine only so long as the odontoblast layer, or "membrana eboris," retains its integrity; so soon as this is lost, the remainder of the pulp becomes converted into an irregular osseous structure. Thus in the specimen here figured, as also in that described by Mr. Salter, there is a mere thin shell of true dentine, the interior of which is filled up by the products of calcification subsequently to the production of true dentine: whilst at the lowest point of the first-named specimen (along the line *d d*) no true dentine was found, but only an irregular bony structure, enclosed in thick laminated cementum.

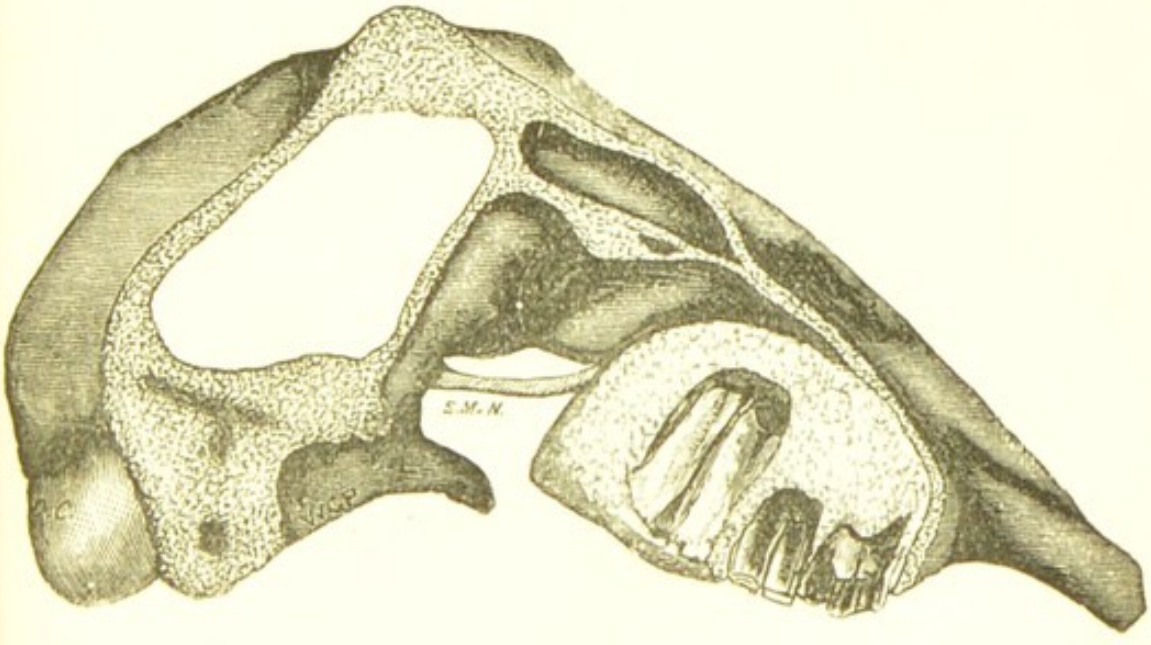
From what has been already said, it will be seen that the correct diagnosis of these various forms of odontome is a matter of no small importance, since an error will probably lead to an unnecessarily severe operation; as has, indeed, already happened in several cases. To distinguish those encysted fibrous tumours which Professor Broca claims as odontomes, from ordinary fibrous tumours of the jaw before the actual operation, is perhaps hardly possible; but the distinct limitation of such a tumour, joined with the absence of one or more teeth, might lead to a suspicion of its circumscribed nature, and an incision over it would serve to show whether it was encysted, or widely fused with surrounding structures, without much interfering with the operation, should the latter be found to be the case.

The absence of one or more teeth from their proper places is a character which has constantly existed in the cases hitherto recorded; though it is, of course, conceivable that the pulp of a supernumerary tooth might take on this morbid development. And this has actually been observed in animals, in whom supernumerary teeth are comparatively rare. But wherever in cases of enlargement of the jaw, teeth are found to have never made their appearance, there is a very strong probability that the missing tooth is at the bottom of the mischief; and if this fact be steadily kept in mind, many severe operations may be avoided, and the

tooth tumour removed with but slight destruction of the bone.

Contrary to what might have been expected, these odontomes remain for a considerable time without giving rise to any inconvenience ; they may even take up their position with the other teeth and perform their share of mastication, as is well exemplified by an enormous odontome attached to the molar of a horse, which is in the Museum of the Odontological Society, and was described in the Transactions for February, 1872. Sooner or later, however, they generally set up inflammation in the surrounding parts, and profuse and prolonged suppuration ensues, leading to the inference that the bone is diseased. Of course the immediate removal of the mass is the only available treatment ; and in most cases this can easily be effected through the mouth, without

Fig. 262. (1)



making any external incision, portions of the bone overlying it being removed with a Hey's saw, or by bone-nippers and a gouge.

The removal of the mass will be followed by subsidence of

(1) Mr. Sutton's specimen of odontome in the jaw of a goat.

all the symptoms, and the large cavity left in the bone will very speedily contract and fill up, leaving no permanent gap behind.

As has been incidentally mentioned odontomes occur with some frequency in animals, and Mr. Sutton's paper, so often referred to, will be found to give a very complete account of them. He has met with one at the base of the incisor of an agonti, and with four in the jaws of a single marmot, all in connection with the roots of incisors of persistent growth.

But the most instructive, perhaps, of the many which he records, is one which was met within the jaws of a goat, in which each antrum was occupied by a thick walled cyst, in the interior of which was a molar tooth. The walls of these appear to be the walls of the tooth-follicle enormously thickened, and had the mass gone on to further calcification, there would have resulted an odontome composed mainly of cementum, like those usually met with in ungulates.

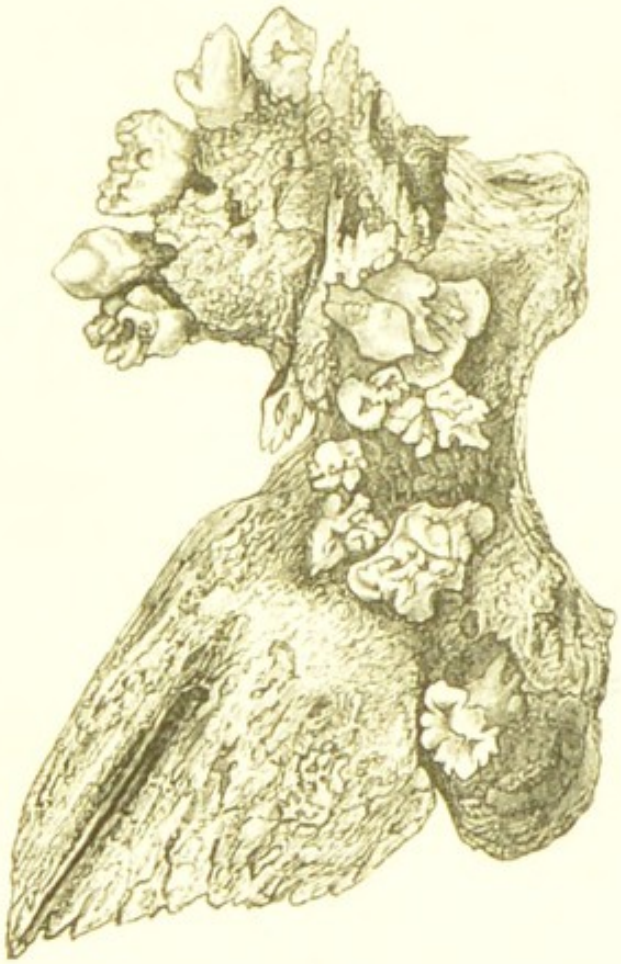
Thus the specimen gives us a view of an odontome in an early stage, and is thus of much general interest.

DENTIGEROUS CYSTS.

Tumours containing confused masses of tooth-structure have been met with elsewhere than in the jaws.

Ovarian cysts are sometimes met with which contain, amongst other structures, teeth, sometimes implanted in a

Fig. 263. (1)



species of jaw ; a good example of this, here figured, is in the Museum at Boston, Mass.

Cysts are also found in the mouth and neighbouring parts other than the jaws : for example, these dermoid cysts have been met with in the substance of the tongue, and in the

(1) From an ovarian cyst. Specimen in Boston Medical Museum.

large majority of recorded cases have not been detected till the period of full adult life.

Confused masses of dental tissues have been met with about the petrous portion of the temporal bone in horses, and in one instance, the body of the sphenoid was found to be the seat of a tumour containing dentine; but as is pointed out by Mr. Sutton, these are to be regarded as dermoid cysts and not as true dentigerous cysts. This author, analysing the conditions present where dermoid cysts arise, points out that they occur in the situation of obsolete canals, once of functional importance in lower animal forms; where malformations exist in the way of locking in or adventitious mixture of parts derived from the epiblast, hypoblast, and mesoblast; and that these adventitious elements and dilated canals play the part of tumour germs.

But the term "Dentigerous Cyst" is limited in its application to cysts which arise in connection with developing teeth, or teeth which, though their development has been completed, are retained within the substance of the jaw. In the majority of cases they are connected with permanent teeth, and in some instances with supernumerary teeth. A remarkable case of dentigerous cyst containing supernumerary teeth occurred in the practice of Mr. Tellander, and was described in the Transactions of the Odontological Society for the year 1862, whence the accompanying illustration is borrowed. The teeth, the number of which was no less than twenty-eight, mostly present the usual character of supernumerary teeth; some are built up of adherent denticles, and some are of very irregular form, one having no less than nine cusps. When first seen by Mr. Tellander, the patient stated that on the right side of the upper jaw the canine, bicuspids, and first molar had failed to make their appearance. At the age of twelve, a hard, painless swelling appeared on that side of the jaw which subsequently became inflamed and painful. When first brought under observation there was enlargement of the bone and great

swelling of the surrounding soft parts; a profuse discharge of pus oozed up round the root of a temporary molar which had been retained.

On proceeding to remove the supposed carious bone, it was found that there were a number of loose hard bodies enclosed in a shell of dead bone, and these proved to be the teeth here figured; but as their importance was not at first recognized, it is more than probable that some were lost.

After the lapse of six months, all swelling of the jaw had

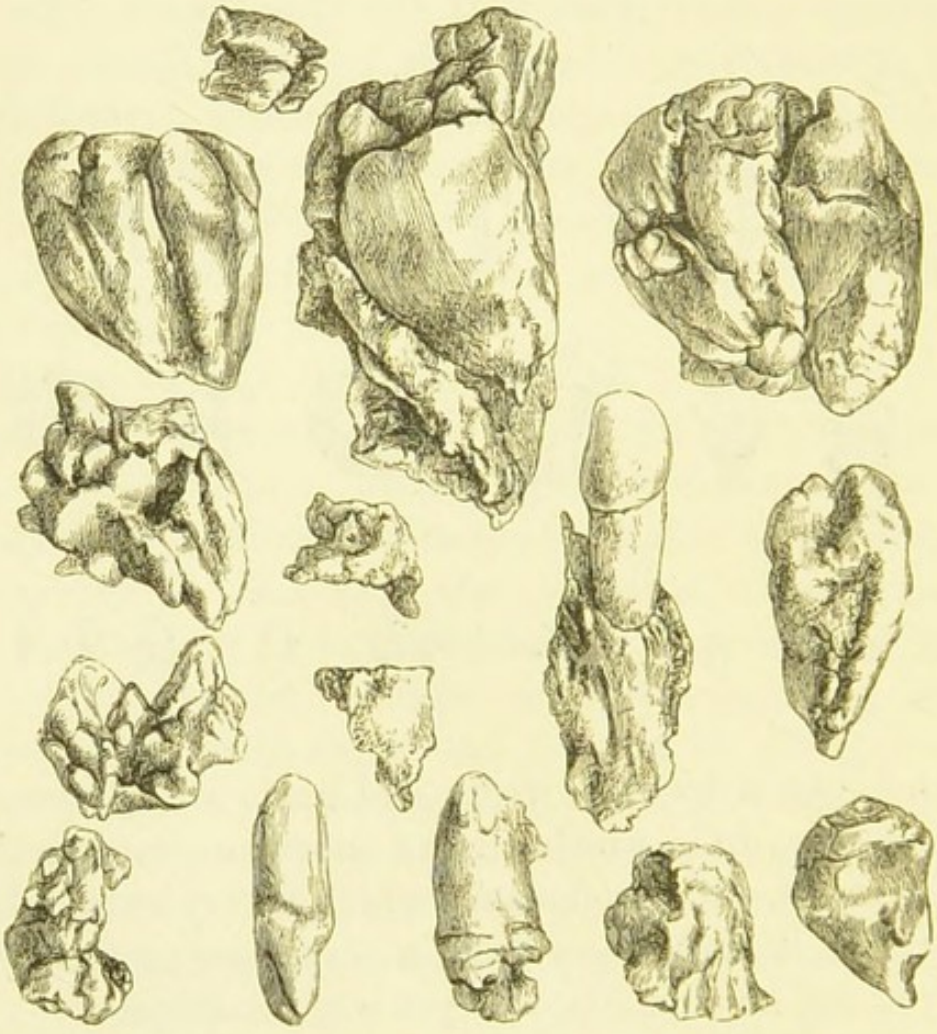
FIG. 264.

subsided, but a bicuspid tooth had made its appearance in the very place from which all the supernumerary teeth had been removed,—a circumstance which is very extraordinary, seeing that it must have been in very close proximity with the cyst and its contents, and yet was unaffected.

But a still more remarkable case of a cyst containing supernumerary teeth occurred in India under the care of Mr. Mathias. The patient, aged twenty-five, was unable to close his mouth on account of the presence of a large tumour in the front of the upper jaw, which pressed the lip up against the nose. The surface of the tumour was eroded by ulcers, from which a profuse offensive discharge poured out. The man was much emaciated, and the appearance presented

was that of malignant disease; but on passing a probe into the tumour it was found to strike on a hard loose body, which proved to be an agglomeration of ill-formed teeth. One after another the whole of the teeth figured on this page were removed; but as there are fractured surfaces which will not fit together, the inference is that some have been lost. The soft parts around rapidly returned to a

Fig. 265. (1)



healthy condition, and all deformity disappeared. The teeth absent from the mouth were the central and lateral incisors, the canines occupying their usual position.

The masses of tooth-substance removed are in the Museum of the Odontological Society, and a more full

(1) Contents of dentigerous cyst. Mr. Mathias's case.

account of the case will be found in the Transactions, vol. iii., p. 365.

Cysts, however, arising in connection with teeth retained in the jaw do not always contain a number of supernumerary teeth, but often only one tooth, which commonly belongs to the permanent set, though there are cases recorded of cysts arising in connection with temporary teeth.

Teeth which lie buried in the jaw do not by any means invariably give rise to irritation. Numerous examples of teeth occupying abnormal situations are to be found in museums, with no sign of disease around them; and there are even instances of teeth inverted and embraced between the fangs of other teeth, whose presence has never been suspected until the erupted tooth has been extracted in consequence of caries.

But in a certain number of cases these retained teeth cause

FIG. 266. (1)

to be developed around them a cyst with bony walls. An excellent example of this is here figured: the drawing is taken from a wax model of a portion of the lower jaw excised by M. Maisonneuve: at the bottom of the cyst is seen a canine tooth lying horizontally. In this case a

(1) Cyst of the lower jaw, containing a canine tooth. M. Maisonneuve's case.

saline fluid flowed from an opening behind one of the front teeth, leading into the cyst.

In this case the patient's age (fifty-six) would add to the difficulty of diagnosis, as dentigerous cysts, in the majority of cases, come under the surgeon's notice at a much earlier age.

A considerable number of such cases have from time to time been put on record, and the museums of the different London hospitals, many of them, contain portions of jaws which have been removed through a mistake in the diagnosis. The cysts in these cases have generally consisted of a thick soft membrane, outside which comes a bony shell, formed by the bone of the jaw expanded over the growth within it. This membrane in some instances becomes calcified, as is well exemplified in Fig. 271; or it may become infiltrated by earthy salts, without definite structural arrangements.

Some of these cyst-walls when examined have been found to be lined with a distinct polyhedral epithelium, the origin of which is a little difficult to understand; from the inner surface shreds often hang loosely into the cavity which have been supposed to be uncalcified portions of tooth-germs, as they sometimes bear small nodules of dentine and enamel.

The tooth very generally has its crown projecting into the cavity, while its root is buried in the cyst-wall; sometimes, nowever, the whole tooth appears to lie free.

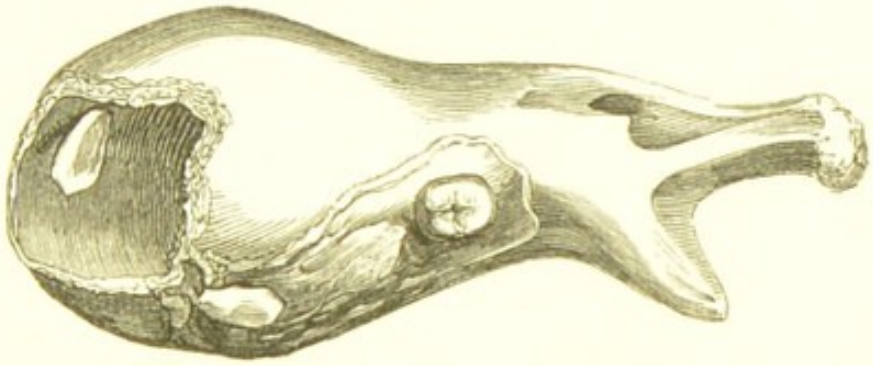
Mr. Heath met with a large cyst in the lower jaw, which when punctured was found to be quite empty, the fluid which it once had doubtless contained having been wholly absorbed. No tooth was discovered at the time of the operation, but after some little suppuration had occurred, one (a bicuspid), which had previously been buried in the cyst-wall, came to light.

The cyst is usually filled with a clear glairy fluid, in the first instance; but not uncommonly it has become inflamed at some period, and its contents will then be pus, or perhaps a yellowish fluid loaded with cholesterine.

