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A SYSTEM

OF

DENTAL SURGERY

BY

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SECOND EDITION

REVISED AND ENLARGED



With 263 Illustrations

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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 proceeding 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.

PREFACE

TO THE SECOND EDITION.

The material progress which has been made by the science of Dental Surgery since the publication of the first edition of this work, has necessitated large additions to the text; the bulk of the volume has, however, been kept within convenient limits by a slight reduction in the size of the print. Those portions of the book which are devoted to the description of neuralgia, dentigerous cysts, odontomes, secondary affections resulting from the irritation set up by dental disease, as well as many other shorter sections, are entirely new; and nearly sixty fresh illustrations have been added, of which a few have been, by permission of Messrs. Longman, borrowed from my father's earlier work, the lectures on dental physiology and surgery; others have been, with the consent of the Council, reprinted from the Transactions of the Odontological Society; to the kindness of Mr. Christopher Heath also I am much indebted for the use of several figures, which have been reproduced from his valuable work on the "Diseases and Injuries of the Jaws," to which frequent reference will be found in these pages; whilst a considerable number of woodcuts have been specially executed for this edition by Mr. W. H. Wesley.

The description of dental caries, with the exception of some slight additions and alterations, remains much the same as in the first edition; but a fuller discussion of the whole subject has been added in the form of an appendix, in which a summary of the conclusions to be drawn from recent investigations will be found.

In the section relating to the dental tissues due prominence has been given to the opinions of continental observers, and references to the more important works consulted have been inserted, though it would be impracticable, even were it desirable, to encumber a text-book by tracing every statement to its source. But I cannot refrain from acknowledging the assistance which I have derived from Prof. Wedl's recent work, "Die Pathologie der Zähne," as well as from the atlas published jointly by Professors Heider and Wedl.

CHARLES S. TOMES.

37, CAVENDISH SQUARE,
January, 1873.

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 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 proposed, therefore, in the present instance, 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 I undertook to write the present volume, the museums in which an extended series of young skulls would be likely to be found were visited, but without success. So far as I could learn, 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 has been done, and the preparations comprised in the collection are sufficiently numerous to allow of deductions being made

from the characters they present. But should the conclusions drawn from the study of these ultimately prove in some respects incorrect, the want of accuracy can only be substantiated by the study of a still more extended series. But until such a collection is made, it will be safer to adopt the conditions of the preparations at present at my disposal, as fair examples of the states of the dental apparatus at the several ages, than to assume that the opinions generally extant, when at variance with them, are in all cases correct. Feeling that this course is the more likely one to lead to a correct knowledge of the subject, I shall, in the following pages, describe the conditions presented by individual specimens, selecting such as appear most typical of the ages chosen for description.

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. 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 their mode of growth, and are connected with 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 tissue, or tooth-pulp, of equal size and form to the future tooth, must at all times be kept in view. Not that the pulp assumes the dimensions of a perfected tooth before the development of the hard tissues commences, but that each part of the gradually developing tooth is first formed in soft 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 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 *full-grown 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 teeth-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. They are divided from the crypts of the lateral incisors by a septum, which runs obliquely backwards, and a little inwards towards the median line. The sockets of the lateral incisors occupy a position slightly posterior to those for the central teeth, and are divided from the canine alveoli by a septum which proceeds obliquely backwards, and in the lower jaw (as regards the median line of the mouth) outwards (Fig. 2). By the arrangement of these 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. The septum dividing the canine from the first temporary molar crypt is not subject to the obliquity observed in the two preceding examples, but proceeds directly across from the outer to the inner alveolar margin, giving to the socket for the canine a greater breadth in front than behind, which peculiarity is still further increased by the anterior wall being bulged outwards. 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 serve in some measure to explain the liability of children to reflex nervous disturbances dependent on the teeth. The nerve and artery enter the alveolus on either side through an aperture in the base of the septum, which divides imperfectly the first from the second temporary molar, and pass out to the external surface of the jaw through an orifice in the septum dividing the canine from the former tooth.

Posterior to 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, is continued through the alveoli of the two posterior teeth, having entered the jaw by 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.

Fig. 1. (1)

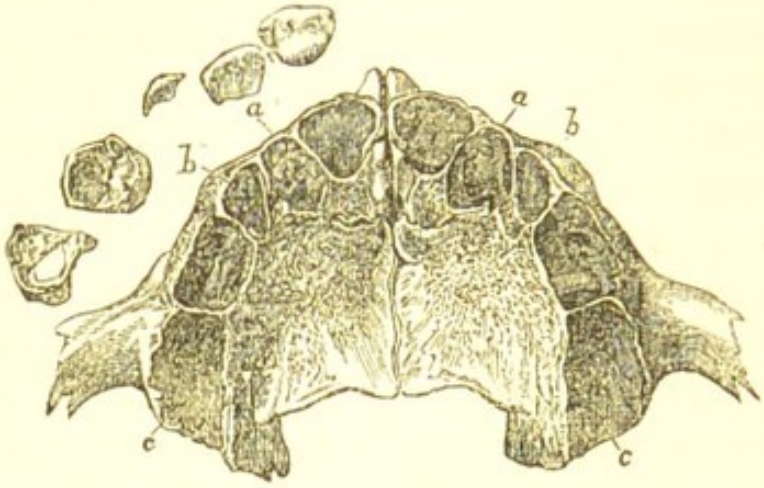
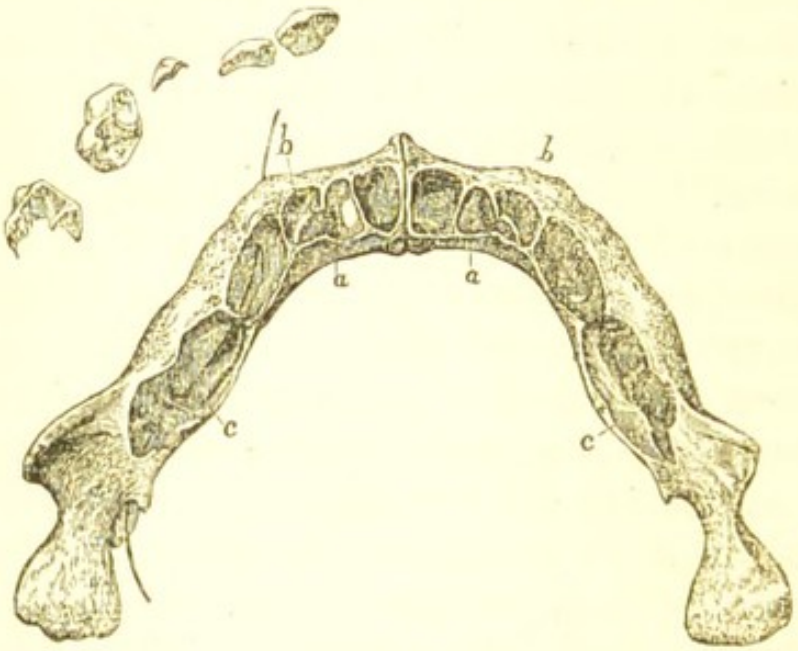


Fig. 2. (2)



(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.

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 inferior edge of the lower jaw in the nine-months' fœtus is undulated; the angle and the point where the sockets of the first and second temporary molars join being the lowest points, while the intermediate parts of the margin are curved upwards. Viewed in profile, it will be seen that the alveolar margin projects over, and therefore forms a bolder curve than the inferior borders of the jaw. At the junction of the two halves each portion is expanded, forming on the anterior surface a vertical process, which extends from the alveolar to the inferior margin of the maxilla, the greatest prominence being attained in the middle part of its course. (Fig. 4.)

The position of the zygomatic process has been already noticed, but the general peculiarities of the alveoli remain to be described. In the upper jaw the inner alveolar ridge descends but little below the level of the hard palate, although the sockets have attained a considerable depth. At this age the antrum is represented by a depression on the outer wall of the nasal cavity, while the alveolar cavities extend to the base of the orbit, from which they are separated by a thin plate of bone; similar relations being maintained with regard to the anterior part of the nasal cavity.

The temporary teeth at this period 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. These 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, which ends

Fig. 3. (1)

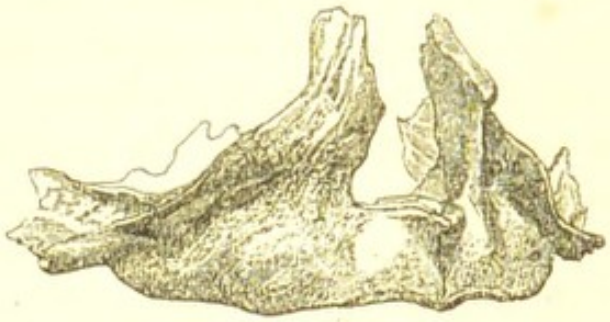
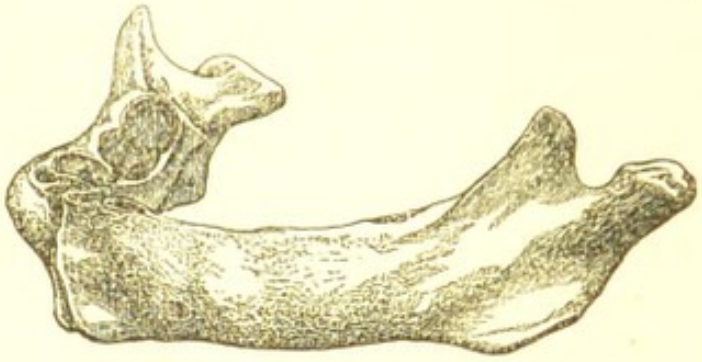


Fig. 4. (2)



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

By dividing the mucous membrane and subjacent periosteum a little below the upper margin of the alveoli, both on the labial and lingual surfaces of the jaw, in a specimen which has been kept a short time in spirit, and then carefully raising the membrane from the surface of the bone, we shall be

(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.

enabled to withdraw from their sockets the developing teeth enclosed in their sacs, which will remain firmly attached to the gum. The relative position of the dental sacs will be seen to correspond with the arrangement of the alveoli already described. The union of the external coat of the sac with the tissues of the gum, and of the lower portion of the pulp with the base of the sac, may be demonstrated.

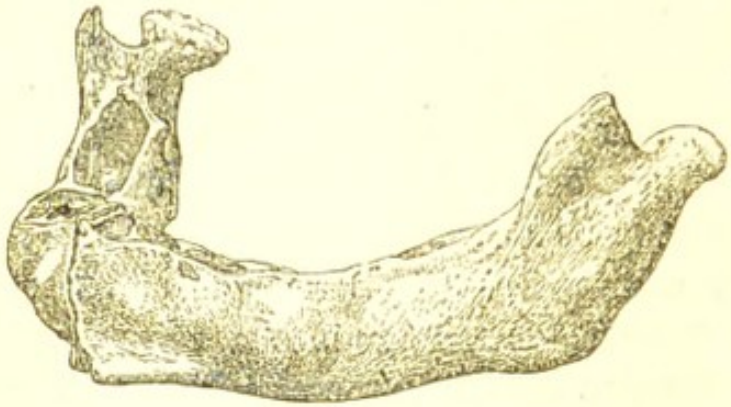
At the age of *two months* but little change from the fœtal characters has taken place in the upper jaw. The maxilla is, however, generally a little larger, and the sockets slightly deeper and more prominent at the anterior free margins, than at the time of birth; the relative position of the teeth being 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 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, 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 in the positions mentioned, development has gone on from the opposed surfaces of the two halves encroaching upon 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 of

which are closely approximated, while the deeper parts become separated from each other.

Fig. 5. (1)



Fig. 6. (2)



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

(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.

septum dividing this from the socket of the second temporary molar is incomplete.

When the *third month* has been attained, the maxillæ show

Fig 7. (1)



Fig. 8. (2)



(1) The upper jaw of a male two months old, showing the condition of the 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.

a further development in the directions already indicated. The angle of the lower jaw is more pronounced, and the bone much more solid. The alveoli, however, exhibit a considerable change in character; their depth has increased; and the free edges, which were before open, so that in a macerated preparation the teeth readily fall out, are now turned inwards towards the median line of the alveolar ridge, thereby contracting the orifices, and affording protection to the enclosed teeth, which are no longer liable to fall out when the bone is examined. The direction of the rami is but little changed,

Fig. 9. (1)

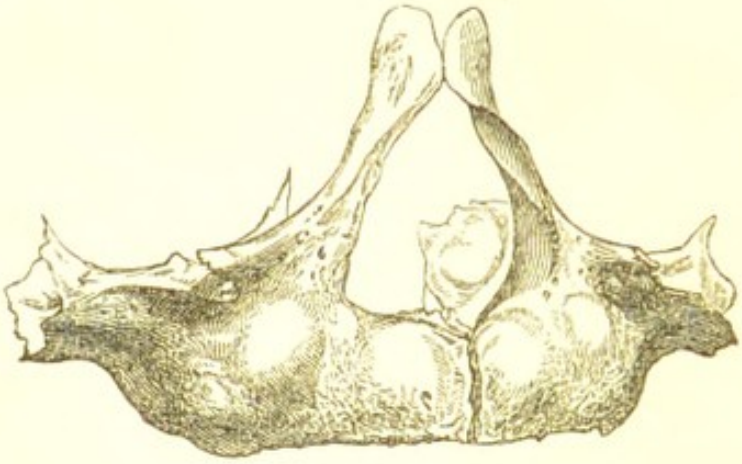


Fig. 10. (2)



(1) The upper jaw of a male three months old, two-thirds life-size.

(2) The lower jaw of a male three months old. In the specimen from which this figure is taken the lateral incisors are wanting.

but considerable addition of bone at the lower border of the angle will be observed, the sigmoid notch at the same time being widened. The symphysis is still strongly marked in

Fig. 11. (1)



Fig. 12. (2)



(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.

each half of the bone, and viewed in profile the curved outline is still preserved. The figures illustrating the condition peculiar to this age are singular from 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.

Passing from a subject of three to one of *six months old*, the differences are not at first sight very striking. The angle formed by the borders of the body and ramus of the lower jaw does not appear to be less obtuse than in younger skulls. This is, however, due to a considerable increase of bone on the lower border, especially near and about the symphysis, at the same time that the mental prominence is beginning to appear and occupy a more forward position than the margin of the alveolar ridge. The sockets are generally increased in depth, but in a greater degree in the anterior than at the posterior part of the line. The posterior wall of the crypt of the first permanent molar in the upper maxilla is still imperfect; and the septum between the second temporary and first permanent molars in the lower jaw is incomplete. The teeth at the age of six months are more advanced than at the ages previously described; but the difference is much more marked in the incisors than in the other teeth. The canines and second molars are more forward, but the rate of progress has been slower than in the other teeth.

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

The bony cells for the permanent central incisors are now well marked, producing a prominence on the palatine surface of the alveolar process, but they usually communicate with crypts of the temporary teeth by a large orifice. The cells for the permanent lateral incisors are at present indicated only by a depression on the lingual surface of the crypts occupied by the temporary teeth.

At the age of *eight months* we may see indications of further progress. In the specimen figured, that of a male nine months old, the conditions of the alveolar ridge are becoming rapidly changed. At the front part of the mouth, the alveoli, which have hitherto developed more rapidly 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. Indications of the removal of the anterior walls of the sockets of the lateral incisors are shown in their emarginated edges, while the alveoli of the other teeth still preserve their inverted margins.

The crypts of the permanent central incisors are becoming separated from those of the temporary teeth by the growth of septa, which rise towards the surface from the deeper part of the sockets; and growth is continued in this direction until the opening becomes level, or nearly so, with the free margin of the sockets of the temporary tooth.

The sockets of the molar teeth, which in the fœtus ex-

tended to the floor of the orbit, are now separated from it by the antrum, which at this time is represented by a deep

Fig. 13. (1)

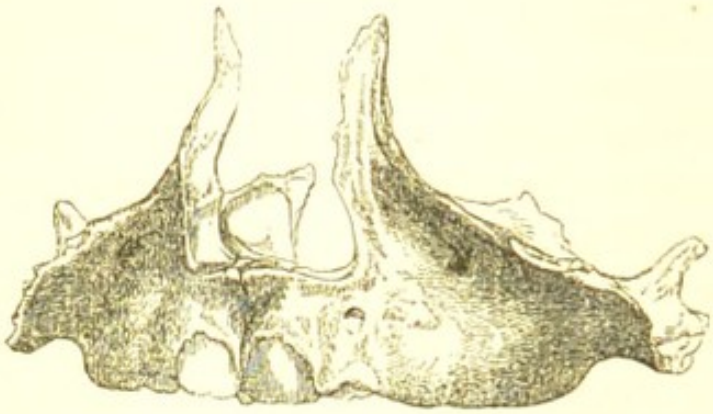
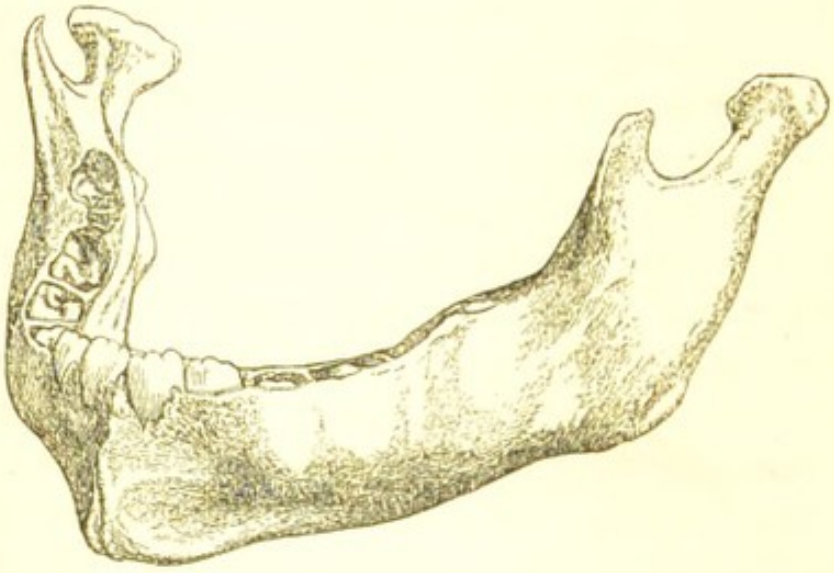


Fig. 14. (2)



depression, extending under the orbit in its inner two-thirds. The septum between the socket of the second temporary

(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.

and first permanent molar is still imperfect, and the posterior wall of the crypt of the latter tooth, although incomplete, is in progress of development.

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 at the alveolar margin turned outwards, 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 line of the symphysis at the posterior surface of the jaw 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 heights 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 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.

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 this 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 as it were gliding 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; 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

(1) G. M Humphrey, in Trans. Med. Chirurgical Society, vol. xiv.

permanent teeth: then developed afresh around the roots of the permanent set of the teeth, so that in the sockets 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 on the latter as points of measurement from which to estimate the relative proportions of these two parts 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, 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 the position of the latter tooth and its successor remains 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 from 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 18). 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 pairs 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 between 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. Humphrey read a paper before the Cambridge Philosophical Society,(1) in which an identical conclusion was arrived as to the growth of the jaw by inferences from a series of experiments performed by inserting wires into the jaws of growing animals.

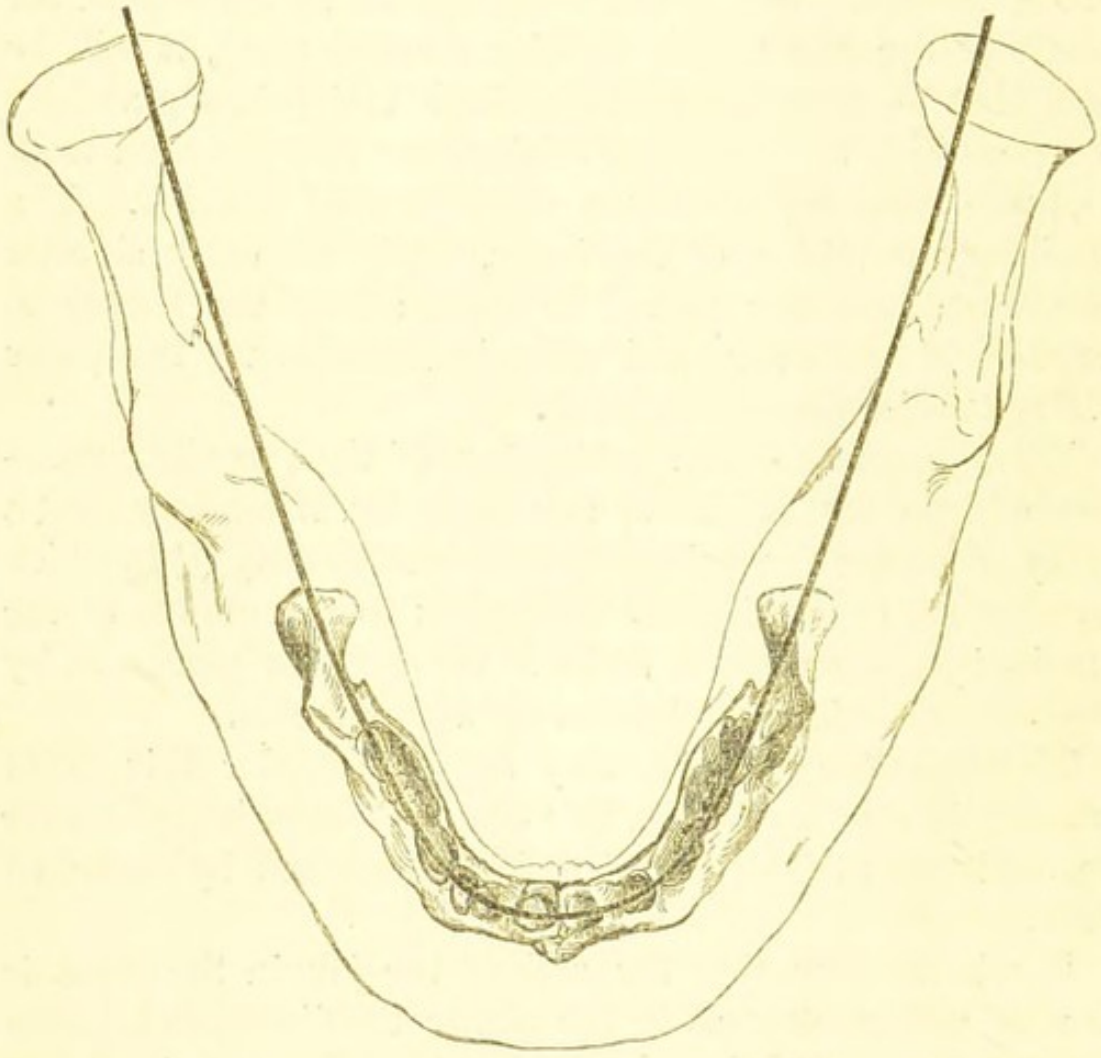
The following diagram may serve to render this point clearer; in it a jaw from a nine-months' fœtus is placed over an adult jaw, the limits of which are marked by unshaded lines.

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. Humphrey, "Although the bones of the alveolar arch are lengthened, and the arch

(1) "British Journal of Dental Science," vol. vi., p. 548.

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 pro-

Fig. 15.



cess, 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 of the nine-months' jaw compared with the fœtal bone. 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 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, I shall subsequently be able to show, 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 pro-

gressive absorption of its parietes, and the enlargement of the outer dimensions by development of bone upon the surface.

The description of the jaws of the nine-months' child has been given at greater length, in consequence of the specimen having attained that stage of development which immediately precedes the eruption of the teeth.

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 of which are 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 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 set in, and at the latter age is in full activity. In the upper jaw the two halves of the bone are becoming united; and although they may be separated after maceration, yet it requires some force to part them, a condition very different to that which obtains at an earlier period, when they readily fall apart. It was stated that the anterior wall of the alveoli of the central incisors in the nine-months' jaw had been diminished by 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 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.

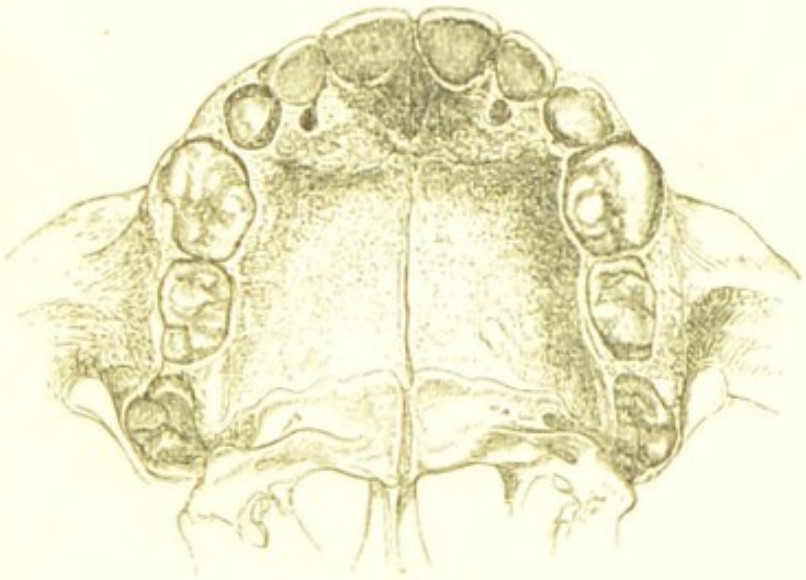
The alveoli of the canines preserve their depth, but the opening is somewhat larger than heretofore, indicating the commencement of the change which precedes the eruption of those teeth. The lateral incisors have escaped from their

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

Fig. 16. (1)



Fig. 17. (2)



(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.

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.

Fig. 18. (1)

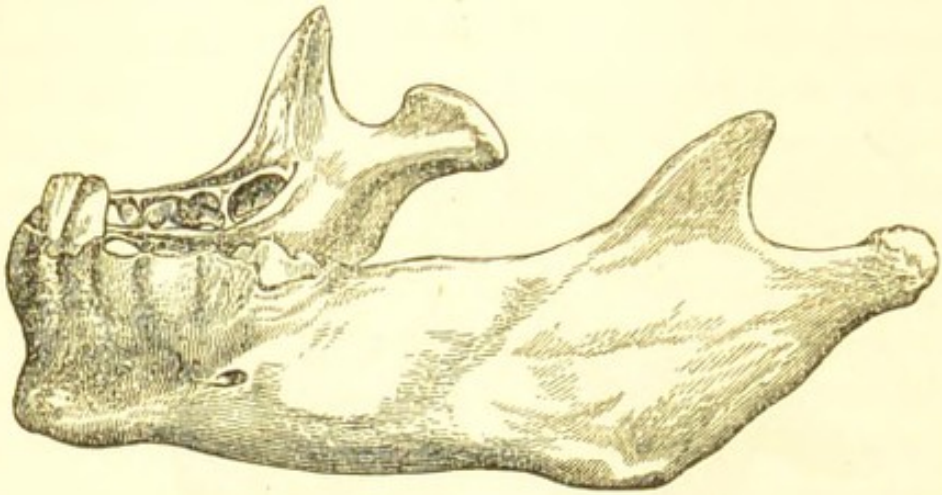
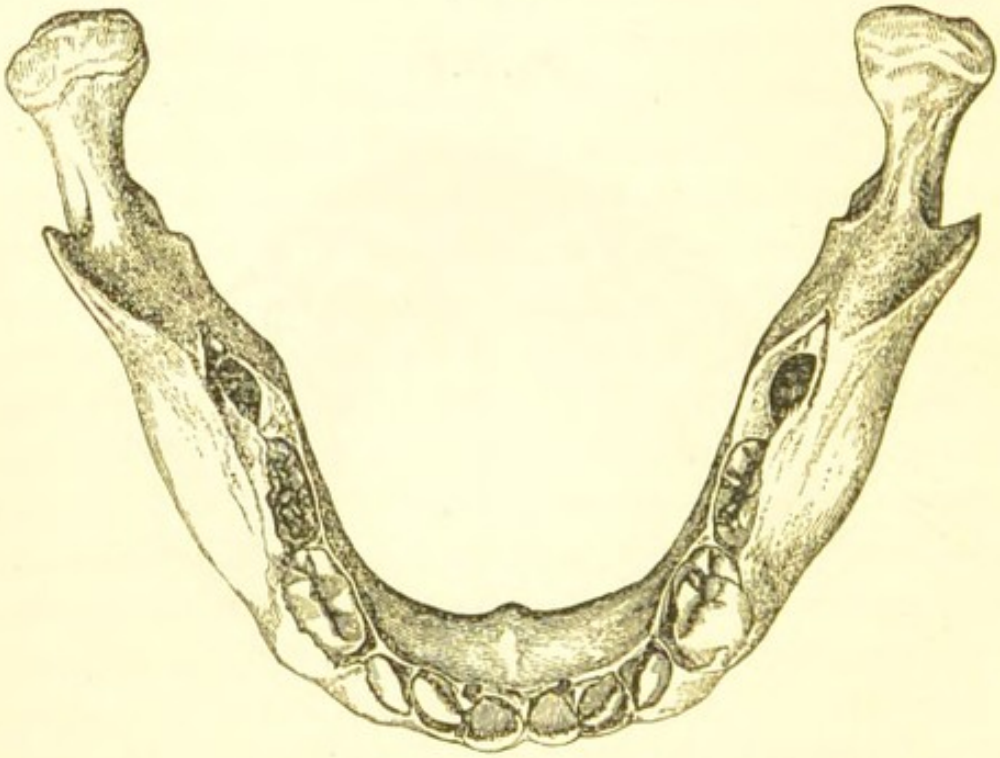


Fig. 19. (1)



(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.

The alveolus of the first permanent molar, which at an earlier age was destitute of any posterior wall, and had a large open orifice, has now become more perfect, and communicates with the surface by a comparatively small opening situated on the alveolar ridge, and in a line with the openings of the anterior sockets. The lingual margin of the socket is much more strongly developed than that of the outer alveolar plate, and indeed rises into a process continuous with the corresponding part of the sockets of the more anterior teeth. The base is continued outwards so as to arch over the inner part of the developing tooth, a condition calculated to protect the latter from mechanical injury, now that the mouth is becoming furnished with organs of mastication.

Excepting in a general increase of size, the lower jaw does not present any considerable change in character from that of the nine-months' subject. The central incisors have risen out of the sockets, and the emargination of the outer plate of the alveoli of the lateral incisors and of the first temporary molars has commenced; those teeth are, however, scarcely raised above the level of the alveolar ridge.

The next specimen in the series is that of a female subject, *eighteen months* of age. This, as compared with the twelve-months' maxillæ, shows an advance in the process of dentition, but not to the extent usually assigned to the age. The crowns of the central incisors both of the upper and lower jaws, are fully exposed; but the fangs, although approaching the normal length, are as yet incomplete, the extremity of each presenting a sharp thin edge, with a large aperture, instead of the conical termination, perforated by a minute foramen, peculiar to perfected teeth. The lateral incisors have emerged from their sockets, but the crowns have not reached to the level of the central teeth, those of the upper being more forward than the corresponding teeth of the lower jaw. The conical points of the canines have become visible above the emarginated edges of their alveoli; while the first temporary molars have been protruded in the upper to the extent of two-

thirds of their crowns, and to one-third in the lower jaw. The roots exhibit corresponding stages of development, those of the upper jaws being nearly half their ultimate length, and the lower ones about one-third. The second temporary molar is at present wholly within the socket, the margins of which are arched over so as to diminish the alveolar aperture, and protect the developing tooth, an effect which is partly produced by the edge of the external alveolar plate being more produced in height, and at the same time more arched over the tooth than the inner edge of the socket. The roots of these teeth are scarcely indicated, excepting by the septum of dentine which in each may be seen extending across the base of the crown, and marking the position for the future roots. The first permanent molars lie deep within their respective sockets, the orifices of which in the lower jaw are contracted by the inversion of the outer alveolar plate and the base of the coronoid process, the teeth at this time being placed with their posterior two-thirds internal to and beneath that portion of the jaw. The posterior edge of the socket is brought forward over the back part of the crown to the extent of one-fourth of its antero-posterior dimensions. On the upper surface of this, within a line of its edge, a depression in the bone may be seen. This is the commencement of a crypt for the second permanent molar. (Fig.19.) The corresponding teeth of the superior maxillæ occupy the tuberosity, the posterior part of which is extremely thin, and in the median line imperfect. This gives a long and curved opening to the socket, and a posterior direction to its further half. In the upper jaw we have as yet no indication of preparations for the lodgment of the second permanent molar.

If the eighteen months' maxillæ 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 fang. 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.

Twenty-one Months.—The differences observable between the preparation last described and the maxillæ of a female subject twenty-one months old, with the exception of a slight general increase in size, are confined to the more advanced condition of the teeth. The four incisors of either jaw have assumed the normal position; the crowns being fully exposed, although the fangs are not quite completed. The sockets have, however, contracted, and closely embrace the implanted portions of the teeth, at the same time that they have grown up with the teeth as the latter have increased in length. The canines show only their tips above the alveolar margin; but the first temporary molars in the upper jaw have fully emerged, and are closely embraced at their necks by the margins of the sockets. In the lower jaw, these teeth have escaped from their sockets, but as the thicker part of the crown is scarcely through the aperture, the emargination of the edge of the alveoli has not been obliterated by development of bone at these points.

Twenty-eight Months.—In a twenty-eight-months' subject, in addition to the teeth which have been described as having taken their permanent position in the younger jaws, the crowns of the canines have partly passed out of their sockets, those

of the upper being in advance of the corresponding teeth of the lower jaw.

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 towards the adult form. 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 is reduced to the peculiar form 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 the lower border, the relations between the body and the rami would have been maintained. But growth at that part is relatively slight, hence the angle formed by the two divisions of the jaws has become changed contemporaneously with rapid growth of the alveolar margin.(1) The rami have been gradually elongated. The 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 increased depth of the alveoli, still further 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

(1) Compare diagrams on page 104.

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 increased 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 direction.

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.

Four Years and One Month.—The next specimen in my series was taken from a subject who died at the age of four years and one month. In these jaws, the incisor teeth are the only ones which are really perfected. The fangs 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 I have 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.

If the maxillæ of the forty-nine months' subject be compared with the one previously described, it will be seen that the slight depressions which marked the spots destined for the pulps of the second permanent molars, have now become large crypts with well-defined margins, the superficial extent being proportionately much greater than the depth. In the upper jaw these depressions look backward towards the pterygoid plates of the sphenoid bone: in the lower, upwards and a little inwards, their floors lying immediately over the inferior dental canal, near its commencement. Situated on the floor, near the posterior wall of the crypt, is a small foramen, which passes through into the dental canal, and gives passage to vessels which supply the developing tooth. Passing over the septum, dividing the sockets of the permanent molars, is the groove which in the younger specimen was but slightly marked. In this subject it is broad and strongly pronounced, the margins being raised into two thin processes of bone.

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 indicate different 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*, and that directed towards the tongue as the *lingual*, surface. The surface which lies against a neighbouring tooth, and is directed towards the point of junction of the two halves of the alveolar ridges, 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, so far as I know, 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 median 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 fangs 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.—The

number, order, and position of the deciduous teeth, as they arise in the jaws when the development is normal, have been described. The deviations from these conditions remain for consideration prior to entering upon the eruption, or cutting of the teeth, as the process is commonly called.

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. I have not had an opportunity of examining a case, either in the living subject or in a preparation. Recently I met with a gentleman who informed me that a member of his family, a female, 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. I have in my own collection two instances in which the lateral incisors are absent—one in which they are wanting in the lower (Fig. 12), 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. I am indebted to Mr. Ibbetson for a cast taken from a case under his charge, in which there were five incisors in the lower jaw. They were uniformly arranged, and there was nothing peculiar in the form of either: so similar indeed were they, that it was difficult to determine which should be regarded as the supernumerary tooth. In my own collection,

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.

Several years since, a child, aged five years, was brought to me, 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 my 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,

Fig. 20. (1)



(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.

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.

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.

Another deviation from the ordinary course of development remains for consideration, and 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 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 fangs 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)

Mr. Salter has a paper in the "Transactions of the Medico-Chirurgical Society" upon this subject, and gives an illustration confirmatory of the fact advanced by Desirabode, but taken from two similarly united permanent teeth.(2) Mr.

(1) American Journal of Dental Science, 1847.
(2) Medico-Chirurgical Transactions, vol. xxxv.

Brookhouse, of Manchester, sent me two examples of geminated teeth. The laterals and centrals are joined laterally throughout their length, and have 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, thus affording an opportunity for a complete examination. 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 central and lateral incisors, or the lateral incisors and canines, appear to be the only teeth of the temporary set subject to gemination. The accompanying figures illustrate the appearances presented by united teeth. (Figs. 21 and 22.)

Fig. 21. (1)



Fig. 22. (2)



The eruption or cutting of temporary teeth.—Having traced the growth of the temporary set of teeth in connection with the jaws, from the time of birth up to the period of their completion, upon a series of preparations from which the soft parts had been removed, it is now necessary to consider

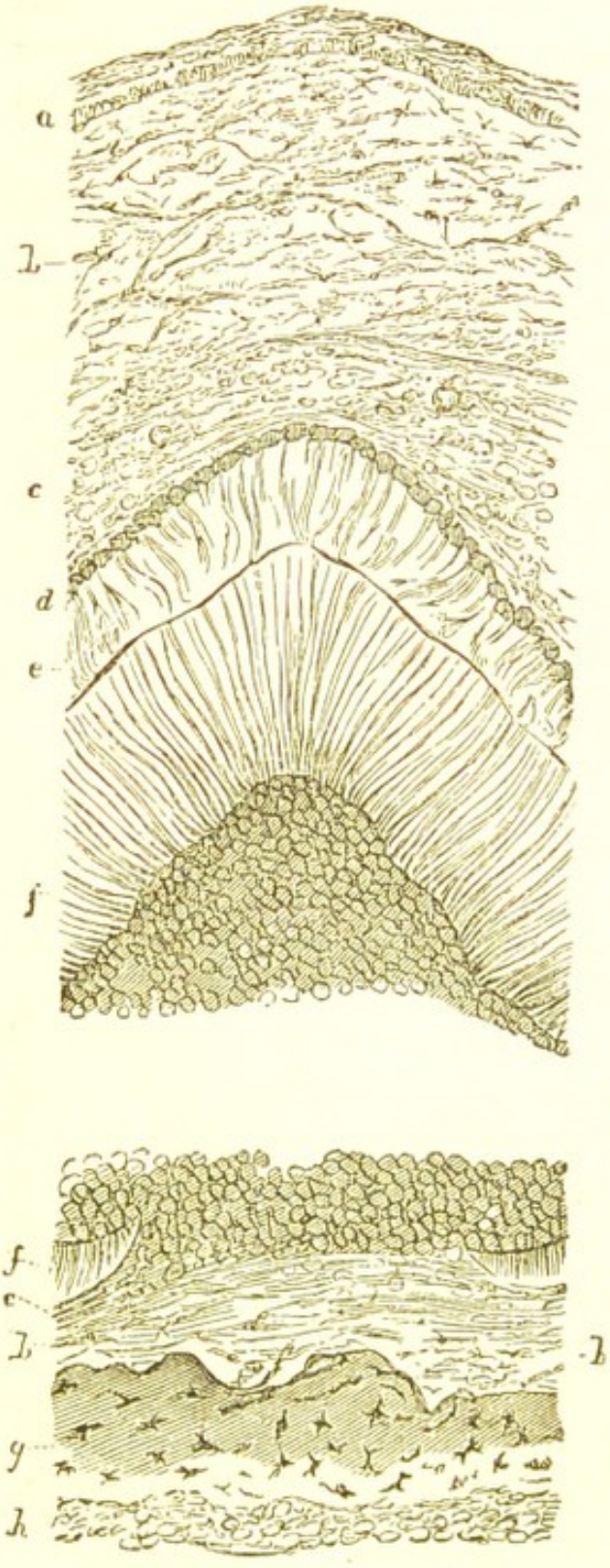
(1) Shows the front view of the lateral incisor and canine from the left side of the under jaw, united throughout their entire length, but with the line of junction well marked. The age at which they were removed was seven years. The corresponding teeth on the opposite side of the jaw were similarly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

(2) 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.

the conditions of the latter so far as they are connected with the eruption of the 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 thickness the further they are removed from the surface, and eventually terminate in a series of slightly elongated cells, the long axes of which are placed at a right angle with the surface of the gum. Below the epithelium comes a thick layer of stellate areolar

Fig. 23. (1)



(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.

tissue, the meshes of which are comparatively large and open. Nuclei are present in the centres of the stellations, while others may be found in fibres which have not conformed to the axial arrangement, or which, in progressive growth, have not yet arrived at the stellate form. 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 the one surface, and the lower border of the jaw on the 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.

After the crown of a tooth has been formed, before it can be cut, the aperture of the socket must be enlarged, 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

balanced—that the subject of these changes suffers no inconvenience. In a child who was constantly under my own notice, tooth after tooth appeared without any premonitory symptoms. The period of teething came and went, attracting attention only when a new tooth was discovered. Instances of teething such as the foregoing are, I believe, comparatively rare, and can only occur in children who are and have been in all respects perfectly healthy, the fulfilment of which involves a series of conditions which our artificial state of living does not tend to bring about, or, it may be said, can scarcely 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. 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. To these deviations from normal dentition, attention must now be directed; but in treating upon this part of the subject, I must borrow largely from the experience of others. 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 coin-

cident disorders necessarily becomes limited and excused, a condition which has arisen within the last fifty or sixty 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 I have endeavoured to describe 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, and I cannot do better than avail myself of 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 digestion, 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, I presume, 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 incapable of producing the fatal disease. I have not been able to find any account 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 re-

course 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 I 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 in-

creased 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 a somewhat different condition 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 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 lately expressed by Dr. West, (2) 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

(1) Clinical Lectures, Trousseau, vol. iv. (Sydenham Society Edition).
(2) On some Nervous Disorders of Childhood, by Charles West, M.D.

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 place when he mentions their length of fang as being another difficulty in the way of their easy transit; for the fang is not fully formed until the crown is well advanced in its movement towards its final position.

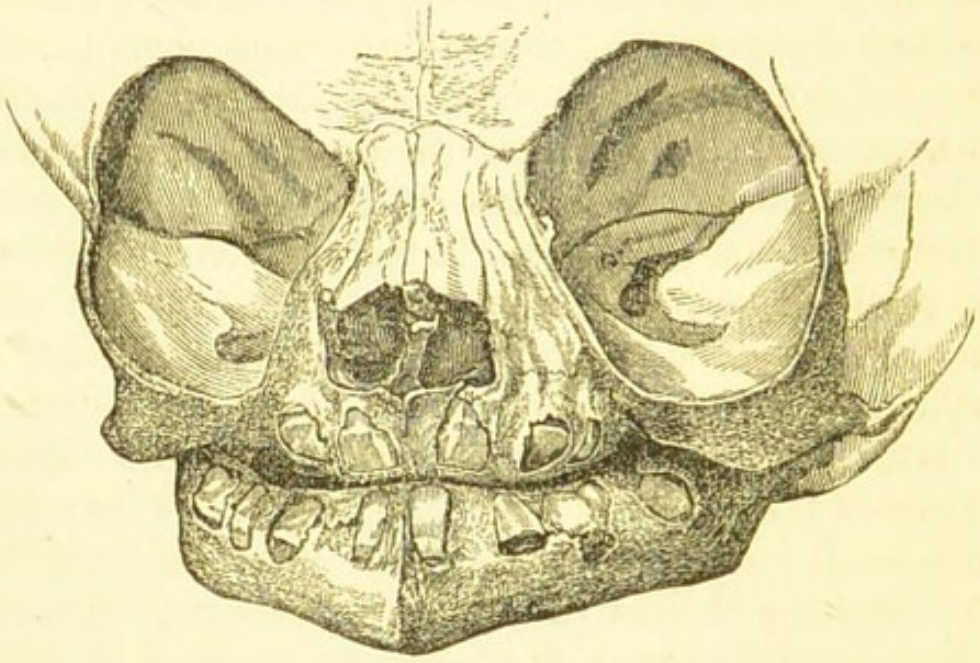
Tubercle does not appear to interfere with the progress of dentition, but rickets does so in a very great degree; in fact great delay in the appearance of the teeth would always lead to a suspicion of the existence of rickets.(1)

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

(1) It will be noticed on looking over the maxillæ figured in this work, that the teeth are, in many instances, hardly as far advanced as would be expected from the age of the child; this may be due to the fatal illness having been of considerable duration, but that within certain limits there is some little variability, even in healthy children, is indicated by the fact that almost every author assigns a different period to the eruption of the teeth.

unusual porosity, the defect being in quantity only,—a peculiarity which is extended to the whole of the bones of the face. (Fig. 24.) I saw a patient some months since, 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

Fig. 24. (1)



required 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

(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.

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 I have seen in a few cases only. 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 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. I was unable to determine 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

(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.

teeth have appeared to be sources of irritation, medical men,(1) all other remedies having failed, have 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 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 happened 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.

(1) 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.

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: the incisions should not, however, be deep, as in the former case, but superficial only, and performed with a sharp instrument, shaped like an ordinary lancet, and with an equally sharp edge. 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, I must refer the reader to works treating upon the diseases of infancy and childhood. These are subjects which seldom come under the notice of the dental surgeon; 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 preclude 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.—In following the plan which has been adopted in arranging the matter of the present volume, it will be necessary to point out the normal relations of the two sets of teeth before entering upon the irregularity in the arrangement of the permanent organs while still within the alveoli. 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 develop-

ment 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 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 succeeding teeth.

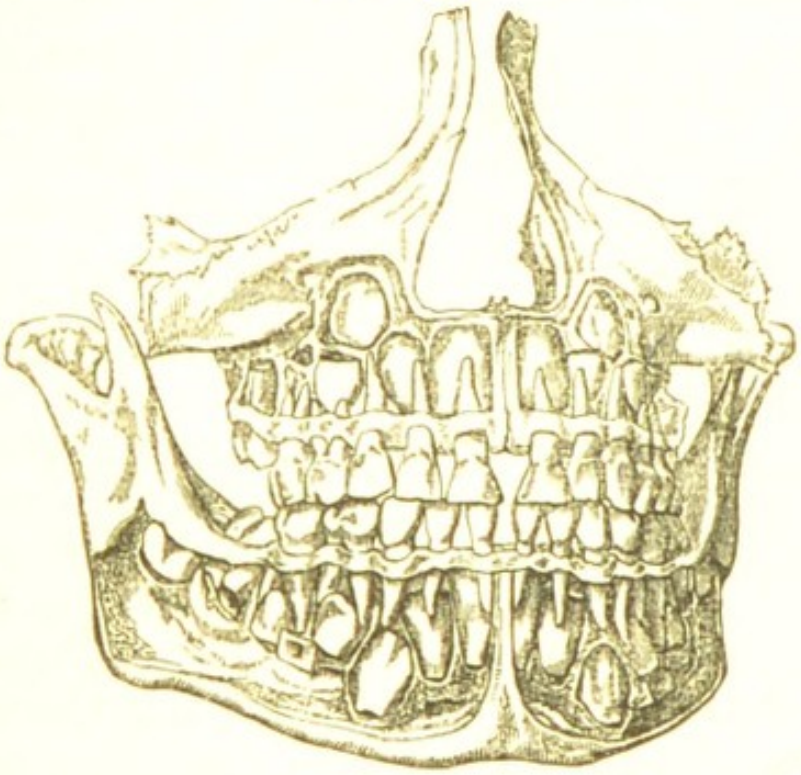
The permanent teeth are at this age contained within bony cells, which have been aptly enough compared to the dense layer of shell which surrounds an almond, and which, like the dental cells, is connected with the contiguous tissue by a comparatively porous structure. The alveolar cells may be readily isolated by breaking away the porous bone by which they are surrounded, except at those points where they come in contact, and blend with the dense bone which contributed to form either the outer surface of the jaw, or the dense wall of a neighbouring cell.

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

Fig. 25. (1)



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, and a little over the contiguous portion of the central incisor. The point at 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.

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 of either side is turned from the mesian line, and lies obliquely over the canine, to the extent of about half of that tooth. They do not, however, 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 inwards. The bicuspids are placed in cells situated between the roots of the temporary molars.

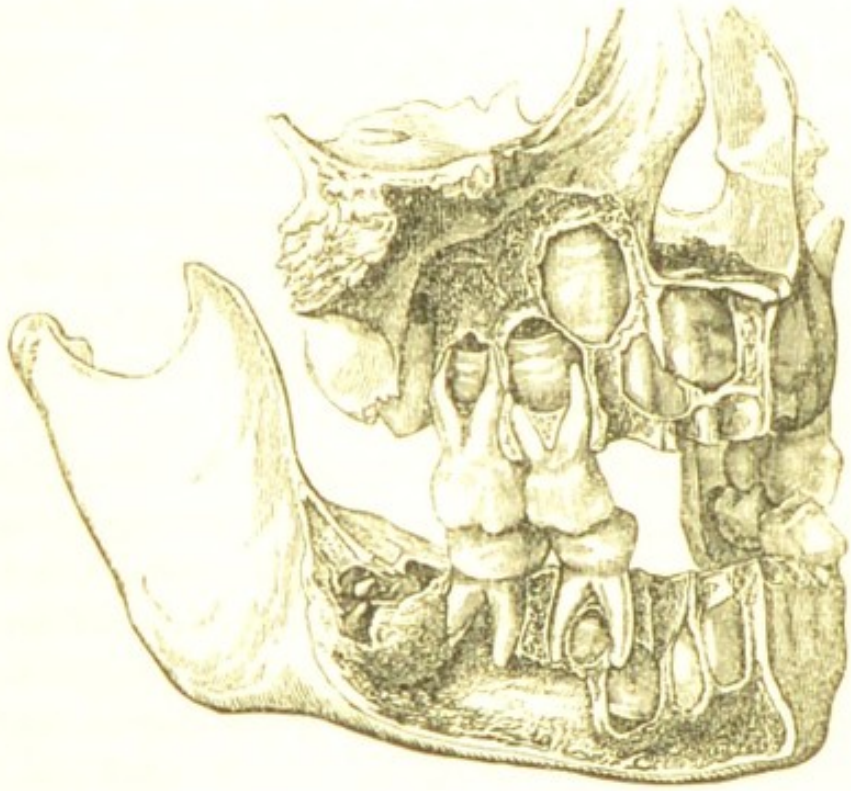
In the specimen which I have chosen for description, and from which the illustration is taken, we have perfectly well-grown jaws, showing very completely the relations in position of the first to the second set of teeth, and the relative position of the several members of the latter to each other. It is very desirable that the practitioner should be well acquainted with the conditions which 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. 26), 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 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 median edge turned outwards towards the lips and is accompanied with a diminished size of the anterior 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

Fig. 26. (1)



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

(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 distal edge turned outwards.

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

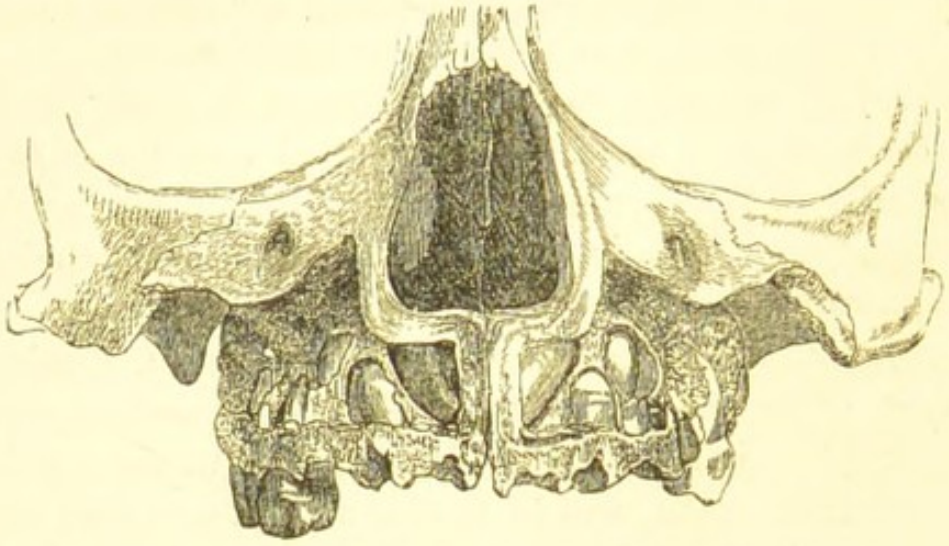
of opinion as regards treatment, leaving a wide and very productive field for the cultivation of the charlatan, who sees in every case of irregular disposition of the teeth an opportunity for mechanical interference, in some cases securing to himself a large fee for doing by means of mechanism that which 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, an attempt is made to bring together a series of conditions connected with the subject of irregularity of the permanent teeth, taking up the inquiry at an earlier period than is usually done, and tracing the deviations onward until the teeth are matured.

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 position which, until the teeth have passed through the gums, cannot be materially changed. The development of the teeth has been continued while the jaws have been comparatively stationary. The oblique and twisted position of the central incisors will be maintained until they are acted upon by the antagonistic teeth of the lower jaw; and the first bicuspids,

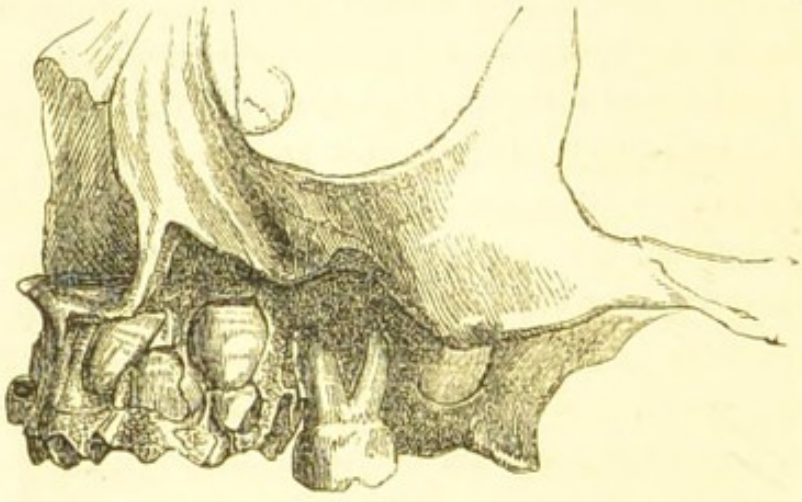
which have been encroached upon and retarded in growth by the canines, will be crooked and misshaped, at the same time that they will be forced into an irregular position in common with the impinging canines, leading probably to one or other of the permanent forms of displacement of the later teeth,

Fig. 27. (1)



considered in a future page. In this case, the teeth in the lower jaws are subject to but slight irregularity.

Fig. 28. (2)



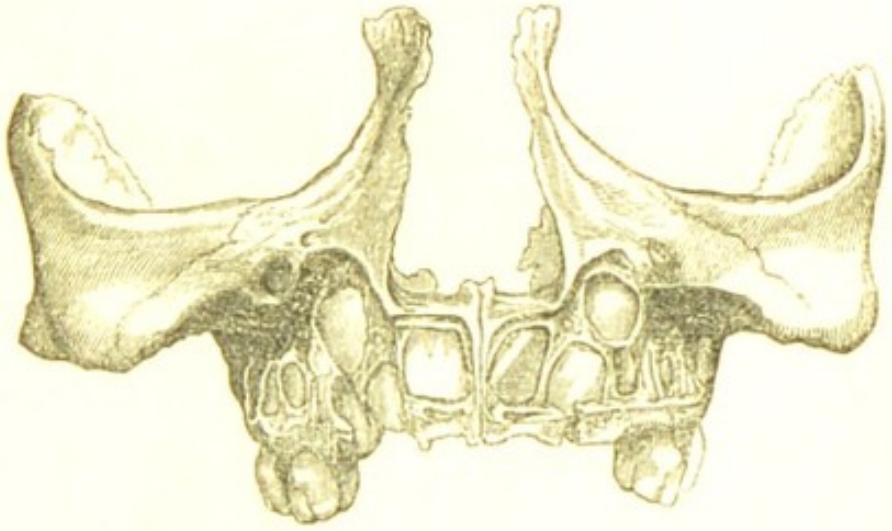
(1) Showing the permanent central incisors, with their median side directed forwards and outwards, while the distal edges lie behind the median sides of the laterals.

(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.

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 central is turned outwards, while the corresponding part of

Fig. 29. (1)



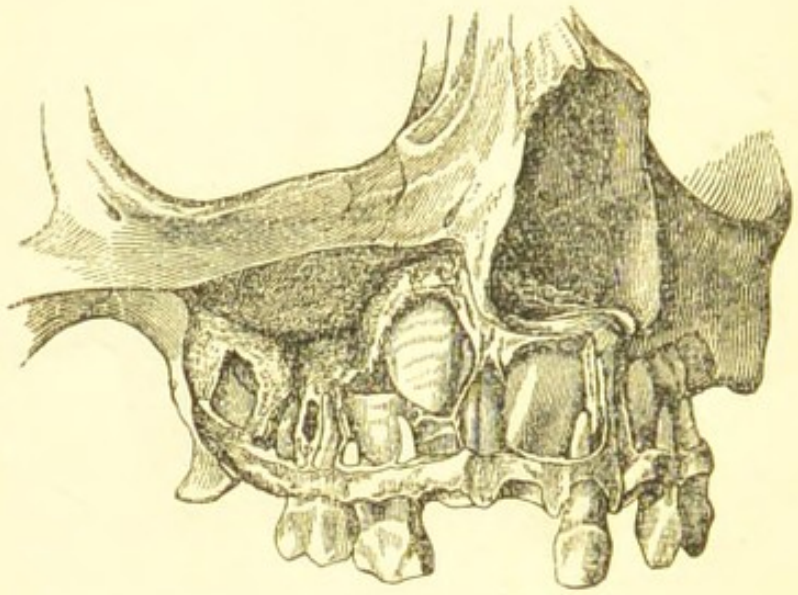
the fellow tooth is turned inwards. The mesial side of the left lateral incisor lies in front of the distal side of the central, and on the opposite side of the jaw the mesial side of the lateral is placed behind the distal side of its contiguous central tooth. The canine and bicuspid teeth hold the 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

(1) Shows mal-position of the incisors. The left central has its median 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.

childhood. In this the distal sides of the upper centrals are slightly everted, while the crown of each tooth, regarded in its length, slants outwards from the mesian 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.

Fig. 30. (1)

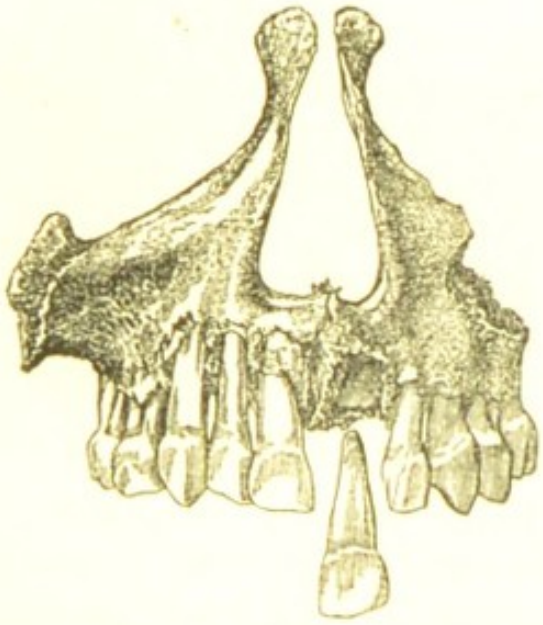


Hitherto, the relations of the teeth to each other and to the jaws, have been considered in cases where the maxillæ present the normal structural appearance, as distinguished from cases in which there are obvious marks of a diseased condition of the bone. In the specimen from which the two succeeding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

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

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 mal-position 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.

Fig. 31. (1)



The canines lie with their median surfaces in contact with the distal sides of the central teeth, leaving no space whatever for the lateral incisors. These are placed within the dental line, behind the temporary canines (Fig. 32), 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

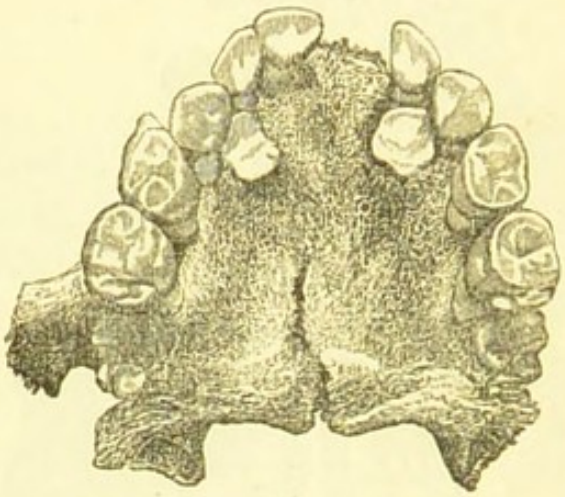
(1) Front view of the upper jaw of a male subject who died at the age of six years, showing a defective condition of the outer alveolar plate and an imperfect implantation of the temporary teeth.

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. 32. (1)



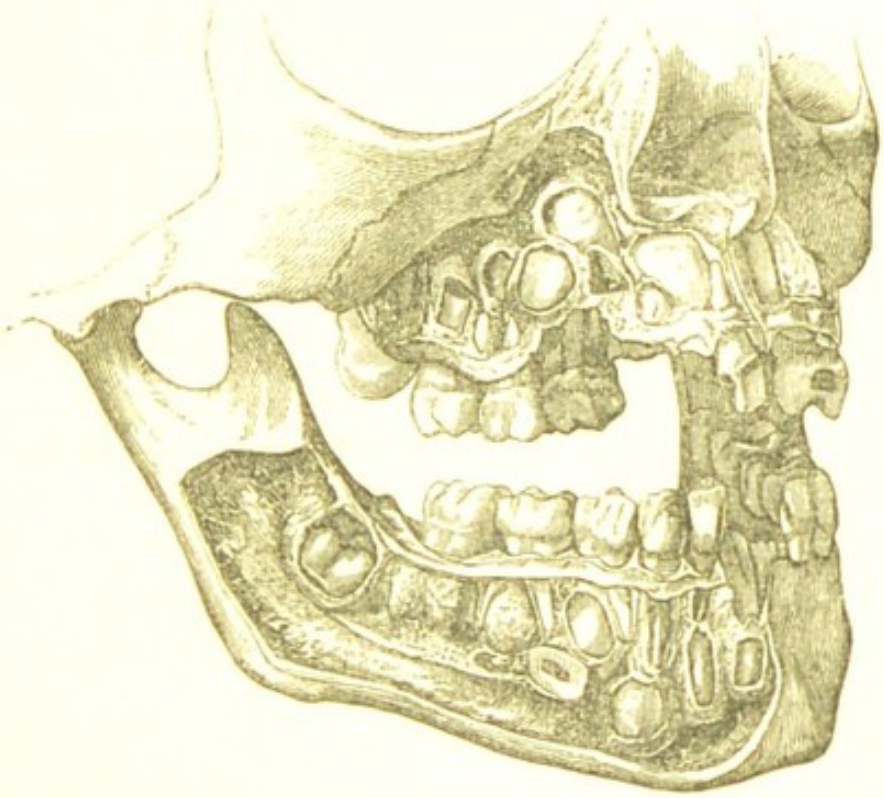
the effects produced from the development of the maxillæ having been suspended, while that of the permanent teeth was continued. We here see the great amount of displacement that may arise from the presence of long-standing constitutional disease.

Local disease in the temporary may also affect the permanent 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

(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.

or second temporary molars, than when the front 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.

Fig. 33. (1)



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

(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.

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 fangs of the incisors are attacked by absorption.

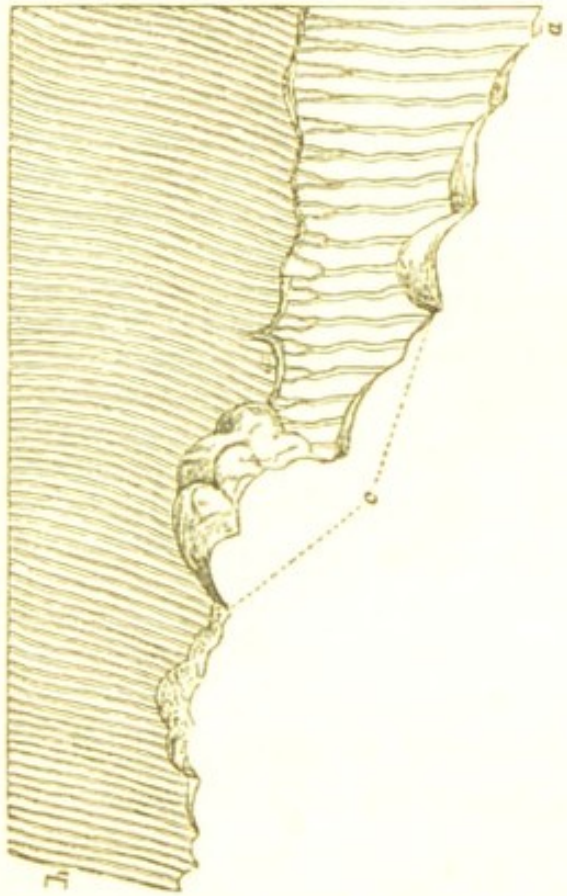
The destruction may commence on any part of the root, or at several spots simultaneously. Particle after particle is by degrees carried away, until nothing but the crown of the tooth is left, and even this is often so much hollowed out, that little save the enamel remains, and sometimes not all of that.

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 fang of a front tooth is commonly attacked, the process commencing at

or near the extremity; but the proximity of the permanent tooth is not by any means a necessary point. 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.

Having latterly had occasion to devote considerable attention to the phenomena attending the absorption of bone and

Fig. 34. (1)

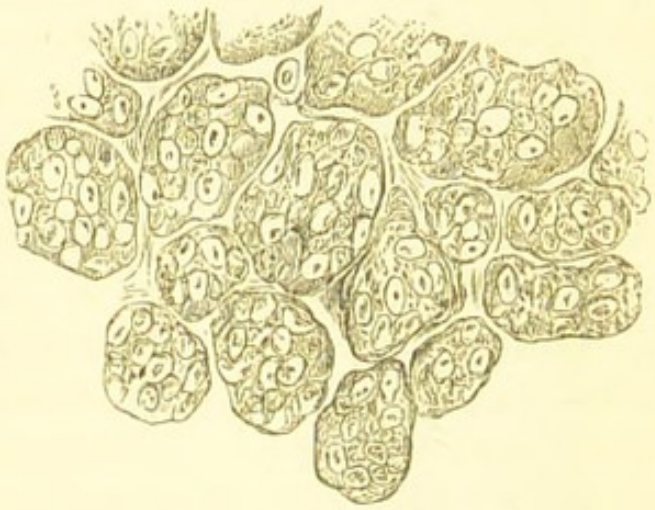


the wasting of the roots of the deciduous teeth, several conditions relative to absorption have come under my notice, which, as applied to teeth, had, I think, hitherto escaped observation. The cementum is first attacked, then the dentine disappears, and the enamel at those points where the dentine has been entirely removed suffers from the same action. But

(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*).

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 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

Fig. 35. (1)



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 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

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

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 possible 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 fang 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

(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.

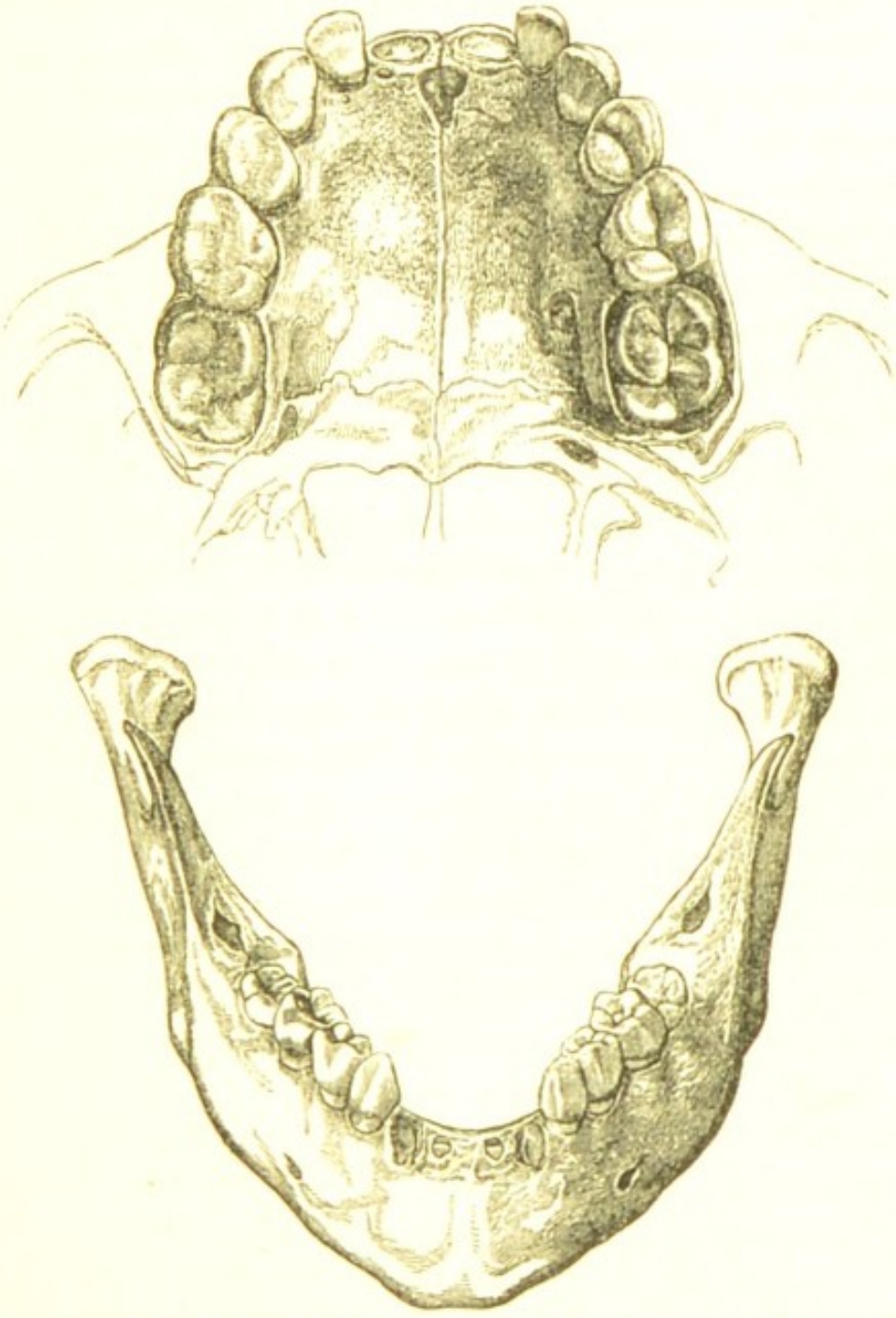
will be equal to that part of the tooth undergoing waste, but the extent, as regards depth, is slight; for, as the root of the tooth disappears, the socket is contracted by the deposition of bone, which forms at the base of the absorbent organ as rapidly as the cellular surface encroaches upon the tooth. 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. From the following quotation, it does not appear that Mr. Bell observed these conditions:

"It has been already stated, that the permanent teeth during their formation are crowded together in the jaw, by being placed in a smaller arch than they would occupy if regularly placed side by side. As the latter, however, is their destined situation, we find that as soon as they are advanced to a certain point of their formation, and can no longer be contained within the alveoli, absorption takes place in the anterior parietes of the cavities, by which means the teeth are allowed to come in some measure forward. In consequence of this absorption it often happens, that not only the socket of the corresponding temporary tooth, but that of the tooth on each side, is also opened to the permanent one. Absorption now commences in the root of the temporary tooth, generally on that part nearest its successor, and thus goes on by degrees as the latter advances, until the root is completely removed, the crown at length falls off, leaving room for the permanent tooth to supply its place."

Mr. Bell, however, rejects the idea that mere pressure of the one tooth against the other has anything to do with the absorption of the first set; an opinion that he would probably

have expressed even more strongly, had he observed 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,

Fig. 36. (1)



(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.

as I have in my own collection several 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."

But there is still a disposition on the part of many who are entrusted with the treatment of teeth, to attribute the absorption of the roots of the one tooth to pressure occasioned by the growth of its successor; and the development of the permanent may have something to do with the shedding of the other. But this does not offer a satisfactory explanation of all the circumstances attending the absorption of the fangs of teeth. In the first place, we sometimes meet with cases in which the fangs of permanent teeth are as completely absorbed as those of the temporary organs. Then, again, the fangs of temporary teeth, which have no successors, are also absorbed: and it not uncommonly happens that absorption takes place at several points on the fang, some of which are far removed from the successor, being oftentimes on the opposite side of the root. These circumstances, taken with the hitherto overlooked fact, that with the waste of the temporary tooth we have in many cases a corresponding development of bone within the socket, to be removed before the permanent tooth appears through the gum, render the pressure theory altogether untenable. Another condition may be adduced, tending also against that opinion,—namely, that 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. Recent examinations have enabled me to add the following additional facts bearing upon this subject to those already known. 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. 37.) 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 in my collection 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 osteal cells, with here and there a lacunal cell. 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

Fig. 37. (1)



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)

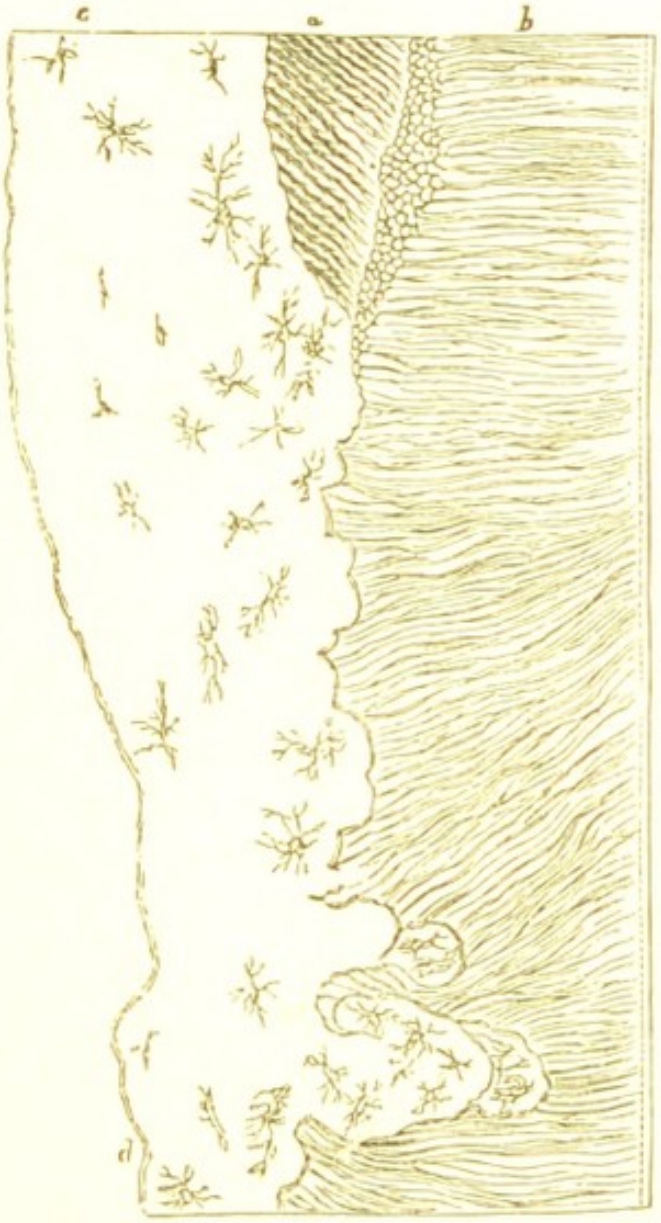
The part of a tooth which has the greatest power of resisting absorption is that which is in immediate contact with the pulp.

(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.

We find examples in which a thin shell of dentine encircles that organ, while all around it has been in great part taken 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 may find sections showing in one part dentine which has been

Fig. 38. (1)



(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.

but recently formed, with its nodular outline and contiguous cells capable of developing dentine; 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, have I seen 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 Mr. De Morgan and myself, 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, and the tooth is again perfect. When the time approaches for shedding the teeth, the two actions alternate; 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 fangs diminish in size, the teeth become loose, and eventually 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 the permanent tooth may be 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. Judging from the conditions presented in my own specimens, I should incline to the opinion that the presence of the temporary teeth is in such cases due to some extent to original malposition of the developing permanent organs. Many instances in which the second temporary molars have been retained until the middle period of life has passed, have come under my 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.

Before we dismiss the subject of absorption, a few lines may be devoted to the consideration of the manner in which the absorbent organ is developed, and of the tissues from which it arises; both are points of great physiological interest.

In a paper read before the Odontological Society, Mr. Spence Bate advanced the opinion that the outer surface of the enamel organ assumed an increased degree of vascularity, and took upon itself the office of absorption. If our observations were restricted to the phenomenon as it is usually presented in the temporary molars, this opinion might, perhaps, be maintained; but when we find absorption commenced and continued upon the labial surfaces of the front teeth, where no enamel organ exists; and when we find a number of specimens in which a layer of bone separated the developing tooth from the one undergoing absorption, considerable doubt is thrown upon the accuracy of Mr. Bate's views. He, however, considers the foregoing as exceptional cases, and regards them as abnormal. Any vascular tissue, on assuming an increased degree of vascularity, may, he considers, exercise the function of absorption. But the wasting of the fangs of permanent teeth, together with the class of cases cited above, he regards as instances of abnormal action, the absorption being performed by the peridental membrane, the vascularity of which has been increased by irritation at the same time that it has become detached from the surface of the tooth. The admission of this distinction into normal and abnormal absorption, in respect to the removal of the tissues of temporary teeth, will not, I think, help us to a better comprehension of the subject; for in the one case we cannot know when the action has commenced on a part distant from the enamel organ until the tooth has been removed, and in the other the septum of bone cannot be recognised but by dissection. But the most fatal objection of all to such a far-fetched supposition is, that at the period when absorption of the fang of the temporary tooth is going on with the utmost activity, the enamel organ of its successor has not only long ceased to be vascular, but has in most instances actually ceased to exist, the external epithelm of the enamel organ having become inseparably attached to the surface of the enamel.

All recent observers will, I think, admit that the dental

tissues are removed through the agency of a growing papilla, and I do not think a difference of structure or function, referable to the particular tissue from which it may have arisen, can be established. Whether the development takes place from the enamel capsule or from the peridental membrane, the structure and the function of the papilla will be the same. The precise nature of the action by which the cells eat away the hard tooth structures still remains a matter of great uncertainty. Kehrer, having observed chalk granules in the protoplasm of young cells, believes that the amæboid cells of the granulations destroy the dental tissue by a kind of mining process, effected by their pseudopodia. (Waldeyer, in Stricker's Human and Comparative Histology.)

In a paper published in the "Philosophical Transactions," some of the foregoing facts are described in connection with the absorption of bone, and an opinion was advanced, to the effect that the absorbent organ grew at the expense of the wasting bone or dental tissue, as the case may be. At that time the peculiar character of the superficial compound cells, and their correspondence to and lodgment in the minute concavities of the wasting tissue, had not been observed. But when it is considered that the dental tissue is decreasing, while the compound or mother cells (as they have been called) are increasing, and that the convexities of the latter are fitted into the concavities of the former, we are irresistibly led, not only to the conclusion that the growing papilla is the absorbent organ, but also to the belief that the superficial compound cells are the immediate agents by which the tissues are removed, and that the peculiar surface presented by either bone or dental tissues, is secondary to, and produced by the cells which form the surface of the papilla.