As a general rule, the cyst appears to give rise to a distinctly localised enlargement of the bone; but in some

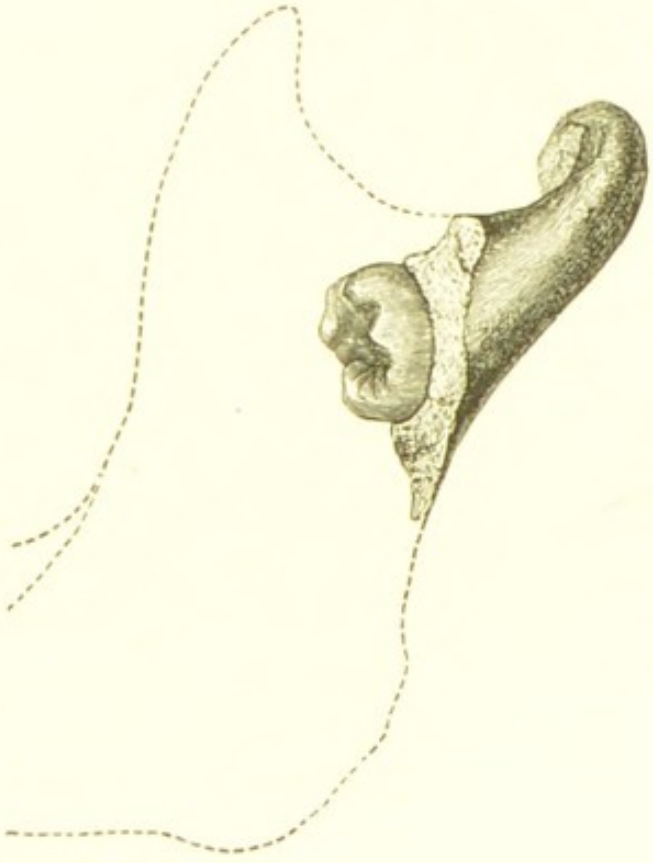
instances, as in the very remarkable case recorded by Mr. Fearn (1), the whole jaw was expanded by a separation

FIG. 267. (2)



of its internal and external plates, extending from the

FIG. 268. (3)



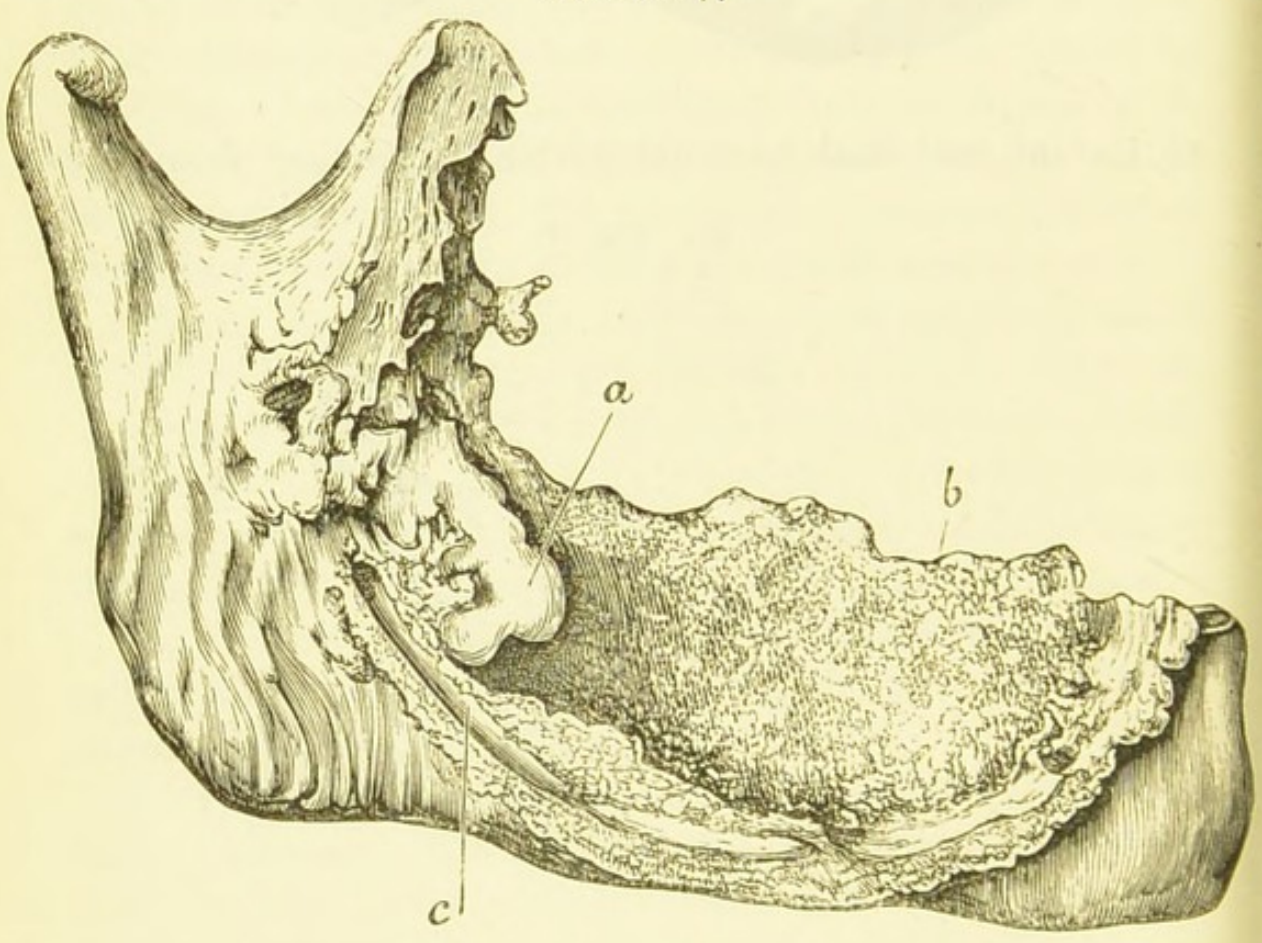
ascending ramus on the one side, to a point beyond the symphysis on the other. The figure of this jaw here given

(1) "British Medical Journal," August 27, 1864.
(2) Mr. Fearn's case of dentigerous cyst.
(3) Dr. Marshall's case of dentigerous cyst.

is borrowed from Mr. Heath's "Diseases and Injuries of the Jaws," where a very comprehensive account of dentigerous cysts is to be found.

Dr. J. S. Marshall ("Chicago Medical Journal," January, 1884), describes a dentigerous cyst in a boy aged sixteen, which had been noticed for two years. On being incised it was found to contain about four drams of fluid, and it had loosened and displaced the first and second permanent

FIG. 269. (1)



molars; well up towards the sigmoid notch the crown of the wisdom-tooth could be felt. On this being grasped it readily came away, having little or no root, and the condyle and back of the ramus were found to be loose and detached from the surrounding parts, being apparently necrosed.

(2) Right half of the lower jaw, expanded out by a dentigerous cyst. *a*, inverted wisdom tooth; *b*, internal wall of the cyst; *c*, inferior dental canal. M. Lisfranc's case. I am indebted to Mr. Christopher Heath for the use of the woodcut.

The periosteum being comparatively uninjured, the ramus, and what is more extraordinary, the articulation, were almost completely reformed, so that two years afterwards hardly any deformity or inconvenience remained.

Another case, in which the whole of one ramus was expanded, is given by Dr. Forget in the work before referred to. The tumour, which proved to be a cyst in which lay an inverted wisdom-tooth, had been slowly growing for ten years, and at the time of operation was larger than a hen's egg. In this case the half of the jaw was removed by M. Lisfranc, the patient recovering the operation well; though of course, had the true nature of the case been recognized, this formidable procedure would have been unnecessary.

This inversion of a tooth is not uncommonly found in cases of dentigerous cyst; as is seen in the following case, related in the first edition of this work :—

A girl of sixteen, the daughter of a tradesman, gave the following history of her case : "Nine months since a swelling appeared in the lower jaw, about the implanted portion of the second molar, which was supposed to be a gum-boil.

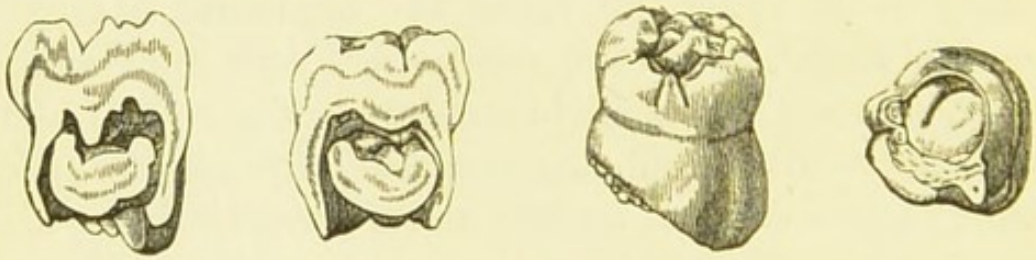
"The pain was at first slight and intermittent; but as the size of the swelling gradually increased, the amount of discomfort became greater, though never amounting to acute pain. I saw her for the first time on December the 15th, 1856. There was a very considerable enlargement of the alveolar portion of the jaw around the second molar. The tooth, however, was perfectly sound, and although tender when pressed upon by the antagonistic teeth, yet it was not considered by the patient to be the seat of pain. The colour of the tooth was perfectly good, and its implantation firm—indeed, there was a total absence of any indication which would induce a belief that disease had arisen firstly in it and subsequently extended to the jaw.

"The swelling was not confined to the soft parts—the bone was obviously involved. At one point, however, fluctuation could be felt, and the examination did not

appear to produce any considerable amount of pain. The absence of acute inflammatory symptoms, and the comparative freedom from tenderness, coupled with the large amount of local swelling, rendered the nature of the disease obscure. Mr. Arnott was kind enough to see the case, and he introduced a grooved needle ; several drachms of a clear yellow fluid escaped, and the swelling of the soft parts to a certain extent subsided, leaving the outline of the enlargement of the bone comparatively distinct. The patient felt relieved by the operation from the sense of tension and weight, which had latterly become distressing. On the 26th of January the swelling had again returned, and with it dull aching pain ; the involved tooth had in the interval become slightly loose, and was turned inwards towards the tongue. The swelling was again punctured, with results similar to those already recorded.

"On the 5th of February the patient again returned.

Fig. 270.



Since the last puncturing of the tumour she had suffered great pain, accompanied with constant throbbing in the tumour, and pus had subsequently been discharged from the puncture. The amount of constitutional disturbance had been sufficient to confine the patient to her room for several days. Finding that the tooth had become much more displaced than before ; that it was quite loose, and that the surrounding gums were greatly inflamed, I determined to remove the tooth, although it was by no means clear that it was the primary cause of the mischief. On its removal a most curious state of things was made manifest.

Instead of having its normal two roots, the implanted portion of the tooth was dilated into one large concavity, in which was placed the crown of a second tooth, perfectly invested with well-developed enamel, but having its masticating surface directed downwards towards the jaw. The two teeth appear to be united by dentine at one point, and to have one common pulp-cavity. The appearances presented by the united teeth are shown in the figures on the previous page.

"The pain from the operation quickly subsided, and within a fortnight all swelling and pain in the soft parts had disappeared: the enlargement in the bone had also sensibly diminished."

A case presenting somewhat similar general characters

FIG. 271. (1)

was treated at the Middlesex Hospital. In a female under thirty, the lower jaw had become enlarged and painful in the neighbourhood of the second molar, behind which was a fistulous opening. Through this opening a probe passed

(1) Dentigerous cyst which has invaded the antrum, and has subsequently become calcified.

readily into a cavity in the substance of the bone, but no tooth could be felt. An opening was then made with a trephine, and the finger introduced, when a tooth covered in great part, if not entirely, by membrane was found lying upon the floor of the cavity. The tooth proved to be a perfectly sound wisdom tooth.

When one of these dentigerous cysts is situated in the upper jaw, it is very common to find the antrum involved in the disease; a number of cases are quoted by Mr. Heath in which this has taken place: one remarkable case is quoted by him from Dupuytren, of a cyst developed between the plates of the palatine process of the upper jaw. There is a preparation belonging to Mr. Cartwright, formerly allowed to remain in the museum of the Odontological Society, in which a cyst of this kind occupies the antrum; the cyst wall has become calcified, so that it presents the remarkable appearance depicted in the figure of a very fragile bony shell, attached only at one point, and elsewhere free of the walls of the antrum. The cyst contains a supernumerary tooth.

But a yet more remarkable case (Baum's case), is cited by Mr. Heath, in which *both* antra were dilated to an enormous size by cysts, in the one of which was a canine, and in the other a molar tooth.

A very interesting case of dentigerous cyst in the antrum is reported by Mr. McCoy in the "Lancet" (1871). The patient was a negro, aged fourteen, and the tumour, which had been first noticed about two and a half years previously, was as large as an apricot. The cavity of the antrum was found to contain a small quantity of glairy fluid, but to be chiefly occupied by a gelatinous substance, apparently thickened mucous membrane. Projecting into the cavity was a perfectly sound canine tooth, which was imbedded in a distinct socket situated in the nasal process, on the inner angle of the orbital process of the maxillary bone: it required some force to extract it. Previously to the operation it was noticed that the left upper canine tooth was missing from its natural place.

No reasonable doubt can be entertained that the teeth are, in these cases, the primary sources of the mischief, aided perhaps by constitutional tendencies of the patient. But the question as to the precise manner in which the morbid conditions were developed is more difficult of solution. It will be remembered that, when treating of the eruption of the temporary teeth, attention was directed to the occasional presence of vesicular enlargements over teeth about to penetrate the gums, the contents of which presented the characters of serous fluid; and to the fact that, on incising such enlargements, the knife comes down on the enamel-coated crown of the coming tooth. In connection with this subject, allusion was made to the fact that, when the development of the enamel is completed, its outer surface becomes perfectly detached from the investing soft tissue, and that a small amount of transparent fluid not uncommonly collects in the interval so formed. Now I believe we may find in this an explanation of the manner in which cystic tumours containing buried teeth arise.

I conceive that, in the cases cited, fluid collected between the enamel and the tooth-capsule. As the cyst enlarges, the contiguous bone is removed to make room for it, fresh bone being concurrently deposited on the outside of the jaw. In the case of such a cyst lying in front of a tooth which is being cut, it is obliterated by the advancing tooth, or it bursts; but when situated deeply in the jaw, a cystic tumour may be the result.

If the foregoing views be correct, it is not difficult to see how an encysted tumour may be produced by a hidden tooth; in M. Maisonneuve's case a perfectly sound canine lay at the bottom of a cavity lined by membrane and filled by fluid.

Nasmyth's membrane is furnished by the tooth-capsule, and is nothing more than coronal cement; if, then, the "cuticula dentis" is present on these teeth enclosed in cysts, the fluid cannot, strictly speaking, be regarded as situate between the enamel and the tooth-capsule.

But, so far as I know, no observations have been made on the presence or absence of Nasmyth's membrane on these abnormally-placed teeth; so that, so far as it is concerned, the question must remain in abeyance.

A case that lends some support to the above view was met with by my colleague, Mr. Moon, at the Dental Hospital, in which a dense, elastic tumour, simulating a solid growth, occupied the place of one of the central incisors of a child. On incising it, it was found to contain clear fluid, and the crown of the missing incisor was exposed in the cavity; it was described by Mr. Moon as an example of a dentigerous cyst devoid of bony walls.

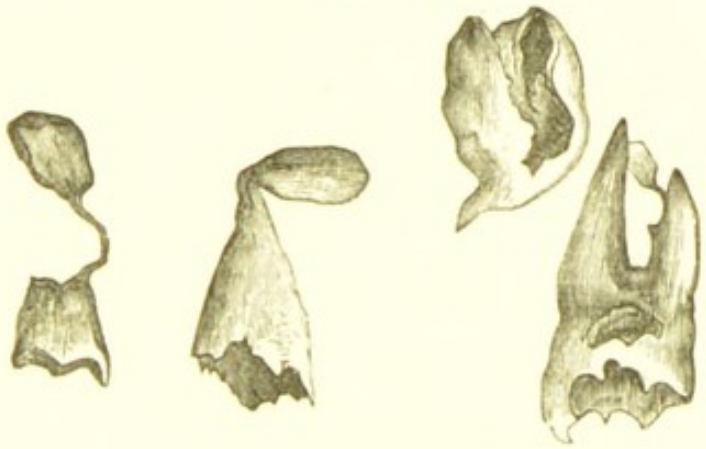
It must, however, be recollected that cysts lined with a very distinct fibrous membrane occur in other bones than the jaws, so that it is not at all necessary that the lining membrane of a dentigerous cyst should have been in any way derived from the tooth and its capsule. And Professor Wedl (*op. cit.*) suggests that it is quite as probable that a tooth growing in an abnormal direction should set up an irritation, resulting in the surrounding bone becoming abnormally developed into a cyst, as that the dental sac should itself degenerate into a cystic formation. Mr. Eve ("Brit. Med. Journal," 1883), holds the opinion that the epithelial lining of such cysts may be due to an ingrowth from the epithelium of the gum.

The subsequent changes which may occur, such as calcification of the cyst wall, or the alteration of the contained fluids by inflammation and subsequent suppuration, do not require any special comment. But when once a buried tooth has become a source of severe irritation, it is seldom that the mischief ceases until the source of irritation has been removed: when this has been effected, the cure is usually rapid and complete.

Not only, however, may cysts arise in connection with teeth which have remained buried in the jaw, but a similar form of disease may originate about the roots of normally-erupted teeth. Such cysts are not usually called by the

name of "dentigerous cysts," that term being restricted to those forms of tumour already described. Cysts of small size are tolerably frequently met with attached to the roots of extracted teeth; in the first instance the morbid process is probably identical with that resulting in the formation of alveolar abscess, but the process being less acute, a serous cyst takes the place of a rapidly suppurating sac. As such cysts increase in size they produce absorption of the bony

FIG. 272. (1)



structures around them, and may in this way come to occupy the cavity of the antrum. Mr. Heath quotes a case of Fischer's in which he was able, by post-mortem examination, to clearly trace that a cyst occupying the whole antrum had no connection whatever with the walls of that cavity, but was attached solely to the apex of the fangs of a molar tooth, from the periosteum of which it sprang.

Mr. Coleman (2) drew attention to a tooth, to the side of the root of which a cyst containing cholesterine was attached, in addition to an alveolar abscess situated at the apex of the fang. These cysts connected with the roots of teeth occasionally form swellings in the angle between the alveolar borders of the jaw and the reflected mucous mem-

(1) Cysts attached to the roots of permanent teeth. From Heath: "Injuries and Diseases of the Jaws."

(2) Transactions of the Odontological Society, 1862.

brane of the cheek, and when opened are commonly found to contain a fluid loaded with cholesterine: a case of this kind occurred at the Middlesex Hospital, under the care of the late Mr. Moore, which had apparently originated in this way; the cyst refilled several times after it had been punctured, but after being freely slit open from end to end, it filled up with granulations, and no further trouble was experienced from it.

M. Magitot (Mem. sur les Kystes des Machoires), relates a case met with by Verneuil in which a cyst as large as an orange was opened, and on introducing the finger the roots of a tooth entirely denuded of all soft parts were felt: after its removal its roots were found roughened and eroded.

It seems very probable that cystic disease of the lower jaw may not infrequently be due, in the first instance, to the irritation set up by stumps or carious teeth: the following case, which lately occurred in my own practice, will serve to illustrate this point, as well as the general characters of cystic enlargement of the jaw.

The patient, a lady aged thirty-five, stated that two years previously she had had a severe inflammatory attack, involving the stumps of one of the molars in the lower jaw; at that time her face was excessively swollen for some days, after which the inflammation gradually passed off; but she distinctly states that the enlargement around the affected tooth never disappeared. When first seen by me, the second bicuspid and the three molars of the right side were all decayed down to the level of the gum, and the stumps were somewhat displaced inwards. From the stump of the second bicuspid to that of the second molar, the groove between the cheek and the bone was entirely obliterated by a rounded tumour, but the internal alveolar plate was only very slightly bulged inwards. On pressing firmly with the finger on the front or the back part of the tumour, a peculiar crackling sensation was felt, but a bridge of firm bone crossed its central portion which did not yield in the least to pressure. The stumps of the teeth were all loose, and the

patient stated that a glairy fluid had at times oozed from around one of them. The face was considerably disfigured by the enlargement; but the skin was perfectly movable over the tumour, as was also the mucous membrane in the mouth. No enlarged glands were to be felt in its neighbourhood; and the tumour was quite painless, save that the patient complained of a sense of fulness and tension.

The patient was placed under an anæsthetic, and the stumps extracted, a slight flow of clear fluid from the sockets following their removal; an incision was made midway between the cheek and the jaw along the whole length of the cyst, which was cut into by bone-forceps, and a portion of the firm bar of bone which arched over its middle cut out. On passing the finger into the cavity, its walls felt as though made up of small fragments like a broken egg-shell, and by pressure on the outside it could be made to partially collapse.

The cavity was stuffed with carbolised lint, which was removed on the third day.

Three months afterwards all enlargement had disappeared, and no trace could be felt even of the strong bony bar which had bridged over the tumour; several small pieces of bone had come away in the meantime, but no fragment of any considerable size had separated.

In the development of cysts within the lower jaw, it is the outer plate which commonly becomes bulged by the tumour, which, if left to itself for a sufficiently long time, effects the complete absorption of the bone investing it, so that fluctuation may be readily detected through its membranous walls.

A fuller account of cystic disease of the lower jaw will be found in Mr. Heath's admirable work, to which the reader is referred for cases and information which hardly fall within the scope of the present book.

A case is recorded by Mr. Coote of cystic tumour of the lower jaw, which was referred to the irritation of tooth-stumps, and was treated by the extraction of the stumps—

the patient's age (seventy-five) and condition precluding any more radical operation. But the patient's death occurred before sufficient time had ensued to show what result would have been attained.

Diagnosis.—The recognition of dentigerous cysts, in the earlier stages of their growth, is exceedingly difficult, and they have in a number of cases been mistaken for solid growths. As a rule they grow very slowly—in one case the tumour having been noticed for ten years; and they are often painless, though not invariably so. The surface of the tumour is rounded, hard, and smooth; or it may be lobulated, from the existence of several cysts. The age of the patient, which *à priori* might have been expected to have afforded some clue, is not a reliable guide in diagnosis, as out of the cases mentioned by Mr. Heath, one patient had reached the age of sixty, whilst M. Maisonneuve's patient was fifty-six.

Nevertheless, the majority of the cases recorded have been in persons under thirty; and, taking into account the slow growth of these tumours, their first appearance would have been at a somewhat earlier age.

But a very important point to look for is the absence from its proper place of one or more teeth; or, as in Mr. Salter's case, the presence of a temporary tooth where the surrounding teeth belong to the permanent set. But, as has been noticed by Mr. Heath, the absence of particular teeth is in some instances a hereditary peculiarity; and the retention of a temporary tooth to an advanced age is not so rare an occurrence as to render its presence anything like an absolute proof that the tumour is due to a hidden permanent tooth. Nevertheless, any such irregularity in dentition will be very strong evidence in favour of the assumption that the enlargement of the jaw has for its cause the missing tooth. The presence of the regular number of teeth does not by any means preclude the possibility of the tumour being due to a tooth; for there are several instances of supernumerary teeth lying buried in cysts; for example, the

very remarkable case of cyst in the antrum belonging to Mr. Cartwright.

However much care may be taken, it will sometimes be impossible to arrive at a certain diagnosis without making an exploratory puncture, which should never be neglected in a doubtful case, lest an operation of needless severity be performed.