Perhaps Mr. Spence Bate might be right were he to assert that the outer surface of the capsule of the developing permanent tooth, may become the seat of the vascular structure which fulfils the office of absorption. But I am unwilling to

admit that a similar structure arising in other parts and under other circumstances, is to be regarded as abnormal. Supposing the distinction to hold good, we must regard the action by which bone is at all periods of life removed, prior to the development of new tissue, as an abnormal process, and also the corresponding changes which go on in the cementum clothing the roots of permanent teeth. It would appear rather, that wherever the necessity for the removal of osseous tissue arises, the structure capable of fulfilling the office is developed, and in a vast number of cases quite independently of abnormal action, and that the seat of the development may be in any vascular structure.

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.

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 its direction; and on the other hand, the action of the tongue on the lips will suffice to bring 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. 36, 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 eruption, 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 line with the last-named point, extending on either side to 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 line 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.

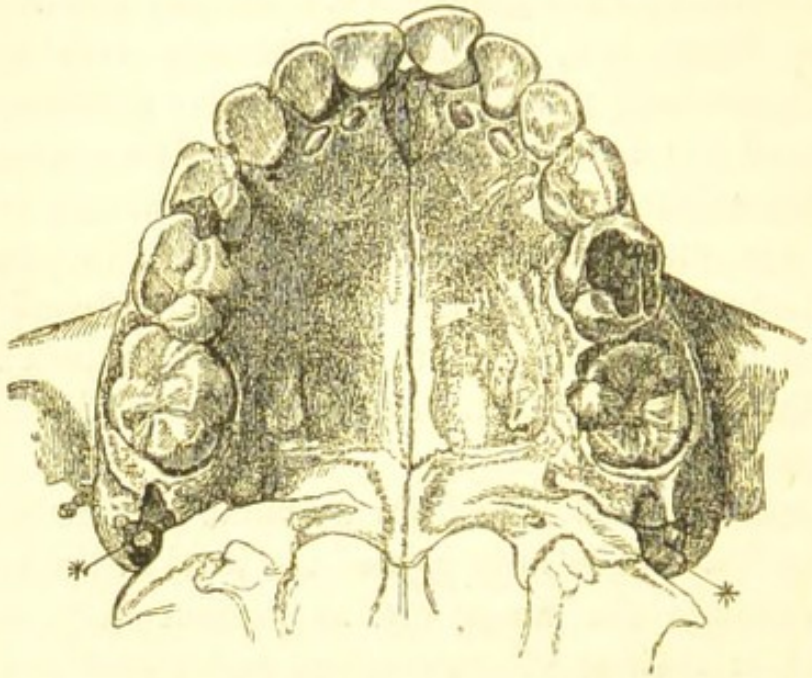
The first permanent molar of the upper not uncommonly precedes by a few weeks the corresponding tooth of the lower jaw; but I do not know that, in respect to priority, any great uniformity prevails. The conditions presented by these teeth

at the age of *six years and five months*, are shown in Fig. 36. 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 thickness, 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 beneath 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 at their as yet incomplete ends; 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. 39), 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, while 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

Fig. 39. (1)



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 in their implanted portions are quite equal to the 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

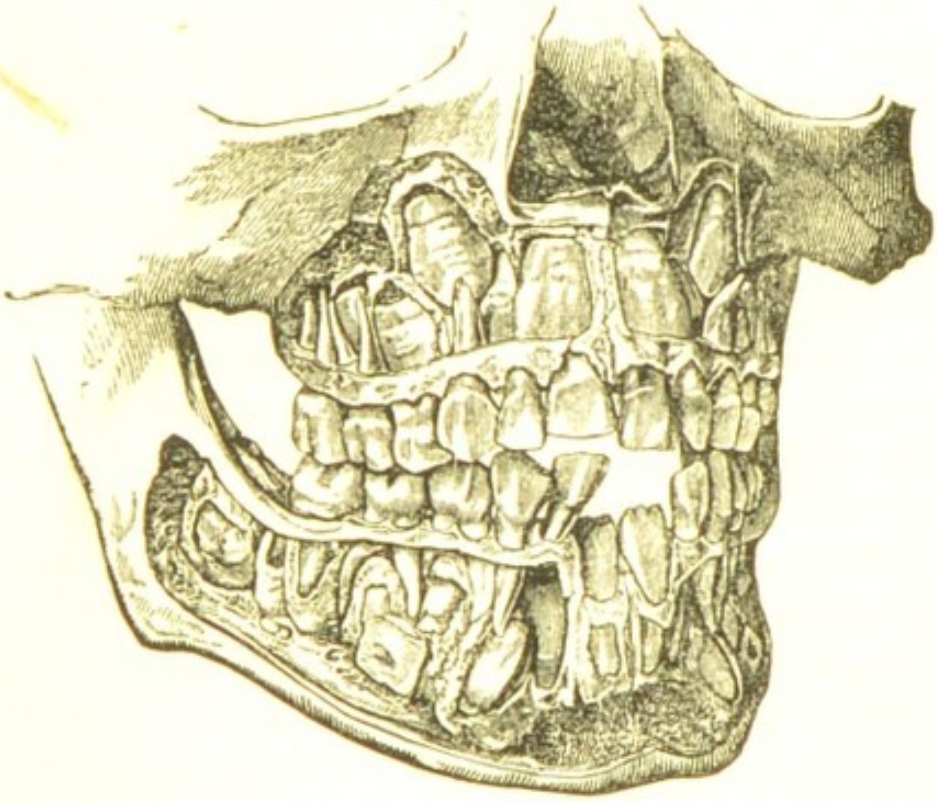
(1) Showing the condition of the alveolus of the first permanent molar at the time the tooth is advancing to the surface of the gum. The tooth on the right side is a little in advance of that on the left side of the mouth. *The crypt of the second permanent molar.

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 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

Fig. 40. (1)



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

(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.

plate to a considerable depth. The condition is shown in Fig. 40; 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 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 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 terminations of the two advancing incisors hold the position which the ends of the roots of the fully formed corresponding teeth occupy.

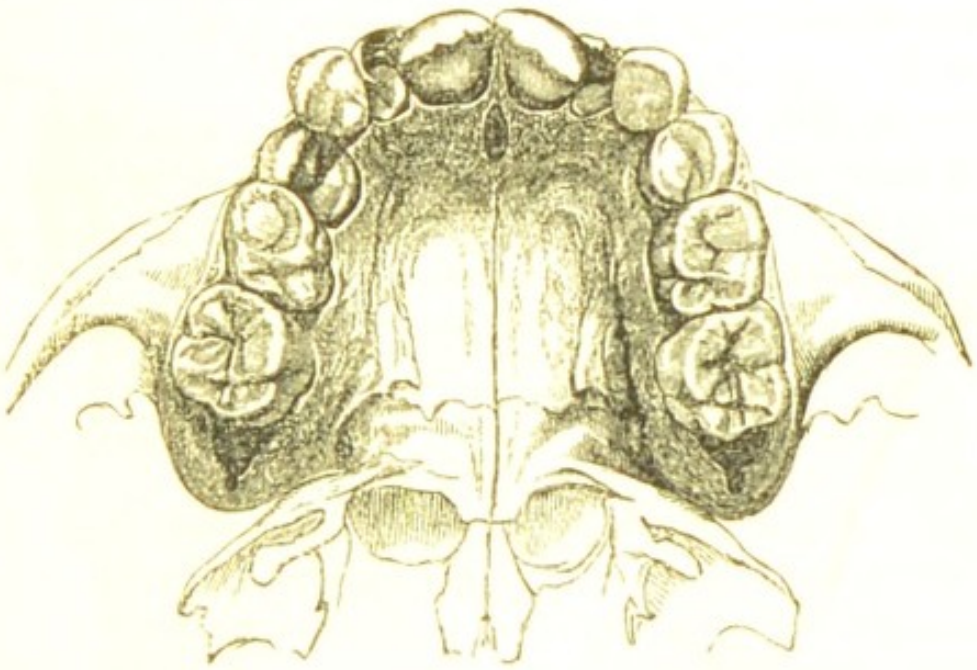
The conditions which have been described as pertaining to the eruption of the lower central incisors, will be found to accompany the evolution of the upper central teeth; the amount of bone removed by absorption varying with the position and size of the teeth. It is, however, by no means easy to obtain 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 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 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

Fig. 41. (1)



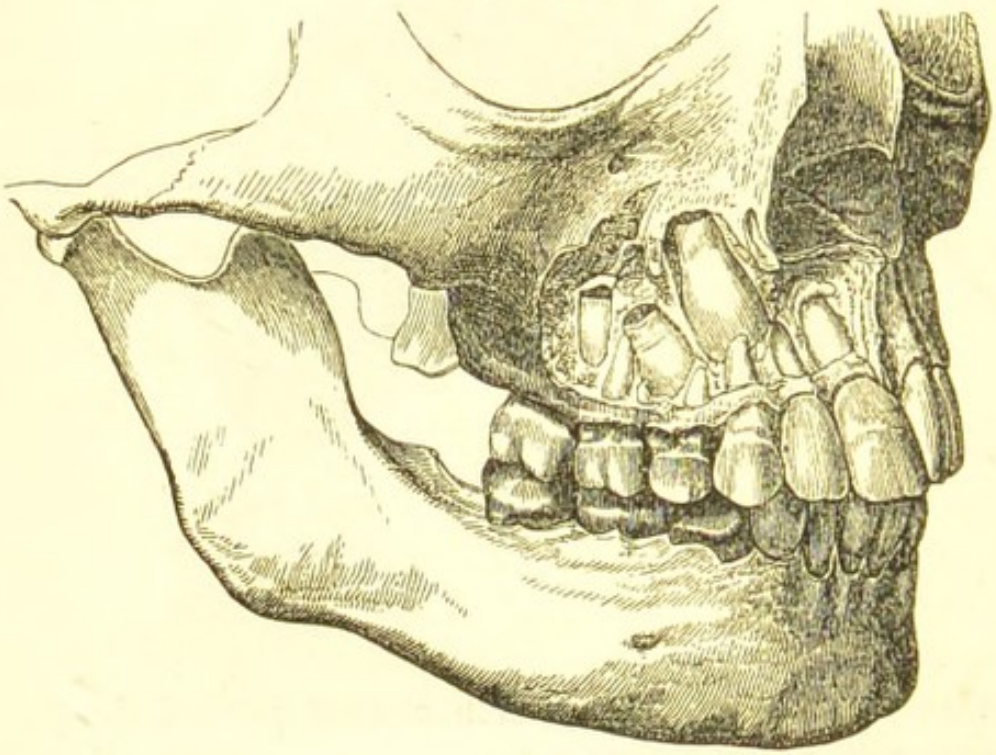
take a more forward position, which, as they descend obliquely outwards, will be still further increased when the teeth have attained their full length. And thus the space, at present too limited for the normal arrangement of the neighbouring teeth, will eventually become sufficiently extended.

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 advanced in development, and their large, rounded, mesial

(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.

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. 42.

Fig. 42. (1)



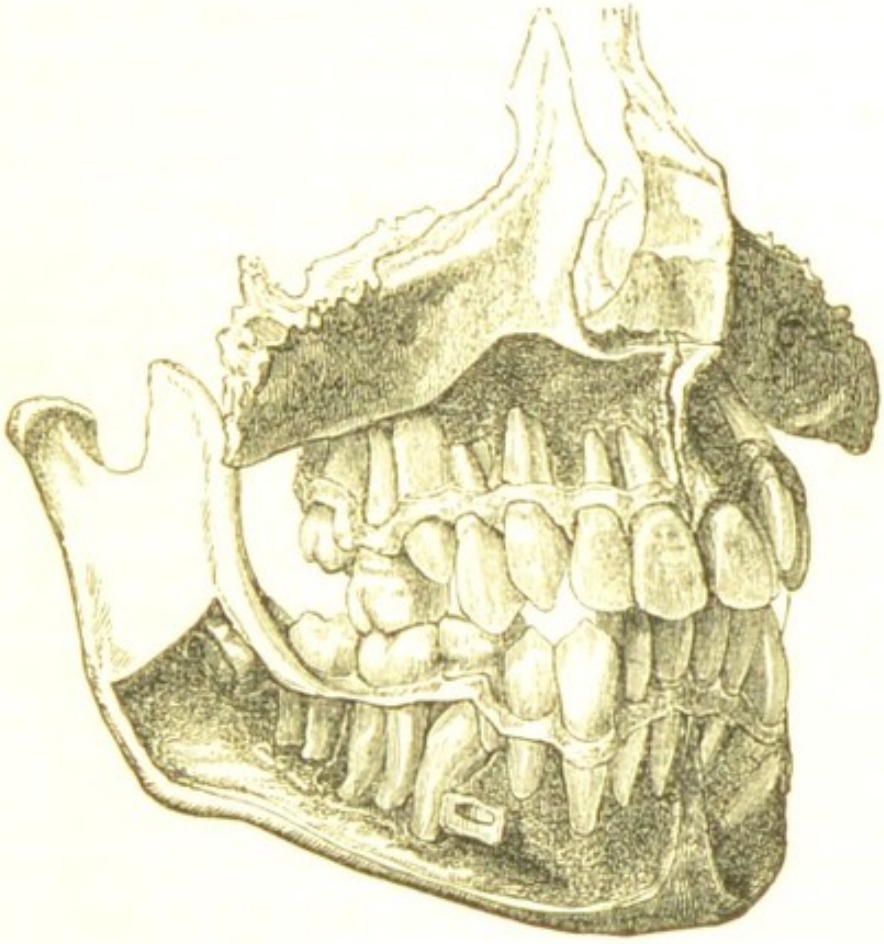
Taking what may be regarded as the normal order of eruption, the first bicuspids will succeed the lateral incisors. If Fig. 40 be examined, it may be seen that the convex distal side of the crown of the upper canine lies upon the mesial side of the neck of the first bicuspid, and necessitates the flattened or grooved surface which characterises that part of the tooth, while the distal side of the tooth is similarly 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

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

appearances presented by the teeth in a favourable specimen are shown in Fig. 43.

Fig. 43. (1)



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

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

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, their advance being 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 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 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, Mr. 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, Mr. 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	..

Mr. 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."

More recently Mr. S. Cartwright, jun., 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 cuspids.	Lower cuspids.	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

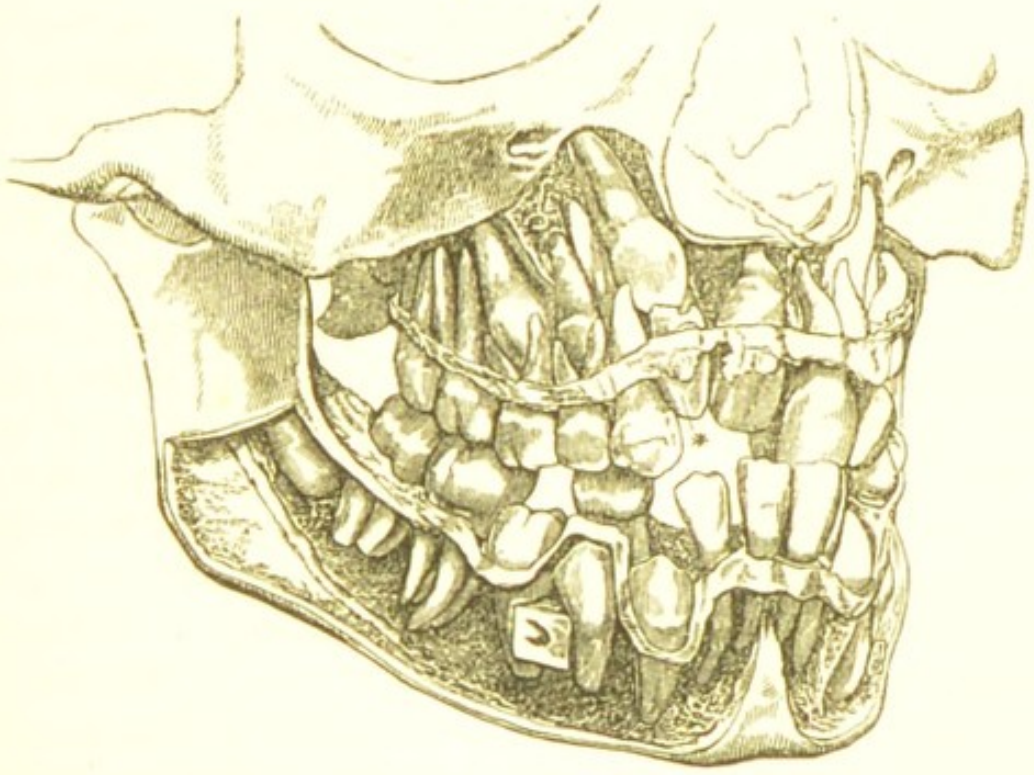
Before we enter upon the subject of irregularities in the development of the permanent teeth, and the various disturbing causes, it will be advantageous to give some further attention to the conditions under which the alveolar processes are formed, and to the laws which regulate the growth of the jaws.

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 the 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. 33 and 40; 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 described by the alveolar margin, both in the upper and lower jaws. It may be seen that the terminal edge of each socket corresponds

Fig. 44. (1)

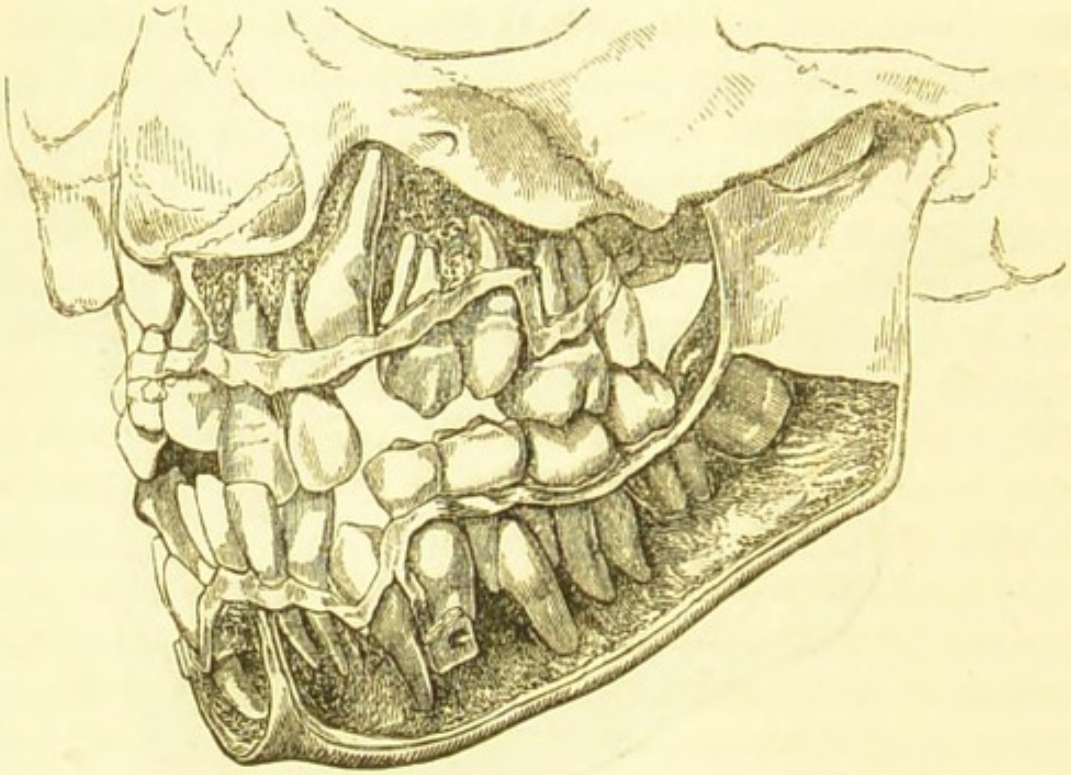


with the neck of the contained tooth, however irregularly the latter may be placed with respect to its fellows, exception of course being made to those teeth which have not yet passed through the gum. On the right side of the lower jaw, the first temporary molar is retained; and on the left, the second

(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.

temporary molar is present. In each case the tooth and its alveolus is raised to a higher level than is usually attained by the temporary teeth, and higher than the adjoining first permanent molars and their sockets. This elevating process

Fig. 45. (1)



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 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.

(1) View of the left side of the specimen figured No. 44. 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 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 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 smaller 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 19) 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 18), 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 edition 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.

Figs. 46 *and* 47. (1)

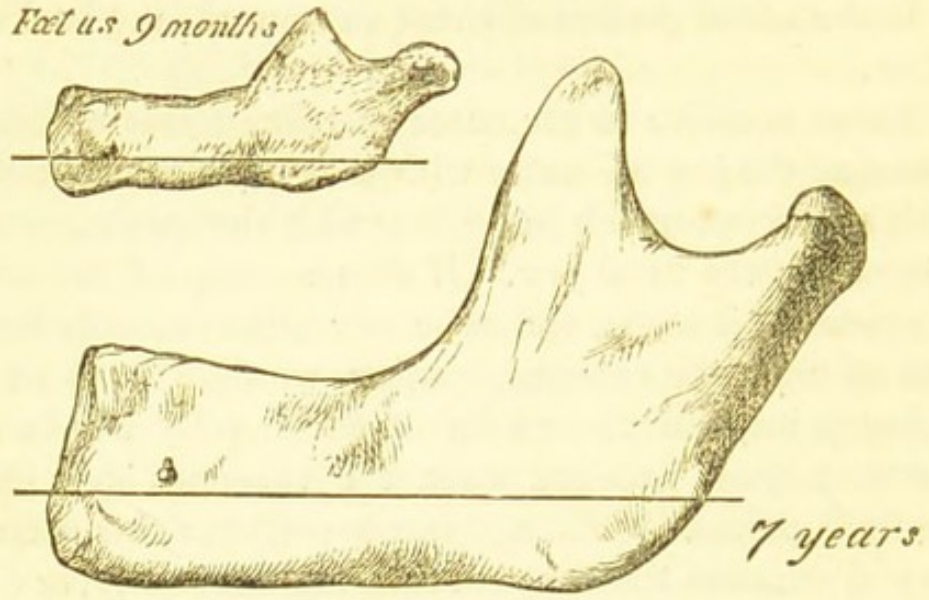
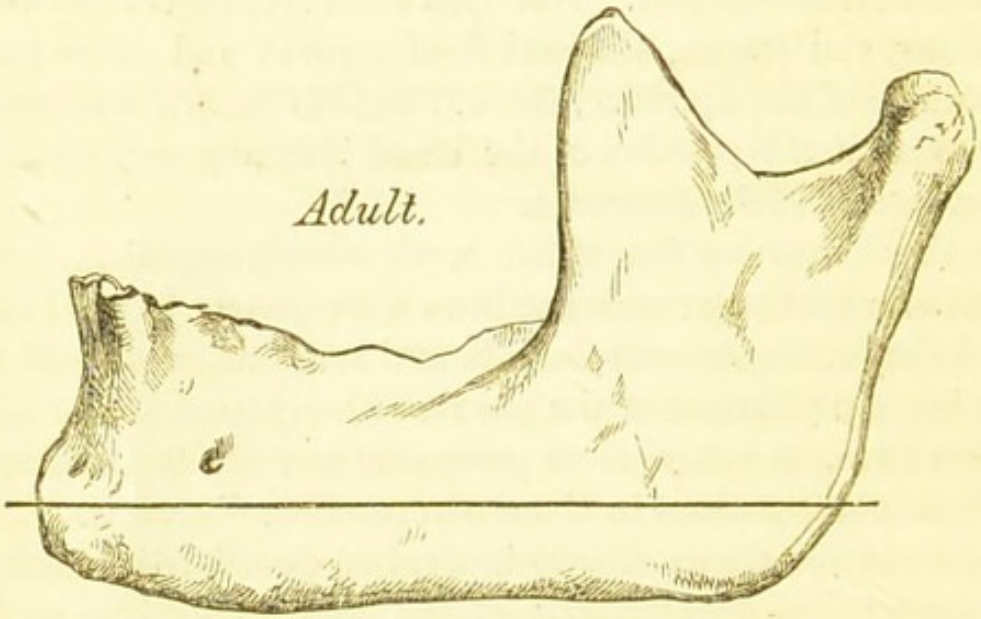


Fig. 48. (1)



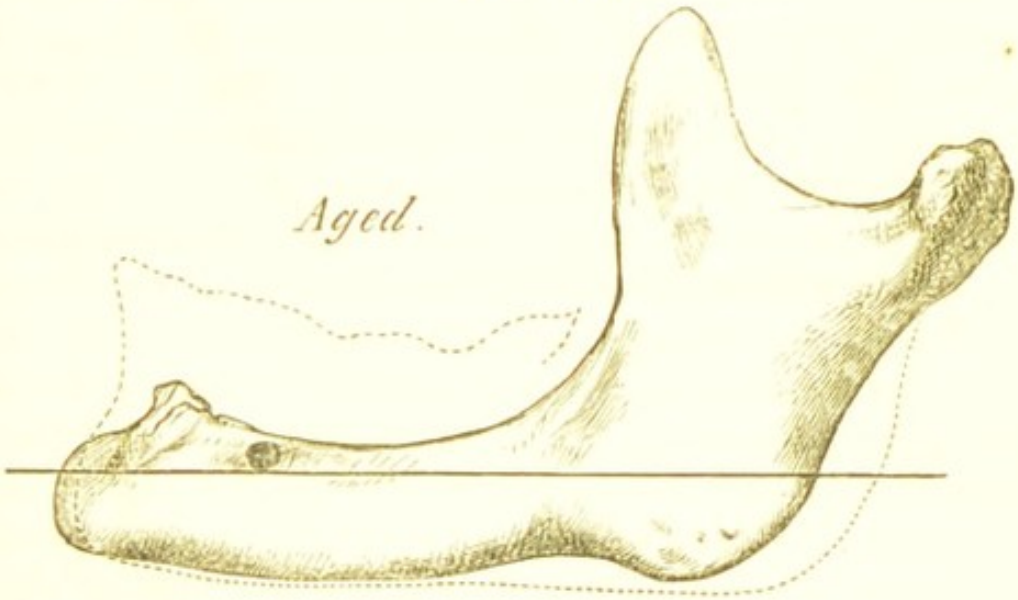
On comparing the jaw of the nine months' fœtus with that of a seven years' child it is seen that that portion which lies

(1) Figs. 46, 47, 48.—In these figures the horizontal line marks the corresponding parts of the several jaws, so that the relative increase above and below it, that is to say, in the alveolar and basal portions of the jaw, may be readily seen.

below the line has more than doubled in its depth; but 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

Fig. 49. (1)



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 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

(1) The dotted line in this figure represents the outline which would have been presented by the same jaw during the middle period of life, the parts intervening between this line and the drawing having been removed by absorption, after the loss of the teeth.

about to be cut, the 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 forming scarcely more than one-third of its entire length in the adult. 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 its 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 a breadth of 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 22); in this respect also Dr. Humphrey's experiments are confirmatory of the inference here drawn.

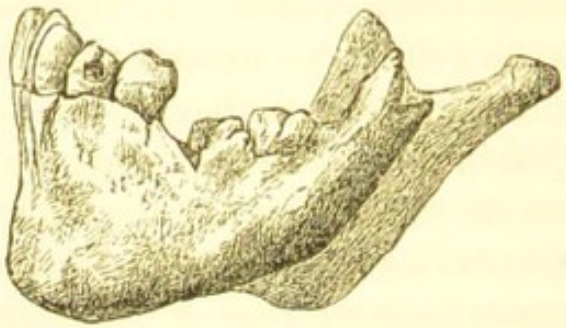
The correctness of the above views, as to the development of the jaw, has received a somewhat unexpected confirmation from two examples of arrested development of the one ramus of the jaw whilst the other has attained its normal size. The first of these two specimens (1) was brought before the Patho-

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

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

Fig. 50.



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.

The great elevation of the incisor teeth is simply the con-

sequence 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 ramus 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 of the genio-hyoid and genio-hyo-glossus, which probably marked the median line of the body, do not correspond with

(1) Transactions, Odontological Society, March, 1872.

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 towards the right side.

In examining a series of suitable preparations, it may be seen that the crypts for the permanent molar teeth are in the first instance formed internal to the ridge of bone which forms externally the base of the coronoid process, and that this ridge is continuous with the external oblique line of the jaw. Absorption in this neighbourhood appears to stop short before reaching the absolute base, and leaves a trace of the ridge alluded to: the trace constituting the oblique line within which the alveoli of the molar teeth grow up.

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 (see Fig. 49); neither is the waste limited to the alveolar margin. Both the outer and inner surfaces of the bone are 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. 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 ts 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. 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 defi-

ciency 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 pertaining 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.

(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.

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. Coincident 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 in the sub-articular cartilage of the lower jaw.

The growth of the alveolar process need not be again referred to.

After the teeth are lost, the upper jaw undergoes great change both in size and in form, not, however, from what is called interstitial absorption, but simply from progressive superficial absorption. The alveolar processes are gradually lost, and the whole bone is reduced in thickness. The pterygoid plates of the sphenoid bone become greatly diminished in size and strength, while the glenoid cavity loses its strongly-pronounced margin, and hence becomes flattened.

Certain forms of irregularity in the conformation of the jaws being closely connected with deviation from the normal arrangement of the teeth, will be considered in connection with the latter subject.

Irregularity of the Permanent Teeth.—Hitherto the description of the permanent teeth has been confined to their evolution when those general laws which regulate the time of appearance, the position, the form of the individual members, and the implantation of the whole set, have operated without interruption.

The deviations from the normal conditions as respects arrangement, number, form, and the period of eruption, have yet to be considered before we come to the conclusion of that division of the subject which has been placed under the general head of teething. The divisions of this subject will be treated in the order in which they have been enumerated.

But before passing to the consideration in detail of these several irregularities, it will be interesting to inquire into the conditions under which deviations from a normal type occur. In a very considerable number of cases the whole abnormality is caused by purely mechanical agencies, such as the undue retention of temporary teeth, and may be almost regarded as accidental in their origin. The crowns of the teeth in such cases deviate from their normal position far more considerably than their roots, the apices of which will very generally be found to occupy their proper places.

But it is far from uncommon for the alveolar border, or even the whole jaw, to be malformed, so that the whole length of the implanted portions of the teeth will participate in the irregularity.

The origin of such malformations must be sought at a period long antecedent to the eruption of the permanent teeth; they are, in fact, often congenital, and traceable to hereditary tendencies.

It must not however be supposed that because an abnormality is slight, and is apparently due to some mechanical cause, it may not have been inherited.

There is no lack of evidence to prove that variations in the position or number of teeth which might at first sight seem accidental are transmitted from parents to children; of this Dr. M'Quillen gives some striking examples.(1) Thus, he found the upper lateral incisors biting inside the corresponding lower teeth in a gentleman, and in three out of

(1) Dental Cosmos, vol. xii., p. 75, et seq.

four of his children; the fourth child had not cut these teeth at the time when the observation was made. In another family a gentleman, his son, and his grandson alike never had any lateral incisors in the upper jaw; a second son of the same gentleman had them exceedingly dwarfed, and in some of his children these dwarfed lateral incisors had been so unsightly as to lead to the teeth being extracted and artificial substitutes put in their place. In a later number (1) of the same journal a family is mentioned as well known to American dentists, in whom no permanent teeth at all are found.

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.

Irregularities apparently 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 exists in the father of the child, and will apparently be repeated in another child, in whom the tooth is as yet only partially erupted. A case is quoted by Mr. Sedgwick in which, *during both dentitions*, a double tooth took the place of the left lateral incisor, this peculiarity being inherited from a paternal grandfather. (3)

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

(1) Dental Cosmos, vol. xiii., p. 123.
(2) Injuries and Diseases of the Jaws, p. 185.
(3) British and Foreign Medico-Chirurg. Review, April, 1863.

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.

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.

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 so many supernumerary teeth in the mouth that the appearance of a double row of teeth in each jaw was presented.

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

It is remarked by Mr. Darwin (1) that those orders of the 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.

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 only 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.

Irregularity in the position of the permanent teeth, irrespective of the number involved, admits of division into two distinct groups. 1st. Irregularity in the position of the crowns, while the roots at their terminal points hold the usual place. 2nd. Irregularity both in the position of the crowns and roots. The former usually admit of treatment which does not necessarily involve the loss of either the misplaced or a neighbouring tooth; while the latter cases do not admit remedy, excepting by removal of the malplaced organs.

Those examples which fall within the first division will be first considered.

The front teeth of the upper jaw, including the canines, may deviate from the usual position either by projecting forward or retreating backward. In the former deformity, the prominence is sometimes sufficient to prevent the lips from closing; hence the teeth are constantly exposed, even

(1) Animals and Plants under Domestication, p. 328.

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 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 rectangular, 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 at present under my 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 my treatment four 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 metal 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.

The foregoing case may, I think, be regarded as presenting typical characters, and may therefore be dwelt upon for the purpose of elucidating some of the general features connected with irregularities before we advance further. Possibly the front teeth, while within the alveolar crypts, assumed an unusual obliquity of position, and thus grew outwards independently of any influence exerted by the antagonistic teeth. But whatever may have been the cause of malposition, the growth of the teeth was accompanied by the development of strongly-pronounced alveoli, correspond-

ing in direction with that of the teeth. In cases such as that described, it is sufficiently obvious that before the direction of the teeth can be permanently changed, the direction of the sockets must also be altered; a considerable portion of the existing alveolar processes must be removed, and new bone for the repair or rebuilding of the sockets be produced. It may not, however, be 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 redevelopment 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 cotemporaneously 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 two days the out-standing 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, I think, 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 be so slow that both the patient and practitioner will 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 movement 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 implantation 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 the disadvantage the fact that the labial 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 treat-

ment 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, and 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 outstanding front 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. I believe it is in accordance with the experience of those

who have devoted their attention to the treatment of irregularities, that where the front teeth have been brought in 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.

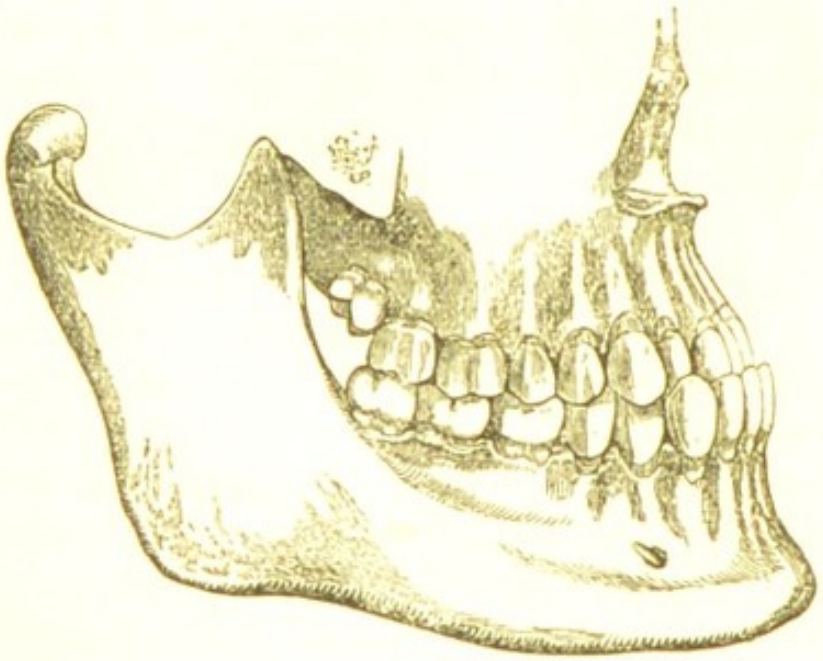
Reverting to the case related for the purpose of introducing a statement of those conditions which prevail more or less in all cases of malposition of the teeth, it may be observed that other methods than that adopted might have been pursued for bringing inwards the projecting teeth. Thus, a plate either of vulcanite or of metal might have been fitted to the hard palate and to the necks of the molar teeth, and to this the front teeth might have been tied, either with silk or caoutchouc ligatures; or a metal plate might have been fitted to the palate, and extended to the labial surfaces of the molar teeth, and on either side attachments for a band of india-rubber stretched over the labial surfaces of the front teeth might have been made. The apparatus adopted, however, possessed an advantage over these; it prevented the

under lip from exercising an antagonistic influence, while it was simple in construction, and readily applied.

An opposite form of displacement to that which has been described is far from uncommon.—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

Fig. 51. (1)



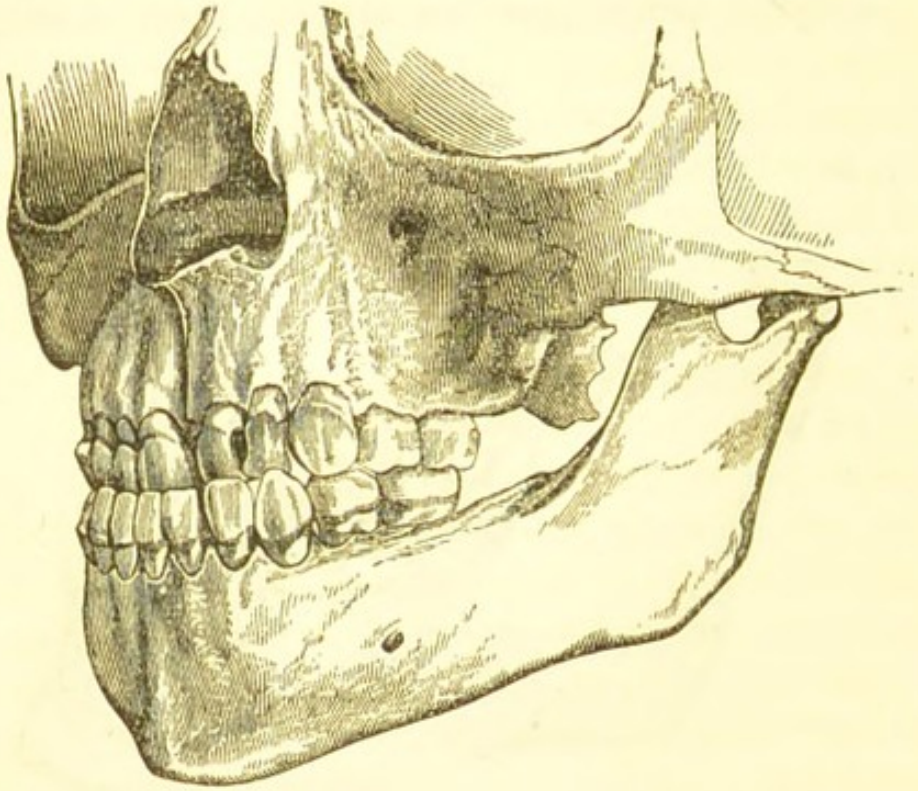
maxilla is unusually small, as shown in the accompanying figure, or that the lower jaw has departed from the normal form. In the specimen from which the illustration is taken, the inferior maxilla does not differ, either in general dimensions or in configuration, from the normal specimens; but the upper jaw in its alveolar portion is below the usual di-

(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.

mensions. 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

Fig. 52. (1)



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 of the articular process, is calculated to give great length of

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

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 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.

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 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 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.

This explanation is not, however, wholly satisfactory, inasmuch as it ignores the existence of certain mechanical agencies which are in constant operation, namely the pressure exerted by the tongue and by the lips. If any tooth project 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

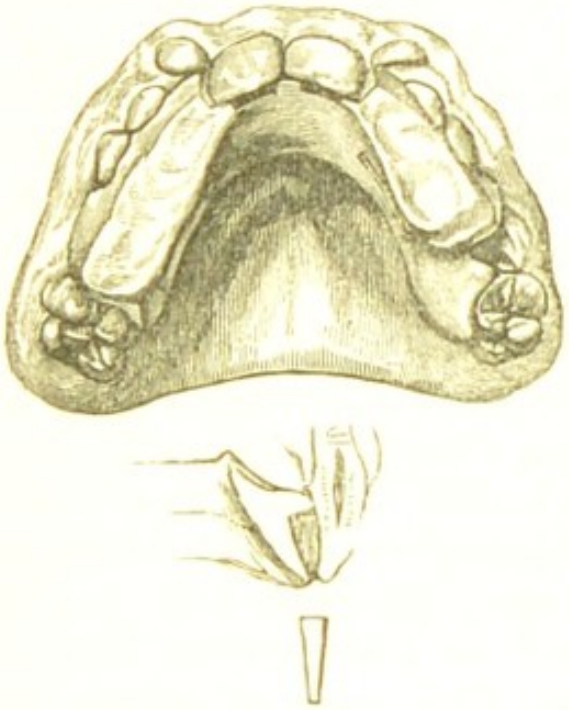
wood are placed, in cavities cut in the vulcanite for their reception. Each instanding tooth will have its corresponding cavity in the plate, the formation of which requires some little attention. The form should be similar to that of a shallow drawer, the front of which has been removed, and so proportioned 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. 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, and continued obliquely in a direction continuous with the line followed by the gum in its passage between the teeth. If this precaution be observed, the ligature 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 particularly suitable for the purpose, and the short period during which they will be retained renders their injury a matter of little consequence.

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

Fig 53. (1)



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

(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. I am indebted to my friend, Mr. Harrison, for the specimen from which this figure has been taken.

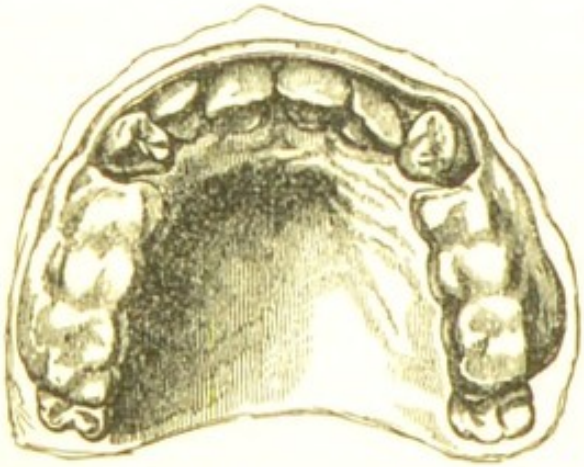
are capable of the least resistance, they are the first to yield, and therefore gradually advance before the expanding wood. From time to time the wedges must be renewed, each new piece being slightly larger than its predecessor; and as the teeth move upon an axis situated near the apices of their respective 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 required had the treatment been continued with 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 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 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. The molar teeth on either side are capped with gold, the caps

Fig. 54. (1)



being made so that they fit tightly upon the teeth. From these a band of metal is extended in front of the teeth.

(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.

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 was at first a difficulty; tying was 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. 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. 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 advantages.

The treatment upon the principle of elongating the lower teeth need not be recurred to, as it has nothing whatever to recommend it. The plates used may be made of vulcanite or of gold, each having its special 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 those 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 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.

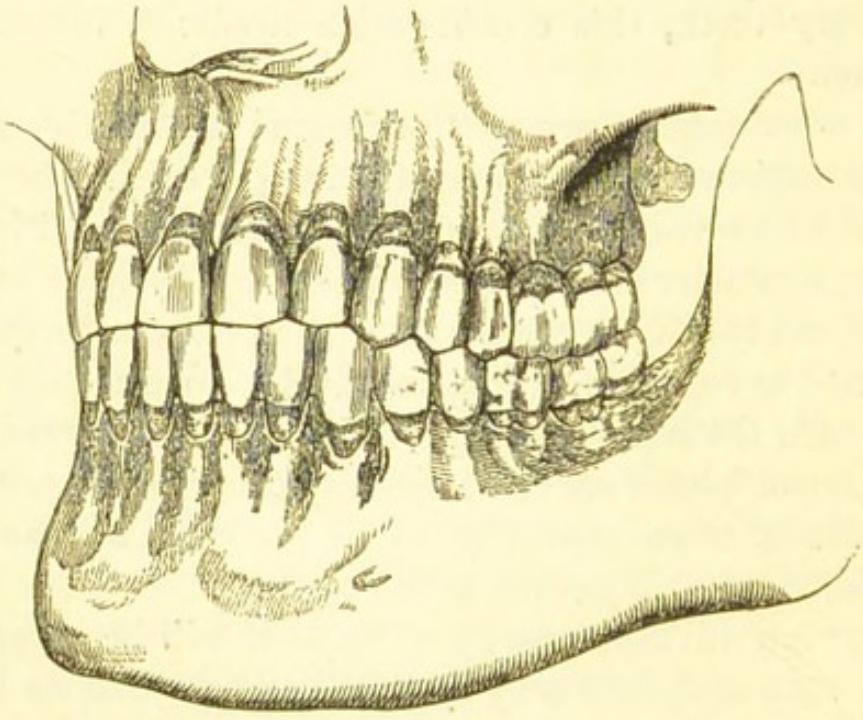
The advantage in respect to time and the relative amount of inconvenience entailed upon the patient by the one or other method of procedure must not be disregarded. The ever-varying character of the cases renders it difficult to lay down any general rule as to the advantages of the one method over the 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 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

Fig. 55. (1)



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

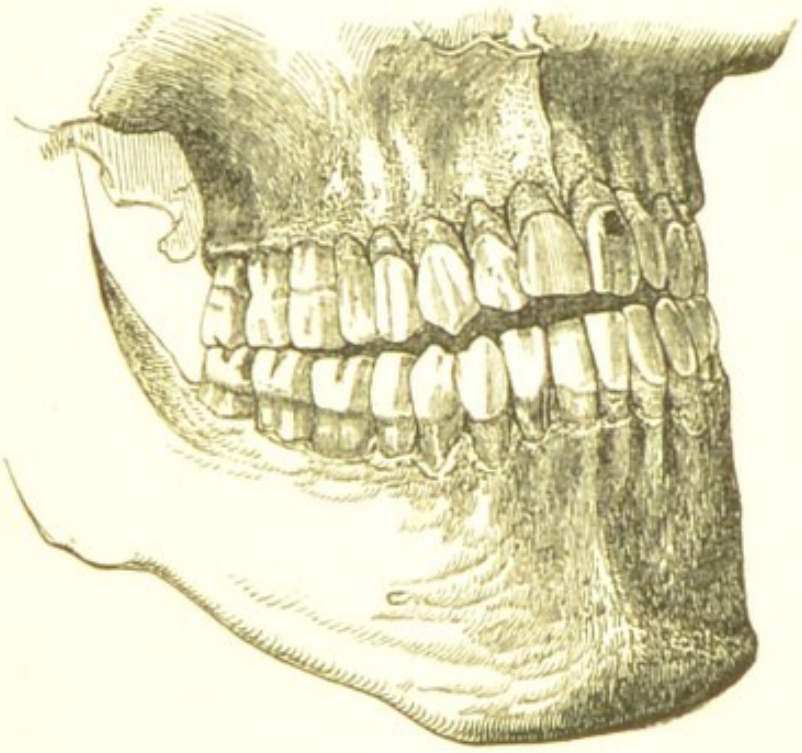
(1) Showing the front teeth meeting edge to edge.

treatment far more readily than those in which the whole alveolar portion of the jaw is involved, and which are often of congenital origin (Cf. p. 114).

Intermediate between the two forms of irregularity already described, is that in which the front teeth meet *edge to edge*, as shown in the preceding figure (Fig. 55). 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

Fig. 56. (1)



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

(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.

(Fig. 56), 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 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 one case only. 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 contrivance 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.

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 from the first in the course she was directed to follow, 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 obli-

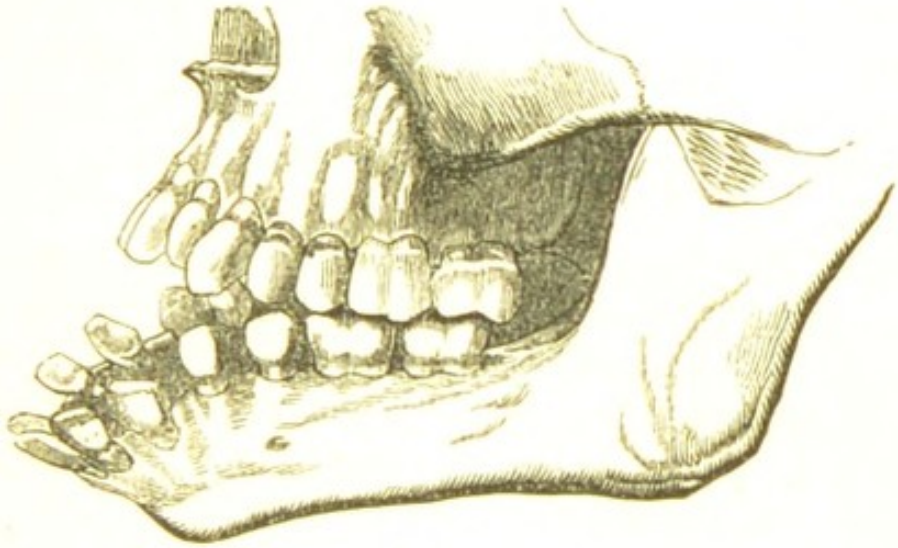
quity at which the ramus is placed with respect to the body of the lower jaw. The line of growth has been almost directly backwards, and the inferior dental canal, instead of being carried upwards in its posterior third, is almost straight from end to end. That form in which the rectangular position 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 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. 56) 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 formed 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 interesting case shows to what extent the form of the jaw may be modified by the maintenance of constant pressure during early life. The patient was a strong healthy young woman, twenty-two years of age. Her chin

was drawn down toward 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

Fig. 57. (1)



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

(1) Drawing taken from a cast of the upper and lower teeth and gums of a patient, aged twenty-two, 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 a faithful representation of the condition of those parts.

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 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.

There is yet another form of irregularity in which the whole of the teeth of one or of both jaws are more or less involved. It is that which is commonly called the V *or wedge-shaped mouth;* the teeth, in place of holding the elliptical arrangement, occupy two converging lines which meet at an angle in the anterior part of the jaw, producing, as an almost invariable result, an extremely high and vaulted palate. The position of the teeth on the two sides of the jaws may be perfectly symmetrical, and the conformation may, in rare instances, correspond in the upper and lower maxillæ. More commonly, however, the deformity is confined to, or exists in a much greater degree in, the upper jaw, the central incisors of which frequently slant forward and stand in advance of those of the lower maxilla. There is an appearance of contraction across the line of the bicuspid teeth, looking as if the jaw had been pinched inwards at this point (*see* Fig. 57); behind this the molar teeth rapidly diverge. Each case will present its special peculiarities. In one, the median sides of the central incisors will project forwards and meet at 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 median

sides an angle directed inwards, and with their distal sides and the median 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, 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. But through whatever influence the defect may have primarily arisen, the result is a departure from the normal anatomical relations between the teeth and the jaws, and as the size of the former is determined some years before the latter have arrived at their ultimate dimensions, we can but regard the fault as originating in the jaws.

Mr. Coleman (1) has examined a large number of children with a view to tracing the connection 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 a 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

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

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.

It was remarked by 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.

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.

And Dr. Langdon Down (2), after making observations on

(1) Transactions of the Odontological Society, new series, vol. ii., 1869.
(2) Ibid., vol. iv., p. 16, 1871.

a very large number of congenital idiots, has 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.

The fact that this deformity of the permanent dentition is held to be the mark of congenital defects of organisation lends a special interest to the enquiry, at what period does it really originate? It has been usually explained as in great part a consequence of a disproportion between the size of the teeth and the base of the jaw, but this explanation obviously will not account for all the observed facts.

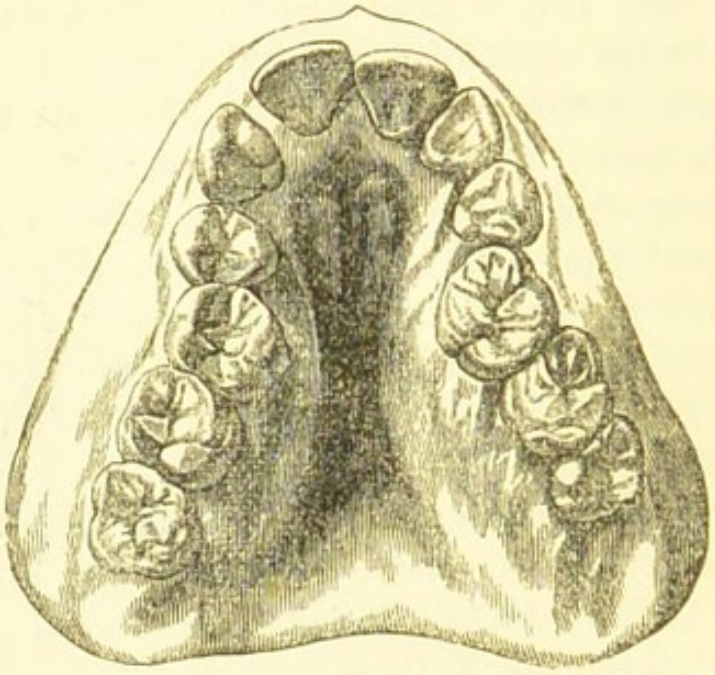
If reference be made to that portion of the work in which the growth of the jaw is described (page 102), it will be seen that the front portion of the jaw, that which contained the temporary teeth and afterwards the permanent incisors, canines and bicuspids, undergoes no material alteration in form after birth, but the gain in size is effected by addition to its outer surface and to its posterior cornua.

But an increase in width is a necessity, in order that the jaw may maintain its relations with the increasing cranial base; and if the cornua of the fœtal jaw are not in the first instance divergent, the newly added portion at the back of the alveolar border will form an angle with that previously existing.

Hence, if the fœtal jaw have not attained to the form appropriate to its further growth at an early period, the fault is not obliterated by the further process of development, but the newly added portions form an angle in the bicuspid

region, which remains through life as a mark of malformation, scarcely noticeable at the time, which occurred during intra-uterine life. This serves to explain how it is that a character of permanent dentition may come to be diagnostic of congenital disease, and also how it is that the lower jaw is so seldom affected by this malformation. For, as has been more fully described elsewhere (1), the cornua of the alveolar border of the lower jaw have attained to their posterior divergence at a period when the corresponding parts in the upper jaw are as yet parallel.

Fig. 58. (2)



In some instances the deformity is confined to the alveolar ridges, whilst in others the whole base of the jaw is involved.

(1) Charles S. Tomes, "On the Developmental Origin of the V-shaped Maxilla." Monthly Review of Dental Science, June, 1872.

(2) 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 Mr. Harrison for the use of this interesting specimen.

If the process of outward growth during the presence of the temporary teeth has been defective, and the permanent teeth while within the alveolar crypts have been forced to take such a position as the space allotted to them would allow, on successively appearing through the gums they will necessarily present the irregularity of arrangement into which they had fallen during development. But if the base of the alveolar portion of the jaws has reached the normal dimensions, the teeth, although mal-placed at the time of eruption, may ultimately become regular, as at this period the alveoli have yet to undergo modification and further development.

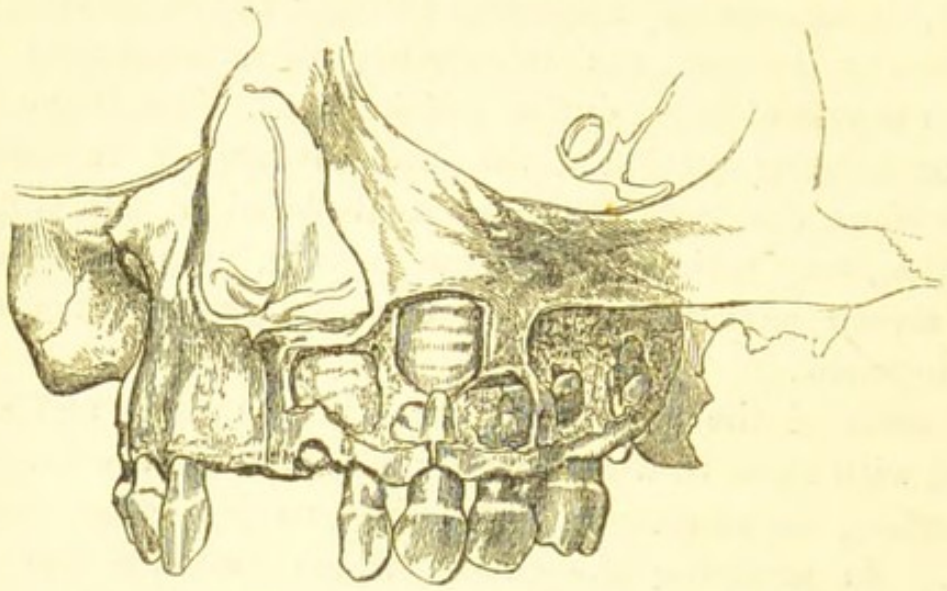
If some of the preceding figures be examined and compared with those in which the arrangement of the two sets is normal, the manner in which irregularities arise may be seen. In studying the causes which produce the malpositions in which the whole of the anterior teeth are involved, the investigation must be commenced prior to the eruption of the permanent teeth.

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 accompanying 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

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

inflicted on the mother's nipple, the laterals when erupted do not obliterate the space.

Fig. 59. (1)



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 crowned 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

(1) 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.

a prejudicial influence upon the arrangement of the permanent teeth. In the case shown in Fig. 59, 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.

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.

It may in some respects be 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. When the subject of partial irregularity is considered, this point will be rendered evident by the accompanying illustrations.

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 return to the original 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 (p. 130).

When there is every reason to suppose that the base of the jaw is free from contraction, the teeth may then be forced outwards till the desired conformation is attained; and in cases where the deformity has been equal both in the upper and lower jaws, and the antagonism perfect, it will be necessary, after the upper teeth have been re-arranged, to repeat the operation in the lower teeth, and thereby restore the antagonism which would otherwise be disturbed, and in the efforts of re-adjustment, influence unfavourably the results of the operation.

The form of apparatus suitable for expanding the V-shaped dental arch need not be minutely described, as either the ivory or the metal plate—a description of each of which

is given in connection with the treatment of inverted teeth—will be found effective.

In the succeeding figure, furnished me by Mr. Harrison, the deformity is so great, and the base so contracted, that successful treatment would be attended with great difficulty. The bicuspids were removed with the hope that the front teeth would fall back; but, with the eruption of the wisdom teeth, the first permanent molars moved forwards into the vacant spaces, and the more anterior teeth preserved their original position. It would appear in this, as in many other cases, that nature, having recognised a special, though an irregular form, offered resistance to any subsequent change (Fig. 60).

Hitherto attention has been directed to those cases only in which the front teeth, though uniform as regards their individual arrangement, have been as a whole out of the natural position. Instances in which some of the teeth are mal-placed as respects the crowns, while the remainder hold the normal position, have now to be considered.

Separation of the central incisors, leaving an unoccupied space in the mesian line, is perhaps the most simple, and at the same time the most manageable, form of irregularity which comes under our notice. If the teeth are otherwise correctly placed, a ring of india-rubber stretched over the two teeth will in the course of a few days bring them together, after which the occasional use of the ring or of a silk ligature will be sufficient to retain the teeth until they become fixed in the new position.

Although the true V-shaped jaw is a congenital malformation, yet the deformity so produced may be in some cases partially remedied, or at least improved by treatment; and this opportunity may be taken of discussing some points which bear on the whole question of dental irregularities. It must first be determined how far the whole jaw is malformed, for it sometimes happens that while the V-shaped conformation is presented by the upper jaw, the back teeth

of the lower bite outside those of the upper jaw. But little can be done to remedy such extended malformation by treatment; it is, however, interesting to note that this, like the occurrence of the V-shaped upper maxilla, is in a measure the retention in the adult of a condition of things which in the fœtus is normal. For at the period of development already alluded to (p. 148), the posterior divergence of the lower jaw would, if there were teeth in it, lead to their biting outside those of the upper maxilla at the back part of the mouth.

Inversion or eversion of the central incisors is not uncommonly seen in cases where the ejection of the temporary teeth has been delayed, and the successors have come down either behind or in front of them, or when the eruption has been postponed until the lower teeth have attained their full height, and in the absence of any counteracting influence from antagonistic teeth, have either taken a higher or a more forward position than they should have done; consequently the upper teeth have been driven, when in a state of active growth, either outwards or backwards, just as they may strike on the labial or lingual surfaces immediately after emergence.

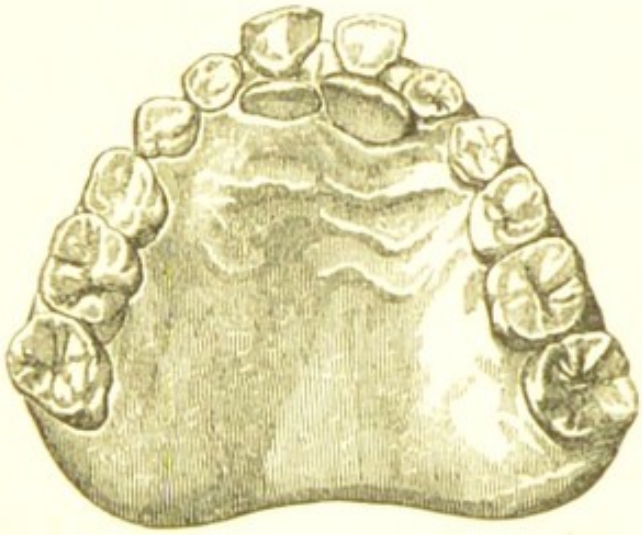
On the other hand, the lateral incisors may, as in the case figured at page 64, lie in front of the central teeth during development, and the four teeth, advancing in growth with equal rapidity, oblige the latter, at the time of eruption, to take a backward place.

But by far the most common cause of displacement is the persistence of the temporary teeth. 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.

Whatever may be the cause of the irregularity, the diffi-

culty involved in its reduction will not be great. In case they are directed inwards, the use of either a metal or a vulcanite plate, provided with chambers for compressed wood, will speedily force them into a sufficiently forward position. Or they may be dragged outwards by caoutchouc bands passed through a slit bar of metal, passing in front in the manner already described. If the fault be undue prominence, this may be overcome either by an elastic band of

Fig. 60. (1)



metal attached to the labial surface of caps fitted to the molar teeth, or fixed to metal studs placed immediately behind the incisors to be acted on; or by silk ligatures passed through a plate adapted to the hard palate, and over portions of compressed wood, which have been fitted in square chambers produced on the lingual surface for their reception. When applied in this manner, the wood will expand in the inward direction, and consequently carry the ligatures backward, and with them the outstanding teeth. Should the mesial edges of the lateral teeth be so placed that the inward movement of the central incisors is obstructed,

(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.

our treatment must commence by forcing the former outwards from the median line, until they cease to embarrass the operation. This may in most cases be done by placing pieces of india-rubber between the lateral and central teeth. It is scarcely necessary to repeat, that when the lower teeth close in front or upon the edges of the upper, the plate must be made sufficiently thick at those parts which pass over the back teeth to prevent the antagonistic influence.

Torsion, or twisting of the central incisors upon their axis, 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. 29).

In a case recently under treatment, 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 to 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 mal-position 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 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. 43, where the descent being arrested by the presence of a supernumerary tooth, the fang 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 fang 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 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.

(1) Lectures on Dental Physiology and Surgery.

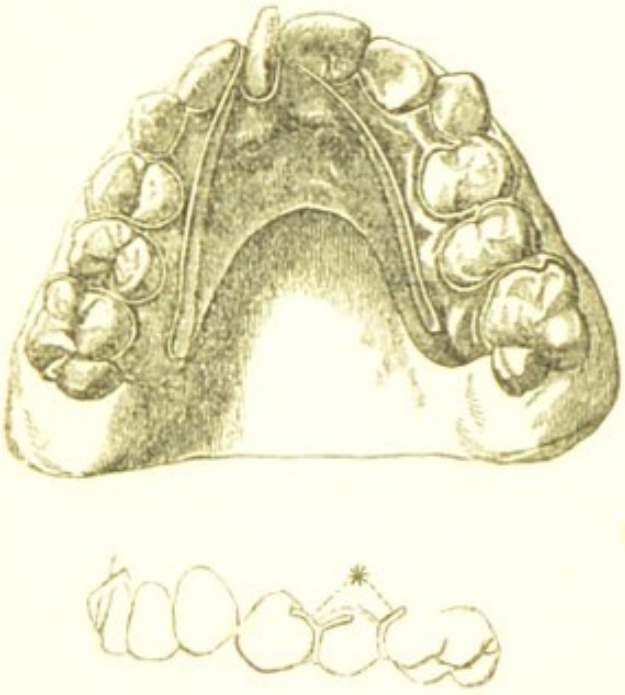
As respects the treatment to be adopted, I cannot do better than describe the course pursued in the following case, inasmuch as the illustrations necessary for the elucidation of details will serve the further purpose of showing the method applicable to cases of irregularities affecting other teeth. 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 median 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 produced 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

Fig. 61. (1)



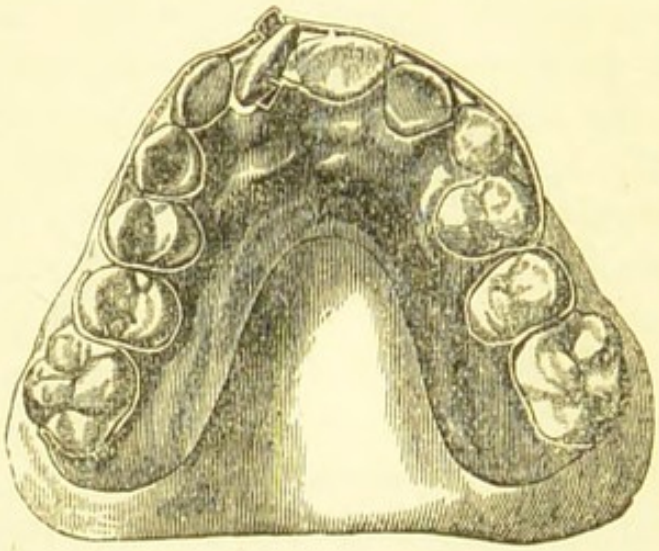
the distal angle of the tooth, the other upon the labial surface near the median angle. The forces thus brought into play acting in opposite directions, turned the tooth upon its axis, and were sufficient to influence the impinging lateral and central teeth, and force them out of the way of

(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 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 angles 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 stood slightly in front of the left incisor, and the distal side

Fig. 62. (1)



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 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.

(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.

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 conducted, although the wood-retaining cells are given in one position only. It must be understood that they were moved from time to time, so as to follow up the moving tooth, and so adjusted as to bring the pressure to bear in such directions as at the time appeared to be required.

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. This, then, is the condition of the case at the time I am writing (1859), and I feel no doubt that before the expiration of twelve months the teeth will have settled down in their present position.

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 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 eight or nine 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. 61), 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 lead-foil 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.

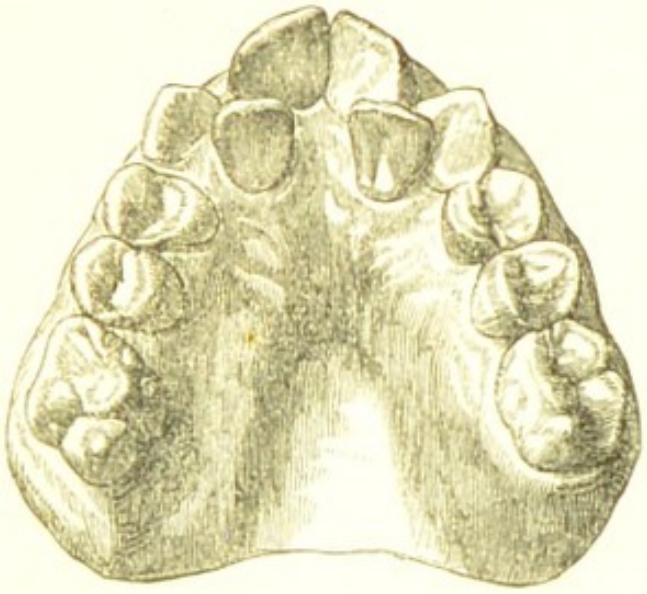
This will keep in its place, and should be worn for twenty-four hours at least, or longer if the tooth remains very loose; of course it must be removed during meals, but it is safer to confine the patient's diet to soft things for a day. The extreme tenderness and looseness will pass off in a day or 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.

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 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 median edge of each lying

behind the contiguous side of the central incisor, and the distal edge behind the median side of the canine.

Fig. 63. (1)



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 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.

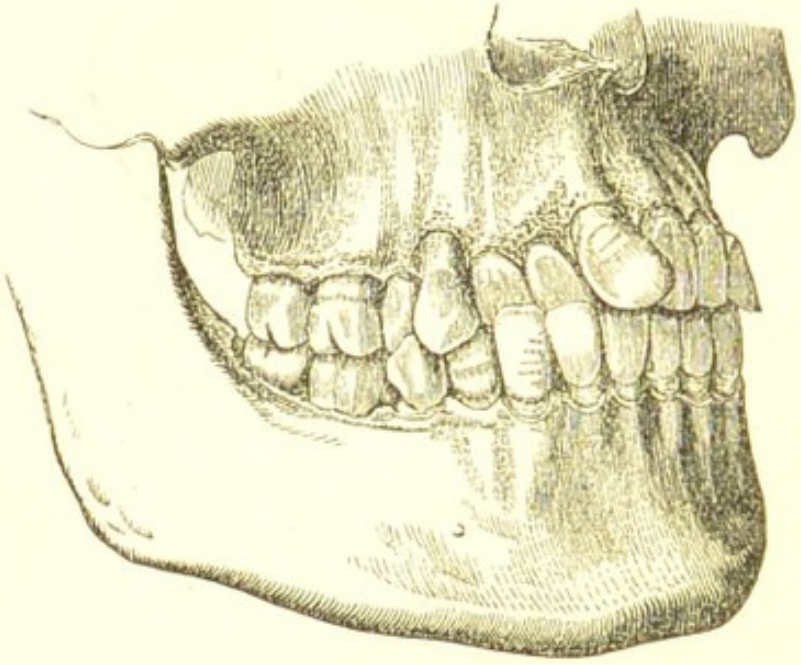
We must not, however, in endeavouring to trace the cause of mere misplacement in cases like the one figured, forget that had a proper direction been given to the teeth as they successively appeared through the gums, the alveoli would have grown up with them, and if the base of the jaw had attained a 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

(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.

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 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

Fig. 64. (1)



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

(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.

from the central tooth at the time when the canine is advancing 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 following figure shows the effect produced by the foregoing combination of circumstances.

Fig. 65. (1)



When the conical form of the canine, its crown being so 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

(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.

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. 67).

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. 63, 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. 64, 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 the 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, these 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 130), and these will operate not only by bringing in the outstanding canine, 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 posterior 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. 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 sound one, it must not be blindly followed in every case, but the ultimate prospect of getting it into place must be carefully considered.

When we have reason to suppose that an out or instanding 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 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."

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

(1) Lectures on Dental Physiology and Surgery.

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 method described as having been successful in turning into place a twisted central incisor will be found effective; or a vulcanite plate may be used, if the operator regards metallic regulation plates with distrust.

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 it 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 148 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 (page 148).

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. In the case figured at page 69, 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. 69), 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 will 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. Either metal or vulcanite may be used in constructing the apparatus, and the 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 malplaced 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 occurence 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 my friend 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 malplaced 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 an early number of the "American Journal of Dental Science," an apparatus for expanding the whole arch is described and figured. It consisted of a metal plate fitted to the palate, and jointed in the median line. The plate was fitted to the necks of the teeth, against which it was made to press by a spiral spring, the extremities of which were connected to either side of the plate. I have no experience of the value of this method of proceeding, neither have I attempted to change the position of molar teeth by mechanical means. In the vast majority of the cases which have come under my notice, this treatment has been rendered inadmissible by the coincident 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 malposition 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, so that 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. 66) 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 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.

Fig. 66. (1)



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.

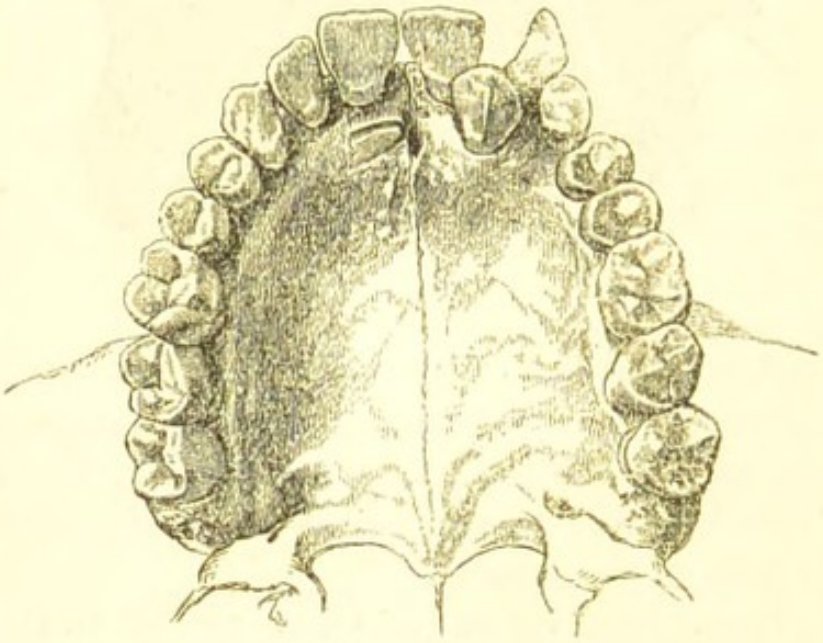
The foregoing observation cannot be applied to the canine teeth. They are more frequently than any other description of teeth the subjects of total displacement. Even in my own collection there are many examples illustrative of the abnormal positions into which these teeth may be thrown.

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 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

(1) Shows the right central incisor with both the crown and root displaced its normal position being occupied by a supernumerary tooth.

subject of Fig. 67, restoration to the normal arrangement, though perhaps not impossible, would be attended with difficulty. The question then arises as to 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

Fig. 67. (1)

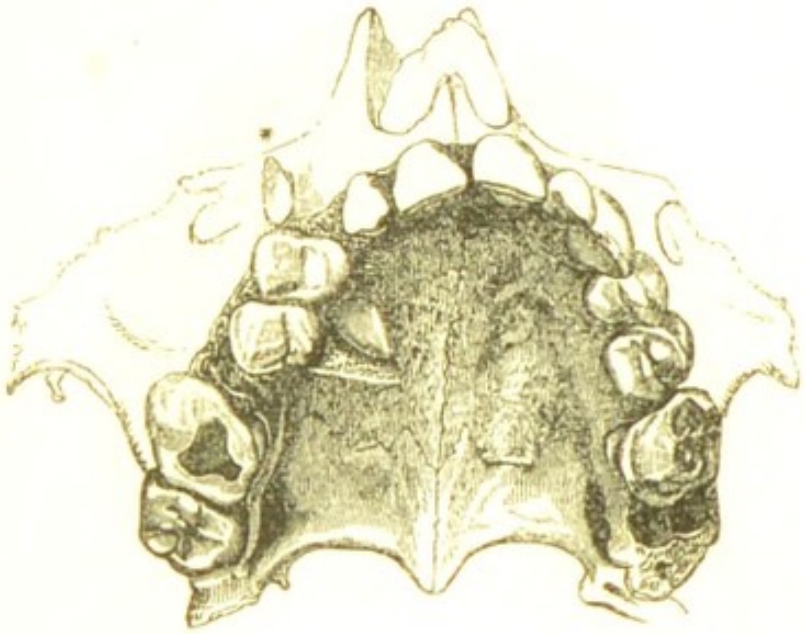


own choice would fall upon the canine. It would, I think, be more easy to press the lateral tooth inwards, the terminal portion of the root of which is not displaced, than to draw outwards into line the canine. In deciding on our treatment, we must in no case lose sight of the fact, that although it may be quite possible to force a tooth from an irregular into a regular position, yet that the operation may, under some

(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.

circumstances, be so prolonged and painful, that the proposed advantage will not compensate for the suffering which its accomplishment would entail.

Fig. 63. (1)



In the preceding figure a case is shown in which the right canine is placed across the dental arch, the root being 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.

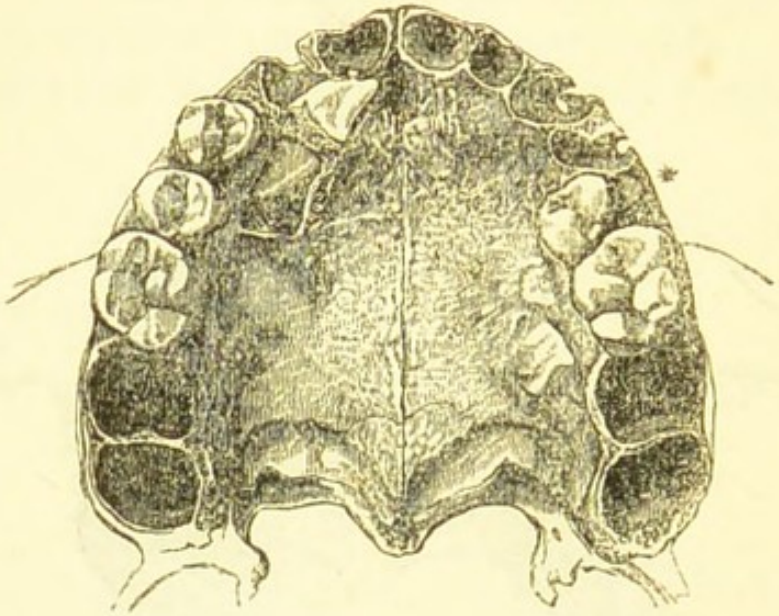
A horizontal position in the base of the alveolar ridge is sometimes taken by the canine, the apex of the crown being exposed to view, or covered only by gum or imbedded in bone.

Teeth so placed may remain without producing inconvenience through a long life, and be discovered only towards

(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.

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

Fig. 69. (1)



set of teeth. The two following illustrations are taken from a remarkable specimen given to me by Dr. Brinton, in which the canines were symmetrically arranged in the horizontal position described in a preceding case.

A patient admitted into the Middlesex Hospital under the care of Mr. De Morgan, lost a portion of the upper maxilla from syphilis. The dead bone on its coming away was found to contain a canine tooth, which ran under the floor of the nose in a direction parallel with the median line of the palate (Fig. 72). Excepting the absence of the canine, the dental

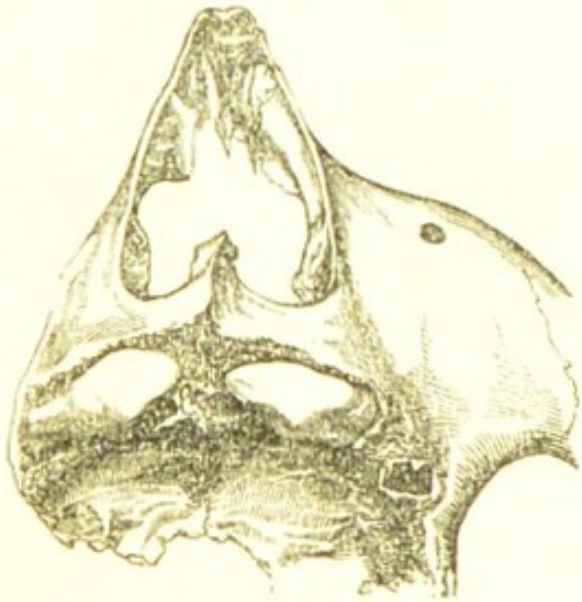
(1) Shows the right canine of the upper jaw buried in the base of the alveolar prominence, its course corresponding with that of the latter part. The bone has been cut away to show the direction taken by the tooth. The first bicuspid has become slightly twisted on its axis by the malplaced canine. On 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.

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.

Fig. 70. (1)



Fig. 71. (2)



(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.