This exploratory puncture is best made with a trocar, or by a narrow-bladed knife, and it is well to follow up the puncture tolerably speedily by the operation required. Punctures made with a grooved needle seem particularly prone to excite inflammation (cf. p. 672), and there are very few instances in which its employment is desirable.

Of the diagnosis of those forms of cystic disease which do not depend on retained teeth, but which are in relation with carious teeth or stumps, little need here be said. The tumour will present the usual characters of a cyst ; that is to say its growth will be slow and painless, its outline smooth and regular, and, if it be thin enough, the bony shell covering it will crepitate on pressure. If it be situate in the lower jaw, the outer plate will be bulged, and the inner plate but little distorted. The increase in size of an abscess is far more rapid, and its boundaries less sharply defined than those of a cyst, and accumulations in the antrum produce a more uniform bulging of the walls of the jaw ; though a certain diagnosis cannot invariably be made, as has been exemplified by Mr. Fearn's and other cases.

Treatment.—In those cases where the disease is due to the retention of teeth within the jaw, the removal of the cause will generally effect a cure, without any more formidable operation being practised. In most instances this can be done through the mouth, without having resort to an external incision ; if more room is required, it may most advantageously be gained by dividing the lip into the nostril. The bony wall of the tumour having been exposed, a free opening must be made by means of a trephine or bone-forceps, and the offending tooth or teeth removed.

When the disease is in connection with the roots of carious teeth, it has been proposed, and successfully practised in some cases, simply to remove the tooth, enlarge the alveolus, and through it stuff the cavity with lint. But it is not a manner of treatment which has very much to recommend it: by making a small opening into a considerable cavity below, you expose the patient to the chance of pent-up matter decomposing in the cavity, and to all the risks attendant on this state of things. It is a far safer course to at once make an opening of such a size as to ensure the ready escape of the pus which must be formed. It is not easy to err in the direction of making the opening too large, for the cavity has to be filled by the process of granulation, and a large orifice will not at all retard its healing; but there is considerable danger attendant on exciting inflammation in a partially-closed osseous cyst. The operation recommended by Mr. Butcher consists of freely opening up the cyst, and removing, by bone-forceps and gouge, the external plate of the jaw where expanded over it; but in ordinary cases even this is more than is necessary, for it will generally suffice to remove so much only of the bony wall as will give free access to the cavity, and then fill it up with lint. The bony walls will slowly shrink down till the outline of the jaw is wholly restored; but in those cases where the bone has been excessively expanded, the cure may be accelerated by crushing in the yielding walls of the cyst.

The severer forms of cystic disease, where the whole bone is involved, will hardly come under the notice of the dental surgeon, so that they do not fall within the scope of the present work. It may, however, be mentioned that though some cases of multilocular cystic tumour are inclined to recurrence, most surgeons would nowadays, before having recourse to more severe measures, at all events in the case of tumours containing but little solid material, operate at first with gouge and bone-forceps, watching the case carefully for any indication of recurrence, and if this does happen, then resecting the bone widely.

THE SALIVA AND SALIVARY CALCULUS.

THE fluid found in the mouth is a mixture of the secretion of the salivary glands and of the buccal mucous glands, and its chemical and physical properties vary as the one or other preponderate. It is a glairy fluid, containing epithelium cells, mucous corpuscles, and salivary corpuscles.

Its re-action is alkaline, though when it is scanty the re-action of the mouth may be acid; the first few drops collected from the parotid may be acid, but this is due to its having been retained in the duct for a time and having undergone change there; it serves to show how easily acids are formed in the mouth by fermentative processes.

The most abundant source of saliva is the parotid gland, which seems to discharge the function of keeping the mouth moist; it is not viscid, and contains no structural forms; it has one peculiarity which is not shared by the saliva from any of the other glands, and this is that when left to itself for a few minutes it becomes turbid from a deposit of carbonate of lime taking place.

This fact explains the enormous deposits of tartar which are often to be seen on the molar teeth opposite to Steno's duct; another reason for the great amount of these deposits being, perhaps, that this gland is constantly pouring forth its secretion, though not in great abundance, independently of the stimulus of food.

The submaxillary saliva is more strongly alkaline, and much more viscid; it contains many salivary corpuscles, and masses of albuminous matter, which show amœboid movements; it is poured out but little except in response to the stimulus of food, or of mechanical irritation such as is set up in operations upon the mouth.

The secretion of saliva is mostly a reflex act, the impulse being conveyed in the case of the parotid by way of the auriculo-temporal nerve, and in the case of the submaxillary, by the chorda tympani; the afferent impulses being conveyed by the lingual or glossopharyngeal nerves under the ordinary circumstances of taking food. But that stimulation of other branches of the fifth nerve will have the same effect, is every day demonstrated to the dentist by the gush of saliva which follows instantly upon the infliction of pain in excavating sensitive dentine.

For the relation of the sympathetic to salivary secretion in the way of diminishing the flow, while at the same time its activity in acting upon starch is increased, the student must refer to physiological text-books; the subject is too complex for discussion here.

The sublingual gland pours out a viscid fluid, rich in the "ptyalin" of Berzelius, and also alkaline.

In addition to the products of these several glands, we have the "buccal mucus;" according to the experiments of A. Bernard and of Dr. Magitot this also is alkaline, and is very rich in albuminous matters, which may form concretions about the teeth, as is seen in fevers and certain other disorders.

The mixed saliva from these various sources is alkaline, and separates on standing into layers, the lowest of which contain epithelial cells, mucous corpuscles, fat, vibriones and cryptogams, and other accidental constituents.

But notwithstanding the alkaline nature of each and all of these secretions in health, a piece of litmus paper applied to the neck of the teeth, or to the borders of the gum, often shows an acid reaction. This is due to products of fermentation, and not to secretions originally acid; and the more the mucous element of the saliva predominates, the more fermentation will there be; the mucus being rich in albumen, and the viscous albuminous element of the glandular saliva (ptyalin of Berzelius), being also albuminous, furnish in abundance the ferment required. Moreover, the more

abundant these viscous matters are, the more will food be retained in the fissures between the teeth to undergo fermentation; but this acid reaction, often present to some extent in the neighbourhood of the upper incisors, is never found on the gum in the neighbourhood of the lower incisors (Magitot, *loc. cit.*); in this situation the flow of alkaline saliva effectually neutralises any acid that might be formed, and in this way the frequency of deposition of tartar on the lower, while it is comparatively rare on the upper incisors, may be explained.

Analyses of Saliva.—As it is almost impossible to obtain the saliva from one set of glands alone in man, our information is mainly derived from that of lower animals.

Bidder and Schmidt give the following as the constitution of parotid saliva in the dog:—

Organic matter (albumen and globulin) .	1·4
Potassic and sodic chlorides	2·1
Calcic carbonate	1·2
Water	995·3

Submaxillary saliva—

Organic matter (mucin with traces of albumen)	2·89
Potassic and sodic chlorides	4·50
Calcic and magnesic phosphates and carbonates	1·16
Water	991·45

Traces of sulphocyanide of potassium are also met with in saliva.

Dr. Fenwick states that sulphocyanides are in excess in cases of acute rheumatism, acute gout, and bilious headache, and in early stages of all inflammatory disorders; in these cases there is excess of fibrine in the blood, and, may be, an excretion of unoxidised sulphur resulting from the large amount of albumen altered by inflammatory process and so rendered unfit for organization.

Some have held them to be a result of decomposition set

up by decayed teeth—others that they are due to smoking—but his investigations did not lend confirmation to these ideas. ("Trans. Med. Chirurg. Soc.," 1882.)

The saliva undergoes great alteration in certain morbid conditions of the mouth, or of the general system.

To take the simplest example first: in stomatitis, tonsilitis, or pharyngitis, there is a greatly-increased secretion of buccal mucus; as a consequence of this there is greater acid reaction in the mouth, which is made evident not only by litmus, but by the solution, and consequent disappearance at such times, of deposits of tartar. It is also susceptible of alteration by chronic disorders of the mucous membrane, such as are generally associated with enlarged tonsils, and a granular, flabby-looking appearance of the pharynx (Magitot, *loc. cit.*).

In the course of many acute diseases the secretion of saliva is greatly affected. In small-pox, salivation, often profuse, is met with; but, as a rule, the febrile condition is associated with a dry tongue, from the suppression of the secretions of the salivary glands, and with the formation of sordes upon the teeth, due to a relatively excessive outpouring of buccal mucus. The formation of sordes around the teeth is further favoured by the temporary cessation of mastication, so that the mucus can collect and harden undisturbed.

It is in great part due to such causes that a severe illness often entails great destruction of the teeth; the thickened mucus affords a ready nidus for fermentation, and furnishes also the ferment required, so that the reaction upon the gums becomes strongly acid.

The condition of the oral secretions is markedly dependent on certain chronic disorders, of which, perhaps, dyspepsia exercises the strongest influence.

The fluid poured out by the glands is unusually rich in viscous albuminous constituents, whilst the mucous secretion is greatly increased in quantity. Hence arises that peculiar condition of saliva in which it may be drawn

out into strings between the teeth, or wherever the mucous membrane is touched by the finger; a condition with which, in association with most extensive caries, every dental surgeon is familiar, and which has already been noticed, so that we, in connection with the subject of Dental Caries, merely note here, that the deposition of tartar composed of carbonate of lime is little known where this condition of mouth exists.

The secretion from the salivary glands may become purulent, and may long remain so. A patient of the writer has had purulent parotid saliva for fifteen years, ever since an attack of typhus (? typhoid), and has suffered no inconvenience beyond dryness and clamminess of the mouth, with very extensive caries.

There is great discrepancy in the results which have been attained in experiments upon the acidity or alkalinity of the saliva.

Thus, Dr. Cushing ("Trans. Illinois Dental Soc.," 1874), found in a healthy mouth a slight acid reaction to be nearly constant in the neighbourhood of Steno's duct, and under the tongue; his experiments did not in any way isolate the saliva from the buccal mucus.

Dr. Spalding found that the saliva is alkaline in most cases of rapid decay; altogether the evidence collected by various observers is hopelessly discrepant, as others report that precisely the contrary is the case.

Perhaps the truth may be that the saliva is always alkaline, and the buccal mucus sometimes acid, but sometimes not: and that the reactions obtained by test papers laid upon the surface are determined by the preponderance of one or the other.

The saliva, together with oral and pulmonary mucus, holds in solution various salts, which are precipitated in greater or less quantity on natural or artificial teeth, in those situations where the fluids of the mouth remain at rest. Epithelial scales, and other extraneous matters that may be floating in the oral fluids, or are entangled amongst the teeth, become

impacted in the precipitated salts, and thus contribute to form the concretion known as tartar.

According to Berzelius, tartar is composed of

Earthy phosphates	79·0
Salivary mucus	12·5
Ptyalin	1·0
Animal matter soluble in hydrochloric acid .	7·5

But no two analyses of tartar give the same result, for the reason that it varies indefinitely in composition. For instance, if the tartar deposited near the orifice of Steno's duct be examined, it will be found to contain much carbonate of lime, whereas that from the lower incisors will contain little carbonate, and much phosphate of lime.

Tartar has been described by dentists as of several different kinds, and named from the variation of colour and density it presents. Thus, one sort is called black, another green, a third yellow tartar. The division is not, however, so far as I know, based upon any ascertained chemical difference, and may therefore be disregarded. I conceive that in most instances these physical variations are traceable to the time occupied in its formation, or to the habits of the individual.

Thus, when the tartar collects quickly it is usually soft and yellow; and, on the other hand, when the process is slow, it is dark and hard. Then, again, in those who smoke much, the tartar is of deep brown or black colour. In teeth where one fang has been necrosed, and stripped of periosteum, the surface of the dead fang is often studded with nodules of very hard greenish tartar, which, during the time of its deposition, has been bathed in pus secreted from the lining membrane of the socket. This tartar is so strongly adherent to the teeth, that its removal is a matter of difficulty; it would seem probable that it is chemically distinct from that which occurs above the level of the edge of the gums, but this is only conjecture.

Tartar occurs in a great variety of animals when kept in confinement, but is less common in wild animals; indeed in them it is generally a sign of disease of particular teeth, from injury or other cause, and this would suggest that its frequency in man is in a measure due to diminished use of the teeth.

Tartar collects in the largest quantity in two situations: behind the lower incisors, and on the outer or labial surface of the upper molars. Its formation in the latter situation is very readily explained by the fact that parotid saliva, on exposure to the air, deposits carbonate of lime. In the other situation, there is a constant alkaline reaction maintained by the parts being constantly bathed in saliva from the glands; very large depositions of tartar are only possible where an alkaline reaction exists, and hence has arisen the idea that tartar is a preservative of the teeth, whereas the truth is that it can only collect largely in a mouth the condition of which renders the progress of caries slow.

If a vertical section of a piece of tartar be carefully made, it will be found to present a wedge shape, the base of which lies in contact with the gum. The surface towards the tongue or cheek is usually smooth, but that against the gum is rough; and it is to the latter additions are mostly made. The gums become irritated and inflamed from the contact of the rough surface of the tartar; the alveoli become absorbed, and the gum recedes, making way for the further accumulation of the salivary salts. To the dental tissues themselves the tartar does no direct injury, but its effect upon the gums and alveoli is destructive, and hence indirectly upon the teeth, by depriving them of their sockets.

This deposition may go to such an extent that not only the crowns, but the whole roots of several contiguous teeth may be hidden in one shapeless mass of tartar. The friction of mastication does much to hinder its deposition, and careful daily brushing will do much to prevent the accumulation of tartar on the teeth, but should an accumulation

take place, it must be removed from time to time by instruments fitted for the purpose.

Large accumulations of tartar, rich in organic constituents, render the breath insufferably offensive, and lead to the discharge of fœtid sanious matter from the gums; but the slow accumulation of a very dense, hard tartar in minute quantities along the edges of the gum, occurs in the mouths of the most healthy people, and may almost be considered as a normal occurrence.

The benefit derived from scaling the teeth, in great measure depends on the thoroughness of the operation; for if small fragments are left, they form nuclei for the deposition of fresh salts. In order to secure the smoothness of the scaled surfaces, they should be polished with pumice-powder on a piece of wood, after the tartar has been removed by suitable steel instruments.

The tartar which lies within the edges of the gum is tenfold more destructive than that which is in full view, and must be sought for and removed with the most scrupulous care.

Tooth-powder that will dissolve the tartar will also dissolve the teeth, and therefore may not be used.

In young people the permanent teeth soon after their appearance through the gum may become disfigured by the deposition of dark-green pigment upon the surface of the enamel near its terminal edge. If tartar were present it would project from the general level of the tooth, but in the cases of green discoloration the surface of the enamel is not raised.

The habitual use of the tooth-brush and the act of mastication gradually rub off the pigment, and the teeth are restored to their proper colour. If, however, the disfigurement remains after the teeth are fully developed and the enamel has acquired density, the unsightly appearance may be removed by rubbing the part with a piece of soft wood loaded with fine pumice-powder.

As to the nature of this green discoloration, the most

diverse views are held: in the tenth edition of Harris's "Principles and Practice of Dentistry," it is said to erode the enamel with great rapidity; but this does not accord with the experience of most writers, who have found it to be perfectly innocuous. It is sometimes met with amongst the lower animals, both domesticated and wild, in whom caries is very rarely seen; and the colour, which is perhaps of vegetable origin, probably occupies the substance of the enamel cuticle; on the other hand the enamel is sometimes found roughened and chalky looking under it.

It must be remembered that syphilis may be communicated by means of the saliva; out of 1,200 cases 94 per cent. had the primary sore upon the genitals, but 3 per cent. had it in the mouth; but apart from the existence of primary sores infectious discharges may exist. Thus, a sailor tattooed 22 people, wetting his needles with saliva, his mouth being at the time covered with sores; out of these no less than 15 acquired syphilis (Dr. Harlan, "Illinois State Dental Soc.," 1881).

Kissing, the use of borrowed pipes, tooth-brushes, and the like, have been known to carry it, and whistles, tin trumpets, &c., sold in the streets are not without their dangers; whilst a wound from an elevator during the extraction of stumps from a syphilitic mouth has been known to infect the operator.

It therefore behoves the dentist to use every precaution as to cleanliness in his forceps, scalers, &c., for the sake of his patient, as well as for his own sake to observe all possible precautions in operating upon any suspicious looking mouth.

The mouth lesions come on rather late as a rule, after six months or a year; they then present themselves as white or slightly excoriated patches, or as simply raised patches; when there is ulceration they are far less tender and painful than their size would lead us to expect, so that painlessness comes to be one of the diagnostic signs of a syphilitic ulcer; after the lapse of longer periods more or less scaly patches, like ichthyosis, are met with.

ABSORPTION OF THE ALVEOLI.

The gradual wasting of the alveolar processes, accompanied by a corresponding recedence of the gums, keeps pace with those general changes which attend the advance towards old age. The necks of teeth become exposed, the gum continues to sink lower and lower till the whole of the roots are uncovered, and the teeth at last fall out. Then the alveolar ridges waste, till, in some instances, the upper jaw becomes nearly flat, and the lower is reduced to a mere bar of bone, almost flat topped. Prof. Humphery found that 47 centenarians had an average of 4-5 teeth each.

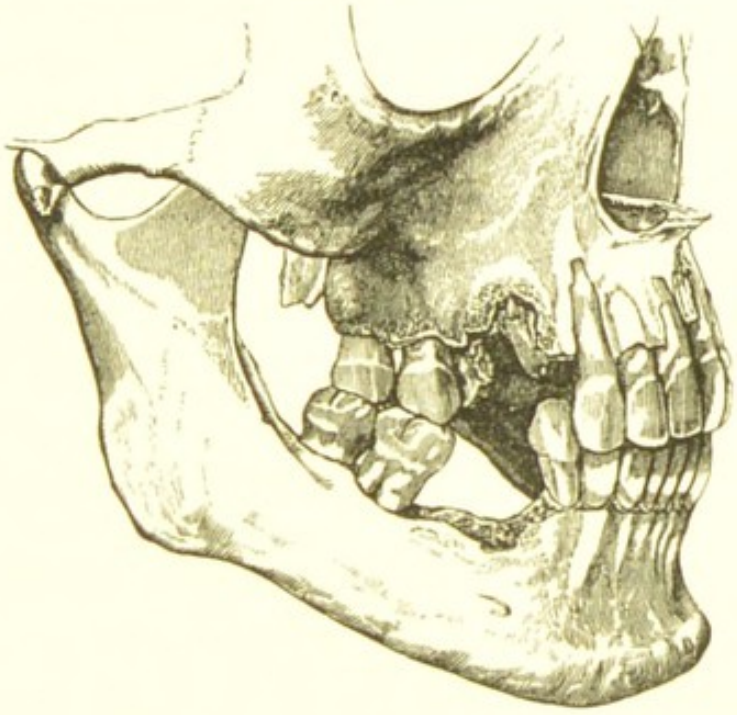
Were this only met with in advanced age the dentist might well look upon it as a thing altogether beyond remedy, but unfortunately it frequently antedates any other indication of senility, and even comes on in middle life. Thus, in a middle-aged patient, without any appreciable wasting of the gums, the whole of the upper front teeth became excessively loose and fell out. The alveoli were altogether absorbed, or were greatly enlarged; but the presence of any manifest disease, either in the teeth themselves or in the surrounding parts, could not be detected. The gums were not more vascular than would be considered consistent with health, and in the teeth there was a total absence of that horn-like appearance of the roots sometimes seen; indeed, the cause of the malady was too obscure to admit of recognition.

Sometimes, however, the destruction of the socket is more partial.

The more prominent of outstanding teeth are those the sockets of which are most liable to become absorbed; teeth, in fact, the roots of which are but thinly covered by bone

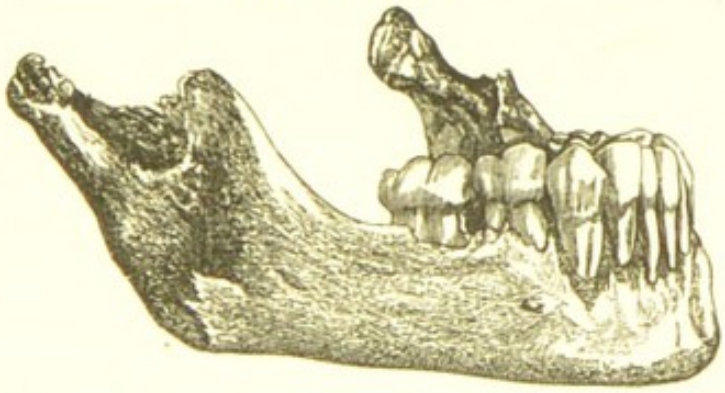
and soft parts. This is shown in the case figured. The right upper canine has lost the whole of the anterior wall of its

FIG. 273. (1)



socket, while the contiguous lateral incisor, which lies back, has retained the corresponding part of the alveolar invest-

FIG. 274. (2)



ment. The canine teeth being the last of the front teeth to take their position, in a contracted jaw are likely to stand

(1) The upper and lower maxillæ, from a subject aged thirty, showing extensive absorption of the alveolar processes of the front teeth.