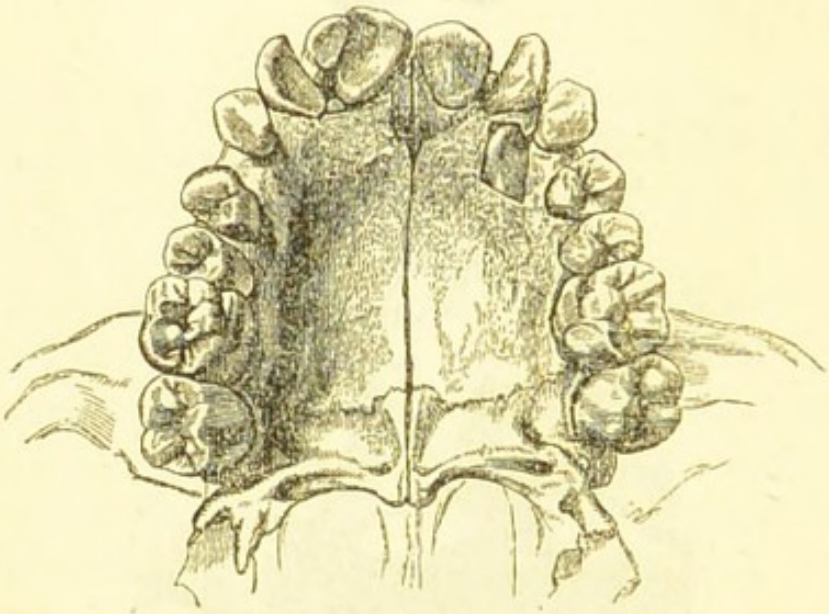
(2) Palatal view of the same specimen shown in the preceding figure.

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

Fig. 72. (1)



Fig. 73. (2)



(1) 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.

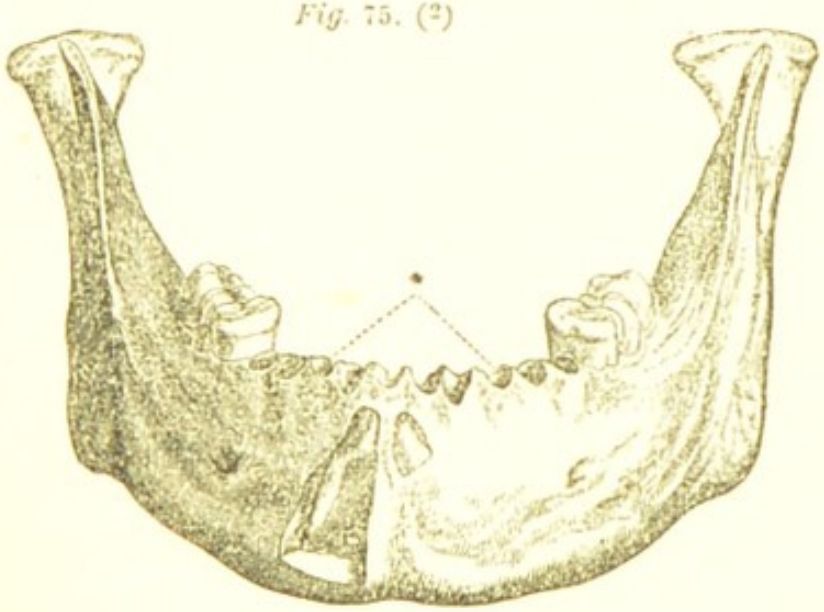
(2) From a specimen in which the temporary canines were persistent, and the permanent canines placed horizontally. On the left side, a sufficient amount of bone has been removed to show the position of the buried tooth. On the right side the point of the canine may be seen between the lateral and the central incisor. The right temporary lateral incisor has been retained, wedged between the permanent central and lateral teeth.

with. Of the two specimens selected for illustration, the one in which the tooth is placed horizontally is the more peculiar.

Fig. 74. (1)



Fig. 75. (2)



In the second, the temporary canines were retained, and the permanent canines became matured within the substance of

(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.

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.

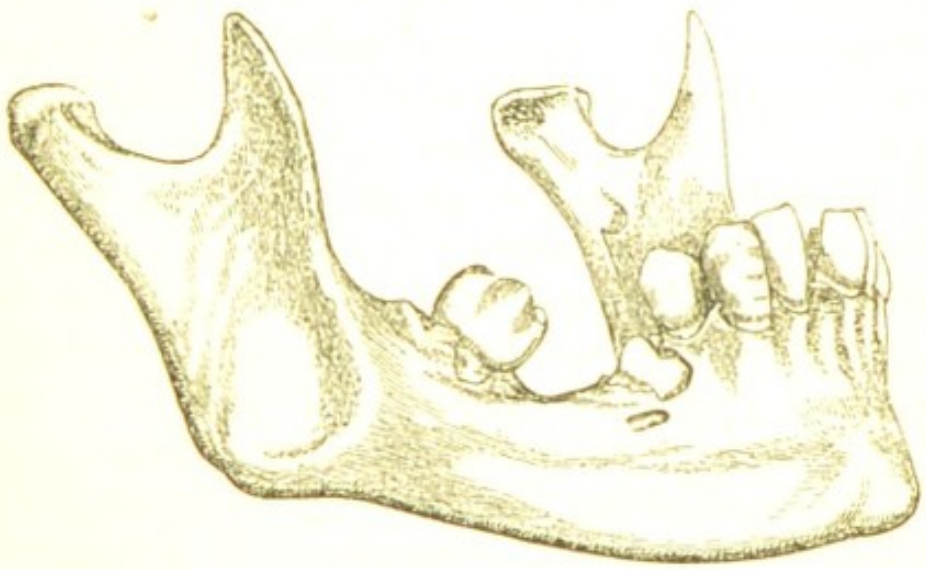
The presence of disease, or the occurrence of mechanical injury in that part of the jaw in which the canines are situated when undergoing development, may drive them from their proper position. I cannot, however, call to mind a case which would serve for illustration on this point.

The results entailed by total malposition 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 embedded 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. In the case shown in Fig. 72, it is probable that the presence of the canine not only determined the site of the necrosis, 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 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

Fig. 76. (1)



is much the same as in the foregoing case, although 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

(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.

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 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

(1) The Anatomy and Physiology of the Human Teeth. By Paul B. Goddard. Philadelphia, 1844.

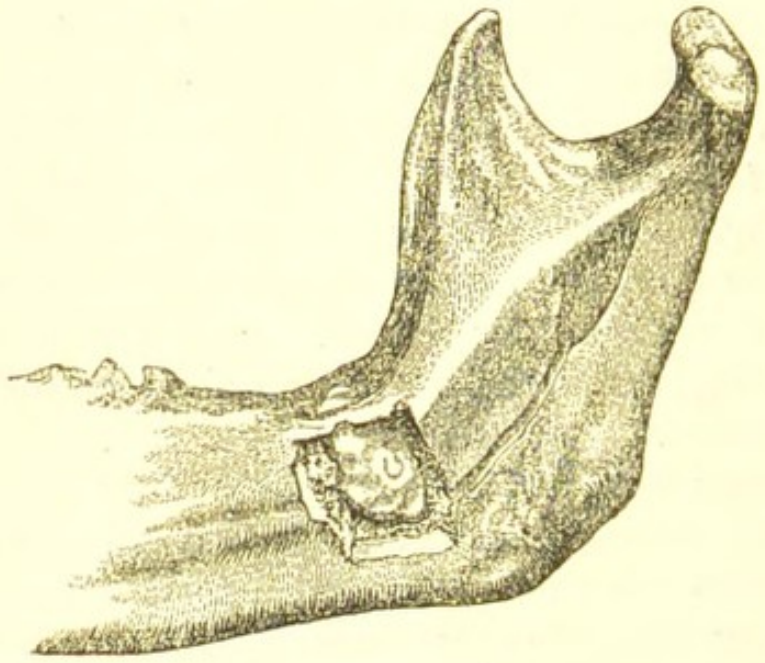
itself. The tooth takes its natural direction, but the space into which it has to force itself is insufficient, consequently the distal side lies close against the anterior surface of the coronoid process, leaving no room for the gum. The latter part, under these circumstances, is pressed upwards, and 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

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 mis-

Fig. 77. (1)

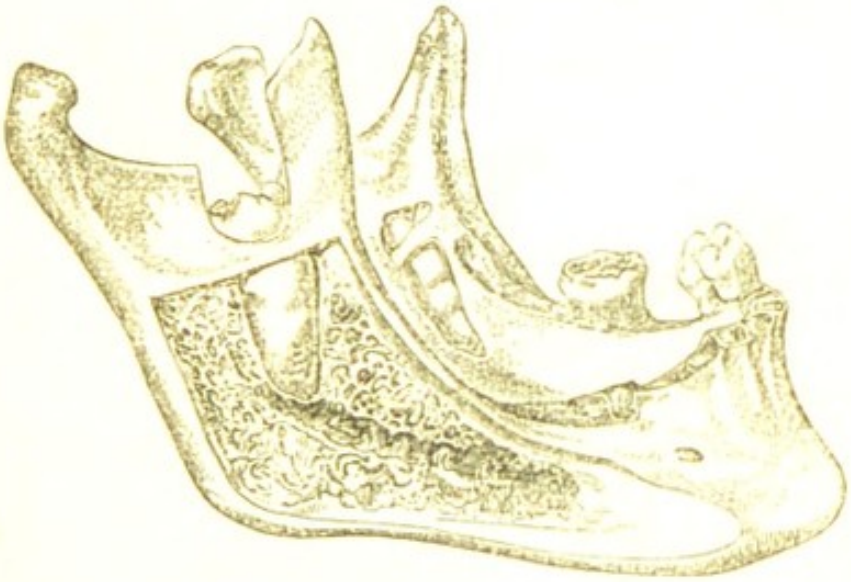


chief will be determined partly by the height to which the tooth rises in the jaw, as respects the antagonistic tooth, and partly by the constitutional state of the patient. The same condition of parts which in one person would lead to little or no inconvenience, would in a less healthy subject produce 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.

(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.

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. I am indebted to Mr. 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

Fig. 78. (1)



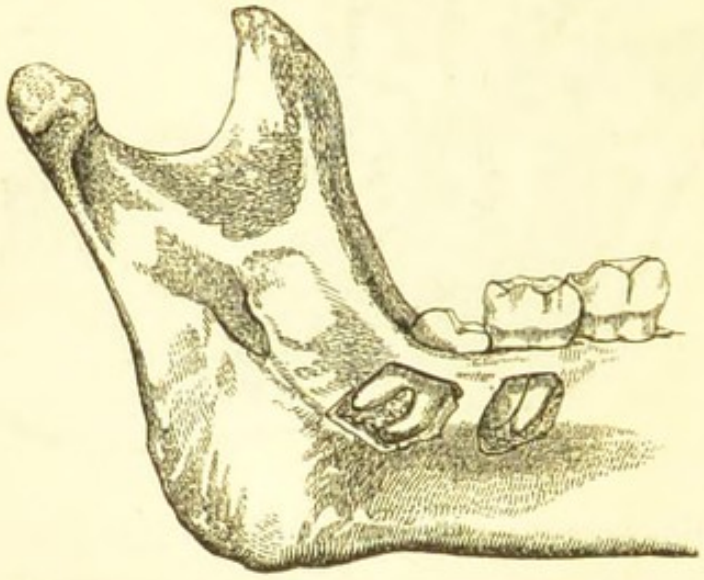
the ramus, the crown reaching nearly to the level of the sigmoid notch. Although situated in such an unusual position, judging from the state of the bone, it does not appear that they were a source of irritation. There is a total absence of that porous condition indicative of increased vascularity in 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,

(1) Showing the wisdom teeth imbedded in the rami of the lower jaw Presented by Mr. Saunders to the museum of the Odontological Society.

it is desirable that it should be borne in mind, when disease about the posterior part of the 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.

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. 79. (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 malposition has been assumed at a comparatively early period of development,

(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.

irrespective of resistance at the time of eruption. In Figs. 79 and 80, the teeth appear to have advanced until

Fig. 80. (1)

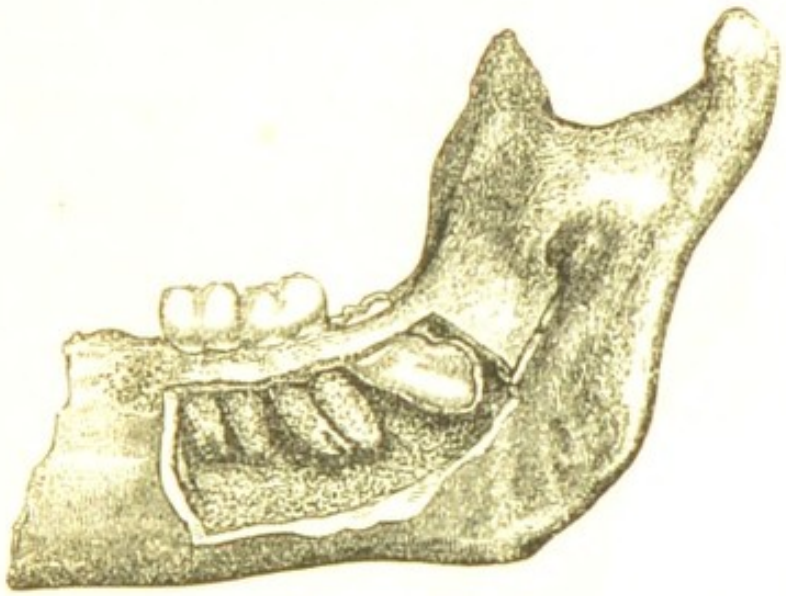
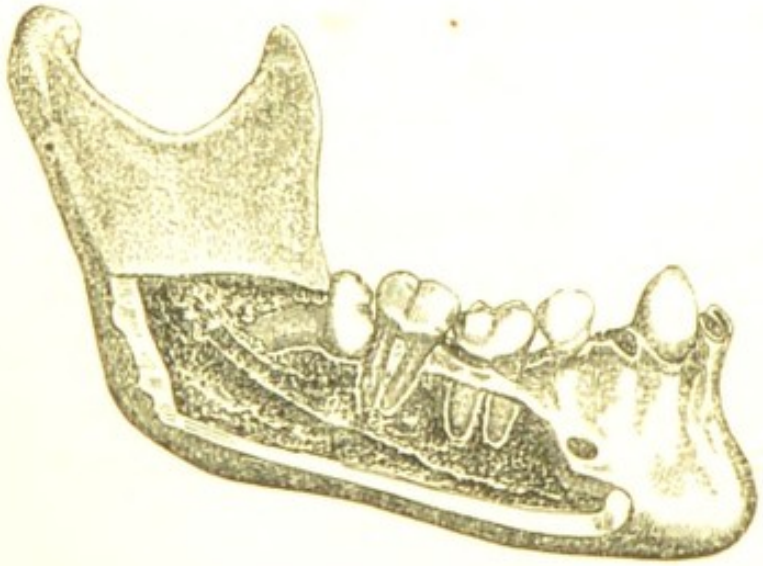


Fig. 81. (2)

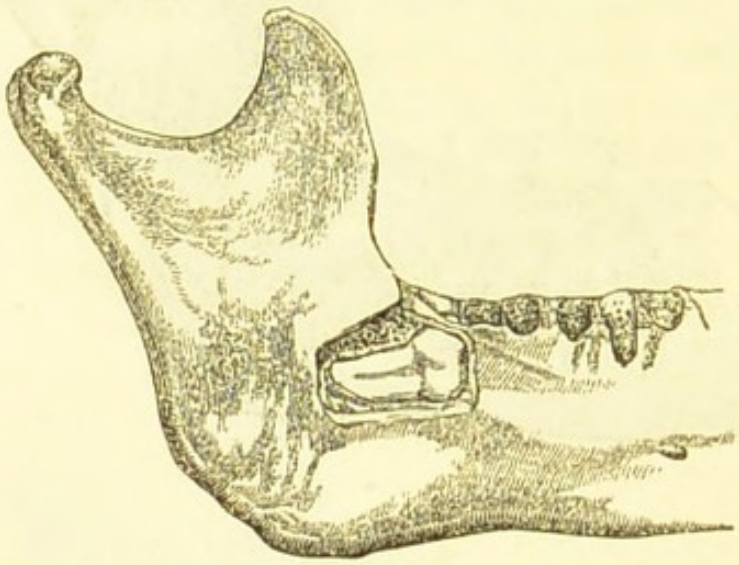


(1) View of the right side of the lower jaw, the inner alveolar plate having been partially removed to show the oblique direction of the third molar.

(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 median edge or angle of the crowns impinged upon the necks of the anterior molars. The forward movements of the teeth then became completely arrested. In Figs. 81 and 82, the teeth must have been from the first formed pretty much in the position which they are shown to occupy.

Fig. 82. (1)



In the upper wisdom teeth the oblique direction forwards is less frequently assumed. The following figure will, however, illustrate the form of irregularity in the upper maxilla (Fig. 83).

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. 84), taken from a specimen in my own collection, this form of

(1) Shows a lower jaw in which the wisdom tooth has taken a horizontal position below the level of the alveolar margin.

malposition is shown. A few years since, many practitioners had an opportunity of seeing a case in which the wisdom tooth

Fig. 83. (1)

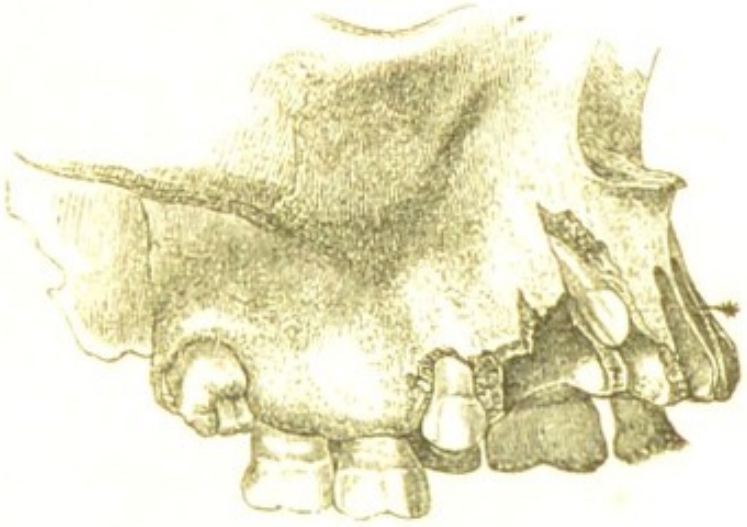
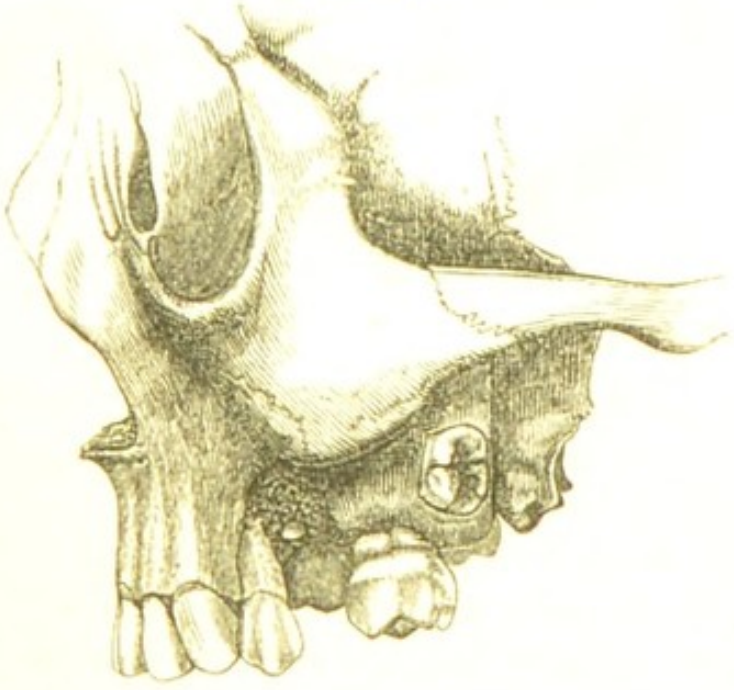


Fig. 84. (2)



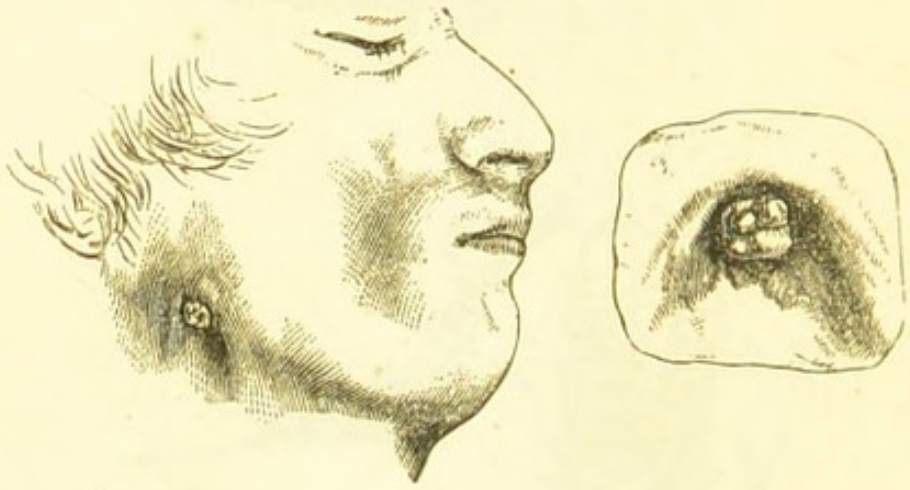
(1) Showing an upper jaw, with the third molar directed forward, and impinging upon the second molar. The small tooth situated high up in the anterior part of the jaw, was forced there by the spade of the grave-digger. The artist s accuracy in delineating all parts of the specimen has rendered this explanation necessary.

(2) Shows the wisdom tooth of the left side of the upper jaw directed outwards.

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 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. 85. (1)



In this case the tooth was removed, and the opening in the skin closed spontaneously, without necessitating any further surgical interference.

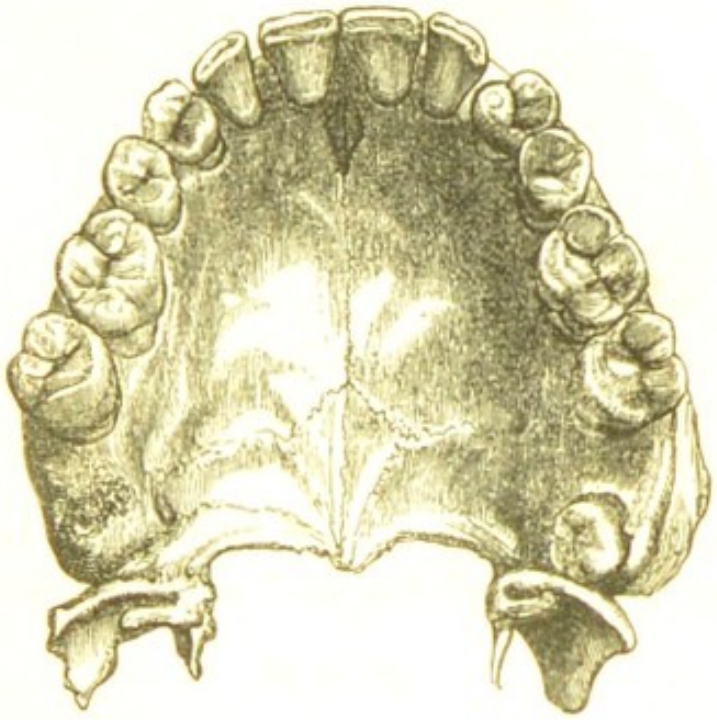
Cases in which the third molar is directed with more or less obliquity inwards are met with in the lower jaw, but in the upper maxilla they are very uncommon. Examples of teeth which lean inwards in a slight degree may be seen from time to time, but such hardly call for description in this place.

I do not remember to have seen a case in which a lower

(1) The figure is taken from a wax model belonging to Mr. Cartwright, which is deposited in the museum of the Odontological Society.

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

Fig. 86. (1)



horizontal position, with the crown directed backwards and a little outwards, and in the museum of the Odontological Society is a model showing a wisdom tooth erupted in the middle line of the palate.

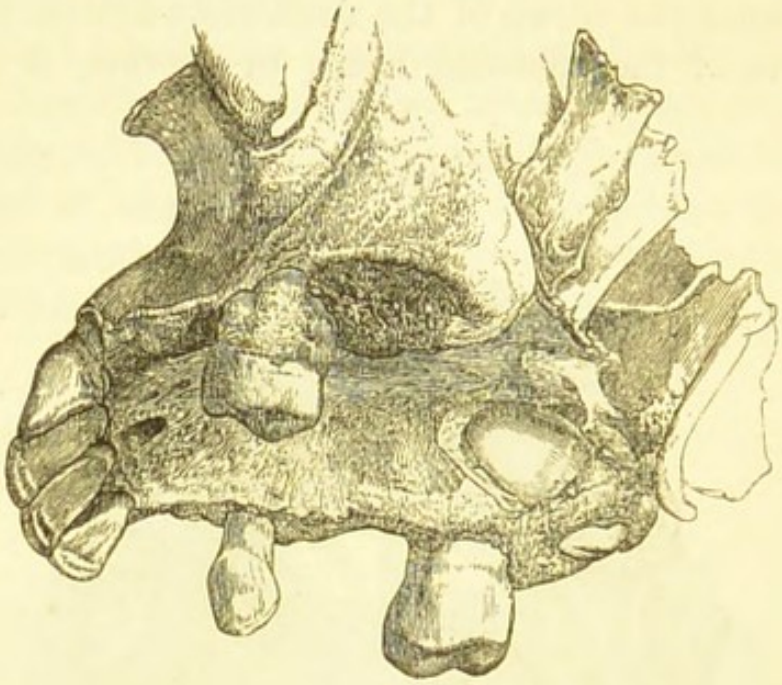
There is no reason for supposing that the irregular tooth in these instances produced any inconvenience.

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

(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.

rare form of displacement came into my possession with the following history. The patient suffered pain from a carious

Fig. 87. (1)



second molar of the upper jaw. The aching tooth was removed, and with it came the third molar, the fangs of which

Fig. 88. (2)



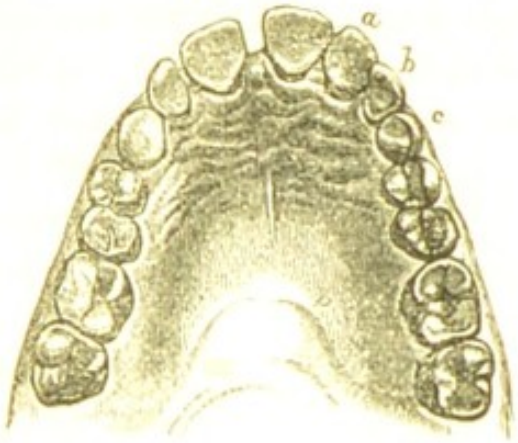
(1) Shows the wisdom tooth of the right side of the upper jaw placed horizontally, and the crown directed backwards and a little outwards. The bone has been removed to show the position of the tooth.

(2) A second molar of the upper jaw, with the wisdom tooth inverted and embraced within the roots.

were interlocked with those of the diseased tooth. The crown and roots of the second held the usual position, but the corresponding parts of the third molar were completely inverted, the well-developed roots of the one embracing those of the other tooth (Fig. 88).

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 admit of remedy. The succeeding illustration is taken from a case in which the canine is placed between the central and lateral incisor. Some-

Fig. 89. (1)



times 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 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

(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.

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.

Irregularity in the number of the permanent teeth presents itself as the next subject for consideration. 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 (page 116), 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. 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,

(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.

undistinguishable from the normal tooth, I 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, though I believe they are extremely 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 Fig. 65; 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 collection 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 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, cor-

Fig. 90. (1)



responding 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 into 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.

The roots of supernumerary teeth are, I think, almost

(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.

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 so-called 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 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.

Fig. 91. (1)



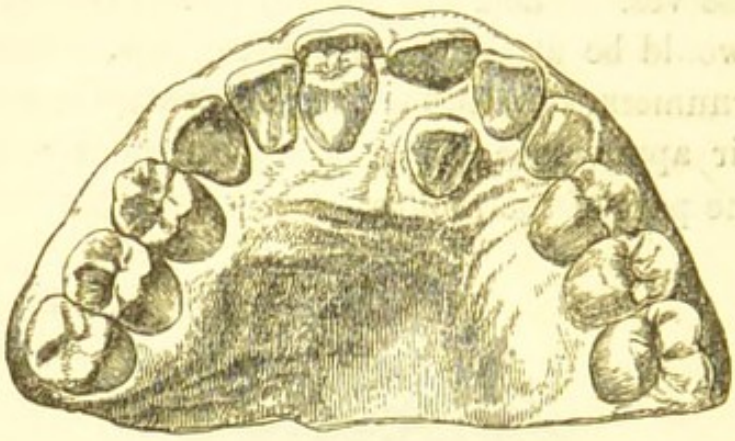
In the case figured at page 177, the position of the central incisor is preoccupied. In the succeeding illustration, a supernumerary tooth holds the place of the lateral incisor, which, with the central, is held back from taking the normal position. In the specimen from Mr. Saunders' collection,

(1) A palatal view of the specimens shown in Figs. 44 and 45. The supernumerary tooth is situated between the canine and the central incisor of the right side.

two supernumerary teeth (Fig. 93) occupy the place of the central incisors. One of the excluded teeth has come through above the alveolar line.

Again, in Fig. 92 there are two supernumerary teeth, and one of these has to a certain extent interfered with the posi-

Fig. 92. (1)

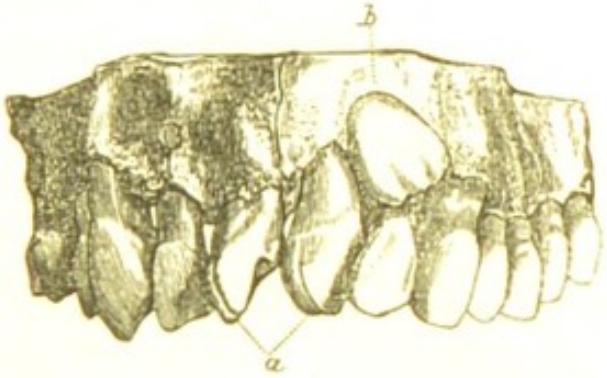


tion of the central incisor. Now, in each of these instances the abnormal have preceded the normal teeth, and occasioned the malposition of the latter. But it may happen that a supernumerary tooth appears in the place and at the time of a normal tooth, the latter having been retarded in its development 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. Instances, however, are not wanting in which the additional teeth appear among the molar division of the series. In a

(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.

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 (Fig. 94). The age of the patient and the appearance of the teeth themselves led to the supposition

Fig. 93. (1)



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. 94. (2)



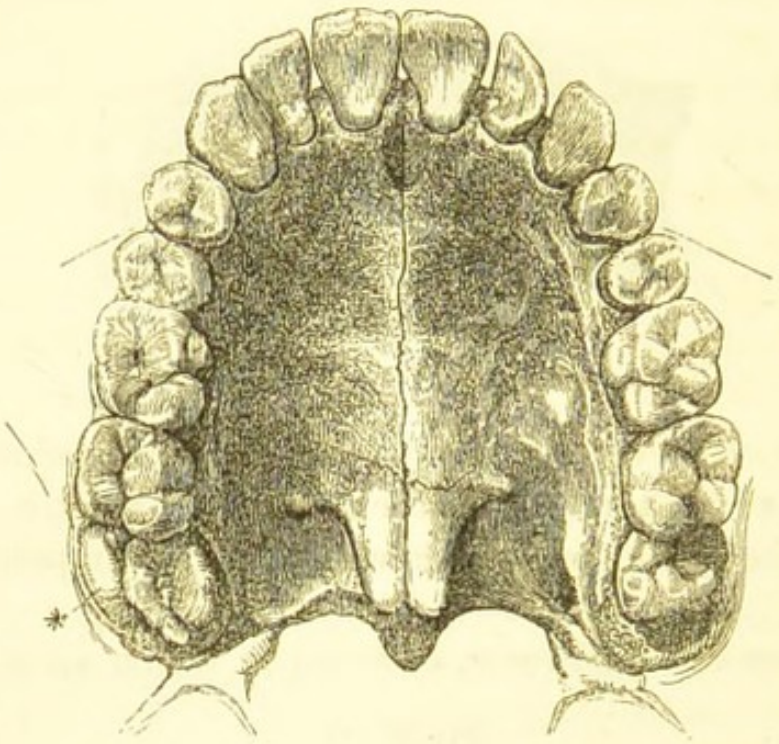
molar tooth has appeared undistinguishable as regards form from a normal member of the series, and a similar occurrence has been remarked in respect to the bicuspids.

(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 Mr. Saunders for the use of this specimen.

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

The following illustration is taken from a specimen in which a wisdom tooth and a supernumerary occupy the 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

Fig. 95. (1)



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.

Fig. 96. (2)



Indeed, I do not know that any connection between good or bad development of the jaw, and the occurrence of super-

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

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

numerary 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.

The relations of supernumerary to the temporary teeth during the development of the former are not, in the absence of actual observations, readily understood. The growth of the formative pulps of the permanent within the sockets of the temporary teeth has been described, together with the progressive formation of crypts in the inner walls of the sockets for the reception of the pulps. 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. It remains for future anatomists to determine whether supernumerary teeth arise in connection with the temporary or with the permanent teeth, or whether a normal permanent tooth may arise in connection with a supernumerary, the one holding the same relations to the other as, under ordinary circumstances, the first and second teeth do to each other.

A single phrase will suffice to describe the treatment of cases in which supernumerary teeth make their appearance. They should be extracted so 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. 66, 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. 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.

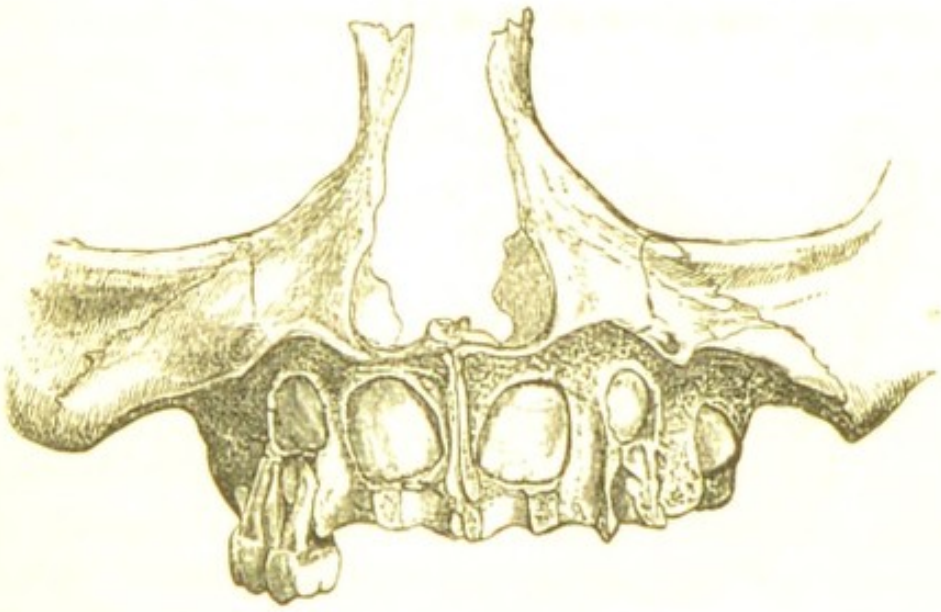
According to the statements of the patient and of her friends, the temporary teeth presented no peculiarities either as regards their number or the manner or the time of their shedding. A temporary canine tooth was retained in the upper and lower jaw; the other members of the deciduous set dropped out 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 arrange-

(1) In the museum of the Odontological Society are several models of cases in which the teeth were deficient (see Catalogue, page 23), and allusion has already been made to the subject in discussing the origin of various abnormalities (page 116).

ment. Now, although these two instances may be looked upon as very rare and exceptional ones, yet they prove that 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

Fig. 97. (1)



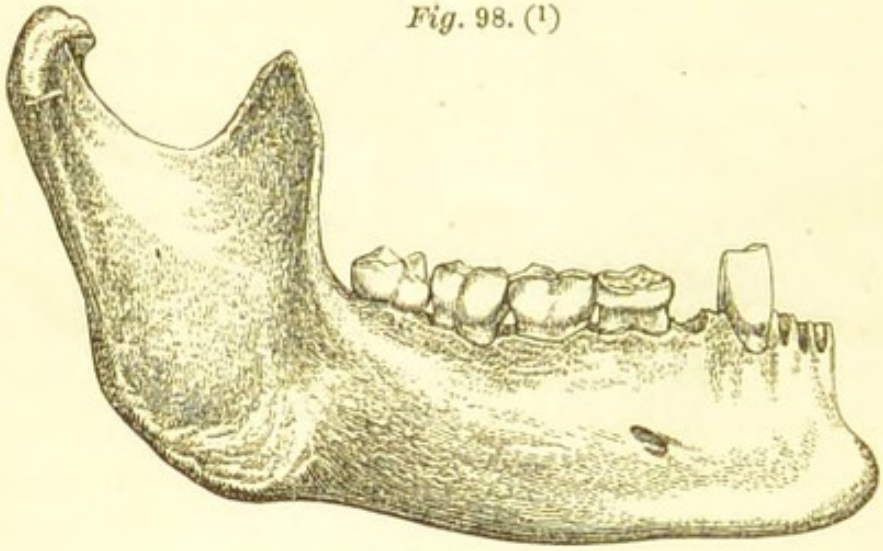
members of the set is far from uncommon. I know several families the members in each of which are destitute of lateral incisors in the upper jaw. Although it is usual for abnormalities, whether consisting in an excess or a deficiency of number, to affect both sides of the mouth, yet this symmetry is not always meet with. I have two patients (sisters) in whom the right upper lateral incisors are absent the left laterals are small, but otherwise well formed.

(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.

I am indebted to Mr. James Parkinson for a specimen of a young jaw in which both the temporary and permanent lateral incisors are wanting.

The son and daughter of a gentleman who had no lateral incisors in the upper jaw, each bore the marks of their parentage in respect to the teeth. The son had but one lateral incisor, and that was a very small and imperfectly-developed tooth. The daughter had, however, two lateral incisors. They made their appearance at a very late period, and presented the characters common to supernumerary teeth, each tooth being nothing more than a small sharp-pointed cone; and other instances of inherited peculiarities have already been given at page 114.

Fig. 98. (1)



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 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

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

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. 99 and 100) are taken life-size from two sets of teeth, the one composed of teeth individually the largest, the other of the smallest, I have ever seen.

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 central incisors may greatly exceed the average size, while

Fig. 99.(1)

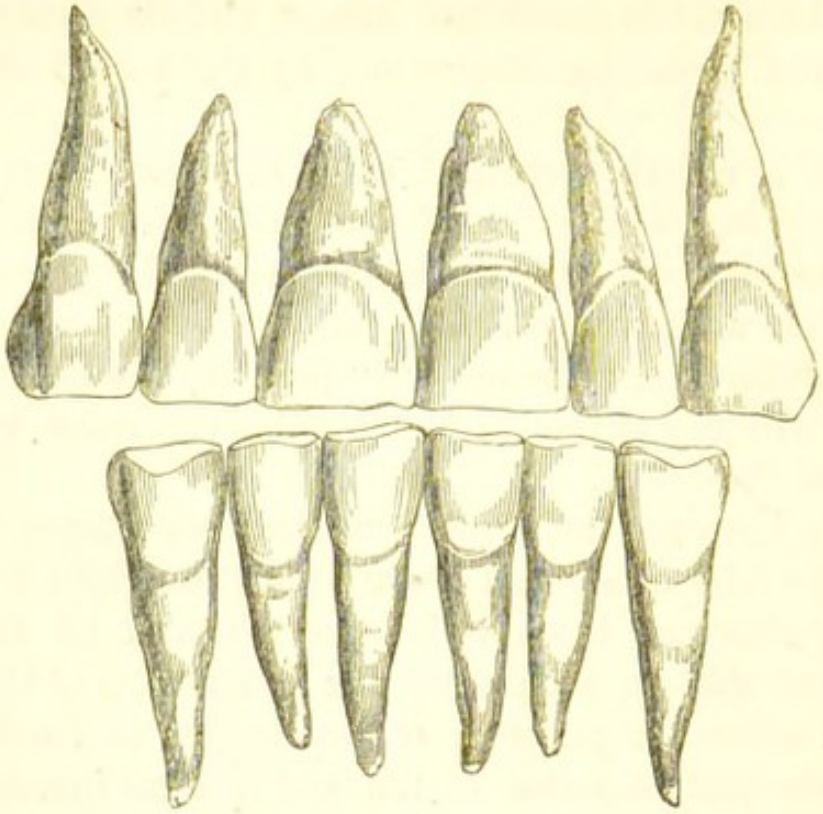
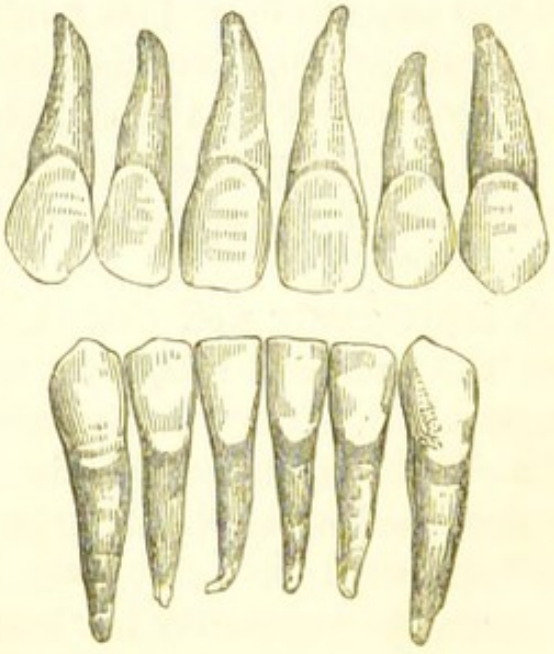


Fig. 100.(2)



(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.