(2) The lower jaw of a male subject who died at the age of six years, showing the results of absorption of the alveoli of the temporary teeth.

in advance of the dental arch. The course taken by the root can be readily traced, and the small amount of bone and gum by which its anterior surface is clothed recognised. It is from the roots of a tooth so placed that the anterior and projecting wall of the socket most frequently disappears. The labial surface of the root becomes exposed throughout the greater part of its length, leaving the tooth dependent upon the posterior or lingual wall of the socket for its retention in the jaw. A prominent and comparatively unsupported position would seem to offer an explanation of the early disappearance of the outer plate of the alveolus, but cases are now and then seen to which this explanation could not be satisfactorily applied. A specimen in my own collection exhibits the full complement of teeth in the upper jaw, sound and well arranged, but from a bicuspid tooth the whole of the labial plate of the alveolus has been absorbed.

It is in many cases very difficult to discover a satisfactory cause for the premature disappearance of the alveolar processes. The presence of inflammation of the gums, or of the alveolar periosteum, or of collections of tartar about the necks of the teeth, and the consequent irritation of the edges of the gums, are followed as a secondary consequence by absorption; but as will presently be seen, these causes do not always seem to account for it. The frequent use of a hard tooth-brush will hasten the wasting of an outstanding socket, the corresponding gum of which has the appearance of being stretched in a thin layer over the neck of the tooth.

When the alveolar loss is general throughout the mouth, it will, on inquiry, very commonly be found that a similar misfortune has befallen other and antecedent members of the family,—that the predisposition to an early failure of the teeth, from the recedence of their sockets, is hereditary.

Teeth which have no antagonists in the mouth are perhaps more liable to be lost in this way than those which are in full use; and it is not unusual for the bicuspids and

molars to be thus shed, whilst the teeth in the front of the mouth remain fairly firm.

The remarks which have so far been made have reference to the loss of teeth in advancing age; but there is a class of cases in which this loss is very premature, and in which it takes place with a rapidity and an amount of inflammatory disturbance which have gained for it a specific name. The discharge, which is a prominent symptom in the more acute cases, suggested the name pyorrhœa alveolaris, which has passed into general currency, while the warm advocacy of a particular form of treatment, and the consequent attention drawn to its advocate in connection with the disease, has led to the frequent use of the term Riggs's disease; this is to be regretted, as we might as well call small-pox Jenner's disease.

One of the earliest indications of the advent of this state of things, is a thickening and rounding of the edge of the gum, which ceases to be closely adherent to the neck of the tooth.

In this sulcus between the neck of the tooth and the free edge of the gum there is generally a little pus, and as the disease progresses, the tooth becomes detached from the soft parts to a considerable depth, so that a piece of so-called "dentist's twist" may be passed up between the root of the tooth and the alveolus. At this stage there is usually a considerable amount of discharge, which is peculiarly offensive, and the breath of the patient has a nauseating odour, by which it is often possible to tell what is the matter before inspecting the mouth at all.

There is often a considerable amount of neuralgic pain attendant upon this condition, which is very commonly attended with chronic inflammation of the gums, and may arise as a consequence of scurvy or of mercurial salivation.

The causes and pathology of the disease are very obscure; it often arises in thoroughly healthy persons who have hardly passed the period of middle life, and whose teeth have been exceptionally free from caries.

On passing an instrument down between the edge of the gum and the neck of the tooth a thin rim of tartar will very often be detected, even in those cases in which there is no visible deposit above the level of the gum, and the frequency of its occurrence has led some observers to attribute the whole disease to the irritation set up by its presence. But there are many cogent arguments against the acceptance of such a view: in the first place, in those most acute cases in which the progress of the disease is very rapid indeed, some of the most trustworthy observers have found no tartar at all; whilst, on the other hand, its occurrence in such a situation, if only the gum be parted from the tooth for a long enough time, would be almost a matter of certainty, and therefore much may be argued from its occasional absence and little from its very general presence.

While it must be acknowledged that the pathology of the disease remains uncertain, yet there is good reason for supposing that its original seat is either the edge of the bony socket, or what amounts to almost the same thing, the junction of the gum with the periosteum of the tooth socket; and it bears some little resemblance to a very limited caries of bone, a resemblance which is at least not diminished by the light thrown upon it by the results of treatment.

If a skull, whether of an animal or of man, in which alveolar absorption be going on, be closely examined, it will be found that round the neck of each tooth affected there is a sort of gutter; that is to say, the loss of bone has taken place to the greatest extent close to the neck, and to a much less extent at a little distance from it; in other words, the outer and inner alveolar plates of the jaw resist and stand up like rims.

This appearance is very marked in the early stages of the disease, and strongly suggests that the primary mischief is not in the gum, in which case the outside of the bone might be expected to suffer at all events equally, with the immediate

surroundings of the tooth, but in the alveolo-dental periosteum.

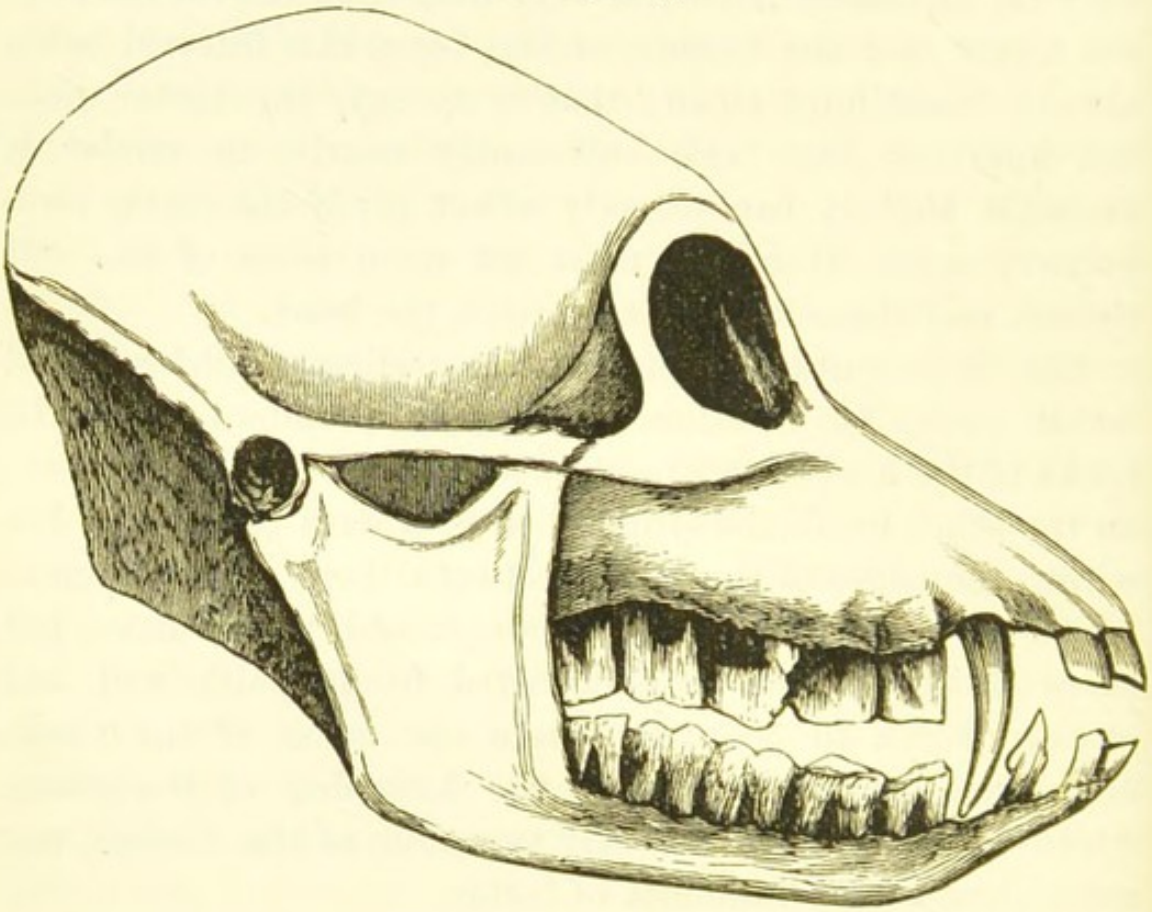
And if in such skulls the teeth be looked at with a view of ascertaining what relation the tartar (which is not lost by the ordinary processes of maceration, &c., but is always to be found intact) bears to the absorbing sockets, it will be found that there is always, at all events until the disease is very far advanced indeed, a very material interval between the tartar and the surface of the bone, this interval being always beautifully clean; that is to say, the tartar does not approach the bone sufficiently nearly to render it probable that it can directly affect it; if the tartar be a primary cause at all, it must act upon some of the soft tissues, and these in their turn upon the bone.

And it is quite certain that the ordinary light-coloured tartar, such, for instance, as that so abundant upon the backs of the lower front teeth, does not set up the process; on the other hand, the form which is of dark colour and lies within the edges of the gums, between them and the teeth, which is open to more suspicion, could never have got there until the gum had departed from health and had already begun to peel away from the necks of the teeth. Hence we must admit that the loosening of the gums, which we recognise as an early symptom of the disease, was antecedent to any influence of tartar.

Mr. Bland Sutton has described the jaws of a monkey (which he has presented to the Museum of the Odontological Society), in which he believes that the very extensive alveolar waste has been due to the effect of tartar, and this is the more significant inasmuch as he is an advocate in general for the existence of a constitutional type of the disease. Although not occurring in man, the case is one of such significance that I have borrowed the figure for reproduction here, though unfortunately it is too rough in execution to show all the points of the case. One side of both upper and lower jaws is almost free from disease, whilst upon the other the teeth are exposed almost to the

ends of their roots. The cupped appearance already alluded to is very well marked, the outer and inner plates of the jaws standing up with sharp margins; while there is no appearance of inflammatory affection of the bone beyond the edges, the waste has gone on with singular uniformity along the whole length of the jaws, and there is a great deal of

FIG. 275. (1)



tartar upon the teeth. But there is this peculiarity which would only strike the eye of a dental practitioner,—the tartar is mainly of the soft light-coloured kind, and it extends up upon the working surfaces of the teeth, so that it proves conclusively that this side of the mouth was out of work in the way of mastication for a considerable time prior to the animal's death.

To me therefore it appears quite clear that the bulk of the tartar was deposited after the teeth had become so loose

(1) Skull of monkey (Cercopithecus lallandii) with extensive loss of alveoli.

and tender that the animal had ceased to use that side of the mouth, and if the other side be carefully searched the commencement of the disease may be clearly seen upon the sockets of teeth which are apparently quite free from tartar.

To my mind, therefore, this skull does not lend support to the idea that the tartar really was a cause, but rather that its presence is an effect.

The opportunity of observing the state of the teeth once occurred to me in the following manner: a patient, aged only thirty, whose teeth were very seriously and very rapidly attacked, and some of them loosened to the degree that their extraction was needed, partly from impatience and partly as involving less expense and less frequent visits to the dentist, which his circumstances rendered of great difficulty, urged very strongly the extraction of all the remaining teeth of the upper jaw, some few of which were as yet only in the incipient stage, so that he might at once resort to a suction-plate. Although it was a severe case, these teeth which were not as yet greatly loosened, but still presented all the characters of the disease in the way of discharge from around their necks, &c., were absolutely free from tartar.

Mr. Bland Sutton, in one of his exceedingly interesting papers upon comparative dental pathology, has adduced instances of the premature loss of teeth in animals which were affected with general constitutional diseases ("Trans. Odont. Soc.," 1884).

He instances a crab-eating opossum (*Didelphys cancrivora*), in which the teeth all peeled away with the gum like a row of nails driven through a piece of leather, the bones being so soft that they could be twisted and bent like gutta-percha; all the long bones were affected, the disease being like mollities ossium. In a lemur also, and in a marmoset, the teeth were falling out, and the animals presented unmistakeable evidence of general rickets. "With this array of facts before us—and be it remembered these cases are only selections from numbers which come before me—it

must be conceded that in animals premature falling of the teeth is associated with constitutional diseases. Do the same facts apply to the human subject?"

Fig. 276. (1)

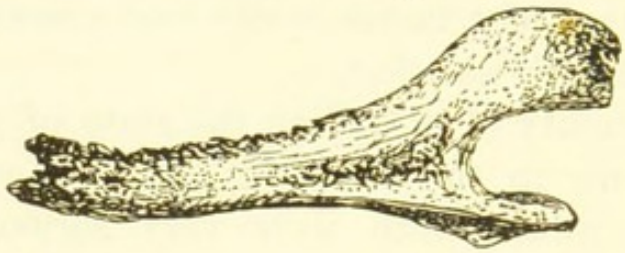


Fig. 277. (2)

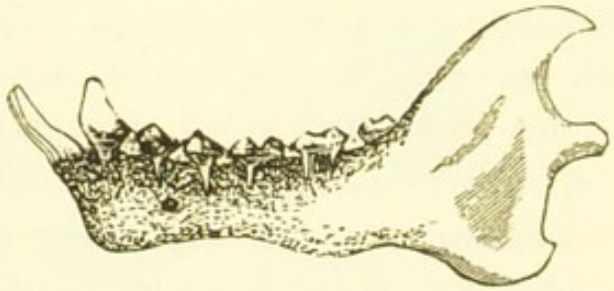


Fig. 278. (3)

The following is a remarkable case in point in Mr. Sutton's words: "During the present year I presented to the museum of the Middlesex Hospital a skull of an old woman which presented the following peculiarities. The entire skull had suffered general diminution in size and thickness; its weight is fourteen ounces, as compared with twenty-four

(1) Lower jaw of an opossum (D. cancrivora) from which the teeth peeled away in the mucous membrane. From Sutton. Trans. Odont. Soc. 1884.

(2) Lower jaw of a lemur (Perodicticus polta) showing alveolar absorption. From Sutton.

(3) Lower jaw of a marmoset, showing alveolar absorption. From Sutton.

ounces, the weight of an average European skull. The alveolar margins have suffered atrophy to such an extent, that in the superior maxilla the alveolus is on a level with the hard palate, whilst the lower jaw is nothing but a slender rod of bone weighing one ounce, as compared with three and a half ounces, the weight of a lower jaw of a lad of twenty years. All the bones were affected by this peculiar osteoporotic process."

"In my previous paper on this subject I have expressed myself cautiously as to the probability of premature absorption of the alveolus in man being really not a local affection, but associated with some general disturbance of the osseous system."

Further inquiry into the question has strengthened that conviction. He then goes on to say that there are two kinds of destruction of the alveoli met with in animals: one where there is not a trace of tartar, the other where there is a great deal of tartar: in the former group of cases there is general affection of other bones, in the latter the disease is purely local.

After all it must be confessed that the pathology of the disease remains very uncertain; there is much to support the idea that a constitutional cause is at the bottom of it, for instance it usually occurs with some near approach to bi-lateral symmetry, and the teeth first affected are often not those most liable to the deposit of tartar.

And even if it be regarded as a purely local, and as it were accidental occurrence, this does not involve the assumption that tartar starts it, and so far as it is possible to draw a conclusion from the imperfect knowledge of the condition which is to hand, I am inclined to assign to tartar a merely secondary influence in the progress of the disease which comes into operation only after the mischief has begun.

In the way of treatment, the first thing to be done is to remove the tartar, especially that which is within the margin of the gum, for this is at all events capable of preventing

the gum from resuming its proper relation with the neck of the tooth.

Where the separation extends far down the root, this may be a matter of very great difficulty. It was claimed by the late Dr. Riggs that the edge of the bone was always in a state of disintegration, and that it should be scraped so as to get a fresh surface; for this purpose he devised a set of instruments somewhat of the form of the pluggers figured upon page 353 (Fig. 154), but larger and having the cutting edges variously disposed, so as to keep a sharp point always, and a sharp edge towards the tooth while there is a safe side towards the gum. This is passed down parallel with the root, and the point used to scrape the bone, an operation which gives a good deal of pain.

There is not the least doubt that a conscientious application of Dr. Riggs' method will in a large proportion of cases effect at least a great temporary improvement, much more than ordinary scaling will effect, and this seems to lend colour to the view that the seat of trouble is at the edge of the bone. But I have seen cases tolerably severe which have seemed to be on the high road to complete cure, and yet six months afterwards have been worse than ever; and notwithstanding the extravagant claims of some practitioners as to their results, it is but seldom that treatment does more than retard the progress of the malady.

The most sanguine operators believe that the lost bone is actually reformed; but although I have been by the kindness of some of my professional brethren allowed to see some of their cases, I am afraid that I remain very sceptical on this point.

The use of escharotics is an obviously similar line of treatment, and the pouches between the gum and the teeth may be cauterised; thus Dr. Atkinson advises when the recession is great, and dark bloody pus is exuding, that a caustic paste made by rubbing together equal parts of carbolic acid, and of caustic potash without any water, be passed down to the bottom of the pouches; other writers

have recommended chromic acid, and others aqua regia, or solid chloride or iodide of zinc. For less severe cases, iodoform or aromatic sulphuric acid are favourite remedies, and Mr. Whatford has had some success with powdered sulphate of copper.

In my own experience I have found that frequent and vigorous rubbing of the gums with the finger, shampooing them in fact, has often been productive of great advantage, the patient of course being cautioned not to rub the actual edge ; but even on this point there is a difference of opinion, for in a recent paper on the subject rest and the avoidance of all friction is advocated.

Where the patient is young, and the disease has supervened after a period of ill-health which has passed by, the prognosis is more hopeful.

In one case of my own, in which treatment of various kinds was conscientiously carried out, the four upper incisors were lost after ten years from the first appearance of the disease ; from my own experience I regard this not as a failure, but as a relatively successful result.

It must not be thought, from what has been said in the preceding pages, that treatment is of no avail ; there can be no doubt that much may be done by thoroughly carrying it out in retarding the progress of the disease, and that teeth may be preserved for a good many years beyond the period at which they would otherwise have succumbed.

But real and lasting cure is so rare a result that many of the most cautious observers are of opinion that palliation is all that can be effected.

HYPERTROPHIES OF THE ALVEOLAR PORTION OF THE JAW.

A FORM of abnormal development of bone in the alveolar region, which is productive of great inconvenience to the patient, consists in a gradual filling up of the sockets of the teeth by bone.

After the luxation of a tooth, the socket in young and middle-aged subjects is to a certain extent filled up from the bottom by the development of bone. This process, which, after the loss of a tooth is reparative, becomes destructive when the action is set up in the socket of a sound tooth. The tooth by slow degrees becomes longer than its neighbours, and after the lapse of a considerable length of time, loosens and falls out, or is removed in consequence of its inconvenient length.

In other cases, again, the teeth, without being extruded by the development of bone within their sockets, are separated from each other by the thickening of the intervening bone. In some cases the shifting of position may be due to derangement of the normal antagonism of the upper and lower teeth; but there are others in which this cause will fail to explain the gradual separation of teeth which are apparently sound and healthy. This deposition of bone may also have the effect of displacing the teeth forward, thus, in the case of the upper incisors, producing a very unsightly appearance. The gum is usually pale, hard, and closely adherent to the necks of the teeth.

Hypertrophy of the alveolar portion of the jaw, when limited in extent, is far from uncommon. I remember one case in which a stout bony ridge ran out to the extent of more than half an inch, and then turned upwards. The

patient stated that the lodgment of food on the shelf, as he termed it, was the only annoyance to which the exostosis subjected him (1).

Otto Weber (2) mentions the occurrence of limited exostoses and thickenings of the bone near the alveolar border, and refers them to the irritation caused by diseased teeth ;

FIG. 279. (3)

he observes that over such exostoses there is marked tenderness on firm pressure.

Small exostoses, which seemed to be due to the irritation caused by carious teeth, have in some few cases been known to disappear after the extraction of the teeth,—a course which should therefore always be tried when there appears to be any such cause in operation.

But symmetrical exostoses upon the lingual aspect of the lower jaw are very common in mouths where the teeth are all perfectly sound ; there are often as many as three or four upon each side, and they usually are not productive of any inconvenience, though they are troublesome to the dentist when it is desired to insert artificial teeth.