I am indebted to Mr. Alfred Canton for the very large wisdom tooth which forms the subject of the next figure, and 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.

Fig. 101. (1)



Irregularity of 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 my treatment about four years since, in which one of the upper central teeth was irregular in shape, and about one-fourth the size of the

Fig. 102. (2)



Fig. 103. (3)



corresponding tooth (Fig. 102). 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 fang imperfectly developed.

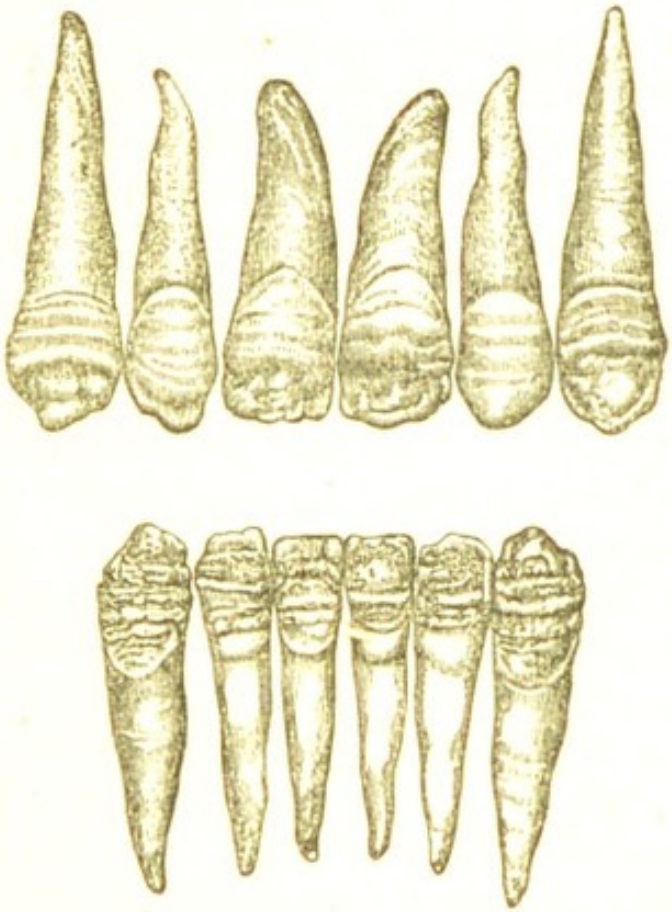
gum; this, with the unsightly character of the tooth itself, led to its being extracted. The teeth adjoining the vacated space were, by means of ligatures, gradually brought towards each other, and eventually so far reduced the interval, that the absence of the faulty central was not missed.

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. 103). 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. 27).

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. 104. (1)



The condition of system which operates so unfavourably upon the developing teeth frequently passes off before they are perfected; 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 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

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

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 a definite point, and that there will be in this respect a strict correspondence in 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 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 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 imperfect, and the ridges of perfect 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 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 organisa-

tion 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.

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

(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.

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

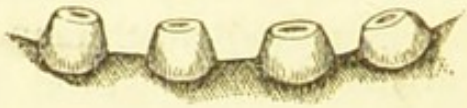
The incisors and canines are of small size, and peg-shaped; the crown is notched, the notch being in the main a concavity from the one corner to the other, though there may be secondary notches in this general concavity.

Fig. 105. (1)

A.



B.



The existence of a "circumferential notch" encircling 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 (see page 214), 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

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

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 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

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

Hill (1), 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 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 (2), without giving definite dates for the commencement of calcification, implies that it is somewhat later; and Robin and Magitot (3) state that the follicles of the permanent incisors and canines first appear within a range of about fifteen days before or after birth, but they do not say at what time calcification first commences on the papillæ.

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 6), it will be seen that only the

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

(2) Kölliker. Manual of Human Microscopic Anatomy. 1860.

(3) Robin et Magitot. Mémoire sur le genèse et developpement des Follicules Dentaires. 1860.

tip of the temporary canine is as yet calcified, so that any check occurring in its development will be marked by a circumferential groove not quite at its tip, but a little way down the crown.

But little can be done to improve teeth with faulty organisation. We may direct the patient to keep the teeth scrupulously clean, and we may from time to time remove or reduce with a fine file the irregularities of surface. When the defective part is confined to the immediate vicinity of the cutting edge of a tooth, it may in many cases be wholly removed. The teeth will look short, perhaps, after the operation, which should, however, be delayed until the development of the tooth is completed. In many instances I have been able to file off all the faulty tissue from the canine teeth, a considerable portion of it from the lateral incisors, and a little from the central teeth.

Some degree of caution will be needed in using the file. If too much at a time be removed, or if the operation be performed at too early a period, the teeth operated upon will become extremely tender. As a general rule, it is well to delay any attempt to improve the appearance of the defective teeth by filing until the patient is from twelve to eighteen years of age.

The depressions or faults in the enamel must, however, from time to time be carefully examined, and should any indication of caries be discovered, the cavity in which the disease is situated must be filled without delay.

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. I have known a practitioner 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. 106) 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.

Fig. 106. (1)



Fig. 107. (2)



Supplemental cusps only have been spoken of, but we sometimes see a tolerably perfect little tooth growing out, as it were, from the side of another tooth. In Fig. 107 a small tooth is shown connected with the distal side of the second or third lower molar below the termination of the enamel.

Mr. Harrison placed at my disposal a molar, from the lateral surface of the crown of 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

(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.

teeth, the matter cannot be altogether passed over at this place.

The incisors may have their roots crooked or bent, or even twisted in a spiral form, but I have seen only one example in which they were bifid. In that 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 fangs in the upper, and two in the lower jaw as a normal condition.

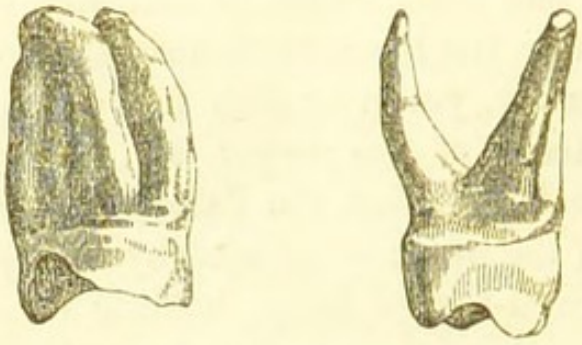
Whether or not we are disposed to accept such facts as the occurrence of three-fanged bicuspids as indications of reversion

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 fangs may be bent, but seldom terminate by two roots.

Among the molar teeth, the first permanent molars will 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

Fig. 108. (1)



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,

(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.

as was before stated, these departures from the normal 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 when-

Fig. 109.(1)



ever 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 (211), in illustration of the sizes between which the third molar may range.

The accompanying figure (Fig. 110), 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. (2)

There appears to be good foundation for the statement that the upper wisdom teeth in the lowest savage races have

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

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

their three fangs distinct(1), 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 civilized 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 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 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."

Fig. 110.



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

(1) Owen. Anatomy of Vertebrates, vol. iii., p. 320.
(2) Huxley. Anatomy of Vertebrate Animals, p. 486.

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 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.

Fig. 111. (1)



In another place, under the head of *Dilaceration* (2), 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 neces-

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

(2) Lectures on Dental Physiology and Surgery.

sarily sacrificed. I have seen specimens in which the crown of an incisor has been placed at a right angle with the root.

The instances of dilaceration which have fallen within 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 tissues can be seen only by the aid of the microscope. If, however,

Fig. 112. (1)



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.

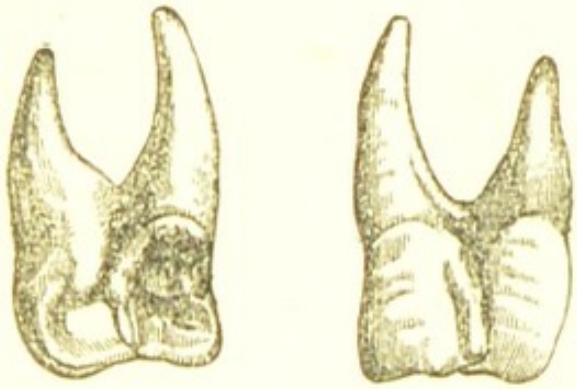
There is one other deviation from the normal condition which, as it affects the forms of individual teeth, must be included under the present heading—viz., *the union or gemination of contiguous teeth.* This subject was entered upon

(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.

in connection with the temporary teeth (page 157), 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 involving 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

Fig. 113. (1)



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. 115) 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 opening the pulp-cavity, and consequently in the death of the united teeth. Extensive alveolar abscess followed, for the relief of which I removed the teeth 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

Fig. 114. (1)

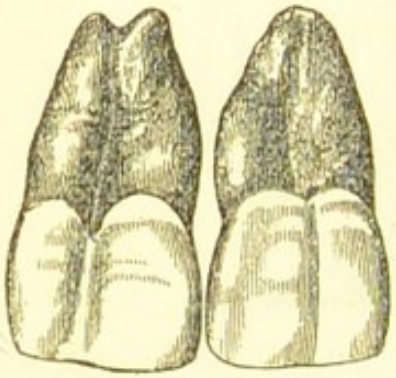
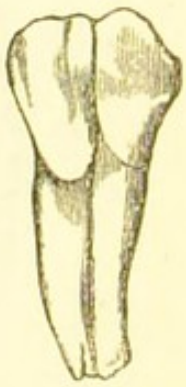


Fig. 115. (2)



size of each tooth were 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 sup-

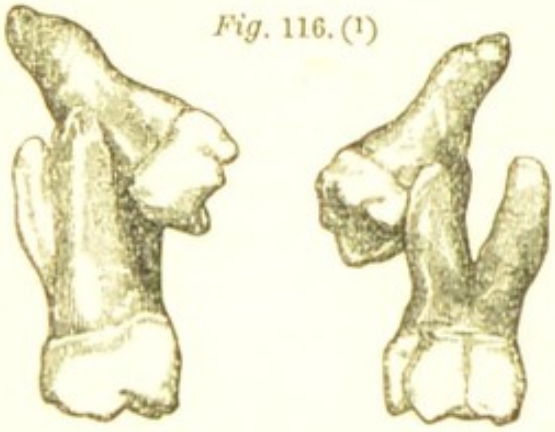
(1) Shows the permanent central and lateral incisors of the upper jaw, united throughout the whole length of the teeth. From a specimen lent to the author by Mr. Styers.

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

plemental lateral. In one example, the 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, excepting as the result of diseased action set up long after the development of the teeth has been completed, is of very rare occurrence.

Fig. 116. (1)



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.

Under the head of irregularity of the permanent teeth, one subject only remains for consideration—namely, *Irregularity in the period of their eruption;* the premature or the retarded appearance of members of the permanent set of teeth, and the deviations from the natural order of 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 antecedence 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 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 organization 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 are now appearing 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 per-

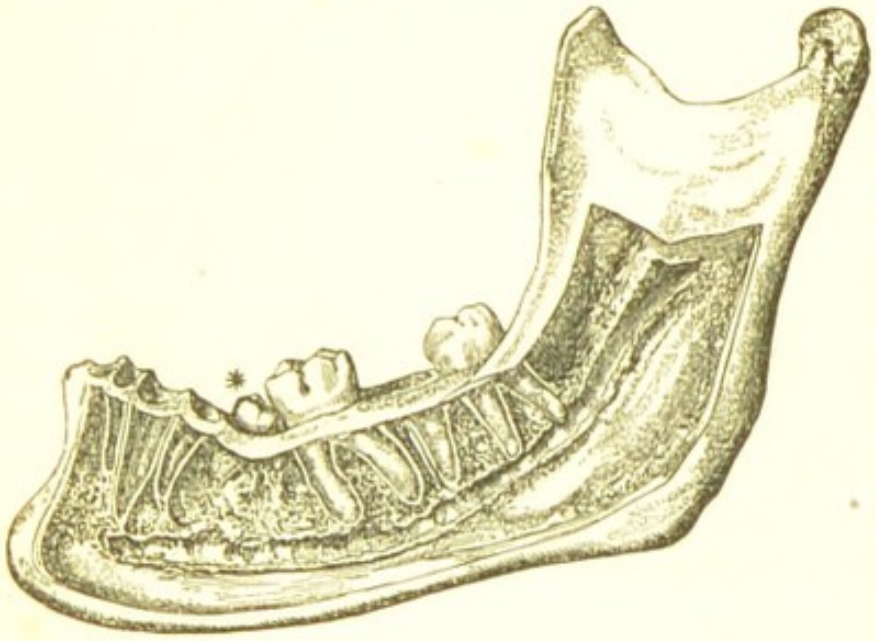
manent teeth would have been injured, and have appeared prematurely through an inflamed gum.

In a practical point of view, the accelerated is less interesting 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.

The 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 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 has been described at page 158, 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,

Fig. 117. (1)



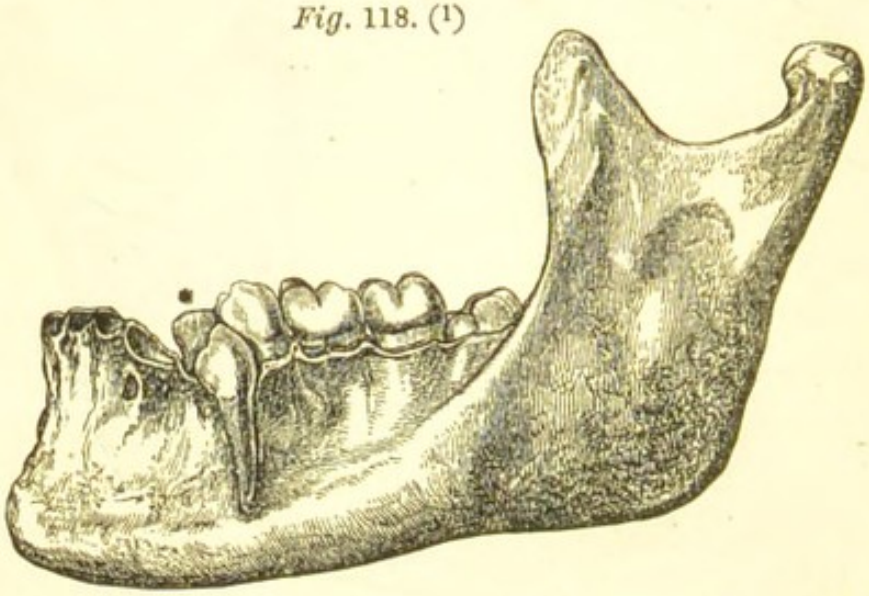
which, having been stationary, would have remained in concealment but for the recedence of the gums.

In the cases of retarded eruption of special teeth in which I have had an opportunity of examining the teeth themselves, 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 crown faulty in respect of form and organization, but the presence of these

(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 Mr. Saunders for the use of this specimen.

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 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 ob-

Fig. 118. (1)

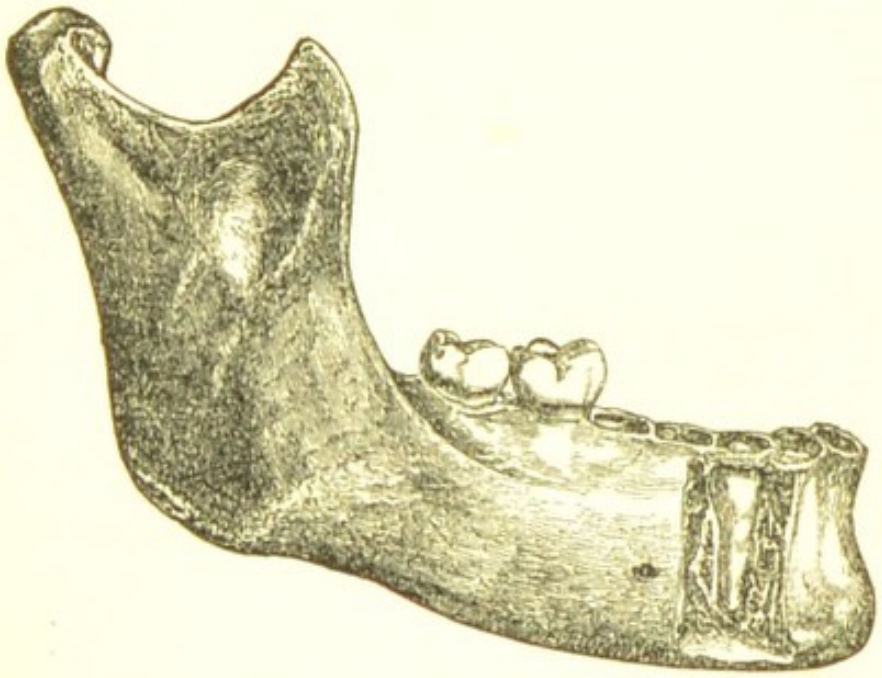


vious, but in others, we fail to see why the tooth did not take its place in the series at the usual time. In the case of a female, the upper canine was absent, a space being left between the first bicuspid and lateral incisor. At the age of forty-five, the missing tooth slowly protruded itself. Now, 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

(1) Showing the first biscuspid 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.

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, the process itself must be in some respects different from that which occurs when teeth are cut under ordinary cir-

Fig. 119. (1)



cumstances. When the process is normal, as respects the time and the stage of development of the tooth, the crown 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 progres-

(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.

sive 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 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.

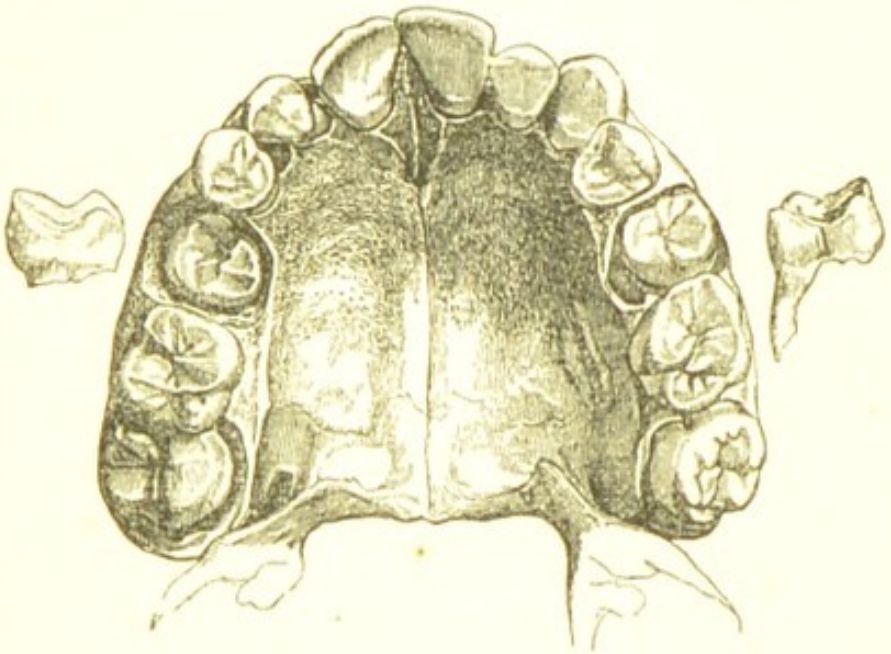
In many cases, however, the retarded teeth become exposed to view by the absorption of the superjacent gum, the teeth themselves being perfectly stationary. The pressure on the gum caused by artificial teeth will not uncommonly cause its absorption and the exposure of a hidden tooth, and this tooth, 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, as in Fig. 117, &c., 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

Fig. 120. (1)



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 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

(1) Showing the second bicuspids, at the age of fifteen years, retarded by the presence of the preceding temporary teeth.

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. 117. 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 disappointment; we may remove a temporary tooth which is destitute of a successor, as shown in Fig. 98, 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. 117.

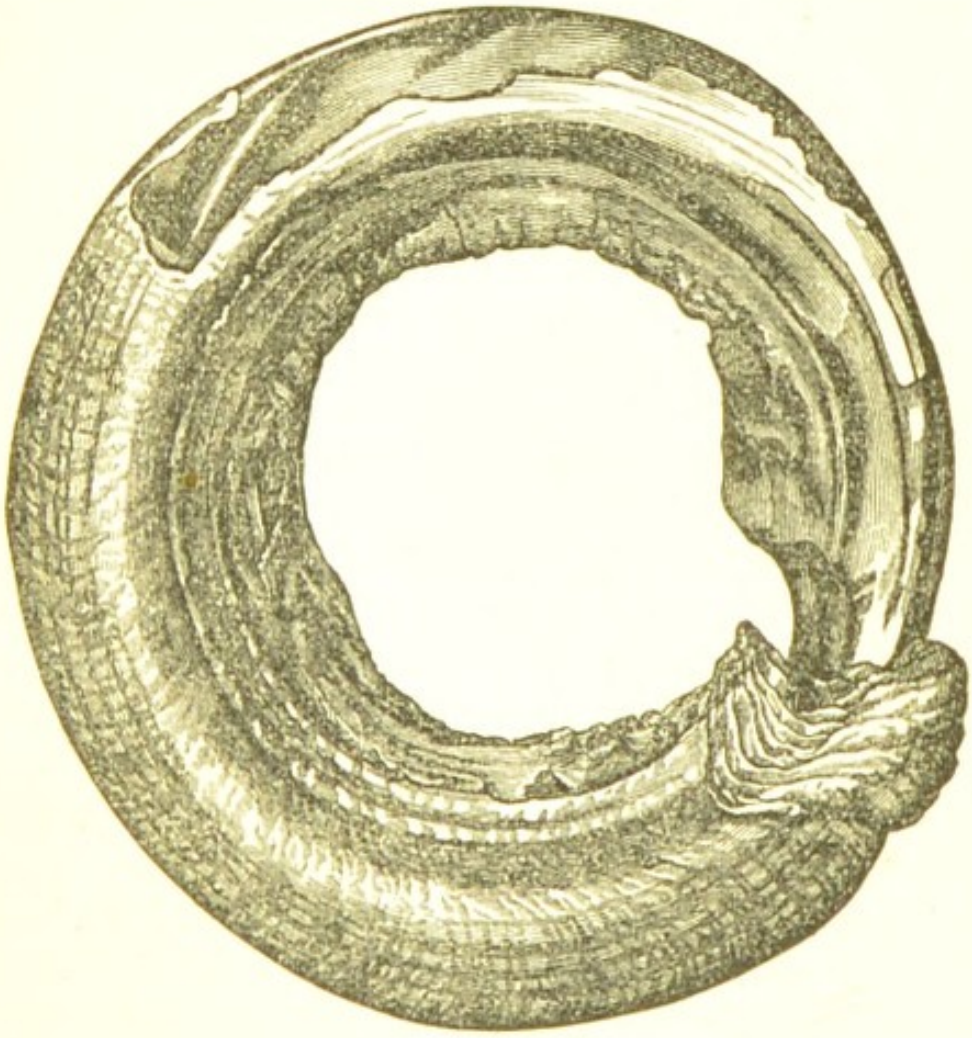
Regarding, then, the persistence of temporary teeth as a cause which commonly operates unfavourably, not only by retarding the eruption of permanent teeth, but also by producing irregularities in the dental series, their removal must, as a general rule, be attended with advantage.

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. The section may

Fig. 121.



be concluded by the introduction of the preceding figure (Fig. 121). The specimen delineated is, I think, unique; 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.

THE DENTAL TISSUES.

List of works referred to in the section relating to the Dental Tissues :— (1)

1. Kölliker.—"Handbuch der Gewebelehre." 5te Auflage. 1867.
2. Waldeyer.—"Stricker's Handbook of Human and Comparative Histology." Sydenham Society Translation. 1870.
3. Boll, F.—"Untersuchungen über die Zahnpulpa." Archiv für Mikros. Anat. Vol. iv. 1868.
4. Hertz.—"Untersuchungen über den feineren Bau der Zähne." Virchow Archiv. 1866.
5. Beale, Dr. L. S.—"On the Structure of the Simple Tissues," 1861; and, "Lectures on the Structure and Formation of the Teeth." (Reprint in "Archives of Dentistry," vol. i.)
6. Hoppe-Seyler.—"Virchow's Archiv." Bd. v. and bd. xxiv.
7. Tomes, J.—"Transactions of the Royal Society." 1850.
8. Salter, S. J.—"Archives of Dentistry." 1865.
9. Neumann.—"Beiträge zur Kentniss des normalen Zahn- und Knochengewebes." 1863.
10. Robin et Magitot.—"Sur la genèse et développement des Follicules dentaires." "Journal de la Physiologie." 1860 and 1861.

(1) As repeated reference will have to be made to the views held by various authorities, it has seemed advisable, in order to avoid needless repetition of the titles of books, to give a list of works referred to in a collected form.

11. Huxley.—"On the Development of the Teeth," &c. "Quarterly Journal of Microscopical Science." October, 1853.
12. Harting.—"Quarterly Journal of Microscopical Science." April, 1872.
13. Rainie.—"British and Foreign Medico-Chirurgical Review." No. xl. October, 1857.
14. Czermak.—"Beitrage zur Mikr. Anat. d. Menschl. Zähne." Zeitschrift. f. Wiss. Zool. 1850.
15. Wenzel, Bruck, Santi Sirena, as quoted in Henle's "Bericht über die Fortschritte der Anatomie im Jahre. 1871."
16. E. Lent.—"Ueber die Entwicklung des Zahnbein und des Schmelzes." Zeitscrift. f. Wiss. Zool. 1854. vi.
17. Tomes, J.—"On the Structure of the Dental Tissues in the order Rodentia." "Philos. Transact." 1850.
18. Tomes, J.—"On the Structure of the Dental Tissues of Marsupial Animals." "Philos. Transact." 1849.
19. Tomes, C. S.—"On the Nature of Nasmyth's Membrane." "Quart. Journal of Microsc. Science." 1872.

Those abnormal conditions of the teeth and of the dental arch which are the direct consequence of interruption, either in the progressive development of the alveolar portions of the maxillæ, or in the eruption of the teeth, have been described under the general head of Teething. We have now to consider the dental tissues in relation to the diseases to which they are subject, before passing to the study of the diseases themselves.

Imperfect structural development, although a predisposing, cannot be regarded as the exciting cause of diseased action. Irregularity, either in the form or the position of teeth, is altogether attributable to a disturbance in the laws presiding over the development of the dental organs; but the destruction of a tooth by caries commences after the tooth takes its place in the alveolar line, and becomes exposed to influences

from which it was altogether protected prior to its eruption. The teeth may, and very commonly do, present all the general characters of well-developed organs, and yet when examined by the aid of the microscope, exhibit unmistakeable signs of defective organization, rendering them highly susceptible to disease when placed within the influence of the necessary conditions.

On the other hand, those defects of structure which render the tooth liable to early and rapid destruction, may be apparent to the naked eye so soon as the crown of the tooth becomes visible.

Before, however, the characteristics of the diseases, and of their predisposing and exciting causes, are entered upon, it will be desirable to give a short sketch of the histological characters of the tissues in which they are situated. It will not be necessary to enter at any great length, either into the development or the structure of the tissues of the teeth, in a work on dental surgery, though, inasmuch as an understanding of pathological conditions requires an accurate knowledge of the characters which appertain to the normal structure, it is desirable to give a brief account of the various dental tissues in this place.

A tooth is composed of enamel, cementum, dentine, and dental pulp.

The relative position of the several structures which collectively form a tooth may be best seen by dividing one of the front teeth longitudinally. Commencing the examination from the surface, we shall find the crown is encrusted by a layer of enamel, which is comparatively thick over the prominent parts of the masticating surface, but becomes thinner on the sides, and is eventually lost on the neck of the tooth. At its terminal edge, the enamel is slightly overlapped by the cementum, which holds to the fang and neck of the tooth similar relations, in respect of position, to that which the enamel does to the crown.

The cementum attains its maximum amount of thickness

about the terminal portion of the root, and suffers a gradual diminution until it is lost on the neck of the tooth. In a few instances it may be traced, not only over the terminal edge of the enamel, but for some little distance upon the coronal portion of the tooth, and specimens are now and then found in which it appears to partially fill up deep fissures situated between the tubercles of the molar teeth. Such, at least, seems the most probable explanation of the occurrence of bodies occupying deep fissures in the enamel, which present all the characters of so-called lacunal cells.

They are, unless distorted by mutual pressure, rounded bodies in the centre of which are hollow spaces of varying size; in some instances the central space is small, in others large and produced out into numberless canaliculi. The resemblance of these bodies to those lacunæ contained in capsule-like investments, which are to be seen wherever cementum is thick (they are commonly abundant in exostosed cementum, or the thick cementum which fills up the interstices of the crown in pachyderms), is most complete, both in size and appearance; and it is difficult to suppose that their origin is different. It would, however, be out of place to enter into any long discussion whether coronal cement exists in man, in the present work; the more so as the facts bearing on the question are to be found in a collected form elsewhere (19). It may, however, be mentioned here that the dark masses found in the fissures of enamel may, by using acid until the enamel is destroyed, be easily shown to be nothing else than portions of Nasmyth's membrane, which has in these places attained a greatly increased thickness.

The enamel and the cementum enclose the dentine, the outer surface of which, if the investing tissues were removed, would still present the characteristic form of the tooth with but little alteration, excepting a slight diminution of size, while the cusps would be somewhat sharper than before the removal of the enamel.

The great bulk of the tooth is made up of dentine, in the

centre of which is found a cavity, bearing a general resemblance in form to that presented by the tooth itself. In the central cavity the pulp of the tooth is contained. In the roots of the teeth the cavity is small, and the pulp is at this point principally composed of nerves and bloodvessels; but as the neck of the tooth is approached, the cavity attains its maximum size, and afterwards diminishes as it assumes the form presented by the outer surface of the tooth. The pulp cavity communicates with the surface of the tooth by a small opening situated at the end of the root, and through this opening the nerves and vessels enter. In a few cases, canals for the passage of vessels may be found entering the pulp cavity through the side of the tooth, midway between the neck and the apex of the root, while in a few others they enter by several minute canals; but these must be regarded as exceptional cases.

The Enamel.—In a fully formed tooth the enamel contains only from one to three per cent. of organic matter, though in the opaque chalky-looking enamel of a tooth not yet completed the organic constituents amount to as much as fifteen per cent. This organic matter, said not to belong to the class of gelatinous tissues, but to be closely similar to epithelium in its chemical relations, is stated not to exist between, but in the substance of the prisms (Hoppe-Seyler). The enamel is made up of parallel fibres which lie in close contact with one another, no intervening substance being demonstrable. From their close mutual apposition they assume forms more or less nearly approaching that of hexagonal prisms; so that on transverse section a mosaic-like pattern of hexagonal areas is seen; but some fibres will be found to be nearly square, others nearly circular.

The inner ends of the fibres rest upon and are united to the surface of the dentine, while the outer extremities form the surface of the crown of the tooth.

In tracing the course of the fibres, it will be found that those situated on the prominent parts of the crown take a

vertical course, while on the sides of the tooth they pursue a horizontal direction. Every intermediate position between the vertical and the horizontal will be seen on examining the enamel as it passes from the cutting edge of an incisor, or the cusp of a molar, down the side of the tooth. The surface of the dentine presenting a more or less conical figure, the enamel fibres in their passage outwards would become separated from each other, unless the fibres gradually enlarged, or unless supplemental fibres filled up the intervals. Most fibres appear to extend from the surface of the dentine to the surface of the enamel; and as there is no reason to think that the fibres are subject to gradual enlargement, the presence of supplemental fibres need not be doubted, though their existence is not easy to demonstrate.

The fibres, in their passage from the dentine to the free surface, pursue a waved, or, according to Hannover, a spiral course; in man the varying direction of contiguous bands of fibres is not sufficiently regular to be readily traced out; but in certain of the rodentia (7) alternate layers of straight fibres pass in directions at right angles to one another, so as to produce a very regular pattern. By tracing the gradations presented in the enamel of such rodents through those in other members of the order in whom the pattern becomes less regular, owing to the assumption of a waved course by the fibres, many of the peculiar appearances presented by human enamel may be more readily understood.

These appearances, known as the "decussation of the fibres," are due to the fact that in the thickness of the section several layers of enamel fibres are included, and the fibres of the several layers passing in more or less different directions give rise to various patterns.

If a thin section, in which the fibres are exposed in their length, be examined, it will be found that they are individually marked by transverse lines, or striæ, situated at tolerably regular intervals. These striæ do not necessarily coincide in the contiguous fibres throughout the specimen,

although they may be continuous over a considerable number of fibres in certain parts of the preparation.

If sections taken from a number of teeth be examined, it will be found that the striæ are much more strongly marked in some than in others, and that they are most strongly pronounced in those parts of the specimens which, when seen by transmitted light, have a brown colour. This, which is an exceptional condition, and limited in extent in well-formed teeth, will be found to pervade the whole of the enamel in the teeth of certain unhealthy subjects. The teeth, in place of the brilliant white and almost translucent appearance, have a dull opaque yellow colour. Enamel having this defect presents structural characters which are much more strongly marked than obtain in that which is more perfectly developed. The cause of this appearance of striation is still a doubtful question, none of the very various explanations which have been offered proving wholly satisfactory.

It is explained by Waldeyer by a reference to the decussation of the prisms; seeing that the prisms are united without intermediate substance, and that contiguous layers do not pass always in parallel directions, it follows as a necessary consequence that the outlines of each enamel prism cannot be perfectly straight and regular, and it is to this cause that he ascribes the varicosities; while Hertz (4) accounts for their presence by the assumption of intermittent calcification of the prism.

The distinctness of the transverse striation can be greatly increased by the use of dilute hydrochloric acid. The manner of procedure is as follows: after reducing a section of enamel sufficiently thin, place it for two or three seconds in the acid (one part of hydrochloric acid to twelve parts of water). Wash the section and examine it in water under a $\frac{1}{8}$ objective. It will now be seen that the acid has acted upon the different portions of the enamel fibres with varying effect, attacking the central portions of the fibres with the greatest vigour.

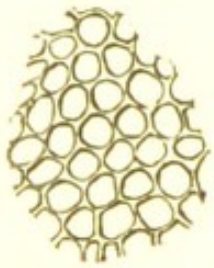
The appearances just described are somewhat difficult of explanation; but exceedingly similar sections may be obtained from developing enamel without the use of an acid. The deposition of the hardening salts takes place in the first place at the periphery of the enamel cells, and goes on towards its centre until it is filled up entirely. Hence enamel as at first formed is fenestrated, and the older the forming enamel the smaller are the perforations; this condition has been well figured by Hertz (4).

It seems, therefore, that the action of dilute acid is to reverse the course of calcification, removing first that which was last deposited, and the varying appearance of the different sections is, in all probability, referable merely to their obliquity.

When enamel is fractured, the line of fracture appears to run through the centre of the fibres, and not, as might have been expected, through their interspace.

In the parts of the section where the fibres have been divided transversely the appearance of a perforated membrane will be left, the openings corresponding to the centre of the fibres.

Fig. 122. (1)

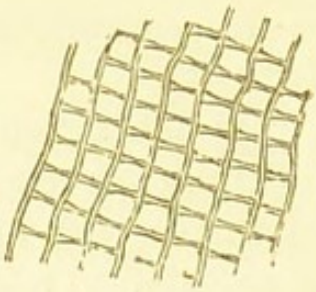


If the section chance to divide the fibres obliquely, the openings left after the action of acid will approach an oval or even a squarish form, according to the forms assumed by the prisms themselves as a result of mutual pressure. Now and

(1) A tranverse section of the enamel, showing the fenestrated structure left after the removal of the central portions of the fibres by acid.

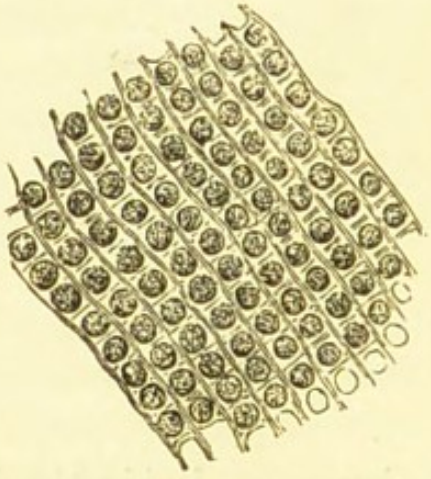
then, however, an appearance is seen which is depicted in the accompanying illustration (Fig. 124). In this case the acid has stopped short of wholly removing the axial portion of the fibres, which remain as a granular opaque mass. From the general appearance of the section from which this drawing

Fig. 123. (1)



was taken, it would be taken for a longitudinal section of enamel; it is, however, exceedingly difficult to get a truly longitudinal section, as the very varied course of the fibres precludes the possibility of getting a section in which their direction remains the same for any distance; and it is more

Fig. 124. (2)



(1) A section similarly treated, in which the plane of the section crosses the direction of the fibres obliquely.

(2) Section in which the acid has stopped short of causing actual perforations leaving instead the centres of the fibres (cut ends of?) looking dark and granular. The figure is in one respect faulty; it is never possible to see the outlines of the dark masses very sharply defined, and they generally have a more square or oval form than is here depicted.

probable that the appearance here depicted is due to the obliquity of the section.

But the conditions which are manifested in perfectly matured normal enamel do not obtain until the development of the tissue is fully accomplished; and it will be recollected that young enamel contains as much as fifteen per cent. of organic matter, whilst this is diminished in adult enamel to three per cent. During the process of formation, the fibrous arrangement is exceedingly distinct, and may readily be demonstrated by the aid of hydrochloric acid. If, for example, a thin section be made from a tooth the crown only of which is undergoing development, and submitted to the action of acid, it will be found that the earthy ingredient disappears, leaving a series of decalcified fibres attached like a fringe to the surface of the dentine. The manner in which these differences arise may, however, be seen if the enamel be carefully examined during the progressive stages of its development. It is desirable to enter to some extent into the subject of enamel development in order that structural defects may be the more readily understood; the more so as the information on this matter contained in the text books ordinarily accessible to the dental student is but scanty.

The investigation may be pursued with advantage in the teeth of a seven or nine months' fœtus. If an incisor be removed from its crypt in the jaw, enclosed within its investing sac, we should, were it possible to make a section through it without disturbing its several parts from their normal relations, find the following succession of structures over the crown of the tooth. On the immediate inner surface of the sac would lie the rounded epithelium-like layer of cells which constitute the external epithelium of the enamel organ; in contact with this, subsequently to the disappearance of the stellate reticular tissue, would lie the cells constituting the stratum intermedium, and next to these the hexagonal, prismatic, cells which are called the internal epithelium of the enamel organ or enamel cells. These last

are connected by one extremity with the cells of the stratum intermedium, by the other with the surface of the developing enamel.

Such a section cannot well be made, on account of the great hardness of the enamel; but these relations may be well seen on sections of the tooth sacs of young animals, which have been hardened in chromic acid, and subsequently decalcified and cut. But most instructive preparations may be made, by which the process of enamel development may be traced, in fresh tooth sacs.

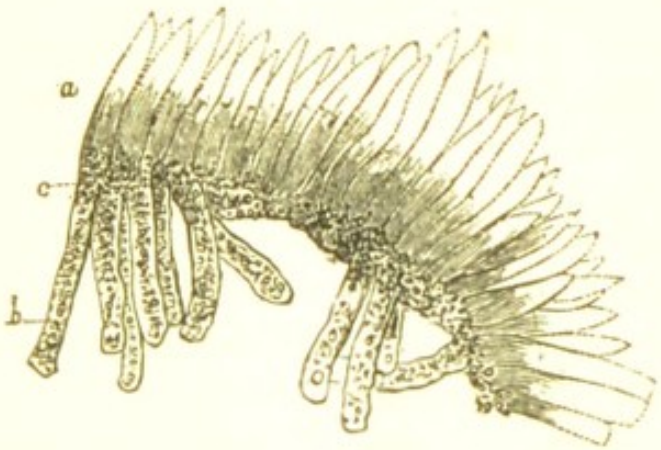
If, for example, a dental sac which has been removed from the fœtal jaw be carefully opened, it will be found that a gelatinous semifluid substance is interposed between the inner walls of the sac and the coronal surface of the young tooth. Cylindrical columns, having near the extremity which lies farthest from the formed enamel a large oval nucleus, together with a large number of spherical or ovoid nucleated cells, will be seen to make up this gelatinous matter.

The long cells are the formative cells or internal epithelium of the enamel organ; and if the enamel itself be examined, similar columns will be found adherent to its surface. Their presence may also be demonstrated in the following manner. After dividing the dental sac, and turning it back so as to expose the forming tooth, place the preparation in a watch-glass containing dilute hydrochloric acid. In a short time we shall see a membrane-like substance detach itself from the surface of the enamel, which, with a little careful manipulation, may be removed to the microscope for examination, and it will then be seen that one side of the membrane is composed of columns of the enamel pulp, and the other of decalcified enamel fibres, and that the columns and fibres are joined end to end.

The columns are, however, very readily detached from the peripheral ends of the enamel fibres, which are at this point laterally united, presenting the appearance of a membrane which not uncommonly assumes a deep brown colour, contrast-

ing with the more internal and colourless portion of the fibres, which, like the columns of the pulp, may become detached. When the columns are detached from the one surface, and the transparent portions of the enamel fibres are removed from the other, we have remaining that which Mr. Huxley has regarded as the membrana preformativa situated between the enamel pulp and the enamel. Mr. Huxley was the first to discover

Fig. 125. (1)

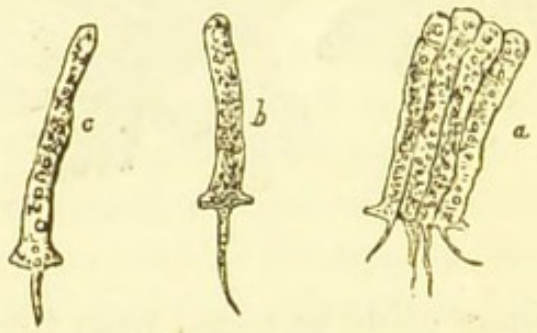


that this membrane could be raised from the enamel at any period of its growth. Up to the time of this discovery it was generally believed that the enamel was formed by the calcification of the columns of the enamel pulp; but if the membrane raised by the acid should prove to be, in the strict sense of the term, a well-defined membrane, separable both from the enamel pulp and the enamel, and not to be a transitional condition of the one in its gradual progress towards becoming the other, then the conversion hypothesis must be relinquished, and we shall fall back upon the opinions held by the older authors; and we must, with Mr. Huxley, regard the enamel organ as exerting no direct influence in the development of the enamel.

(1) Showing the columns of the enamel pulp *b*, connected at *c* with the decalcified enamel fibres at *a*. The nuclei of the enamel cells have been omitted from the figure.

But in a series of investigations made in reference to the elucidation of this point, the results did not coincide with those recorded by Mr. Huxley (11), and subsequently by M. Lent (16). The manner of proceeding was similar to that pursued by the authors cited, which is described in the preceding page. No difficulty attended the production of the membrane, but the columns of the enamel pulp were found at many points adherent, and their continuity with the fibres could in some cases be distinctly traced, as shown in the preceding figure (Fig. 125). Again, the detached columns adhered in bundles to each other by the ends which approached the enamel, and many of the columns were terminated by

Fig. 126.



delicate processes, which must at the time of separation have been withdrawn from the interior of the partially calcified fibres, and consequently must have passed through the membrane which is supposed to separate the two tissues.

Immediately above the point from which the process starts, each column has, when separated from its fellows, a slight circumferential dilatation, as though the cylinder had been everted at the edge when the separation was effected. On closer examination, the columns appear to be made up of tubular membranous sheaths, within which, at the end most distant from the enamel, are large oval nuclei, the remainder of the cell being filled with contents more or less granular. At the end directed towards the enamel the investing membrane appears to be absent, and it is often possible to see with

the utmost distinctness that the enamel cell terminates by a tubular opening. The processes shown in the last figure are not by any means constantly present; the cells often terminate by a somewhat everted, trumpet-shaped mouth, this appearance of eversion being probably due to the fact that the rest of the cell has shrunk in consequence of immersion in alcohol or glycerine, whilst the end lying in contact with the calcified enamel has been so far altered that it is rigid and incapable of shrinking under the action of reagents. It is often possible to see the orifice of this everted mouth in the same cells which present the processes above figured; concerning which it may be added that Hertz (4), and Waldeyer (2), confirm the fact of their occurrence, and accept the explanation here offered of their nature.

Now, supposing the decalcified enamel fibres are detached from the columns and are viewed singly, it will be seen that the ends which approached the dentine are clear and trans-

Fig. 127. (1)



parent, while those which meet the columns are coarse and granular, appearing by transmitted light of a deep brown colour; indeed, but for the colour, it would be difficult to distinguish the distal extremities of the decalcified enamel fibres from the proximal ends of the columns of the enamel organs. (Fig. 127.)

The conclusions respecting the development of the enamel which are most in accordance with the appearances observed

(1) Showing the decalcified enamel fibres connected with the granular columns of the enamel organs.

are these. The columns of the enamel organ (*enamel cells, internal epithelium of the enamel organ*) are subservient to the development of the enamel prisms, into which they by calcification become actually converted. This conversion goes on in the following method: the proximal end of the cell undergoes some chemical change preparatory to calcification, and is subsequently calcified; but this calcification does not go on uniformly throughout its whole thickness, but proceeds from its periphery towards its interior, the central portion of the cell thus being calcified later than the external portion which lies at the same level. At the same time that calcification is proceeding inwards in each individual cell it has united the contiguous cells to each other. At this point, namely, at the extreme margin of calcification, the columns (*cells*) very readily separate from the calcified fibres, leaving the surface of the latter having the appearance of a perforated membrane; the perforations being due to the withdrawal of the central uncalcified portions of the cells, which constitute the processes of the enamel cells figured on a preceding page.

The calcification of the central portions of the enamel fibres does not, as has been already stated, keep pace with that of their exteriors; nor even in fully completed enamel does it attain to precisely the same characters. For, as was mentioned on page 246, the action of acids is more rapid on the axial portion of the adult fibres than on their exteriors, so that by its use that appearance of fenestration which is seen to normally exist in young developing enamel may be restored. In the progress of calcification the nuclei of the enamel cells disappear, and it is probable, as is believed by Waldeyer (2), that the internal epithelium of the enamel is recruited by the cells of the stratum intermedium as it becomes itself used up by advancing calcification converting it into enamel fibres.

But, although the balance of evidence seems to be in favour of this view, it is not assented to by all observers. Thus Kolliker (1) imagines that the enamel cells do not

undergo direct conversion into enamel fibres, but that the enamel is, as it were, shed out from their ends; that it is a secretion from them, not a deposition in their own substance. The processes which are so often to be seen on the ends of enamel cells he regards as artificial products, and explains as being fragments of partially-developed enamel accidentally torn away with the cells.

More recently, Wenzel has written (15) in support of this excretion theory of enamel development, but the grounds advanced by him do not appear at all conclusive.

Again, Professor Huxley (11), whose opinion on histological matters must always carry great weight, expressed the opinion that, "Neither the capsule nor the 'enamel organ,' which consists of the epithelium of both the papilla and the capsule, contribute *directly* in any way to the development of the dental tissues, though they may indirectly."

This opinion is based upon the fact that, by means of an acid capable of dissolving calcium carbonate and phosphate, a membrane can be raised from the surface of developing enamel at any stage in its growth, the membrane so obtained being identical with the membrana preformativa of Raschkow. The structural characters of this membrane have been already in some measure described (page 250), and it now remains to inquire somewhat more closely into its true nature. Whatever be the explanation, it must not be forgotten that the presence of this so-called membrane can be demonstrated only after the use of reagents, and that a tissue the existence of which can only be discovered after the application of potent chemical reagents, is open to the suspicion of being merely an artificial product.

It will be remembered that this membrane, which is found to be foraminated, is what remains after the enamel cells have been torn away from one of its surfaces, and the calcified enamel fibres from the other. But it may be asked, Why is it that we have cohesion at this part, while the cells above, and the fibres below, so readily separate from each other and

from the coherent part? The solution of this question is probably to be found in the chemical nature of the parts concerned. It is probable that this, which intervenes between the fully calcified and the uncalcified parts, has undergone some chemical change preparatory to, or coincident with, the first deposition of lime salts, by which it is rendered more resistant to the action of reagents than that which lies on either side of it. What the nature of this change may be, is to some extent conjectural, though the researches of Professor Harting, to be mentioned on a succeeding page (page 282), throw much light on the question.

In fine, then, this membrane is to be regarded as the youngest layer of enamel, as yet but slightly impregnated with mineral constituents; and this view has lately received full confirmation at the hands of Waldeyer (2).

Although the fibres of the enamel have attained their full length some time before the tooth is cut, the development of the tissue can scarcely be regarded as matured until after that period; for at the time a tooth passes through the gum, the enamel is comparatively soft and fragile, and it is only after the lapse of some months, or even years, that it attains its full degree of hardness.

Prior to the surface suffering any wear, a membrane can be separated from the surface of the enamel by the employment of an acid. Mr. Nasmyth was the first to draw attention to this fact, and he described the membrane so separated as the persistent dental capsule.

Mr. Huxley considers it to be identical with the membrana preformativa, that is to say, the membrane intervening between the enamel cells and the enamel fibres; which must be regarded as a mere artificial product, and as having no real existence.

Waldeyer (2), who recognises the artificial nature of the so-called "membrana preformativa," regards this Nasmyth's membrane, or cuticula dentis, as formed from the external epithelium of the enamel organ, which, after the disappearance

of the stellate tissue, comes into contact with the internal epithelium, or enamel cells. According to this observer, the cells of the external epithelium of the enamel organ have undergone a metamorphosis into a cornified tissue, and he states that the outline of the cells can be mapped out by staining with nitrate of silver.

Kölliker (1), however, strongly dissents from this view of its origin, and, whilst admitting that accurate researches on the matter are wanting, thinks it more likely that it is a connected layer furnished by the enamel cells as a covering to the whole enamel, a manner of finish for which, he says, many analogies may be found. But none of these views are capable of accounting for all the appearances observed in it.

The cuticula dentis (enamel cuticle, Nasmyth's membrane) is a membrane which may be raised as a continuous layer from the surface of an unworn tooth by the action of acids. It is unchanged by maceration in water, by boiling in strong acetic, hydrochloric, sulphuric, or nitric acids, by the last of which it is stained yellow. Boiled in caustic potash it swells slightly. When burnt it gives off an ammoniacal odour, and leaves a spongy ash.

In the first edition of this book it was stated that in several specimens which had been decalcified after being reduced sufficiently thin for microscopic examination, this membrane was obviously continuous with the cementum of the fang; and in other specimens which had not been treated with acid, the membrane was thickened in the deep depressions of the crowns of molar teeth, and there tenanted by distinct lacunæ. The occurrence of these two circumstances would indicate that Nasmyth's membrane is cementum, rather than membrana preformativa. The general absence of lacunæ in this membrane is due to its want of sufficient thickness to contain them, just as we find these bodies wanting in the cementum of the fang when the layer of that tissue is very thin.

But inasmuch as these facts appear to have been overlooked

by most recent writers, and this view as to its nature ignored, a series of observations on a large number of specimens have recently been made, which are in the fullest degree confirmatory of the conclusions stated in the first edition of this book. It would here be out of place to enter at any length into the facts on which this statement is based, the more so as they are to be found elsewhere (1); but it may be mentioned that it often seems to be continuous, not with the fully formed cementum which forms a thin structureless layer round the neck of the tooth, but with something external to this. And it is a very significant fact, that this membrane presents all the characters of tissue prepared for calcification, which we already know undergoes some chemical change preparatory to the actual deposition of salts, conferring upon it a remarkable power of resisting reagents (see pages 256 and 282).

According to these researches, then, Nasmyth's membrane is to be regarded as cementum either imperfectly calcified, or not yet calcified at all.

Apart, however, from this apparently structureless layer described by Mr. Nasmyth, we may sometimes observe a diminution in the fibrous character of the enamel at the terminations of the fibres on the surface of the tooth, and also at the terminal edge of the enamel on the neck of the tooth. In each of these situations appearances may be found which suggest the idea that a fluid blastema became calcified, and that the fibres had in the process become fused and more or less lost in the mass so formed. Indeed, in the situation last mentioned, lamination of an indistinct character may take the place of fibres; or both the laminated and fibrous arrangement may be replaced by a structure exhibiting little arrangement of parts. In well-developed teeth, however, this deviation from the usual character of enamel is limited to the terminal edge of the tissue.

The preceding observations for the most part relate to the

(1) C. S. Tomes. On the Nature of Nasmyth's Membrane. Quarterly Journal of Microscopical Science, 1872.

enamel when perfectly formed. We have now to direct our attention to defects in the structural character of the tissue. Faulty organization very frequently leads indirectly to the development of disease; it is therefore desirable that the conditions which characterise the imperfections should be recognised. We may divide them into defects in the quantity and in the quality of the tissue.

The Dentine.—If a median longitudinal section of a tooth be made, it will be seen that the surface of the central cavity is everywhere pierced by an infinite number of extremely minute openings. They are the orifices of the dentinal tubes, the parietes of which, together with the matrix in which they lie, make up the walls of the pulp-cavity. The tubes take a radiate course from the central axis formed by the pulp-cavity towards the surface of the tooth. In the crown, and also to some extent, though in a less degree, in the root, in addition to numerous secondary minute undulations, the tubes describe several bold curves, which are commonly described as resembling the italic letter *f*. Those situate in the crown differ in some respects from those which occupy the root of the tooth. In each situation the branches which are given off are very numerous, but in the crown there are comparatively few, until the tubes approach the surface encrusted by the enamel; while in the root branches are given off from the tubes throughout the whole of their course, more abundantly, however, as they near the surface of the dentine. The dentinal tubes, by the anastomosis of their branches, become connected with each other, and also establish relations with the external dental tissues; in the crown of the tooth they terminate by forming loops, or become too minute to be traced, or pass into the enamel and become lost. In teeth the dentine of which is imperfectly developed, the terminal branches are lost among, or end in, the minute cavities which abound in the layers at or near the peripheral surface of the dentine. In the neck and root of the tooth, the branches of the tubes anastomose freely, and are lost

near the surface of the tissue; near the neck they stop short of the cementum, but towards the end of the root they not uncommonly pass into the cementum, and connect themselves with the lacunæ. By the extension of the dentinal tubes into the enamel (1) and into the cementum, a connection is formed more intimate than mere superposition and adhesion of the one to the other would have established, and the more so as the three tissues are developed from distinct formative elements.

In a section which has been dried the tubes become very distinct, and it is often possible, by adding a coloured fluid to the preparation whilst it is under the microscope, to observe its gradual passage into the tubes.

With respect to the contents of the tubes in the fresh state, it was formerly supposed that they contained a clear fluid, and were hence not easy to observe in a fresh wet preparation.

But the view that the canals are hollow tubes conveying a nutrient fluid has, for many years, been almost universally abandoned; M. Kölliker (1) and others, who were at first disposed to call in question the existence of solid contents in the tubes, having for some time past given expression to their conviction that they do exist, and may readily be demonstrated. (2)

If a portion of enamel be accidentally broken from the crown of a tooth, so that the dentine becomes exposed, the

(1) In the marsupial animals the uniform extension of the dentinal tubes, not only into but through the greater portion of the whole thickness of that tissue, forms a character sufficiently marked to distinguish the teeth of that from any other order of mammals.—On the Structure of the Dental Tissues of the Marsupiata, Philosophical Transactions, Part II., 1849. It may be incidentally mentioned here that this penetration of the enamel by the dentinal tubes has been doubted by Waldeyer and Hertz; nothing can possibly be more clear than their passage across the boundary in any well-prepared section, and Kölliker remarks (1) that he cannot conceive how Waldeyer and Hertz can deny its existence.

(2) Mr. Salter (8) stands almost or quite alone in denying the existence of soft fibrils in the dentinal tubes, but the grounds on which he does so being fully met by the statements of various writers, notably of M. Kölliker, do not call for more than passing notice here.

surface of the latter will be highly sensitive to any variation of temperature, or to the contact of foreign bodies; even slight pressure from the tongue will give pain. It is, however, noteworthy that the degree of pain is not increased by increasing the pressure. Then again, it is a fact of every day observation that the dentine immediately below the enamel is much more sensitive than that which lies deeper in the substance of a tooth.

If the pulp of a tooth be destroyed, either by an instrument or by the use of an escharotic, the sensitiveness of the whole of the dentine is immediately lost, no pain being experienced when it is subsequently cut, either near to the enamel or to the pulp-cavity.

If the pulp be destroyed the dentine loses for ever its power of feeling pain, though it may in favourable situations remain hard and free from discoloration, even if exposed to the fluids of the mouth; its sensitiveness is then wholly dependent on its connection with the pulp of the tooth, and it has no inherent sensibility in its own substance.

Nevertheless, the sensitiveness of dentine may be got over without the death of the pulp taking place as a necessary condition. The teeth of young subjects are much more sensitive than those of older people, and this is more especially the case when they are attacked by caries.

The dentine of teeth which are rapidly decaying is much more sensitive than that of teeth in which the destruction progresses more slowly. The former condition is indicated by the light colour of the decomposing part, together with the extent of tissue involved; the latter by the deep brown colour, and the comparative hardness of the affected dentine. In certain cases of caries, the softened tissue appears to be extremely sensitive, so that the patient can scarcely bear its removal; but when the instrument reaches the comparatively healthy dentine, the pain, although present, is much less severe.

After a portion of dentine has been for some time exposed,

or if the exposure be brought about gradually by the slow wearing away of the enamel, that acute sensitiveness which has been described is not found to exist. In parts which have been subject to the foregoing conditions, it will, on examination, be found that the dentinal tubes, the peripheral extremities of which have been exposed, are more or less obliterated in some part of their course between the surface and the pulp-cavity.

And it is possible to destroy the sensitiveness of dentine by local applications, such as nitrate of silver, chloride of zinc, or arsenious acid, any one of which will have the effect of rendering perfectly insensible the surface to which it may be applied, though, unless its action be very prolonged, it will not penetrate to any great depth. On removing the immediate surface which has been acted on by these escharotics the dentine beneath will be found to be as sensitive as ever; thus unequivocally showing that their action has not been upon the pulp, but upon the spot to which they have been applied.

On reviewing the various circumstances under which dentine evinces sensibility, and those under which that sensibility is lost, it is difficult to avoid the conclusion that the dentinal tubes are in some way the medium through which sensation is distributed through the substance of the tissue. But if the sole office of the tubes were conveyance of nutrient fluid derived from the pulp, the difficulty of accounting for the sensitiveness of the dentine remains, inasmuch as we have no instance of sensation being manifested in a fluid. We might endeavour to get out of the difficulty by assuming that the dentinal tubes are constantly filled by fluid, and that pressure made upon the fluid at the exposed ends of the tubes is felt by the pulp at their inner extremities. This assumption does not, however, account for nearly all the circumstances of the case, failing altogether to explain the greater sensibility of the dentine at one part of the tooth than at another, or the local effect of escharotics.

The want of accordance between the views formerly entertained upon the structure of dentine and the physiological conditions manifested by that tissue when in connection with the body, has wholly arisen from the assumption that the dentinal tubes are solely for the conveyance of fluid, and that they were destitute of solid or semi-solid contents. With the hope of gaining some further knowledge upon this point, I commenced a series of observations, having, however, but little expectation of finding that one of the most important parts in dental structure had been overlooked, namely, that each dentinal tube is permanently tenanted by a soft fibril, which, after passing from the pulp into the tubes, follows their ramifications. (1)

If a tooth or a section be subjected to the action of dilute acid (hydrochloric acid answering the purpose well), a firm elastic mass is obtained which preserves the external form of the tooth, and, on microscopic examination, is found also to preserve its structure. It is in fact the organic basis of dentine, the framework in which the calcareous salts were deposited, which is left behind after their removal by the acid.

But if in the place of dilute acid, concentrated hydrochloric acid had been employed, after a time nothing but a sticky, slimy mass would have remained, in no way retaining the form of the tooth. And, on microscopic examination, this would be found to consist wholly of long tubes tangled together, and obviously very flexible and very tough.

These tubes, which constitute the special walls of the dentinal canals, are the most indestructible part of the whole tooth; prolonged boiling in strong hydrochloric acid or in caustic alkalies has no effect upon them; and they may be obtained even from fossil teeth (Hoppe-Seyler). They constitute the "dentinal sheaths" of Neumann, and previously to

(1) On the Presence of Fibrils of Soft Tissue in the Dentinal Tubes, by John Tomes, F.R.S., Surgeon-Dentist to the Middlesex Hospital.—Philosophical Transactions, Vol. 146. 1856.

the decalcification were intimately connected with the matrix which they traverse.

They may be obtained after the tooth has been long macerated so as to putrefy, or has been long boiled in caustic alkalies so that any soft tissue would have been destroyed (Kölliker, 1). Their precise chemical nature remains somewhat doubtful. Waldeyer (2) considers them allied to elastic tissue; but Neumann (9) holds them to be calcified; whilst Kölliker (1) compares them to the internal sheaths limiting old Haversian canals, and to the capsules around osteoblasts which may sometimes be isolated in cementum.

Deferring for the present the further consideration of the dentinal sheaths, we pass to their contents. In the interior of each (in the fresh tooth) lies a soft homogeneous fibril (1), by no means so indestructible as the sheath. Thus, if the tooth be allowed to putrefy, or be boiled, or even treated in the cold with caustic alkalies, it absolutely disappears; and it is by no means difficult to destroy it by the use of acids.

If a section be made of a recently extracted tooth in a direction parallel with the tubes, placed in dilute hydrochloric acid till it is decalcified, and then torn in a direction transverse to that of the tubes, the torn edges will be seen to be fringed with transparent processes of varying length.

In repeating the experiment, it is desirable to place the decalcified section upon the slide before tearing it, as if it be lifted from the surface on which it has been torn, some of the longer fibrils may get folded back upon the body of the section, and thus become hidden from view.

Where the separation between the torn surfaces has been but slight, we may often see an unbroken cord stretching across the interval between the two halves of the dentine.

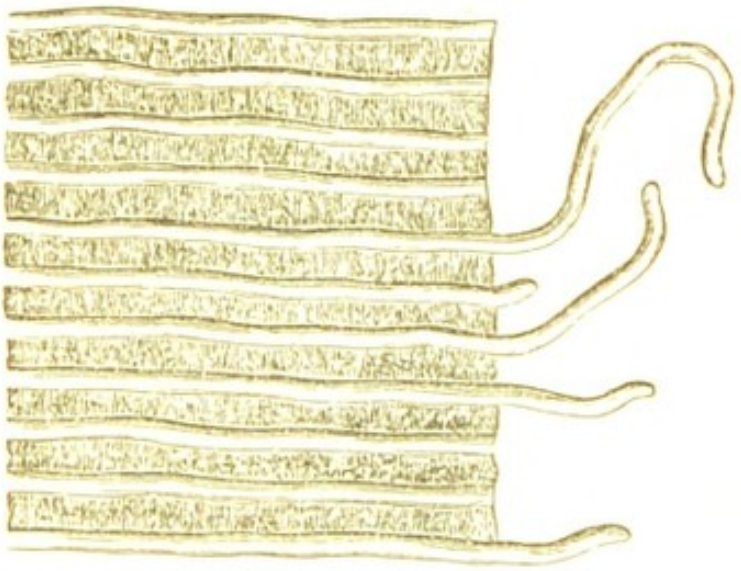
If a section be taken in which the tubes are extended into the enamel, and submitted to the action of acid, it will be found that after the latter tissue has been dissolved, fibrils

(1) Kölliker, Waldeyer, Beale, Neumann, Lent, Boll, Santi Sirena (who has demonstrated their existence in amphibia and in lizards), Wenzel, and others.

will remain connected with the dentine at those points where the tubes penetrated the superjacent structure.

Now, it is perfectly possible to get both the sheaths and their contained fibrils standing out from the edge of the dentine in one and the same specimen. Neumann (9) has succeeded in demonstrating both the sheaths and the fibrils in the same specimen by the use of acids; and Boll (3) has described and figured the sheaths projecting from the edge of the den-

Fig. 128. (1)



tine, and the fibrils from the end of the sheaths, using for the purpose teeth which had been placed in chromic acid in order to harden the soft parts, and subsequently decalcified.

It is quite possible that in some of the decalcified specimens originally figured as showing the fibrils, what were really seen were the dentinal sheaths, the separate existence of which was not at that time fully recognised; but this does not apply to sections which have not been decalcified; in these the fibrils, and they alone, are found to project from the cut edges.

But if the soft parts have been destroyed by caustic

(1) A section from the crown of the tooth of an adult, made in a plane with the direction of the dentinal tubes, and afterwards decalcified and then torn in a line transverse to the direction of the tubes. The fibrils are shown extending from the torn edge of the dentine.

alkalies, or by putrefaction, the soft fibril can no longer be brought into view, although there is no difficulty whatever in demonstrating the walls of the tubes (Kölliker, 1).

It is not necessary, however, to decalcify dentine in order to show the fibrils. If a similar section to that already described be divided with the edge of a knife, many of these

Fig. 129. (1)



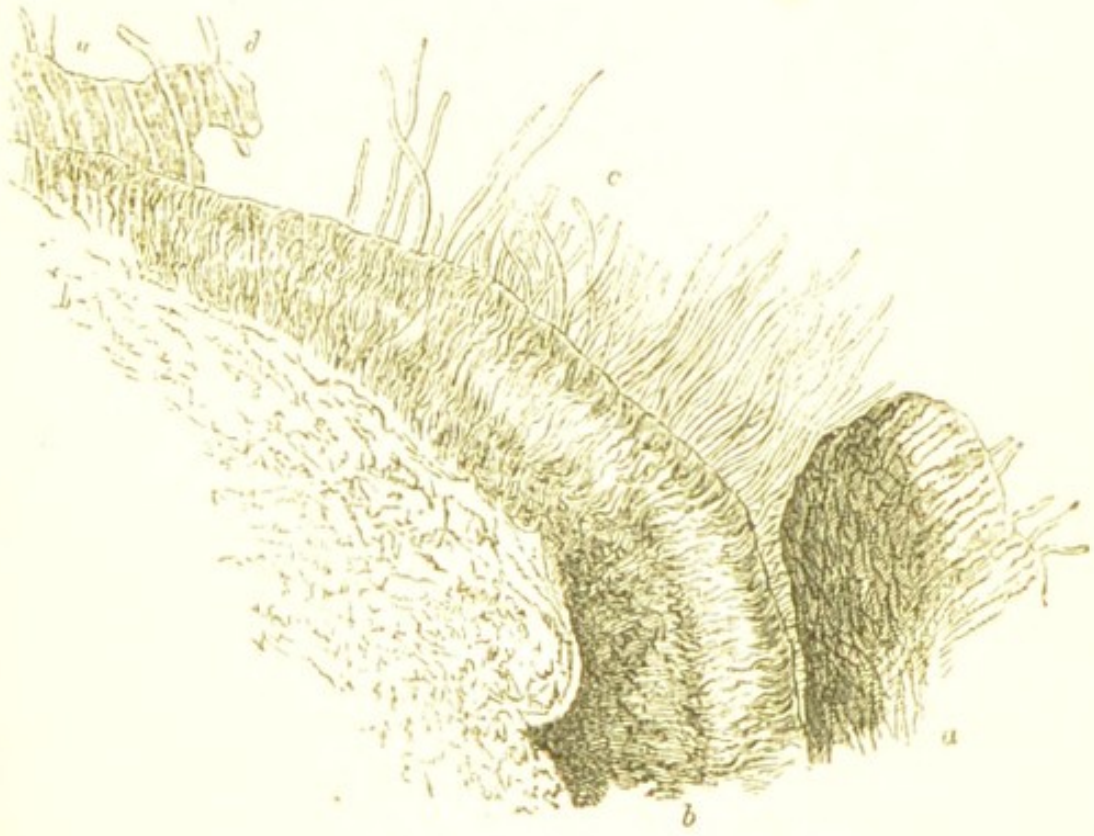
delicate organs will be seen, but they are usually broken off much shorter, many of them scarcely projecting beyond the orifices of the tubes. Again, if a minute portion of dentine be cut with a sharp knife from the surface produced by fracturing a perfectly fresh tooth, the same appearances will be seen, but not with the same certainty and distinctness, as in the previous examples.

In order to demonstrate the connection of the fibrils with the pulp, fine sections should be made with a sharp knife from the edge of the pulp-cavity. In this manner I obtained the specimen from which Mr. De Morgan has been kind enough

(1) After Boll. In this section the dentinal sheaths project for a short distance beyond the investing matrix, whilst the fibrils are seen issuing from the termination of the sheath.

to draw the accompanying illustration, showing the fibrils stretching from the pulp to the displaced dentine, and some of them passing out on the other side of the fragment (Fig. 130). That the fibrils proceed from the pulp may be seen by carefully fracturing a fresh tooth with as little displacement of the fractured parts as possible; and then, by

Fig. 130. (1)



slowly removing the pulp from its place in the tooth, we shall be enabled to examine the fibrils which have been drawn out from the tubes. By this procedure some of the fibrils will be withdrawn from their normal position in the dentine in the greater part of their length, a few of them retaining short lengths of their branches, but sufficient to show that they have come from the branches of the dentinal tubes;

(1) A section made with a knife from the edge of the pulp-cavity of an adult tooth, including a portion of the pulp; (*a*) the dentine; (*b*) the pulp, with the peripheral cells arranged in lines; (*c*) the dentinal fibrils drawn out of the displaced dentine; (*d*) fibrils which pass through the fragment of dentine, and appear on the surface farthest removed from the pulp.

and Dr. Beale has figured (5) a fibril proceeding from an odontoblast through a minute fragment of dentine, in which it appears as though the cell nucleus were produced out into the fibril. According to Neumann (9) and Waldeyer (2), the fibrils become atrophied in their peripheral portions in advanced age, and ultimately the canals become obliterated. This coincides with the observations of Dr. Beale, that the canals are largest near to the pulp, and become progressively smaller towards the periphery; and with the remarks of Robin and Magitot (10), who point out that the great discrepancies found in the results of analyses of human teeth arise out of the fact that the teeth become more rich in calcareous salts as age advances; so that, unless teeth from individuals of the same age, or rather teeth which are just in the same stage of their slow calcification, are selected, the results must be of necessity very various.

This, probably, also accounts for the statements of Hertz, who believes that the soft fibril exists only in the dentine near to the pulp, but that at a distance it is absent; the probability is that the teeth submitted to examination were from individuals of advanced age.

In preparations in which we are fortunate enough to retain a portion of the pulp with the dentine, it may readily be seen that the soft fibrils are processes of the cells known as "odontoblasts," which constitute the peculiar layer called the "membrana eboris." If a tooth be taken in which the formation of dentine is no longer active, the cells are elongated and oval in form, tapering down towards the dentine till they attain the size of the fibril; but if the same cells be examined in a young and rapidly-growing tooth they are found to be much wider and to be truncated towards the dentine, so that they present flat ends, from which spring, rather abruptly, one or more processes which enter the tubes and constitute the dentinal fibrils. Boll (3) has counted as many as six processes from a single cell, but this is an exceptionally large number.

The process which enters the canals in the dentine is not the only one proceeding from the cell; there is always a process at its opposite pole, proceeding down into the pulp and connecting it with cells of a deeper layer, and there are also lateral processes which connect it with the odontoblast which lie around it.

The fibrils are solid and homogeneous, and may be stained with carmine, though they do not take the pigment with the same readiness as the nuclei of the cells do.

On examining a pulp with a low magnifying power a large number of fasciculi of nerve fibres are seen passing upwards, parallel with the long axis of the pulp; these are mainly derived from a single largish nerve trunk which passes into the fang, often accompanied by several smaller branches. In the expanded portion of the pulp in the crown of the tooth these nerve fibres form a rich plexus with elongated meshes, and, according to Professor Kölliker, break up into primitive fibres which form evident loops. By treating perfectly fresh pulps with a very dilute solution of chromic acid ($\frac{1}{32}$ per cent.) Boll (3) was able to discover an enormous number of very minute fibrils, which he traced into continuity with the dark-bordered nerve fibres.

What becomes of these fine fibres, which are especially abundant immediately beneath the membrana eboris, is not certainly known; but from this plexus Boll observed numerous fibrils passing up between the odontoblasts, and projecting out beyond them amongst the dentinal fibrils.

From the direction so frequently assumed by these very fine fibrils, Boll supposes that they must, like the dentinal fibrils, have been drawn out from the tubes, but he has not been successful in actually seeing one passing into a dentinal canal.

The nature and functions of the dentinal fibrils still remain for consideration; but, as Boll also found, the study of this matter is so inextricably mixed up with that of the develop-

ment of dentine, that the one cannot be dealt with without entering at some length into the other.

Various and irreconcilable opinions are held on this matter of development, but on the one point, namely, that the odontoblasts play some very important part in the process, most authorities are agreed; though Professor Huxley maintained that the dentinal pulp had no very direct influence in the formation of the dentine.

The tooth germ, or papilla dentis, corresponds in form to the future tooth, or at least to that part of it which is at the particular time about to be calcified. In its central portion it is very rich in nerves and also in vessels, the latter forming a dense plexus immediately beneath the outer layer of specialised cells. This layer, the membrana eboris, is not penetrated by vessels, but consists of a number of cells (odontoblasts) arranged perpendicularly on the surface, like an epithelium, and pressed closely together so as to be in intimate contact with one another.

The internal portions of the pulp consist of a fine fibrous connective tissue containing great numbers of cells, at first round but later becoming spindle-shaped (Kölliker). With respect to the outer layers of the papilla, some little difference of opinion exists; thus Kölliker holds that it is bounded externally by a structureless membrane (membrana preformativa), which, however, plays no part in the development of the dentine, while the existence of any membrane in this situation is denied by many other observers. The explanation given by Robin and Magitot (10) of this appearance of a membrane in a place where none exists seems reasonable: they point out that the gelatinous-looking intercellular substance which abounds in an early embryonic pulp projects outwards beyond the odontoblast layer, so that it appears to form a sort of film or varnish over these cells. Moreover it is stated by them that this intercellular nature is more dense at the periphery of the pulp than in its interior, so that the resemblance to a definite limiting membrane is yet further increased. This

view, namely, that the membrana preformativa of Raschkow is the most external layer of matrix, projecting beyond the odontoblasts, is also advocated by Hertz and Wenzel (15). It does not, however, appear that this structureless matrix plays any part in dentine formation; in fact, Boll states that it disappears.

With regard to the share taken by the odontoblast cells, the prevalent opinions admit of division into two classes; according to the one, the whole of the dentine structures, namely the fibrils, the sheaths of Neumann, and the matrix, are wholly and directly derived from the odontoblasts, whilst according to the other, the matrix is a separate secretion, an "intercellular" substance, and the canals and fibrils alone are derived directly from a conversion of the odontoblasts.

To take the latter view first, it is supposed by Kölliker and Hertz that the odontoblast layer of cells furnish a secretion which is of a gelatinous nature, and is shed out from the layer of cells in common, but does not stand in any definite structural relation to the individual cells; by the calcification of this secretion the intertubular matrix is formed, whilst the cells and their processes go to form the tubes and their contents. (See also Wenzel, 15.)

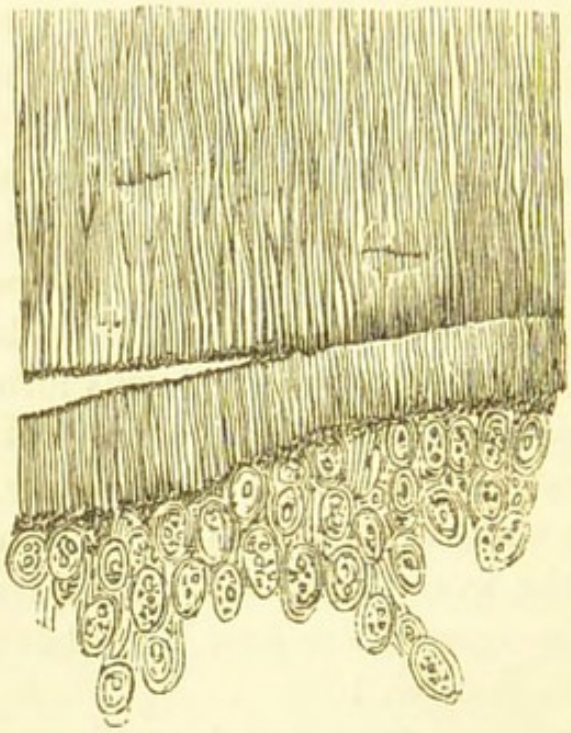
M. Lent figured and described long filamentous processes of the dentine cells which he regarded as forming the canals, the existence of the soft fibrils not having been recognised at that time. Professor Kölliker considers that a single cell may generate the whole length of a tube and its contents, but qualifies the statement by saying that, though constricted cells occur, it is possible that the connection with the mother cell may never be lost, so that it may or may not be true that one cell forms the whole length of the fibril.

In opposition to the views above briefly indicated, is the opinion held by Waldeyer, Boll, Dr. Beale, and many others, that every part of the dentine is a direct product of the conversion of the odontoblasts. This latter view is probably the true one; but, as will presently be seen, it does not, after

all, differ so very widely from that held by Kölliker and Hertz.

On reference to the accompanying figure, or to the excellent figures given by Boll (3), it will be seen that the odontoblasts close up to the dentine are in actual contact with one another, and that there is no room for an intercellular substance.

Fig. 131. (1)



The preparation was made by breaking the tooth through the centre immediately after its removal from the mouth, and cutting with a sharp scalpel a very thin fragment from the edge of the pulp-cavity, the pulp itself being present at the time. We have in this example the dentinal cells adherent to the developing dentine, and the continuity of the calcified and uncalcified tissues clearly shown; and further, that it is only necessary for the cells to become hardened, and, as it were, fused together, by the reception of the salts

(1) Showing the appearance presented by a section cut with a sharp knife from the edge of the pulp cavity of a tooth recently extracted. The peripheral dentinal cells are retained in their natural position as respects the developing dentine.

of lime, in order to convert them into a mass similar to the dentine to which they are attached.

The most external portions of the odontoblasts undergo a metamorphosis into a gelatigenous matrix, which is the seat of calcification, while their most central portions remain soft and unaltered as the fibrils. Intermediate between the central permanently soft fibril and the general calcified matrix, is that portion which immediately surrounds the fibril,

Fig. 132. (1)



namely, the dentinal sheath. According to this view the fibril, the sheath, and the matrix are but three stages in the development of the same tissue; as it is expressed by Dr. Beale, they are bioplasm, or germinal matter, formed material, and calcified formed material. There is much to be said in favour of this theory of dentine formation; there is the fact, insisted on by Dr. Beale, that the hollows of the canals are largest nearest to the pulp, and smallest at the periphery of the tooth, in other words, at the oldest part; and that calcification is still slowly going on, even in advanced life, leading to the peripheral obliteration of the tubes. A further corroboration of this may be found in a paper published

(1) Isolated dentinal cells, which have become detached, and were found floating about in the fluid in which the preparation forming the subject of the last illustration was placed. In these the pulp process and the lateral processes are not seen, as is apt to be the case unless special precautions are taken in preparing the specimen.

some years ago, on the Dental Tissues of the order Rodentia (Tomes, 17).