Sometimes exostoses occur upon the outer surface of the

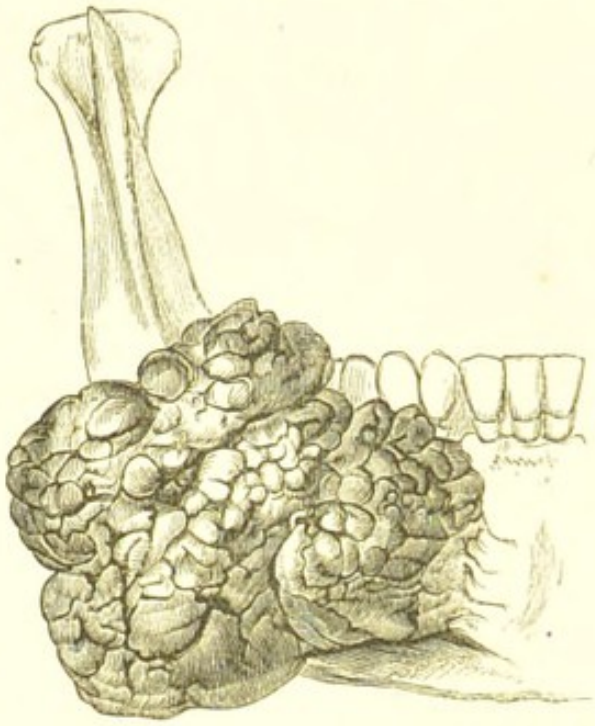
(1) An excellent example of numerous exostoses, studded over the alveolar border of the jaw, is given in "Atlas zur Pathologie der Zähne" von Heider and Wedl, Plate xv., Fig. 138.

(2) Otto Weber, "Lehrbuch der allgemeinen und specialen Chirurgie."

(3) Shows the front teeth in the lower jaw separated from each other in the median line by the thickening of the intervening bone, independent of the presence of disease. (From Sir E. Saunders's collection.)

bone, as in the specimen here figured; and when they attain to such size as to be productive of serious inconvenience, which they rarely do, no treatment but excision of the morbid growth will be of any service. Owing to the excessive hardness of some of these exostoses, their removal

FIG. 280. (1)



is often attended with more difficulty than was at all anticipated. A Hey's saw or a surgical engine will generally be found suitable for its removal; it is often too hard for a gouge or bone-forceps to be of much service.

In other instances the enlargement of the bone is of a soft, spongy character: teeth removed in such cases come away very readily, the bone conveying a peculiar yielding sensation to the operator, as though it crushed under the application of moderate force. This form of enlargement slowly disappears after the removal of the source of irritation.

Hypertrophy of the Gums and Alveolar Processes.—In some few cases a general hypertrophy, involving the whole

(1) Large exostosis on outer plate of lower jaw. From a specimen in the Boston Medical Museum.

or the greater part of the gums and alveolar processes, has been observed : for the opportunity of examining one of these cases the author was indebted to the late Mr. Alfred Canton. The whole of the alveolar bone was greatly enlarged ; it projected upwards in the lower, and downwards in the upper jaw, carrying before it a red and thickened gum, and concealing within the groove formed by its lingual and labial portions the corresponding surfaces of the teeth. The thickening in the front part of the mouth was so great that the lips could not be closed. At the back part of the alveolar arch the thickened and elevated gums of the respective jaws, though flattened by mutual pressure, did not allow the molar teeth to come in contact.

The patient was a half-witted, strumous child, aged about

FIG. 281. (1)

thirteen years, whose appearance led to the presumption that the disease was a manifestation of the strumous diathesis. No treatment was attempted in this case, the patient returning to her native village.

Several cases of the affection have been put on record (2). A fairly characteristic case, which occurred in the practice of

(1) From a model of the upper jaw of Mr. Syme's case.

(2) Other cases may be found in—"System of Surgery," by S. D. Gross, M.D., Philadelphia, 2nd edition, vol. ii., p. 535 ; "Boston Medical and Surgical Journal," April, 1869, two cases ; "Injuries and Diseases of the Jaws," by C. Heath, 3rd edition, 1884, p. 227.

Mr. Syme, and was seen more than once by my father, was met with in an adult, and affected both jaws alike. The increase was slow, and no operation was resorted to; the accompanying figure is taken from a model now in the museum of the Odontological Society.

Another case, in which the growth was much larger, and caused more distortion of the features, was successfully operated upon by Mr. Pollock.

The following notes of Mr. Pollock's case are abridged from Mr. Salter's (1) article. At the fifth week after birth,

Fig. 282 (2)

six teeth had appeared, and it was noticed that the gums were thick and puffy. At the age of two years all the temporary teeth were extracted, and the gums cauterised.

At the time of admission into St. George's Hospital the child was eight years old; it was remarkable for an abnormal development of hair, which grew low on the forehead, and reached in front of the ears on to the cheeks. A large pink mass, which could not be covered by the lips, protruded from the mouth; it was indistinctly lobed, with a dense, insensitive, skin-like surface. The greater bulk proceeded from the upper jaw, which overlapped the lower, the latter

(1) "A System of Surgery," by Timothy Holmes, M.A., 2nd edition, 1870. Art. "Diseases of the Teeth," vol. iv., p 342.

(2) From a plaster model of the upper jaw of Mr. Pollock's case.

being, as it were, imbedded in it. The mass was removed by operation, portions of it being cut away with scalpels and bone-nippers, and the removal completed at successive operations.

There was a slight tendency to recurrence of the growth. In structure it was found to consist of hypertrophy of the alveolar border, together with immense thickening of the fibrous portion of the gum, which bore an exuberant growth of papillæ. In the upper jaw it extended three-quarters of an inch forwards beyond the alveolar border.

Those of the temporary teeth which had not been extracted were deeply imbedded in the mass, though the first permanent molars had appeared, and the second lower temporary molars were visible, as the hypertrophy was not so great at the back of the mouth.

The roots were found to be imbedded in sockets, but the crowns were enclosed in serous-like chambers in the dense fibrous tissue, and were free from bony surroundings. One of the superior central incisors was nearly an inch from the surface. The permanent teeth were excessively large—the incisors larger than any which Mr. Salter had ever before seen in a female's mouth—and their bony loculi had not been absorbed to the extent usual at the patient's age. The epithelium had become converted into a thick and hard epidermis, beneath which were enormously long papillæ, attaining to one-sixth or one-fourth of an inch in length; this papillary growth being in unity with the great teeth, excess of coarse hair, thick skin, and other indications of a tendency to tegumentary hypertrophy.

Mr. Erichsen operated upon a child two and a half years old, by simply paring the mass off, extracting some of the teeth, and freely cauterising the cut surfaces; it proved to be a simple hypertrophy, no abnormal structures being found in the mass, but five years afterwards it had all been reproduced, and was described as almost completely covering the teeth, and forming numerous papillomatous growths. The patient presented peculiarities of

the skin, subcutaneous connective tissue, periosteum, and ends of the fingers and toes; the patient's brother, aged four, and a sister, aged two, presented a similar condition of mouth. A fuller description of these children will be found in the "Medico-Chirurgical Transactions," vol. 56, "On the three cases of molluscum fibrosum" by the late Dr. John Murray. The hairy woman, Julia Pastrana, formerly exhibited in London, was also an example of this affection, and the Odontological Society is fortunate in possessing models of her mouth. She was called the pig-faced woman, and was supposed to have had an excessive number of teeth, and in this connection is mentioned by Darwin in several of his works; this, however, was not the case, though the

Fig. 283. (1)

teeth, such of them as can be seen not completely buried in the hypertrophied gums, are excessively large.

But by far the most remarkable example of this hypertrophy is related by Mr. MacGillivray (2), from whose paper (for the use of which I am indebted to Mr. Heath) this account and figure are taken. It is noted that the gums

(1) From a photograph of Mr. MacGillivray's case.
(2) "Australian Medical Journal," August, 1871.

were unusually large at birth; of the deciduous teeth two only made their appearance, and by the time that the girl had reached the age of four, the growth attained to such a size that her medical man attempted its repression by caustics with little or no success. At the age of ten an operation was performed in which nine completely hidden teeth were extracted, and the redundant gums pared down.

When first seen by Mr. MacGillivray, the patient was twenty-nine years of age; the mouth was kept widely open by great lobulated masses springing from both upper and lower jaws. These huge lobular excrescences were found to spring mainly from the palatal surface of the alveolar portion of the jaws, the labial surfaces being comparatively healthy. Inside the mouth they reach backwards along the hard palate, and project below the soft palate. The surface of the growth was everywhere lobulated; in some parts smooth, in others rough from the presence of enormous papillæ; it was nowhere ulcerated, and no pain was felt in the masses.

Its removal was effected in three separate operations, performed at intervals; the lobular masses of gum being pared off with a scalpel, and the hypertrophied alveolus excised with bone-forceps; profuse hæmorrhage occurred, but was arrested by the use of the actual cautery.

The patient made a good recovery, and the operation seems to have been perfectly successful, both as regards the patient's appearance—she now being able to close the mouth—and as regards the recurrence of the disease.

In this case, as in Mr. Erichsen's, which was examined by Mr. Bruce, no abnormal structures were found: it was a case of true hypertrophy, in which some of the papillæ attained the enormous length of half an inch.

Mr. Heath gives a report of another case in a child aged four and a half. "She is one of five children; the other four are healthy. Two years ago the swelling of the gums began by the side of the temporary molars, which were just coming through, and from them the swelling has spread

right round the jaw. At this time she had fits about once a week; the fits have continued up to the present time, but with longer intervals. They appear to be epileptic. The patient is a very tractable child; her general health is good. The gums are enormously hypertrophied, the teeth being entirely covered, with the exception of the tips of the crowns, which appear depressed in the gums. The hypertrophy of the gums is so great that the cheeks are bulged out on each side, and the cavity of the mouth is almost filled with them. The teeth are irregular and slightly carious. The child is always biting and putting cold things in her mouth. She can bite nothing hard, and has been fed entirely on liquid and pulpy food. Her breath is very offensive. Under chloroform I removed the hypertrophied gums and the alveolar margin of the lower jaw in two pieces. On one side the first permanent molar came away; on the other it was left, not being quite erupted. Hæmorrhage, which was free, was stopped with the actual cautery. A fortnight afterwards I detached the hypertrophied gums and alveolar border of the upper jaw in one semicircular piece. Roots of the permanent teeth left. On June 3rd the patient was discharged well."

"A microscopic examination by Mr. Charles Tomes showed that the structure of the growth closely resembled that of the small polypi which are sometimes found occupying the cavity of carious teeth; it was a true hypertrophy of the gums, and chiefly of the fibrous portion. It sprang from the periosteum round the neck of the teeth, just within the margin of the alveoli. From this point a dense stroma of interlacing fibres, covered by a thin mucous and epithelial layer, grew up round the tooth, the growths from opposite sides meeting over it and coalescing, so as almost to cover it. The attachment within the socket was important, for this explained how it was that a successful result could not be obtained without removing some of the alveolus. Unless this was done, part of the growth remained behind, and recurrence soon took place."

It would be interesting to see what would be the result of simply removing the teeth, so as to set up the process of absorption of the alveolus which follows upon their loss; as these cases are not very urgent the loss of time involved would not be serious, even if it afterwards became necessary to resort to a more extensive operation, whilst it seems quite within the bounds of possibility that such a measure might result in the shrinkage of the whole mass.

Amongst the specimens presented by Mr. Sutton to the Odontological Society is one of the jaws of a rickety lion, which presented in all respects the characters of this disease.

In the condition just described the gums and actual alveolar borders alone are affected, but the maxillary bones are sometimes the starting-point of a remarkable form of general hypertrophy of the bone, which in severe cases affects the other bones of the face and cranium, and, more rarely, bones elsewhere in the body.

Although it is a rare disease, and one which falls into the hands of the surgeon for treatment, it is very necessary for the dental surgeon to be acquainted with its nature and characters, as it is likely to be brought before him in its early stages for his opinion.

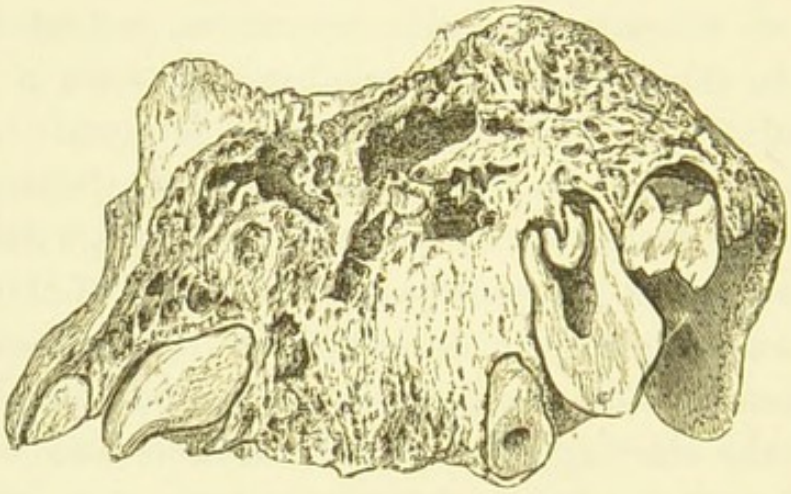
The disease consists in an interstitial growth and alteration affecting the whole substance of the bone, and not merely its surface: in its progress the whole bone becomes enlarged; the antrum, and eventually also the nasal cavities, obliterated: it goes on to encroach on the orbit till the eye is destroyed by its pressure, and the most hideous deformity produced. In Mr. Heath's work (1) several figures are given showing the extreme deformity which is caused by the disease.

The coarse, rough, porous appearance of the surface of the bone is well shown in the plate of Mr. Bickersteth's case (2), and this same porous cancellated structure, extending

(1) "Diseases and Injuries of the Jaws," 2nd edition, 1872, p. 132.
(2) Transactions of the Pathological Society, 1866, p. 245.

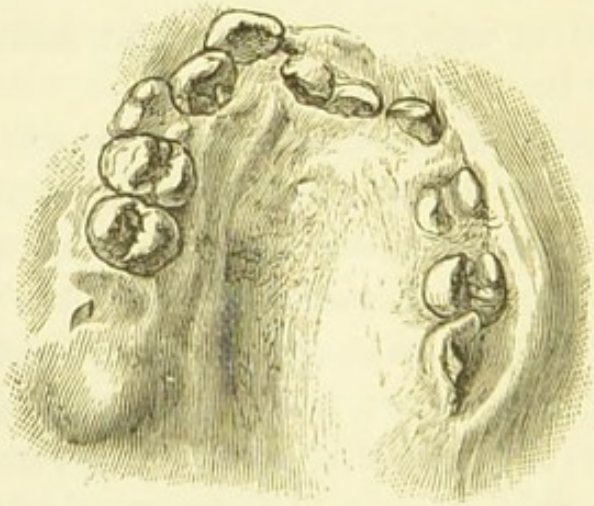
through the whole substance of the bone, is seen in the appended figure, from a specimen for the use of which I am indebted to the kindness of Mr. Christopher Heath. In

Fig. 284. (1)



this case the disease was first noticed at the age of three months, when the left side of the face was found to be

Fig. 285.



enlarging. The left eye became closed at the age of six, and the enlargement steadily increased till the boy reached the

(1) Half of the left upper maxilla (Mr. Heath's case); the section has been carried through the permanent teeth, which had not as yet been erupted; some of the teeth are in the other half of the bone, so that they are not shown in this figure.

age of twelve, when the left upper maxilla was removed by Mr. Heath ; the integument having, however, shared in the hypertrophy, great deformity still remains.

A model of the mouth (Fig. 285), taken before the operation, shows that on the right or healthy side the permanent incisors, canine and bicuspids, are in place ; while on the left side the temporary incisors and canine (?) are retained, and the bicuspids not fully erupted.

As seen in the sections made through the bone after its removal, the incisors, canine, bicuspids, and first permanent molar (carious) are found to be well-developed, full-sized teeth.

Behind the first permanent molar the antero-posterior development of the jaw has been checked, and the second permanent molar is a somewhat stunted tooth, whilst the crown of the wisdom-tooth is extremely small.

In this case, then, the development of those members ot the permanent set which are the last to take their place was stunted, and the whole process of dentition retarded, so that the temporary incisors and canines were retained for several years beyond the period at which they should have been shed. It is stated that the temporary teeth were erupted at their normal periods.

In all the cases the enlargement of the bone is slow, and at first painless, so that commonly many years elapse before the patient suffers the removal of the maxilla, which is the only available treatment ; it seems usually to commence before the age of puberty, though this is not a universal rule.

Little or nothing is known as to its origin : it is apparently in no way connected with either syphilis or struma, and has been supposed to consist primarily of an inflammatory affection of the periosteum—to which view, however, there are some objections ; while by Otto Weber it is supposed to be a result of erysipelas.

In Mr. Bickersteth's case the diseased bone presented a curious microscopical structure, having large branching

vascular canals in its substance, totally unlike the ordinary Haversian canals: these were described and figured by Mr. De Morgan in the Transactions of the Pathological Society (1); but in Mr. Heath's case, which was examined by myself, these canals did not exist, the only noteworthy peculiarity being the absence of well-developed Haversian systems.

(1) Transactions of the Pathological Society, 1866, vol. xvii., plate xii.

TUMOURS OF THE GUMS.

Several varieties of tumour are met with in the mouth, springing either from the gums themselves, or from the sub-adjacent structures, *i.e.*, the alveolar periosteum or the bone at the margins of the alveoli. Polypus or fungus of the gum, hypertrophy of the gum, vascular tumours, and epulis constitute the principal varieties.

Polypus or Fungus of the Gum.—It is not uncommon to find a cavity situated on the mesial or distal surface of a tooth filled up by a vascular mass, similar in colour and general appearance to the contiguous gums. It may be an outgrowth from the dental pulp (see p. 430); more commonly, however, it springs from the inter-dental gum, or, according to Dr. Magitot ([1]), from the periosteum investing the neck of the tooth.

On a close examination it will be found that the tooth has decayed down to the level, or even below the edge of the gum, leaving a sharp, ragged margin, capable of acting as a source of irritation: that the gum has grown up from a flattened pedicle, and expanded out so as to fill up the cavity in the tooth; in other words, that a tumour has been produced by local irritation.

The structure of these growths is very similar to that of the tissues from which they spring. They are for the most part made up of fibrous tissue, with nuclei and fusiform cells; the surface is covered by greatly-enlarged papillæ and a thin epithelium.

The occurrence of pain is not a necessary consequence unless the growth inflames and ulcerates. The patient is

([1]) Dr. E. Magitot, "Mémoire sur les Tumeurs du Périoste Dentaire," p. 58 and figs. 7, 7*a*.

unable to distinguish the pain so produced from that which arises from inflammation of the dental pulp.

If allowed to take its own course, the new growth usually rises to the level of the masticating surface of the adjoining teeth, and its further increase is restrained by the action of the opposing tooth. It will spring up again and again after simple excision; but if the decayed tooth be removed, or reduced to the level of the gum, any subsequent development of the mass is not only checked, but that which has been already produced rapidly wastes away, and is lost.

In the treatment of cavities situated on the mesial or distal surfaces of teeth, it is frequently necessary to cut away the sides of one or more teeth down to the level of the gum, leaving a wedge-shaped interval. Into the space so produced the gum will sometimes advance, and is then liable to be injured by food, which, in the course of mastication, becomes forced into the separation between the teeth. The pain attendant upon this condition is usually attributed to the teeth which have been operated upon, and may very readily be mistaken for ordinary toothache. The absence of a cavity within which the new growth can find partial protection from pressure, appears to limit its growth; for in these wedge-shaped intervals we seldom find that it attains a size beyond that of a slight excrescence. This circumstance may be taken advantage of in our treatment of the disease.

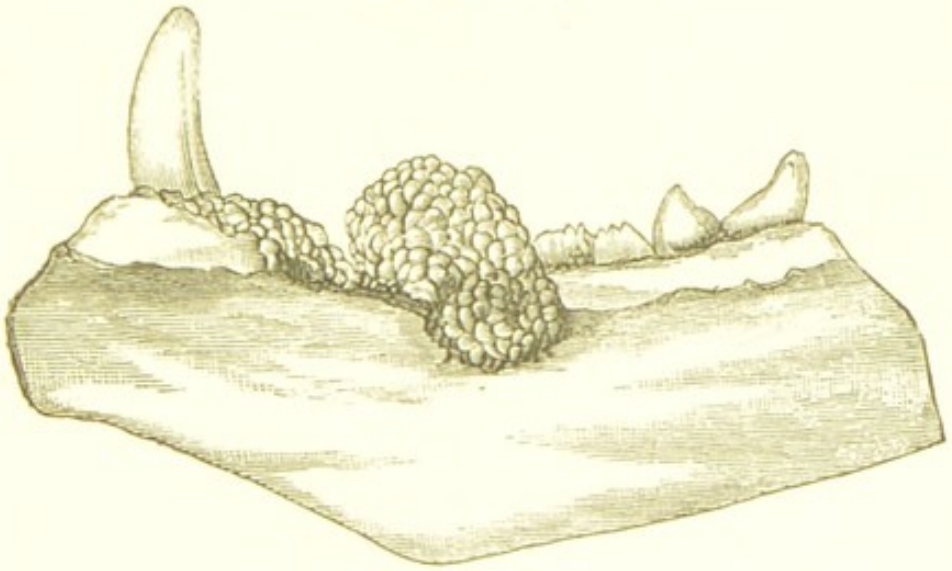
Treatment.—Decayed teeth, when they afford a receptacle for polypus, are usually too deeply involved in disease to admit of successful treatment. It is better that they should be extracted, an operation which not only removes a useless organ, but cures at the same time the disease of the gum.

The extraction of the tooth often brings away the polypus, which is then (see Dr. Magitot, fig. *loc. cit.*) seen to be adherent to the neck of the tooth by a flattened pedicle. If for any special reason, the preservation of the tooth is desirable, the tendency to recurrence of the growth must be kept down by ecsharotics.

Epulis.—Tumours springing up from the margin of the gums, whatever may be their structural character, usually receive the designation epulis.

By common consent, however, the use of the term is becoming restricted to a particular form of tumour, which at first makes its appearance at the edge of the gum, and very commonly at that portion which lies between two teeth, which, with the growth of the tumour, become gradually separated. The separation does not, however, afford sufficient space for the accommodation of the new structure which by slow degrees spreads itself out either upon the labial or lingual surface of the gums, or upon both. The attachment, at first limited to the inter-dental portion of the gum, may not spread with the increasing size of the tumour, or the base may be gradually extended over the alveolar border. In other words, the epulis may be attached

FIG. 286. (1)



by a small and flattened pedicle, or by a broad base. The submucous fibrous tissue, or perhaps the soft tissue contained in the Haversian canals of the bone, usually is the site of the disease, which in its growth carries before it the superjacent

(1) Jaw of a tiger, with a fibrous epulis springing from the alveolus. From Sutton's Pathology.

mucous membrane. The tumours springing from the fibrous tissue are very generally themselves fibrous in character, and, lying close to the surface of the bone, very frequently contain osseous spicula. The new bone may be altogether detached from, or it may shoot out of, the alveolar process, the surface of which, in either case, is usually abnormally rough. In respect to vascularity, an epulis commonly does not much exceed that which prevails in the adjacent gum, and the density of the tumour usually corresponds with that of the latter structure.

The accompanying figure (from Sutton's "Introduction to General Pathology"), shows well the situation of an epulis. As it is not a fatal disorder, such specimens are not often obtainable from the human subject

When the new growth has attained a considerable size, secondary conditions are induced, which complicate, and to some extent alter, the character of the disease. Unrestrained by surgical treatment, the tumour, at first small, and productive of but little inconvenience, increases in size, generally encroaches upon the space assigned to the tongue, or upon the hard palate, and, covering over one or two of the teeth, impedes both mastication and articulation. The surface becomes injured either by the teeth of the opposing jaw, or by those whose crowns it has overrun. The injured part becomes the site of an ulcer, which emits a copious and fœtid discharge; and the patient, in the place of feeling inconvenience only, is subjected, if not to acute suffering, to great annoyance. The external characters of the ulcers sometimes closely resemble those assumed by malignant disease, and may present a further likeness in the occurrence of hæmorrhage; but the cases in which epulis passes into cancer rarely occur (1).

Such, then, are the general characters of epulis. As

(1) A case in which epulis was supposed to have passed into epithelioma is recorded in the Pathological Society's Transactions, vol. xii. Mr. Adams removed the jaw, but the patient died from the recurrence of the disease in the skin.

regards the structure of these tumours, several varieties may be noted: first, those which are composed of fibrous tissue intermixed with cells; secondly, those which are mainly composed of the elastic fibrous tissue, the individual fibres of which, like those of yellow elastic tissue, are tolerably uniform in size, curl up when divided, and remain uninfluenced by the action of acetic acid; thirdly, those composed of myeloid cells. Mr. Heath mentions a form having the character of "giant-celled sarcoma," and another approximating to epithelioma in its structure. The two first forms have come under my own notice; the third has been described and figured by Mr. Hutchinson (1), who gave the following description:—"On examination, the epulis presented all the characters of myeloid growth in a most remarkable degree. Its section was very vascular, and showed hues varying from a deep red to buff, and a peculiar light-greenish tint of yellow (xanthoid of Lebert). Scattered in its structures were some detached masses of soft, spongy bone. Under the microscope were seen abundance of the large poly-nucleated bodies characteristic of these growths, many of them being very irregular in shape, and much branched."

In many cases it may be extremely difficult, if not impossible, to discover any satisfactory cause for the occurrence of epulis; but in others an examination of the tumours reveals a source of irritation to which the presence of the disease may with probable truth be assigned. In a case of epulis treated by Mr. De Morgan, the tumour contained an isolated piece of bone, which, on careful examination, was found to be imbedded and entangled in, rather than adherent to, the fibrous tissue which composed the mass. After it had been dislodged from the tumour, and submitted to microscopic examination, the following characters were clearly manifested:—the whole of the surface bore the marks of absorp-

(1) Transactions of the Pathological Society, vol. viii., p. 380.

tion, while the substance of the bone presented the structural characters of normally-developed tissue.

The presence of these characters, and the size of the fragment of bone, fully justified the assumption that it at one time formed a portion of the subjacent alveolus, and that its detachment had been effected by absorption; and further, that when so detached, it had proved a source of irritation, and thus led to the development of the epulis. In a case previously published, the stump of a tooth, the crown of which had been broken off five years before, was found in the centre of an epulis.

But true bone may be developed in the fibrous tissue of an epulis, just as bone may occur as a new development in various other situations; examples of this are given by Mr. Heath (1), who states that such epulides are hence now regarded as ossifying sarcomata.

Mr. Oakley Coles met with a small tumour attached to the side of the root of a tooth, which was examined by Professor Klein, and was found to be a spindle-celled sarcoma. This came away with the tooth on its extraction.

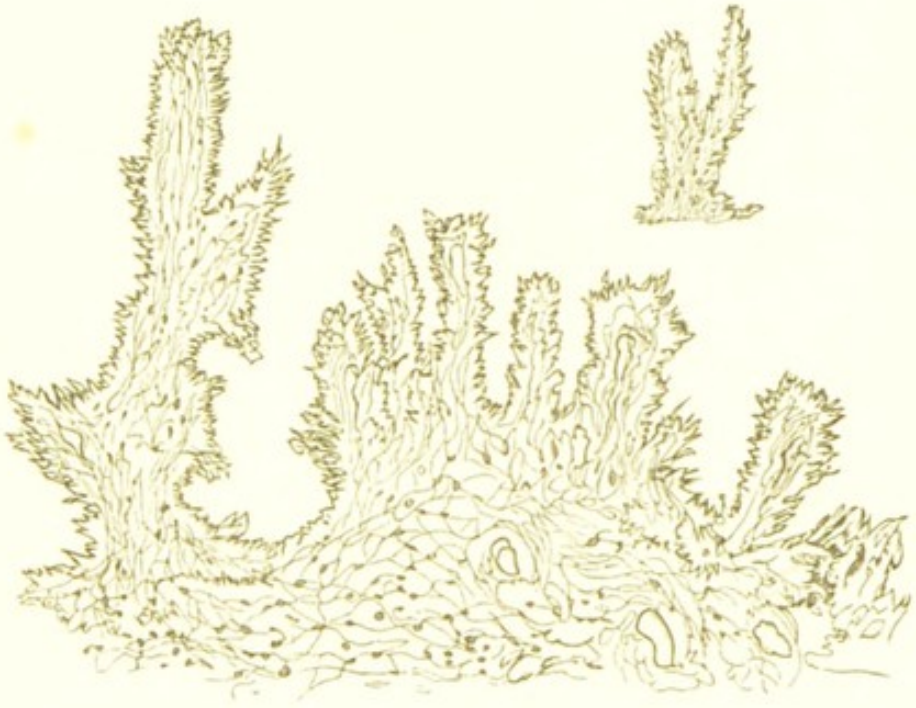
Treatment.—Whatever may be the primary seat of an epulis, it is quite certain that it very generally involves the periosteum or the endosteum; indeed, the balance of evidence is in favour of the view that, although it appears, when first developed, to be confined to the gum, it really springs from a deeper origin. Complete excision of the tumour is the only remedy upon which any dependence can be placed; and in order to effect its complete removal more or less of the bone at its base must be cut away. When it has grown up between two sound teeth, it may be necessary to extract one or both, in order to render the base of the tumour accessible.

As the growth is almost sure to recur if the bone at its base be not removed, it is exceedingly bad practice to cut off an epulis and apply nitrate of silver to the cut surface, or to

(1) "Injuries and Diseases of the Jaws," 3rd edition, p. 236.

remove it with a ligature. If the attachment to the bone appear superficial, the bone may be scraped away with a gouge or a chisel ; but if, as is more commonly the case, its origin is deeper, the alveolus must be freely cut away with bone-forceps. Free removal of the alveolar border of the jaw does no appreciable harm in such cases ; and it is far better to sacrifice a little more of a part which, in old age, nature would mainly remove, than to risk repeated recurrence of the disease. More than this will never be required ; even in

FIG. 287. (1)



the most formidable-looking cases of fibrous epulis, it is only the alveolar portion of the jaw which is involved.

Even the myeloid form, which is more prone to recur, may be successfully treated thus.

The hæmorrhage, which is rarely troublesome, may be checked by the use of the actual cautery.

Papillary Tumour of the Gum.—This is a very rare disease, described by Mr. Salter in Guy's Hospital Reports for 1866,

(1) Section of a papilloma as large as a pea : from a specimen prepared by Mr. Charters White.

in which local hypertrophy of the papillæ takes place to such an extent as to form a definite tumour; Heider and Wedl also (*op. cit.*, Taf. xiii., figs. 118, 119) give figures of what they term "papillary proliferations," occurring in the vicinity of carious teeth, and Dr. Arkövy met with a case at the Dental Hospital. Mr. Mason ("Monthly Review Dent. Surgery," 1873) describes a case in which the new growth had a white shreddy appearance, and an elastic feel. It consisted of an enormous hypertrophy of normal structure, and allowing for difference of situation, was analogous to a wart.

Vascular Tumours of the Gums.—The gums are sometimes the seat of tumours which, but for their close structural resemblance to nævus, might come under the head of epulis. The disease first shows itself in a bright red pimple, slightly raised from the surface of the gum; and in the cases which have come under my own observation, the growth has been situated between the front teeth. The size is gradually increased, the teeth become separated, and the tumour extends along the gum, both in front of and behind the teeth. It bleeds freely when rubbed by the tooth-brush, is soft and compressible, and may be reduced to the colour and level of the gum by steady and gentle compression. Mr. Salter records a case in which the growth was as large as a marble, and which was productive of much annoyance by the constant hæmorrhage to which it gave rise. It twice recurred after removal by ligature, but when it and the spongy bone at its base were detached by cutting down with a strong scalpel, and the redundant granulations which were thrown out from time to time cauterised, a cure was effected.

Some cases which have come under the notice of the author have been successfully treated by the local application of powdered tannin to the surface of the tumour, but one case was met with that frequently recurred after destruction with nitric acid, sodium ethylate, and other caustics. It was never larger than half a pea, and ultimately ceased to recur.

DISEASES OF THE GUMS.

The gums are of course greatly involved in cases of pyorrhæa alveolaris, but independent of this, they are liable to several forms of inflammatory affections.

Chronic inflammation of the gums is often the result of long-continued dyspepsia, and it is interesting to note that it is frequently met with in stall-fed animals; and it is more common in the lower classes, who pay little attention to their teeth, than in the upper classes. Syphilis, or the abuse of mercury in the treatment of syphilis, is a not unfrequent cause of the disease in its more general form; while its local form may be set up in some persons by the slightest source of irritation in the mouth, such as a rough edge left on a filling. It also often follows on pre-existing disease of the dental periosteum.

Treatment.—The cause of the disease, be it local or general, must be sought for, and if it be discoverable, at once removed. The constitutional treatment of such cases will hardly fall within the province of the dental surgeon, but great advantage may be derived from topical applications, even in those cases which depend on some general cause.

The gums, if œdematous and congested, may be freely scarified with a lancet, and the bleeding encouraged as much as possible.

All tartar should be carefully and thoroughly removed, and teeth which have become very loose extracted.

A condition of inflammation of the gums sometimes occurs under plates carrying artificial teeth, and has, when observed under red vulcanite plates, been attributed to the vermilion with which this material is coloured.

But it occurs also under black rubber, and under gold plates, so that there is really not the least reason for attributing it to this cause.

There is a singular modification of chronic inflammation of the gums, in which, instead of becoming thickened and irregular on the surface, they seem rather to decrease in size, and assume a very red, smooth and polished surface and mottled aspect; at the same time the disease may extend over the surface of the hard palate. The malady is attended with acute intermittent pain, which may be confined to one side of the mouth, or even to half of the upper jaw; it very commonly comes on in the evening, and keeps the patient awake half the night. The patients suffering from this complaint who have come under my notice have been, for the most part, poor middle-aged females, in whom menstruation was becoming irregular, or had altogether ceased: and they have always been cured by the use of a mild aperient—such as sulphate and carbonate of magnesia, given in small doses twice a day. Under this treatment the pain in gums will probably cease within a week or nine days, and their restoration to a healthy condition will speedily follow.

Chronic inflammation of the gums may assume characters altogether different from those which have been described. Instead of presenting thickening and induration, the tissues may be loose, spongy, and highly vascular, bleeding freely on the slightest touch, and very tender; the gums rise up and cover over a considerable portion of the crowns of the teeth. The papillæ which stud over their surface become greatly enlarged, the vessels which, in their looping and inosculations form so pretty an object when subjected to microscopic examination, become, if not more numerous, greatly lengthened and dilated. The author was indebted to Mr. Roberts for the use of a beautifully-injected preparation of an inflamed, and as it would be called, scurvied gum. It is not from the human subject. After injecting a monkey, he found that the vessels of the thickened and inflamed gums

had received the injection. From the preparation so obtained the following illustration is taken.

The condition which has been described may arise in connection with, and as a consequence of diseased teeth; the causes and the complaint itself being in that case strictly local. But in certain states of the system attended with an altered condition of the circulating fluid—in blood diseases, as they are often called—the whole of the gums become similarly affected, and in maladies partaking of the nature of sea scurvy and purpura, this peculiar condition of the vascular tissues about the teeth forms a characteristic feature.

In scurvy the gums are greatly affected; the appearance

FIG. 288. (1)

of the mouth is very peculiar, as the lips and tongue are pallid, and contrast strongly with the blotchy, dusky purple gums rising up between and even over the teeth, and bleeding on the smallest touch.

In severe cases, blood continually oozes from the gums, and these may even slough and lay bare the necks of the

(1) Shows the injected vessels of gums inflamed and sufficiently enlarged to cover over and obscure the greater portion of the labial surface of the incisor teeth. The preparation was obtained from the mouth of a deceased monkey, by Dr. Roberts, to whom I am indebted for this illustration.

teeth and alveoli. The teeth become rapidly loose, and finally fall out.

A somewhat similar appearance is met with in purpura; in it the contrast between the gums and the lips is not so marked, and the severer lesions do not often occur.

Washes of chlorate of potash, and painting the gum with the glycerine of carbolic acid, are of some service, and when the patient is mending, the use of astringent and stimulant applications will hasten the restoration of the gums to their normal condition; but until the constitutional mischief is on the wane, local applications do very little good.

Acute Inflammation, when situated in the gums, rapidly involves the adjacent periosteum both of the external and internal surfaces of the alveoli, and by thus extending, tends to mask the original character of the disease, the nature of which, if the case be not seen in an early stage, may be involved in considerable obscurity. The malady, however, extends in another direction, and by so extending its nature becomes declared. The inflammation, at first limited to the mucous membrane of the gums, spreads to that of the mouth. The salivary glands become affected, and pour out an excessive amount of secretion, the flow of which becomes a conspicuous feature in the disorder. When this takes place, the patient is said to be salivated. Although cases of spontaneous salivation are recorded, well-marked examples are rarely met with. As the result of remedies administered for the cure of disease its occurrence is common, but not so common as in former years, when mercury was more frequently used, and its effects were pressed further. In cases of inflammation of the gums so induced, an opportunity of watching the disease from its commencement is afforded.

In salivation produced by mercury, the effect is first discernible upon the gums. Some hours previous to the occurrence of the metallic taste, and to the fœtor of the breath, and also to the soreness and discomfort of the mouth which mark the influence of mercury on the system, the gums show

so that it is not uncommon for the mouth to be permanently closed by cicatrices consequent on the sloughing process.

Aperients should be given, and chlorate of potash, both internally and as a wash for the mouth, and Condy's fluid forms an excellent wash for cleansing the mouth and deodorising the breath.

Occasional scarification of the gums, and the topical application of iodine, will assist in restoring them to their normal condition.

In syphilitic stomatitis there is no greatly-increased flow of saliva; the disease tends to destructive ulceration of the gums and superficial necrosis of the jaw. Shallow ulcers form beneath the tongue, and mucous patches appear on the cheeks. Although other evidences are generally present to aid the diagnosis, they are not invariably present. The disease readily yields to iodide of potassium; but it may be noted that in some persons a few doses of iodide of potassium will set up coryza and a profuse flow of saliva, though in this case there is no inflammatory affection of the gums.

The gums are liable to several forms of inflammation which are apt to run into ulceration.

Simple stomatitis is characterised by slightly elevated, reddish, glistening patches, which may coalesce so that the whole surface presents the characters of inflammation. Occasionally whitish patches occur on these surfaces, due to desquamation of the epithelium, or, in some instances, to exudation.

It is very common during the period of first dentition, and is then accompanied by febrile symptoms, but it is probable that the constitutional disturbance is independent of the stomatitis. It may also be produced by irritants, such as stimulating food, and is not unfrequently caused by gastric irritation, drunkards being particularly liable to this and more severe forms of stomatitis.

Its treatment is simple; a dose of aperient medicine, and emollient mouth-washes, being generally efficient in curing

it: if the patient be an infant who is being brought up by hand, a little lime-water should be added to the milk.

Thrush.—In its early stage this is quite indistinguishable from simple stomatitis; but the patches very speedily become coated with a very characteristic exudation, which is at first closely adherent; but after the lapse of a few days it peels off, only to be replaced by a fresh membrane.

It is a rare disease in adults, but is common in children. It is contagious; but in a healthy child, or in a child suffering from acute disease, it is of little moment; when, however, it supervenes in a child exhausted by chronic disease, it foretells a fatal termination at no very distant date.

The membrane which gives to it its characteristic appearance is in great part made up of the mycelium of a fungus —the *Oidium Albicans.* As might be expected, it is very amenable to local treatment; such applications as borax, alum, or nitrate of silver speedily curing it; but perhaps the best applications are the alkaline sulphites, or even sulphurous acid itself.

Follicular Stomatitis.—In the first instance, the individual inflamed follicles may be seen as isolated red specks; but they very speedily soften down, and pass into small, round, sharp-edged ulcers. Or the first thing noticeable may be a vesicular, herpetic eruption, the bursting of the vesicles leading to the formation of small ulcers, exceedingly painful, and generally surrounded with a narrow bright red zone of inflammation.

The ulcers are seldom or never single, and are oftenest found about the frænum, in the sulcus between the lips and gums, or on the lower surface of the tongue.

It is a trivial disorder, accompanied usually by no constitutional disturbance; but it is productive of great discomfort to the patient, on account of the excessive tenderness of the ulcers.

An occasional touch with nitrate of silver will relieve the tenderness of the raw surfaces, and the use of astringent

washes will serve to accelerate their healing. When it occurs in the sulcus between the lips and gums, the teeth must be kept scrupulously clean, and it will often prove advantageous to paint around their necks the glycerinum acidi carbolici; as an application to the surface, the following may be used, applying it on a slip of lint, which is allowed to lie in the sulcus—

℞. Acidi carbolici glacialis,
Liq. potassæ, āā ʒj.
Aquæ ad ʒiij.

Though follicular stomatitis is most frequently met with in children, it is not peculiar to early life, but is met with at all ages.

Instead of meeting with a cluster of ulcers, we not uncommonly find a single deeply-excavated, small, round ulcer in the sulcus, at the junction of the gums with the mucous membrane of the lips, or on the free mucous membrane. But that the ulcer is single, it might be described as follicular stomatitis; and though it is insignificant both in extent and duration, it is extremely sensitive and troublesome, rendering the movement of the tongue, and the act of mastication painful.

If the surface be touched with nitric acid, or nitrate of silver, an almost instantaneous cure is effected; the tenderness is entirely removed, and the patient will feel no further inconvenience.

Ulcerative Stomatitis.—This form of stomatitis is one which frequently comes under the notice of the dental surgeon.

Commencing at or near the edges of the gums, more frequently in the lower than in the upper jaw, and usually on one side only, it may spread till the whole interior of the mouth is a mass of ulcers. The edge of the gum becomes thickened and congested, and has often a pimply appearance: it assumes a deep purple colour, and bleeds at the

slightest touch. Ulceration speedily succeeds to this condition; commencing on the edges of the gum, it extends deeply into its substance, in severe cases laying bare the necks of the teeth and the alveolar processes. The mucous membrane of the cheek, where it comes into contact with the ulcerated surfaces, often becomes the seat of similar lesions, so that a line of ulceration corresponding to the position of the teeth runs along the inside of the cheek, as though the ulcers were contagious.

In severe cases ulceration occurs also upon the palate, and upon the margins of the tongue where it touches the ulcers around the teeth.

The malady generally originates in the front part of the mouth, and it is only in severe cases that it extends much to the molar region.

It is said that exudation precedes the occurrence of ulceration. In its fully-developed form, the ulcer is marked by the following characters: the surface is covered over by a dirty white or yellow material, which on removal by a current of tepid water, leaves exposed numerous scarlet points on a yellowish ground, which is made of débris of various sorts. The edges of the ulcer are sharp and ragged, of a colour ranging from violet to a brilliant vermilion, and the ulcers are at first superficial; but as the disease progresses they become deeper.

In cases of any severity, the side of the face is apt to be swollen, and the lymphatic glands enlarged and tender; there is, however, nothing like the extreme induration of the cellular tissue met with in cancrum oris.

The disease may run on for some months, in which case its cure becomes troublesome, and, once well established, it is very prone to recur.

In a subject predisposed to the disease, trivial sources of irritation will serve as its starting point, such as an abrasion, or a carious tooth or a half erupted wisdom tooth; fracture and necrosis of the jaw have likewise been known to set it up.

Although adults are not wholly exempt from attacks of ulcerative stomatitis, the disease occurs very much more frequently in children, especially between the ages of five and ten years. The cases which have come under my own notice have occurred in young people living in crowded localities, and who have been imperfectly clothed and fed. According to Dr. West, however, "it is by no means a constant occurrence for any special derangement of the general health to precede an attack of ulcerative stomatitis, though the children who are affected by it are seldom robust, and in many instances are such as have suffered from deficient food, or a damp and unhealthy lodging, or both." In young children who are but indifferently cared for, the disease in its earlier stages is overlooked, until the suspicion of the attendant is aroused by the fœtid state of the breath, the dribbling of the saliva, and the unwillingness of the child to take into the mouth food or anything that is calculated to produce pain in the ulcerated surface. When the disease is unchecked by treatment, it may lay bare a large portion of the alveoli of several teeth, which, with their sockets, become dead and blackened, and these serve to keep up the malady.

The Treatment of ulcerative stomatitis is usually attended with well-marked success. Local treatment is by Dr. West regarded as of secondary importance, and might, he says, in many cases be omitted without prejudice to the patient. He says, "Lotions of alum, or the burnt alum applied in substance, or the chloride of lime in powder, have all been used locally, with more or less benefit. It was my custom also to prescribe these remedies in ulcerative stomatitis; but since I became acquainted with the virtues of chlorate of potash, I have learned to rely upon it almost exclusively. It appears, indeed, almost to deserve the name of a specific in this affection, for a marked improvement seldom fails to be observed in the patient's condition after it has been administered for two or three days; and in a week or ten days the cure is generally completed. Three grains every four hours,

dissolved in water, and sweetened, is a sufficient dose for a child three years old; and five grains is the largest quantity that I have administered to a child eight or nine years old." The general health of the patient must at the same time be watched, and a purgative administered if the bowels require relief. Nutritious food should be given, and in the feeble subjects quinine or other tonics prescribed. In the cases which have come under my own treatment, the administration of these remedies has been followed by the rapid recovery of the patient.

The application of nitrate of silver to the surface of the ulcer at once changes its character, by forming a superficial slough, after the separation of which a healthy granulating surface is left. The excessive tenderness, too, is almost instantaneously relieved. The use of a wash composed of five or six grains of chlorate of soda to one ounce of water, will suppress the offensive odour. Teeth which are hopelessly loose, and productive of irritation, should be removed.

Patients suffering from constitutional syphilis are occasionally subject to ulceration in the mouth, indistinguishable from ulcerative stomatitis. The inner surface of the upper lip may be affected, and an ulceration corresponding to each tooth form, and spread on to the gums. There is some risk of adhesions forming between these contiguous surfaces during cicatrisation, so that the patient should be directed to continually keep a slip of lint, steeped in some disinfectant solution, between the affected parts.

Those cases which I have seen have all yielded to the administration of iodide of potassium.

These syphilitic ulcerations are not characterised by the extreme tenderness met with in the ordinary form of the disease.

Gangrenous Stomatitis. (Noma, Cancrum oris, Phagedæna oris, &c.)

Although this is a disease which would not fall within the province of the dental surgeon, nevertheless he should be able to recognize it, as the only chance for the patient lies

in the immediate and decisive treatment of the sore. The course of the disease is frightfully rapid, and the termination almost always fatal, though it is, happily, far from a common disease.

The first thing generally noticed is swelling of the face: this swelling is peculiar in its character, the skin being very tense and shining; the swelling is very hard, dense, and circumscribed, but remarkably free from tenderness; in its centre is a blotchy-looking red spot.

If the mouth be examined, there is seen to be an irregular ulcer, with livid red edges, sometimes in the sulcus, sometimes on the cheek. It is not very sensitive, but produces profuse salivation, and gives forth a gangrenous odour from the very first. It spreads with extraordinary rapidity, the red spot on the cheek simultaneously becoming black and sloughing, so as to open the oral cavity. The destruction of the tissues of the cheek takes place with extraordinary rapidity, and the death of the patient generally ensues in the course of a week. One of the strangest features of this frightfully destructive disease is the absence of pain, and even of great constitutional disturbance: food is usually taken well, even to the very last. The disease occurs in children of debilitated constitutions, and sometimes presents itself as a sequela to acute diseases, its subjects generally being from two to five years of age.

Constitutional treatment can do but little: so soon as the disease is recognized, the ulcer should be freely destroyed with fuming nitric acid; not a moment should be lost, as if gangrene has once fairly set in the case is almost hopeless; some practitioners prefer hydrochloric acid. But as the access of the disease is not always attended with much pain, it is often not treated until it is too late.

In the mouths of syphilitic persons mucous patches are very common, and there may exist upon the gums as well as upon the mucous membrane of the cheeks, patches of psoriasis; and even something like condylomata may occasionally be seen.

treatment showed no disposition to heal. A diagnosis of epithelioma having been made by Sir J. Paget and Mr. Heath, a vulcanite plate was made, covering the socket, which was packed with wool dipped in deliquesced chloride of zinc; this was left for twenty-four hours, and produced a considerable slough, with the result of getting a healthier surface; this was more than once repeated, but failed to do more than keep it in check, and the ulceration, quite painless and singularly clean in surface, slowly extended. Some few months after the disease was first noticed, Sir Joseph Lister removed the tuberosity and a portion of the soft and hard palate, and the disease has shown no sign of recurrence. In this case the disease certainly originated within the socket of a dead tooth, and the success that has attended its treatment is due to its early recognition, for it is very apt to have insidiously spread far beyond its apparent limits, even at the time of its first discovery.

In persons who have been subjected to the influence of lead the gum has a characteristic blue border, caused by sulphuretted hydrogen, derived from decomposing matter, having combined with lead brought by the blood-vessels.

The late Dr. Hilton Fagge (Transac. Med. Ch. Society, 1876) finds the discoloration to be in rounded loops corresponding with vascular papillæ, and to consist of granules in and around the smallest blood-vessels.

It may perhaps occur in persons who show no sign of lead poisoning, being then due to a very minute quantity of lead which has obtained entrance into the body.

In a person who kept the teeth very scrupulously clean it might probably be absent, for the sulphur might not be in sufficient quantities; the colour is often distributed in dots, and is most abundant in the processes of gum between teeth: when in an interval teeth are absent there is no lead line. But as it is not very rare in persons who are not known to have been exposed to lead, it is possible that other metals, *e.g.*, bismuth, might cause it.

Any of the ulcerations previously described may affect the

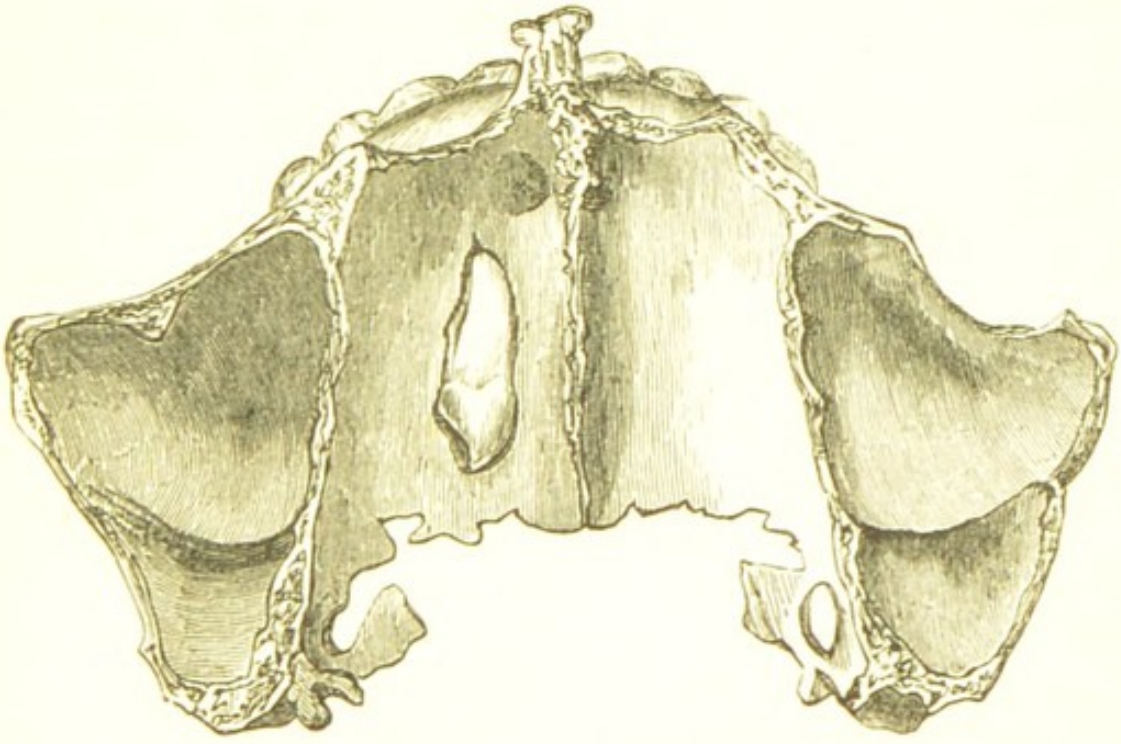
hard palate, which also is sometimes the site of mucous patches; and various tumours may occur upon it.

The commonest cause of swelling on the hard palate is

FIG. 289. (1)

abscess dependent on a lateral incisor tooth, though other teeth do occasionally give rise to swelling in this situation.

FIG. 290. (2)



It is also a situation in which syphilitic nodes may occur;

(1) From a plaster model in the museum of the Odontological Society.
(2) Canine embedded in the palate, seen from above. From Heath's "Injuries and Diseases of the Jaws."

and indolent swellings occasionally appear upon it, in persons who have no ascertainable constitutional taint.

The commonest forms of true tumour are allied to epulis, of which Mr. Heath (*op. cit.*) gives examples; encysted tumours, and cancer, both of the epithelial and medullary type, are met with in this situation; and a remarkable case of papillary tumour, occurring in the practice of Mr. Cock, has been put on record by Mr. Salter.

In forming a diagnosis of a palatal tumour, it must not be forgotten that it may be due to a misplaced tooth, as is exemplified by the accompanying figures; in one a molar tooth has been erupted in the median line of the palate, and in the other the canine is shown lying horizontally along the palate, exposed by the removal of the bone above it.

A rare disease has been observed in the jaws of a human subject (Mr. Shattock, "Pathological Society Transactions," vol. 36), which is due to the growth of a fungus, the actinomycetes. It is so rare that it has little practical importance, but it is more common in cattle, and appears to be communicable from them to man. The development of the fungus gives rise to an inflammatory lump, and these lumps coalescing give rise to a tumour, but as they increase they break down and suppurate, so that the whole mass is riddled with suppuration cavities. In the centre of the new growth, granulations which present a fibroid appearance under the microscope, are masses of the mycelium of the fungus.

easy ; their rapid formation, their irregular form, foul surface, and absence of a definite indurated base, serve to distinguish them from more serious diseases ; and the existence of a roughened tooth will confirm the conclusion arrived at ; though it must always be remembered that a local source of irritation may, and often does, determine the position of such diseases as epithelioma or syphilitic ulceration.

The ulcers met with are (i.) Apthous ulcers, generally multiple.

(ii.) Ulcer the result of local irritation, and

(iii.) Dyspeptic ulcer, just described.

(iv.) Syphilitic ulcer, or ulcerated gummata.

(v.) Tubercular ulcer.

(vi.) Epithelioma.

A syphilitic tongue is generally puckered and fissured, and the fissures may be the seats of slight ulceration, while in such a mouth mucous patches may be very often found on the inside of the cheeks.

A patient suffering from the slighter forms of syphilitic ulceration, may apply to the dentist to have sharp corners filed away from one or more of his teeth, attributing to this cause the discomfort which he feels. On examining the tongue, you may often fail to see anything the matter ; on a closer examination, the organ is seen to be slightly fissured, and the surfaces of the fissures to be red ; or there may be slight excoriations, sensitive to the touch, but not bleeding unless roughly handled ; or flat, leathery mucous patches ; or, again, there may be flat, defined ulcerations. The marked character of those slight superficial ulcerations due to syphilis, is the absence of surrounding inflammation, and the presence of sensitiveness far greater than their appearance would lead the observer to expect.

Deep syphilitic ulcerations specially affect the dorsum of the tongue far back ; their occurrence is preceded by an indurated lump (gumma) proceeding to ulceration in the course of three weeks or a month.

When it ulcerates, portions of the induration appear to

litic ulceration ; several of the characters by which it differs have already been pointed out, but there are some few other points which enter into the formation of the diagnosis, a matter sometimes of no small difficulty.

Epithelioma is more often on the edges of the tongue than on its dorsum ; is often remarkably flat and regular in form, and is seldom found in young persons : the contrary is true of syphilitic ulcer.

Scrapings from the surface may reveal nests of cells, but their absence must not be taken as conclusive.

Epithelioma usually commences as ulceration in a crack, or a wart, or in a patch of leucoplakia.

This affection, sometimes called ichthyosis linguæ, consists of white, slightly thickened and hardened patches. Mr. Hulke and Mr. Henry Morris lay great stress upon its being a very frequent antecedent of cancer, so that it becomes imperative to keep a careful watch upon any tongue so affected, and to exercise extra care lest it be exposed to any irritation.

It has been suggested that leucoplakia may possibly sometimes have been caused by the contact of the tongue with an amalgam filling, but this supposition rests upon an exceedingly dubious basis.

It is not, however, going too far to say that any abnormal condition of the tongue, lasting for a material time, is to be looked upon as a source of possible danger, and in a patient over the age of forty, no consideration of saving teeth should tempt the dentist to expose an unhealthy tongue to any constant irritation.

The fact that a tongue is obviously syphilitic is no safeguard, as epithelioma frequently arises in the furrows of a syphilitic tongue.

IMMOBILITY OF THE JAWS.

THERE are various causes which may lead to loss of freedom in the movements of the jaws, some of which are of very grave import, so that any complaint of this kind on the part of the patient should lead to careful examination, though the diagnosis at best is often very obscure.

The commonest and the most remediable, is the result of muscular spasm, which may be so constant and so prolonged, lasting even for months, that the idea of its spasmodic nature is apt to be lost sight of. A wisdom tooth, which from faulty direction, or from want of space, encounters difficulty in its eruption, is usually the source of the trouble, inducing tonic spasm of the muscles which close the jaws; but I have seen one case in which clonic spasm of the muscles opening the jaws was induced every time that the closure of the teeth brought about pressure on the inflamed parts, and this caused the patient extreme distress. The effect of difficult eruption of the teeth has been treated of at another page, so that it is merely necessary here to allude to the existence of this state of things, and we may pass at once to the consideration of the other causes which have to be kept in mind in forming a diagnosis.

In the majority of cases the irritation is due to difficult eruption of the wisdom teeth, though it is not rarely due to exposure of the nerve in these or the first and second molars. I do not know of its having been produced by teeth situated farther forward in the mouth, though there is no reason why it should not be so caused. The trismus may be of sudden occurrence, or it may come on quite gradually; and the condition of tonic spasm of the muscles may last for months or even years.

The closure of the jaws may, however, be due to actual organic changes. The late Dr. Gross of Philadelphia, enumerated the following as the most frequent causes of immobility of the lower jaw :—

The fixation of the jaw by cicatricial tissue in the cheek, gums, etc., which may result from cancrum oris, or from gangrene supervening on profuse ptyalism. Anchylosis of the temporo-maxillary articulation, which may be osseous, or the result of fibrous adhesions in and around the joint. Or, thirdly, it may be occasioned by a bony bar extending from the lower to the upper jaw, a condition usually resulting from so-called chronic rheumatic arthritis. Or, lastly, it may be due to the pressure of a tumour, especially one occupying the parotid region.

Gangrene of the cheeks, etc., may occur in children worn out by the effect of the exanthemata, as well as in cancrum oris ; and these are amongst the most difficult cases to relieve.

Mr. Heath ([1]), quoting Professor Esmarch, points out that the inability to open the mouth in such cases is due not so much to the presence of actual adhesions, binding together the jaws, as to the destruction of the exceedingly elastic and dilatable mucous membrane of the cheek, and its replacement by a dense unyielding cicatrix.

Hence, in all operative procedures it is the aim of the surgeon not merely to divide cicatrices, but to restore the extensile mucous membrane ; and if there be no available portions of mucous membrane left, the formation of a false joint in front of the cicatricial bands affords the best prospect of speedy relief. This operation, which bears the name of Professor Esmarch, consists in removing with a saw a wedge-shaped fragment of the horizontal ramus of the lower jaw. For a fuller account of the operation the reader is referred to Mr. Heath's work above cited.

Disease restricted to the temporo maxillary articulation

([1]) "Injuries and Diseases of the Jaws." Third edition, p. 398.

is rare, but the possibility of the occurrence of various forms of mischief should be borne in mind. In the Philadelphia Dental College Museum is an example of what had apparently begun as caries, which had gone on to the destruction of a good deal of bone, and then had been succeeded by deposition of bone in an irregular form, but it is possible that this after all was a case of rheumatic arthritis; and in the *Lancet* (1860), is a case of hydrarthrosis which is apparently unique.

Patients will sometimes complain of stiffness and grating sensation in moving the jaws, and it is very unusual for this to proceed beyond the extent of more or less inconvenience; but it is probable that such sensations are often due to a slight degree of inflammatory change in the articulation, which were it to proceed far would be described as chronic arthritis.

In this disease (which as affecting this joint is rarely met with in such development as to be unmistakable), the articular cartilage wholly disappears and the surfaces become greatly deformed, the condyle sometimes becoming distorted but atrophied, and sometimes enormously hypertrophied. Mr. Heath ("Injuries and Diseases of the Jaws," 3rd edition, p. 420), met with a case in which one condyle alone was affected, with the result of throwing the chin far over to one side, and utterly deranging the articulation of the teeth.

The excision of the condyle and its neck, an operation rendered difficult by the size of the head of the bone, gave a result satisfactory in all respects. The thrusting of the chin over to one side was so great as to have suggested to an eminent surgeon that a dislocation existed, but there was nothing else to support such a view at the time when Mr. Heath was kind enough to show the patient to the writer. Mr. Heath suggests that the so-called subluxation, occurring generally in delicate women, and thought to depend upon a relaxation of the ligaments allowing of too free movement and slipping of the interarticular cartilage, is in many cases due to rheumatic or gouty changes in the joint: the

varying degree of inconvenience, its aggravation by damp and cold, and its amelioration by counter-irritation and anti-rheumatic remedies seeming to indicate something other than a constant mechanical cause.

Acute inflammation and suppuration may involve this just like other joints, and such conditions may very easily be confounded with disease of the ear; perhaps, also, suppurations of the middle ear may extend to the joint; fibrous or bony anchylosis is the probable outcome of these destructive inflammations.

Thus, immobility of the jaw may be due to the formation of dense fibrous, or cartilaginous, or even ossified new tissue in and about the joint; sometimes a sort of osseous bridge extending from upper to lower jaw gets formed; in other cases the fixation is brought about by sloughing after cancrum oris, salivation, or other such cause, and the contraction of the cicatricial tissue formed.

In a case which I saw through the kindness of Sir James Paget, there was an increasing immobility, which was due to an exostosed condition of the zygomatic arch, interfering with the play of the coronoid process inside it. Actual anchylosis of the joint is not of common occurrence; it has been met as a result of injury, and sometimes it appears to be idiopathic.

Where anchylosis is becoming imminent the mouth should be regularly stretched, but despite all such endeavours it is seldom that the contraction can be stayed, and the case ultimately calls for surgical interference. The speculum (figured at page 637), used for opening the mouth during anæsthesia, answers admirably for stretching the jaws in these cases.

I have lately met with a case in which almost complete anchylosis slowly supervened after a fall upon the chin: the mobility of the jaw had slowly decreased for two or three years. And some years since there was a case in the wards of the Massachusetts General Hospital, under the care of Dr. Bigelow, in which, for no apparent cause, mobility

steadily diminished for eight years, till at last the teeth could not be separated at all, and the lower jaw had considerably wasted, so that the chin had almost disappeared. Under ether the jaws were forcibly separated, with but little difficulty, but the patient, a healthy woman, aged thirty, had very slight power over the movements of the jaw.

Esmarch's operation has become the usual resort of surgeons where operative interference is called for, and its results are immediate, sure, and fairly satisfactory, but there is another form of operation which, in favourable cases, yields a thoroughly good result, and that is, the division of all constricting bands, and the maintenance of the mobility by the use of properly constructed shields during cicatrisation. It has already been mentioned that one of the causes of immobility, where the soft pliant mucous membrane has been lost, is the substitution for it of dense inelastic cicatricial tissue, which after division would soon re-form, contract, and bring about a state of things no better than it was before. To meet this difficulty metal shields are constructed, capping the teeth or the alveolar border, and extending down between these and the cheek; the adjustment and the subsequent wearing of these is, as might be expected, painful, and needs no little resolution on the part of the patient and the surgeon as well, and thus though good results are attainable, Mr. Heath gives the preference to Esmarch's operation for most cases.

But contrary to what might be expected, there appears to be a re-formation of mucous membrane in the sulcus, and it is upon this that permanent success hinges.

Attention may be again directed to the fact that mobility of the jaws is sometimes the first symptom of a deep-seated growth, of which no other sign may be present; thus, in a case under the writer's care, this symptom was complained of some months before anything else could be detected, although an anæsthetic was administered, the mouth thoroughly opened by means of a powerful speculum, and the whole

region of the joint explored by the finger, both by Sir James Paget and the writer.

Ultimately neuralgic pains became severe, vision was interfered with, some proptosis occurred, and ophthalmoscopic examination revealed signs of pressure; after about eighteen months the patient succumbed to a deep-seated sarcoma, apparently originating from the base of the skull.

Mr. Coleman has also recorded a case in which stiffness of the jaws was the first sign of malignant growth.

An occasional cause of material discomfort is found in the loss of the back teeth having allowed the jaws to close to an unnatural extent; this result has usually come about so gradually that the parts have become accustomed to it, but if it has arisen more quickly there is apt to be a sort of straining of the joint which may become very painful; the remedy is obvious in the insertion of artificial teeth.

INJURIES TO THE JAWS.

Fracture of the Jaw.—Although fractures of the jaw fall within the province of the general surgeon, rather than within that of the dentist, still, as the services of the latter are not uncommonly called into requisition, a few words respecting it will not be out of place here.

Fracture, even very extensive, may be produced by extraction of teeth, though a more common cause is direct violence, such as a blow or a fall. The most usual situation for a fracture of the lower jaw is the region of the canine tooth, though there is no part at which it may not be broken. It is almost necessarily compound in the mouth, as the very close adhesion of the gum renders its being torn inevitable.

The signs of fractured jaw are ordinarily unmistakable: crepitus, mobility of the fragments, and irregularity of the teeth being the prominent indications.

The displacement of the fractured portion has been generally attributed to the action of the muscles, and this is no doubt often a frequent cause, though Dr. St. George Elliott, who has had a large experience of such fractures, thinks that their effect is overrated.

After a severe fracture very profuse suppuration often ensues, extensive abscesses under the chin and in the neck may form, and portions of the bone may necrose and come away.

Thus, in a case of which there is a model in the museum of the Odontological Society, the whole depth of the front of the jaw, containing the right first bicuspid, canines, and incisors, and both bicuspids of the opposite side, has been

lost, and the second bicuspid of the right side has come into contact with the first molar of the left, the two halves of the jaw joining at an acute angle.

Treatment.—By a four-tailed bandage in simple cases, though it is better to add to this a gutta-percha support moulded around or under the chin.

It used to be the practice of some surgeons to secure the fragments in their places by wires passed around the teeth ; it is, however, an objectionable plan, on account of the irritation set up by the wires, and it is very seldom that it can be desirable, it having been superseded by the introduction of the Hammond splint.

This consists of a stout wire, which may be silver, or even iron, bent so as to lie pretty closely along the necks of the teeth on the lingual aspect ; a second wire is moulded around their labial side, these two wires extending round the whole dental arch, and their ends being bent so as to make them round and smooth, or a single wire may be carried all round.

Binding wires are then passed through between each of the teeth at the necks, so as to encircle the inner splint wire, and are twisted up tightly upon the outer wire. In this way, without any strain being put upon any particular tooth, the whole series are held in place by the stout splint wires holding them pressed between them. For general purposes this splint is the most cleanly, the most efficient, and the least cumbrous of any appliance in use, but there remain a certain number of cases in which, from the absence of many teeth, or from other causes, it cannot be satisfactorily applied, and in these more difficult cases recourse must be had to more complicated apparatus. A very good account of such may be found in Kingsley's " Oral Deformities," and it will not be necessary to do more than notice a few of the more general principles involved.

Much assistance in steadying the fragments may be derived from simple sheets of gutta-percha pressed over the crowns of the teeth ; but in severe cases a more stable apparatus is required.

An impression of the jaw in wax or plaster is taken, without any special attempt to hold the fragments in position ; this is cast in plaster, and the displacement remedied by sawing through the plaster model. A gold or vulcanite plate is then made to fit the crowns of the teeth when the halves of the jaw are reduced to their proper position. In some cases it will be best to make the splint fit loosely, and to line it with warm gutta-percha at the time of introduction ; but whether this course is preferable to making the plate itself fit accurately, can be determined only by the inspection of the individual case.

Mr. Hayward has further modified these splints by the addition of strong curved wires which pass out at the angles of the lips, and are attached externally to a gutta-percha splint.

Mr. Gunning has in some cases found it necessary to employ a vulcanite splint fitting the teeth of both jaws, and Dr. Elliott, during the American Civil War, used a roll of gutta-percha an inch thick in the same way, and found that this was quite efficient, besides possessing the advantage of being made and finished at once, holes being left in the front and at the sides for the introduction of food, and the syringing out of discharges. Whatever apparatus is employed, care must be taken to secure the easy and thorough escape of pus, and to avoid heavy pressure on the integuments beneath the chin, where abscesses are very prone to form.

Fractures in the region of the condyle are more rare in consequence of the protection afforded by the thick pad of muscles ; they may be difficult of detection, and a bandage will be generally all that can be done in the way of giving rest to the fragments.

Fractures of the upper jaw are not very common, and there is generally little tendency to displacement ; nor is there usually much difficulty in keeping the parts in position, though occasionally a plate will be required. Comminuted fragments should be almost always allowed to

remain, as, owing to the rich vascular supply, they rarely necrose.

A somewhat remarkable case came under the writer's notice in which a loop of a bell-rope entered the mouth while the patient was bell-ringing in a belfry: it fractured the upper jaw on both sides at the region of the canines, and the fragment was displaced, so that the teeth looked horizontally forwards. It required much force to replace the portion of bone, but it had no tendency to displacement, and speedily united without the loss of any of the contained teeth.

With regard to the removal of teeth in cases of fractured jaw, this should only be done when the teeth are themselves fractured through the pulp-cavity. In any other case they should be allowed to remain, as they often become firm in apparently hopeless cases.

But teeth with pulps exposed by fracture should always be searched for, as their presence will submit the patient to much needless suffering; and it is possible that cases might occur in which the extraction of the teeth would be difficult, owing to the mobility of the fragments, and the fear of tearing away portions of the bone. In such an event I should be disposed to extirpate the nerve with a nerve-extractor.

Dislocation of the jaw.—This may happen during the extraction of a tooth, or even in taking a model of the mouth. The patient is then unable to close the mouth, the lower jaw is protruded, and speech is difficult. A slight hollow may be felt behind the dislocated condyle, and this is the surest guide in the less usual form of the accident —unilateral dislocation.

The readiest manner of effecting the reduction is to seat the patient upon the floor, steadying the head against the operator's knees. The thumbs, well guarded by numerous turns of a narrow bandage, are passed as far back on the molar teeth as possible. By forcible pressure downwards the condyles are disengaged, and the front of the jaw being

simultaneously tilted up by the fingers, it slips into place with a jerk.

Other methods are sometimes adopted : thus, corks may be placed between the molar teeth, and the chin forcibly elevated ; or a long piece of wood may be used as a lever to depress the back of the jaw.

Whatever method be adopted, the surgeon must keep in mind what has to be done : namely, to depress the back of the jaw to such an extent as to disengage the condyles from the prominence in front of the glenoid cavity ; so soon as this is done the muscles will draw it up into its place.

After reduction, the movements of the jaw must be restrained for some days by the application of a four-tailed bandage.

PIVOTING TEETH.

THERE are so many methods by which teeth may be pivoted, and these individually require such lengthy description to render them intelligible, that a mere outline of a few typical plans can here be given.

The circumstances under which the operation of pivoting may be performed with advantage have been mentioned in connection with the diseases and the mechanical injuries of the teeth. Before proceeding to describe the operation itself, it will be, therefore, unnecessary to recapitulate those circumstances further than is embodied in the general statement, that the root destined to receive the pivot, together with the surrounding parts, should be perfectly free from disease.

Hence the most satisfactory cases are those in which the nerve in the root has retained its vitality; and as the ordinary operation of pivoting is only applicable to the incisors and canines, and with less certainty of success to the bicuspids of either jaw, the nerve should be extirpated by a nerve-extractor, rather than by the use of an escharotic, and the introduction of nitrous oxide has rendered this comparatively easy. If the nerve be already dead the root must be brought into satisfactory condition for filling, and its apex closed. Violent inflammation may follow upon pivoting, and one fatal case of tetanus from this cause is on record.

The root may be cut down by means of disks in the engine, &c., or by cutting forceps, but it is not safe to use these latter until the root has been already partly cut through, lest it splinter longitudinally.

The simplest of all methods is the adaptation of a tube-tooth by means of ordinary pin-wire.

The apex having been closed by foil, or by a morsel of wool with zinc oxychloride, the pulp-canal is enlarged by a Morse drill to the size of pin-wire.

The next step is to take an impression of the surface of the root; this may be done by using a tube-tooth which has been attached to a piece of pin-wire by soft solder, the surface which goes against the root being coated with warm impression composition, or with plaster. This, when pressed home, will give an impression of the root to which that or another tooth may be ground; but as it will not give the length and position of the neighbouring teeth, it is usual to take the impression in a specially constructed tray which has running through it a moveable pin.

Some practitioners prefer to do all the fitting to the mouth, thinking that no impression will be sufficiently accurate to do more than the rough fitting, and this after all takes but little time.

The tooth having been satisfactorily adjusted to the root, the side of the pin is slightly roughened, the merest trace of very fine floss-silk wound round it, dipped in a solution of copal, and slowly but forcibly pressed home. Teeth pivoted in this very simple manner have, in favourable cases, been known to last for thirty and more years; but it presupposes a good flat surfaced root, and coincidence in the position of the nerve-canal and of the tube in the tube-tooth.

If this coincidence do not exist, a flat tooth may be used, the pin being soldered to it in such position as may be desired; but it will be necessary to protect the surface of the root, and this is usually done by means of a little plate of metal, which may be made to fit with great accuracy in the following way:—

A thin piece of platinum foil is taken, a hole punched in it, the pin lightly caught to it with solder, and passed into the root; the foil is burnished or malleted into close

contact with the root, carefully withdrawn by means of the pin, and solder flowed over it so as to stiffen it.

In fixing such a tooth in its place, the surface of the root is very thoroughly dried, and then coated three or four times with copal, or with thick gutta-percha solution, the solvent being got rid of with the hot-air syringe.

Instead of a piece of gold or platinum plate, some prefer to solder the pin to the pins of the flat tooth, and to make up the back to fit the root with vulcanite.

FIG. 291. (1)

The source of ultimate failure of this class of pivots is usually the softening of the surface of the root, and ultimate enlargement of the root-canal by caries, and to meet this difficulty various devices have been had recourse to.

When the root is a large one, such as a central incisor, or a canine, the canal may be drilled out to a larger size, and a thin metal tube inserted into it, the pin fitting into this instead of into the tooth itself. This tube may have a screw upon it, as in Mr. Balkwill's tubes, and be fastened thus, a screw thread being tapped in the root. When this is done, a chamber can be formed near the surface of the root, and this chamber filled with gold or with amalgam so as to cover up and protect the whole root-surface prior to the insertion of the pivot-tooth ; or, again, the tube may have its exterior slightly rough, and be itself held in by means of amalgam, this being available in cases where the root-canals are already irregularly enlarged by caries.

By the use of a split pin the pivot may be made readily removeable, which is sometimes desirable when the root is not perfectly trustworthy as to freedom from inflammation.

In this connection it may be mentioned that where it is important to insert a pivot without delay in a tender root of small size such as a lateral, this may be done by the use of

(1) Flat tooth backed with gold, with plate to cover the root.

a hollow pin, which is left open for a time and subsequently closed by a wire with gutta-percha solution worked in with it.

Much-enlarged roots may be dealt with by the old-fashioned wooden pivot, the root canal having been rendered cylindrical, and a special crown manufactured for the purpose employed; but though once in a way useful, this method is not generally regarded as likely to have much permanency. Still cases have been known to be very durable; but it is in dealing with much-damaged roots that the ingenuity of the operator is most severely taxed.

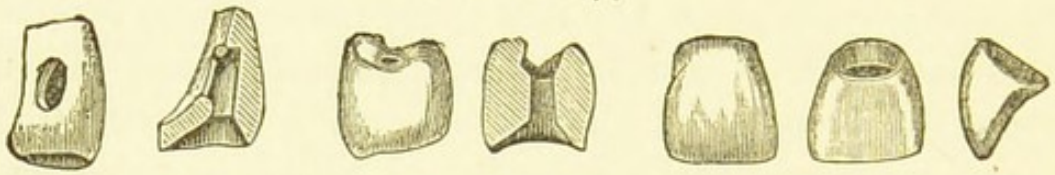
A flat tooth may be taken, and without any backing, soldered to a flattened and much-roughened pin; the root-canal is greatly enlarged, countersunk or grooved here and there, and the pivot attached by filling in the root-canal around it, and carrying the filling up against the back of the tooth, so that ultimately it comes to be a filling with a tooth face held upon it by means of the pin passing down into the root filling. The easiest way of doing this is to fix the pin by filling the upper end of the canal with soft oxychloride, into which the pin is thrust and held until it is set. This should only occupy a part of the length of the root, so as to leave plenty of room for secure anchorage of the gold or amalgam above it. Amalgam will, in most cases, give the best result, as it is very difficult to make gold quite solid under the circumstances.

This method of pivoting is useful in bicuspid roots, in which a round pin is often hardly available; and it is often an advantage to fix the tooth during the operation by plaster applied with a spatula to its labial surface and to that of the neighbouring teeth.

When the bite allows plenty of room, Dr. Bonwill's crowns do very well indeed; his method, which is fully described in the "Dental Cosmos" for August, 1880, and June, 1882, briefly consists in the free reaming out and counter-sinking of the root or roots, and the employment of a porcelain tooth-crown which has a somewhat large hole right through it.

The pin, which is generally flattened and jagged, fits quite loosely into the root and into the hole in the crown, and the fixation is accomplished by means of amalgam in both.

FIG. 292. (1)



Certain precautions are necessary to ensure a good result; a quick setting and strong amalgam must be used; the root must be filled first and the pin thrust into a hole made in the amalgam, or the root will probably be but imperfectly filled, and the pins best suited for the purpose are made of a metal resembling German silver with which the amalgam slightly unites.

The pin being thus fixed in the root, the crown tried on to see that it will come in its proper position, and a little amalgam being built up round the pin, the cavity in the crown is filled with amalgam and is forcibly pressed home over the pin. The force used will expel most of the surplus mercury, and if the crown cannot be forced home it must be removed and some of the amalgam scraped away till it will. Force must be used in placing the crown, or it will not be a success, and after it is in its place very dry amalgam may be tamped in through the hole in the grinding surface. If a quick-setting amalgam be used, and a proper amount of pressure in setting the crown, there is but little danger of its shifting before the amalgam is hard.

Dr. Bonwill claims for his plan that it is easy to replace a broken crown if such an accident occurs, by cutting away a little of the amalgam from round the pin, roughening what is left, and placing on a new crown without disturbing the pin and its setting, though in the first instance he prefers to fix the pin and the crown at one sitting, so that the amalgams in the root and the crown may be intimately united.

(1) Dr. Bonwill's porcelain tooth-crowns.

But there are a great many details for which the reader is referred to Dr. Bonwill's papers, as it is impossible to do more here than to give an outline of his plan, which s available for molar crowns as well as for those further forward in the mouth.

A firm attachment may sometimes be obtained by using a collar of thin gold which embraces the stump below the edge of the gum. This is first adjusted, and is best made of fine gold ; it is left projecting above the level of the gum except at the labial margin, where it is cut down to allow of a porcelain crown being fitted to the root, and this is attached to it by means of backing and soldering. The ring thus obtained is stiffened by means of a wire or by solder, and may be variously attached to the stump. If the root be such as to admit of a cylindrical hole to receive an ordinary pin, a cap covering its top surface may be made, which carries a pivot pin, and the whole appliance fixed just like the most ordinary type of pivot tooth, save only that it has a rim embracing the circumference of the root. Or if the root be irregularly excavated, and there be plenty of room, the top of the ring may be left open, a small roughened pin soldered to the backing of the tooth, and amalgam packed in after the appliance has been forced into place, the amalgam being carried up against the backing so as to bring the whole to a satisfactory and smooth contour ; or again, a screw with a head to it may be used to fix the ring and cap down to the root ; or again a hollow gold crown may be struck up for restoring the inner cusp if the tooth be a bicuspid. This method of attaching a porcelain crown by the help of a ring of metal embracing the root below the gum level, generally bears the name of Dr. Richmond.

The mention of this leads by an easy transition to the all-gold crowns, which are more useful than ornamental. In these, the form of the crown of the tooth is imitated by striking up a thin gold cap, the free edges of which, nicely finished, are made to embrace the neck of the root like the Richmond ring. There are various ways of setting about

this which will occur to any thinking operator; but the result once got of a hollow gold cap which fits the root nicely, it may be fastened on by the insertion into the root of a post which is securely fixed there and left projecting; and then the hollow crown, filled to just the right extent with gutta-percha, is made very hot and forced on. A difficulty is to get just the right amount of gutta-percha in it. Or a hole may be left in the grinding surface of the hollow crown, amalgam being used, and the excess squeezed up through this hole, through which also the amalgam inside may be tamped up against the pin, &c. Dr. W. Morrison, of St. Louis, was one of the pioneers in this operation, which has been varied in many ways since.

Repeated attempts have been made to restore teeth, the roots of which are too bad for pivoting by any of the processes above alluded to; thus, when a feeble root intervened between two tolerably strong teeth, a pin has been inserted into it, and little tags projecting on each side from the porcelain tooth's backing have been anchored into the neighbouring teeth by making use of existing cavities, or even making cavities on purpose to bed them in the substance of fillings. From this it is obviously but a short step to dispense with the pin altogether and to depend wholly upon the neighbouring teeth, and this is the principle of the so-called bridge-work.

Though there are just a few cases in which two or three teeth may be advantageously thus inserted without having recourse to a plate, yet the operation has not gained, and probably will not gain, much favour.

Its extreme advocates will insert a large number of teeth carried by means of a sort of bar along their backings, and anchored to two or three teeth, or even roots, by making use sometimes of collars upon roots, of gold caps, or of anchorage into fillings; such pieces of bridgework may be made removable, but more commonly they are fixtures.

But so far the record as to durability of such operations seems not encouraging; and there is the very great objection

that true cleanliness of the mouth is hardly possible with an extensive fixture of this kind, each tooth being connected to its neighbour by a bar; although in the mouth of a careful patient it is less objectionable than might have been anticipated.

However, the description of this kind of work hardly falls within the scope of this volume; an excellent account of the various appliances, liberally illustrated, is to be found in the fourth edition of Richardson's Mechanical Dentistry.

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