It was there stated, speaking of the incisor teeth of rodents, that "the tubes which proceed from the pulp-cavity near the base of the tooth, are, in most cases, perceptibly larger than those that are situated higher up; hence it follows that, as the latter were once near the base of the tooth, the dentinal tubes undergo a diminution of calibre after their formation. In the teeth of the Sciuridæ I have found a difference of size amounting to a third or half between the tubes near the base and those near the surface in wear."

Then, again, there is the strongly-expressed opinion of Boll, who states that the odontoblasts have certainly no limiting membrane, but shade off insensibly from their innermost to their outermost portion, and it is noticed by Wenzel (15) that fresh odontoblasts have no membranous investments, sharply-defined contours being seen only after the use of re-agents. The recent valuable researches of Professor Harting (12) serve to throw considerable light on the question. He appears to have followed in the line of inquiry first pursued by Mr. Rainie (page 281), and was successful in making a variety of structural forms by inducing the very gradual precipitation of lime salts in solutions containing albumen, or other organic constituents; and not only did the lime salts assume a definite structural arrangement, but the albumen itself became profoundly modified.

It was found that on treating one of the "calcospherites," or other forms thus artificially produced, with an acid, though the lime was entirely removed, the mass retained its form and structure; it had, in fact, an organic matrix.

This matrix was composed, not of ordinary albumen, but of a substance closely resembling chitine in its chemical relations; that is to say, a body exceedingly insoluble and exceedingly resistant to the action of re-agents.

Now, it is a very remarkable fact, that parts which are just on the borders of calcification do present this very character,

namely, a remarkable power of resisting re-agents; thus it will be remembered that the most indestructible part of the whole tooth substance is the dentinal sheath of Neumann, or that part which intervenes between the soft fibril and the completed matrix of the dentine.

Similarly, it is found that the linings of Haversian canals, or the immediate surroundings of a bone lacuna, may be isolated by the use of acids; that is to say, they have a greater power of resistance than either the fully calcified tissue or the soft tissue which Dr. Beale terms bioplasm.

If a tooth which has been affected by caries be taken, appearances may be seen which are wholly confirmatory of the views just expounded. When the progress of the disease has been rapid, the effect is precisely that of an acid; that is to say, the very resistant dental sheaths of Neumann may be isolated in short lengths, and appear as distinct tubes.

But if we take a carious tooth in which the progress of the disease has been slow, and the diseased part consequently firm, and of a deep brown colour, and make thin sections with a knife transverse to the direction of the dentinal tubes, it will be found, by the use of the microscope, that the preparation is made up of comparatively large discs, each having a central aperture or mark; and that the discs are united to each other by an interposed tissue, small in amount, but capable of distinct recognition. Now, these discs have a much greater diameter than the dentinal tubes, as seen in a transverse section of healthy dentine, and they have, moreover, a very varying diameter. If the caries is in an early stage the discs are not very large, and the intervening substance is present in considerable amount, but as the disease progresses, the discs enlarge till they meet one another.

If it be granted that the soft fibril, the sheath, and the matrix are but three stages of the same formative elements, the phenomena observed are readily explicable. The fibre or germinal matter disappears, and leaves the central aperture; the chitinous (?) intermediate layer which forms the sheath

resists the disintegrating action, while the progress of the disease gradually undoes the work of calcification.

In a certain stage of the disease the tubes appear to have extremely thick walls, so that but little space is left for an intertubular connecting tissue, whereas in healthy dentine the diameter of the tubes is relatively small, and the amount of intertubular tissue is comparatively large. The different characters seen in the two cases may perhaps admit of explanation on the following hypothesis, namely, that the optical difference between the sheaths and the calcified matrix is removed by the disease as it effects the work of decalcifying the tissue; but in the later stages the greater power of resistance due to the peculiar chemical characters of the sheaths lead to their remaining behind, isolated by the total disintegration of the intervening tissue. It is quite possible to conceive that an equal degree of calcification would efface the differences which were apparent in the soft tissue prior to its induration, and that a higher or lower degree of calcification in the part in immediate contact with dentinal fibrils, would produce such a distinction of parts as that which characterises the dentinal tubes; and that decalcification might, under favourable circumstances, restore an appearance which had been lost, and obliterate one which had been produced by calcification.

It has already been pointed out that every odontoblast communicates by means of its pulp process with the cells which lie deeper in the pulp. Hence when one odontoblast is fully used up in the process of calcification, another is ready to take its place without any breach of continuity, and every dental fibril may be regarded as the remnant of several continuous odontoblasts.

In respect to the parenchyma of the dentinal pulp, M. Kölliker speaks of its relation to connective tissue. Now, I have seen instances, and not uncommonly, in which connective tissue very similar to the stellate areolar tissue, could be traced in the substance of the pulp of a forming tooth.

Again, the relations of the peripheral dentinal cells to each other, and to the cells placed internally to the outer layer, are not fully made out by the authors cited. If one cell, or even two or three only, is concerned in the formation of a dentinal tube throughout its whole length, it would be difficult to account for the presence of obliterated tracts of vessels found in the teeth of many animals, and occasionally in the teeth even of the human subject. I have several sections of molar teeth, in which large looped tubes, corresponding in size to the capillaries of the dentinal pulp, are present in the dentine. Their position and size will justify the conclusions that they were once occupied by vessels—that they are the remnants of the vessels of the formative dentinal pulp. Now, supposing the parenchyma of the pulp had been bodily removed to make way for the centripetal or inward growth of the dentinal cells, it is not easy to see how these canals could have been left. But if the cells are produced in linear series, the more internal ones becoming gradually developed as the external undergo calcification, the persistence of obliterated vascular canals can be readily understood. It is true the existence of these canals in the dentine is quite exceptional in human teeth, but in the teeth of many mammals they form a constant character. The dentine of mammalian teeth, however, in other respects corresponds too closely to admit of the supposition that the process of development varies in any essential particular. If, for example, we take the developing incisor of a calf, and examine the pulp after withdrawing it from the investing cap of dentine, we shall find here and there long tubular processes projecting from the surface, the continuations of which may be traced into the substance of the pulp. Their size, position, and connection with the pulp leave no doubt that they are obliterated capillaries, the coats of which have been retained while the cells around them have undergone calcification. Had the parenchyma of the pulp gradually made way for the inward growth of the external cells—the *membrana eboris* of

Kölliker—these canals would surely have gone with it. I have made preparations in which several cells, more or less elongated in form, have been united end to end, not with that uniformity, as regards size and position, which characterises the members of a linear series of cells in ossifying temporary cartilage, but still their position and connection with each other has been sufficiently distinct for positive recognition. Again, if we examine the peripheral cells in a pulp in which calcification is about to commence, and compare them with similar cells in a pulp taken from a tooth the development of which is approaching completion, it will be seen that in the former they are much smaller in size and more numerous than in the latter example.

It may be asked, whether one element of the pulp more than another suffers absorption, in order to give space for the dentinal cells to grow, seeing that after the cap of dentine has been formed, it limits, by enclosing within its unyielding case, the general bulk of the pulp. Such a question can be answered only hypothetically. The pulp contains an infinite number of nuclei, any or a certain number of which are probably capable of becoming developed into cells. I believe it will ultimately be found that a growing cell, when placed in organized matter which is not itself in a state of development, is capable of growth at the expense of such matter, whatever may be the degree of its organization. It is quite clear that many of the nuclei, the vessels, and connective material, which constitute the dentinal pulp, disappear in favour of the dentinal cells prior to the calcification of the latter, though the manner of their disappearance is not fully made out.

We have now reached a point when the functions of the dentinal fibrils may be more profitably discussed. The conditions under which sensation is manifested in the dentine have already been stated, together with those under which it is lost, and the difficulty felt in accounting for these phenomena has been pointed out. The recognition of the

dentinal fibrils may, however, I think, help to remove that difficulty, and enable the physiologist to explain why, under certain circumstances, dentine is susceptible of pain, while under other conditions the sensitiveness is lost.

That the dentine owes its sensation to the presence of soft tissue in the tubes cannot, I think, be readily doubted, seeing that if their connection with the pulp be cut off by the destruction of the latter, all sensation is at once lost.

As has already been stated (page 269), no one has ever seen a nerve fibre enter a dentinal tube, though Boll considers it probable that they do so. The present knowledge of the peripheral distribution of the nervous system is by no means so complete that generalisations may be safely drawn from it, and as the use of the higher powers of the microscope becomes more understood, nerves of extreme minuteness are being almost daily traced into tissues whence they had previously been supposed to be absent; at least, in so far as they had never been demonstrated.

It is not absolutely certain that no structures other than nerves have the power of conducting sentient impressions, and hence it is not quite necessary to assume that the dentinal fibrils are actual nerves before allowing them the power of communicating sensation. Many animals are endowed with sensation, which yet possess no demonstrable nervous system; and we may find many points in the human body highly sensitive, without our being able to demonstrate the presence of nerves in such numbers as would account for the pain uniformly experienced from the puncture of a needle, upon the supposition that the needle had in each case wounded a nerve. Additional evidence in favour of the view that the fibrils, or other soft contents of the tubes, possess sensation may be obtained by examining their condition in diseased teeth, in connection with the phenomena manifested by the disease. In those cases in which the fibrils are obliterated in the manner which will be hereafter described, there is perfect absence of pain when the affected part is cut into, but

so soon as the instrument reaches the healthy dentine, more or less inconvenience is felt. If, on the other hand, there is no consolidation of the fibrils, but the pulp is yet living, the operation of removing the carious part is productive of pain, even from the commencement; indeed, pressure upon the surface of the softened tissue gives rise to discomfort. If in such cases the softened dentine be examined, fibrils may here and there be found but little altered from their natural appearance.

The greater degree of sensitiveness observable in the dentine immediately below the enamel—that is, at the point of ultimate distribution of the dentinal tubes, and consequently of their contents—may be fully accounted for on the supposition that the latter are organs of sensation, and subject to the same laws as nerves of sensation, the highest sensibility of which is confined to their terminal branches.

The recognition of the dentinal fibrils must lead to a modification of the opinions once entertained as regards the office of the tubes, namely, that they are for the circulation of fluids only. The presence of soft tissue would not, however, hinder the slow passage of fluids; there are abundant instances of nutritional changes taking places at a distance from vessels, and the fact that calcification of the fibrils goes on in old age shows clearly that fluids can and do pass along them. For when the fibrils become calcified near the surface of the dentine, the hardening material must have been derived from the pulp; at least, when the consolidation has taken place in the crown of the tooth.

From what has been said, it will be obvious that some uncertainty must at present rest on the functions of the dentinal fibrils. That they, or some other soft contents of the tubes, are the agents by which sensation is carried to the pulp may be regarded as perfectly established; and, inasmuch as no other soft structures have been traced into the tubes, the inference is that the fibrils themselves possess this function. At the same time, in other parts of the body there

exist nerves of such minute size that their existence, though it may be inferred elsewhere, has only been as yet demonstrated in tissues which naturally present great facilities for examination, such as the bat's wing stripped of its outer layers; and were such fibres to exist in the teeth, which present such great obstacles to the use of high powers, they would almost surely escape our notice.

With reference to this matter, Professor Kölliker remarks, that, inasmuch as cellular elements have been, according to modern observations, often found in connection with nerve endings, it is not at all impossible that the odontoblasts may stand in some relation to the endings of nerves in the pulp.

In the present state of our knowledge, the question cannot be regarded as capable of being definitely settled; this much only is certain, that sensation is conveyed by some soft contents of the tubes, whether by the fibrils or by something else cannot be positively stated.

According to the researches of Mr. Rainie, already alluded to (13), if carbonate of lime is formed in a thick solution of mucilage or albumen by the decomposition of carbonate of soda or of potash, the newly-formed salt takes a globular instead of a crystalline form. The globules produced are composed, however, not only of carbonate of lime, but also of a certain portion of the mucilage or albumen in which the combination has taken place. In proof of this assertion, he states that the lime may be removed by an acid, without occasioning the destruction of the form of the globule from which it has been so abstracted; just as the form of a bone is maintained after the earthy matter has been removed. It is further stated, that phosphate of lime, if produced under similar circumstances, supposing a minute quantity of carbonate of lime be present, will, like the carbonate, assume the globular form. These globules are laminated in structure, and appear to be capable of increase by the addition of new layers upon the surface. If two or more lie in contact, they become perfectly united into one laminated mass, by the

blending or fusion of the laminæ which come in contact. The globules themselves are stated to be produced by the coalescence of smaller masses, which again are made up of still smaller spherules of similar material; the individuality of the constituent bodies being ultimately lost in the uniform fusion of the whole into one compact mass. Globular masses which at one time have a rough and mulberry-like appearance, gradually, by the coalescence and, as it were, fusing down of the constituent spherules, become perfectly smooth. The lamination is supposed to result from the arrangement of the masses in concentric layers, and their subsequent coalescence. In the discovery of the substitution of the globular for the crystalline form of these two salts of lime, Mr. Rainie considers he has found an explanation of the process of calcification, not only of bone and teeth, but also of the formation of shells, and his results have been confirmed and extended by the more recent researches of Professor Harting (12), who has added to what was already known the important and significant fact that the albumen itself becomes changed into a remarkably insoluble and resistant substance, resembling chitine in its behaviour with re-agents, to which he gives the name of calcoglobulin.

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 a 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.

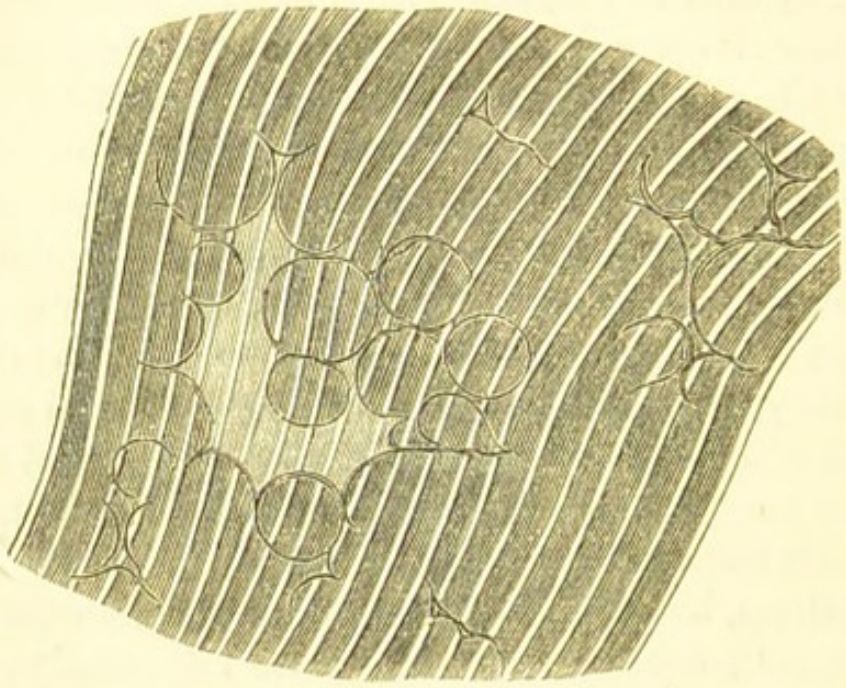
Sometimes, however, the coalescence of the globules formed in developing dentine only takes place imperfectly; that is to say, contiguous globules may coalesce in such a way as to cut off and isolate a portion of the formed matrix which has not as yet been impregnated with salts. When the tooth is dried 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 (14); they may be excellently seen in teeth which have been rendered translucent by boiling in wax. In the specimen here figured (which has been 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. As might be expected, therefore, the tubes and their contents pass across the spaces without any interruption in their continuity. The soft matrix which fills the interglobular space may be

Fig. 133.



slightly stained by prolonged soaking of a fresh tooth in Dr. Beale's carmine fluid, and it differs from the surrounding matrix which has been impregnated with lime in salts, in that it is more resistant to the action of acids. Like the dentinal sheaths, the lining of Haversian canals, or the encapsuled lacunæ of cementum, the soft contents of the space may be isolated by maceration of the tooth in acids; and they present us with another example of that remarkable chemical transformation which tissue undergoes immediately before the deposition of lime salts, conferring on the structures

immediately on the verge of calcification such a remarkable power of resisting re-agents.

Occasionally, however, the contents of the space appear to 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 progress 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 globules 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.

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 dental 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, somewhat irregular in outline, but tolerably uniform in their direction (1). Without following closely the course of the enamel fibres, they have a general direction towards the surface of the tooth, and terminate abruptly after advancing but a short distance into the substance of that tissue.

Many other deviations from that which must be regarded as the normal form of the dentinal tubes, have been already described (2), and might now be enumerated, but that they for the most part are strictly local, being often confined to a few tubes, and are consequently incapable of exerting any influence upon the teeth in which they occur, hence the enumeration does not fall within the scope of the present work.

The structure of the cementum will be described before treating upon its diseases.

The structure of the enamel and the dentine has been entered into at some length, prior to treating upon the diseases to which they are subject, on the supposition that the organization of a part should be kept clearly in view when an attempt is made to appreciate the nature of its diseases.

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 lattter respect the organization may also be imperfect. Teeth presenting such characters are commonly spoken of as honeycombed. 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

(1) Professor Kölliker gives an excellent figure of such cavities in his work on histology, so frequently cited.

(2) Lectures on Dental Physiology and Surgery.

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 grooved only 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 honey-combed 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, 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.

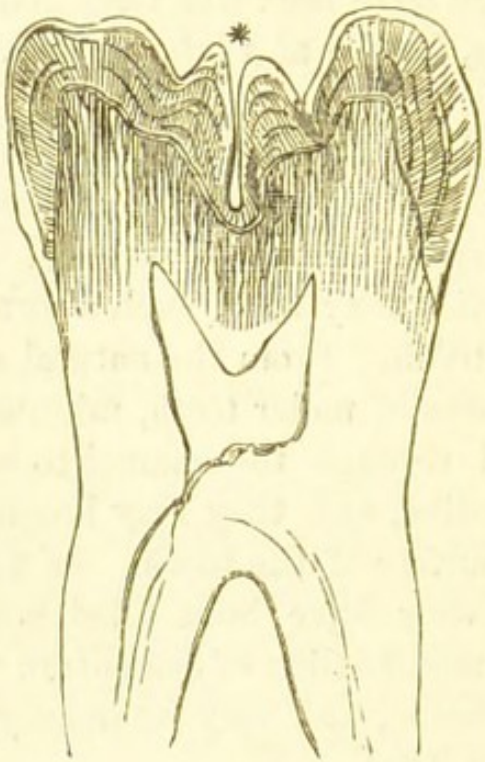
There is another form of defect in quantity. A molar tooth may present to the naked eye all the appearances of a well-developed organ, and yet the enamel may be imperfect, and the imperfection may be in such a form as to insure the early loss of the tooth. From the natural depressions which separated 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 (Fig. 134).

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 account which has been given of the structure and development of the enamel will, though in a histological point of view very imperfect, be sufficient to render intelligible that which has to be said on the subject of imperfection in the organization tissue.

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

Fig. 134. (1)



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,

(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.

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, as shown in Fig. 124, or a line of fine granules. 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 honey-combed 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.

Many other structural defects in the enamel might be noticed here, but, inasmuch as they have no very practical bearing, want of space forbids their introduction.

The close relation which exists between constitutional conditions and imperfect development of the teeth is often exceedingly clearly indicated by the four first permanent molars, which, being simultaneously developed, all present in an extreme degree the character of honeycombed teeth, whilst the other teeth in the same mouth are well formed.

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 commences. The disease may extend to, or may even commence in, the cementum in 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 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. Much has been written in favour of each of these views, and

yet the subject cannot by any means be held to be settled. As it would be impossible to summarise and criticise the views advanced by the numerous English and foreign authorities who have contributed to the literature of the subject, without unduly encumbering the text, and as, at the same time, the present volume would be incomplete without such a chapter, it is thought desirable to embody these theoretical considerations in the form of an Appendix, merely giving here in the text a brief account of the appearances actually observed.

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 has succeeded to one of the forms of imperfect development already described. Either the union between the sheaths of the formative fibres has been imperfect, and the strictly fibrous condition has been maintained until, under the influence of disease, the union, at best but imperfect, becomes sufficiently interrupted to give opacity to the parts; or the granular condition previously alluded to has been continued, and thus rendered the tissue susceptible to influences which would have failed to produce any injurious effects had the organization been more perfect. The predisposing causes to disease have, however, been described in connection with the structure and the development of the enamel, and the description

need not be repeated. After recognising a distinction between the central and the external portions of the so-called fibres, and the more rapid action of a mineral acid upon the contained than upon the containing part, it may reasonably be expected that some such difference would be observed in enamel when undergoing changes from the action of disease. It would be most difficult to obtain a transverse section of enamel which has been subject to the changes produced by caries, but we may, by breaking down upon a glass slide fragments of the brittle and chalk-like enamel taken from a carious tooth, produce a sufficiently satisfactory preparation for demonstrating the fact that the central portion of the fibre is the first to suffer decomposition, much in the same manner as when the destructive agent is intentionally applied to a section prepared for experimental treatment.

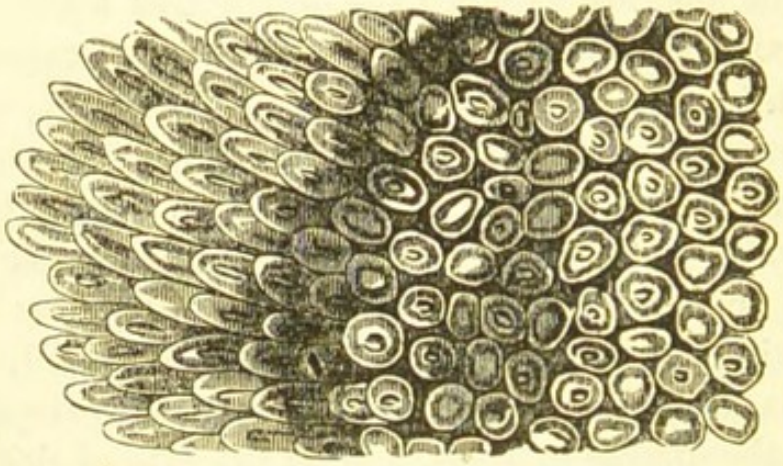
The foregoing description applies to those cases where the disease has commenced upon a surface free from depressions, and extended through the porous enamel into the dentine. Not that the process of decay materially differs in conformity with the character of the surface attacked, but the progress is 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 indications of its presence are not strongly pronounced, until a very considerable amount of destruction has been produced. A consequence which results from the disease having extended 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.

For the convenience of description, the disease, when it assumes this form, may be termed penetrating caries, re-

serving the terms, spreading caries, for the form previously described.

As respects the dentine, the progress of decay does not follow the same course as that which has been described in reference to the enamel. 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

Fig. 135. (1)



has in a measure undone the work of development and thrown light on the question how this was effected; it may 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. 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

(1) A section from dentine softened by caries, showing the consolidated dentinal tubes and fibrils cut transversely.

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 the manner figured in my previous work; 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 pre-

sents pretty nearly its natural appearance, we then pass to a point where the appearances depicted on the preceding page 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 dental tubes be isolated by the application of acids, they will often be found to present varicosities and globular swellings. (1)

If a tooth 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; but that it has spread to a greater length in the course of the trunks of the involved tubes following their convergent course towards the

(1) Excellent figures are given of these beaded, elongated bodies in Heider and Wedl's Atlas zur Pathologie der Zahne, part iii., pp. 792, 93; and they are further described in Wedl's Pathologie der Zahne. In both places, however, they are described as "Dentinzellenfortsätze," a word the exact meaning attached to which I do not know, seeing that its significance greatly depends on the view held by the writer of the share taken by the odontoblasts in the formation of dentine, and of the ultimate structure of dentine. Thus it might mean the dentinal fibril, the dentinal sheath, or both.

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 the defective teeth 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 distinctions 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 unpleasant effect.

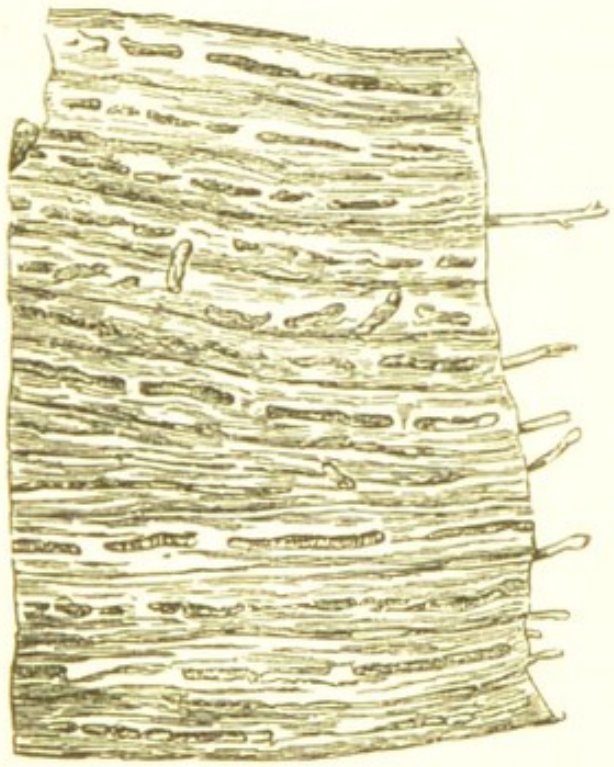
I believe the seat of pain to be mainly in the peripheral portion of the dentine, and that after the destruction of vitality in this part of the tooth has been completed, the sensation of discomfort in great part passes away.

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.

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. If a thin section be taken from the tooth, it may then be seen that the transparency is produced by the air being thoroughly excluded from the dentinal tubes in this part of the section. This seems to be due to the consolidation of the dentinal fibrils within the tubes, thereby obliterating the latter, and rendering their outline obscure. The consolidated condition of

the fibrils may, however, be shown in a more satisfactory manner 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 consolidated fibrils will be seen within the tubes 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

Fig. 136. (1)



occasionally they may be seen with one end projecting from the edge of the section, and the other within the tube.

This consolidation of the fibrils necessarily exercises a considerable influence in arresting the progress of disease, by

(1) A section in a plane with the tubes, from carious dentine, showing consolidation of the fibrils, some of which are seen projecting from the edge of the specimen, while others have been broken within the tubes and are displaced.

rendering the dentine much more dense and impervious than when in the normal state. The zone of consolidation cuts off and isolates the disease from the healthy portion of the tooth, and its production must be regarded as an attempt on the part of nature to circumscribe and limit the mischief. That this interpretation of the phenomenon is correct, will be seen on examining teeth in which the rate of progressive destruction has varied, and also by considering the conditions presented in other tissues when they are attacked by local disease.

In respect to teeth, it will be found that when the dentine has been rapidly destroyed—when, in fact, the amount of softening is great, and the external indication but comparatively slight—when that which at first sight would appear to an unaccustomed eye a small cavity, is, on the removal of the disorganized tissue found to be a very large one; that the consolidation of the fibrils has been imperfect, or perhaps altogether wanting, and that there is coincidently a high degree of sensitiveness under operation. Again, compare the foregoing case with one in which the destruction has been comparatively slow, and the extent of the disease more limited, and it will then be seen that the evidences of consolidation are in the former very slight, in the latter very abundant. It will, in fact, be found that the rate at which the disease advances will accord with the amount of consolidation. It must be borne in mind that the disease is, for the present, regarded as strictly limited to the dentine and enamel, and that the teeth are assumed to be in an otherwise healthy condition. When the pulp becomes exposed, or when the gums have receded and exposed the necks of the teeth, other conditions come into operation, and modify the symptoms.

To what extent this obliteration of the tubes is to be regarded as a vital action is a question the discussion of which must be deferred to the Appendix on the nature and causes of dental caries.

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 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 becames 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, and consequently uninfluenced by the alkaline character of the salivary fluid. The quantity of the mucus may be excessive either from a local or a 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

[1] See the chapter on the Saliva.

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 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, coincident 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.

The case as respects the lining membrane of the mouth is, however, not without a parallel. The mucous membrane of the bladder, when in a state of irritation, pours out a strongly acid secretion.

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. If in such cases the oral fluid be carefully examined, I believe it will be found that the saliva itself has at intervals lost its alkaline character and become acid. 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.

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 may be produced by fermentation of the food, or may find its way from the stomach.

Without going into the consequences produced by caries,

when the pulp-cavity is laid open, 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 operating 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)

Caries.—Treatment.—The disease at present has been regarded as confined to the dentine and enamel only, and in entering upon the treatment, the same limitation will be observed. The exposure of the pulp and other complications will be subsequently considered.

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 second 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

(1) For further information relative to the occurrence of dentine nodules, see Diseases of the Pulp.

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 should we fail in finding such a file as would best answer our purpose, a pattern may be made in any soft metal, and forwarded to the file-maker. 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 having been carried to a sufficient extent, 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 is 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 that 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 freqently 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.

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.

On the other hand, cases apparently most favourable for this mode of treatment will now and then show results equally unsatisfactory. It has recently 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. 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, 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

(1) Treatment and Prevention of Decay of the Teeth. R. Arthur, M.D. Philadelphia, 1871.

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 there is no strong tendency to caries?

Again, 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.

Moreover, teeth thus artificially separated 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.

The file and the enamel-cutter have been spoken of in con-

nection with those cases which may be treated by operations in the performance of which these instruments only are used. But we shall have again to recur to them in connection with the operation of filling, and as the manner of using such instruments will then be described, it will be unnecessary to enter upon the consideration here.

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 its 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 disorganization may be effected. The very fact that caries has appeared in a tooth demonstrates its predisposition to disease. We can, for the time being, arrest the disorder, 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 proper 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, upon the proper performance of which the ultimate success of the operation will in great part depend.

In the treatment of a case, the first 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, rather than 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 disorganized 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 occupied 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

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 cavity, of course the gold could be forced into it, but in practice it would be extremely inconvenient to employ such an instrument, 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 unwilling-

ness 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 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.

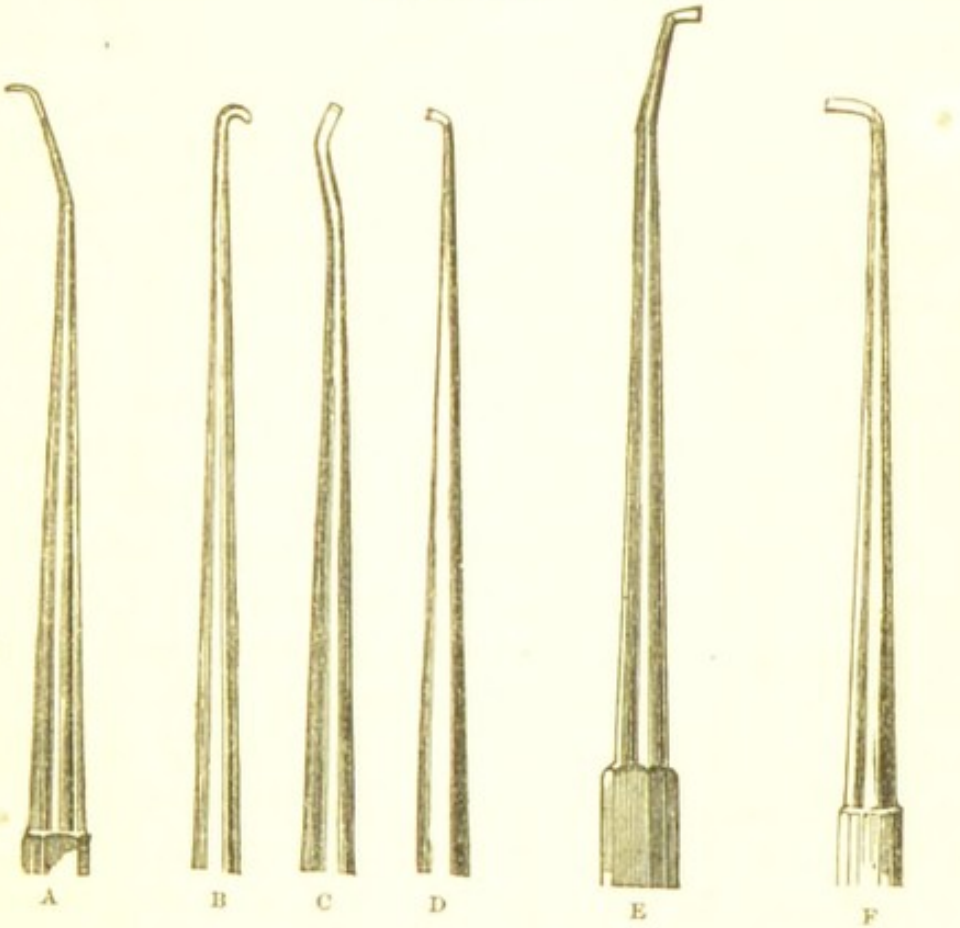
There is yet another point in the formation of a cavity to which attention may be advantageously directed.

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 will do when the disease is situated on the mesial or distal side of a tooth,

then it will be necessary to reduce the margin of the orifice to a flat and smooth surface.

Several forms of instruments are used in preparing cavities for the reception of plugs, but they come under one or other of two heads, viz., cutters and drills. The one class will include what are commonly called "excavators" and enamel cutters, while in the other will be ranged drills of various forms, and burr-heads, as they are called.

Fig. 137. (1)

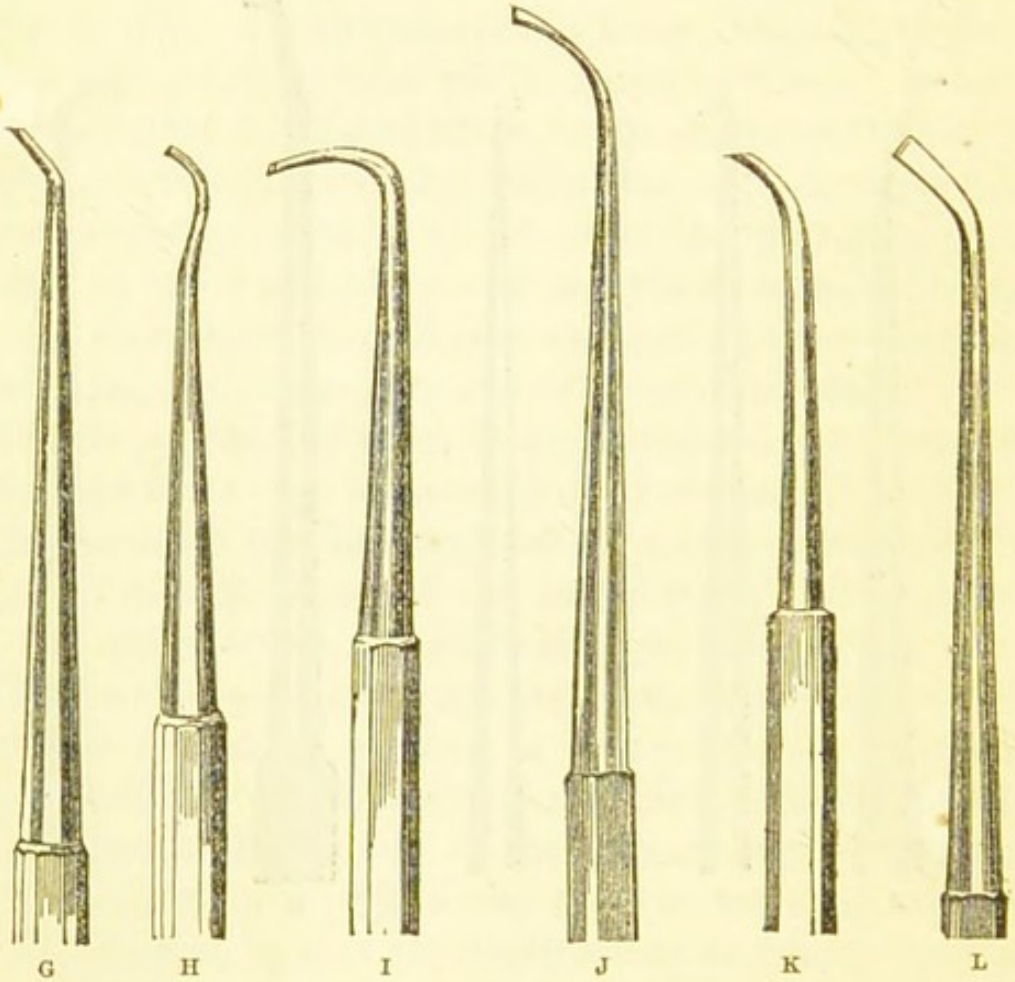


It will not be necessary to do more than make a few general observations upon the manner of using the instruments employed in removing the diseased tissues. The forms which have been figured may be taken as those most commonly used, but the minute variation in size and shape

(1) Figs. 137, 138, show some of the most useful forms of excavators.

required from time to time generally leads to a great accumulation of this description of instruments. The operator should be able to make for himself excavators to suit any peculiar case which may arise. 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 always disagreeable and

Fig. 138.



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 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 seldmo

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.

Under the head of drills are included those instruments used in the preparation of cavities for the reception of plugs, which cut by a rotatory motion.

The rose-head is very serviceable in reducing to a cylindrical form the ragged opening of a small cavity. The file-like character of the surface enables the operator to cut away with readiness the enamel which has become weakened by the softening of the subjacent dentine. Six or eight sizes of heads should be at hand, and each may form a separate instrument made in pinion wire, or from a seven-inch length of square or round steel. But it is perhaps better to have a set of blades fitted to a common holder, and the crutch-handled rose-head and drill-

Fig. 139. (1)



Fig. 140. (2)



(1) Showing three sizes of rose-heads, the centre one placed in the crutch-handled stock or holder.

(2) Modified form of rose-head.

holder will be found to present many advantages. The crutch rests between the thumb and forefinger, or between the latter and the second finger, leaving the tips of the thumb and finger free to rotate the shaft of the instrument, while pressure is made upon the crutch. (Fig. 139.)

Fg. 141. (1)



For some years I have used this instrument with the form of the cutter modified. Instead of producing a spherical head, the steel has been allowed to retain an uniform cylindrical figure, and teeth have been cut, not only at the extremity, but for some distance up the shaft. (Fig. 140.)

With this construction of cutter we secure all the advantages of the rose-head, accompanied with an additional amount of strength in the part corresponding to the neck of the latter; also the capability of enlarging an orifice through which the point has entered by the cutting surface of the shaft.

The rotating file or rose-head is very serviceable when the enamel requires removal, but for cutting the dentine an ordinary drill presents many points of superiority. It cuts more rapidly, can be more easily made sharp, and its course can be more readily directed than the rose-head, owing to the greater amount of pressure required to bring the latter into effective operation. Drills of various size and shapes may be mounted in the crutch-handled stock shown in a preceding figure, or the drill and shaft may constitute one continuous length of steel (Fig. 141). The latter arrangement possesses some advantages. The shaft is held, when rotated, between the thumb and finger; and as but little pressure is required to make the blade cut, the direction and

(1) Drill made from a cylindrical piece of steel, with the point chaptered from each side.

the rate of progress which the instrument makes can be very readily felt. The operator will find advantage in having various sizes of this instrument, the form of the points being also varied.

Several forms of metallic sockets which receive the head of the drill, or rose-headed instrument, are sold for the purpose of protecting the hand, which is otherwise apt to be chafed by the pressure necessary to make the instruments cut; one which answers the purpose exceedingly well, consists of a metallic cup, in which the upper end of the instrument rests, and a ring which retains it in its place by passing over one of the fingers. But, as drilling is at all times tedious and fatiguing, many attempts have been made to devise drills driven by mechanical means. Such an instrument is Harrington's erado, in which the motive power is a strong spring. The drill is driven at a great speed by an arrangement of cog-wheels contained in the box, but, as a matter of course, with a corresponding loss of power. This is the objection that has proved fatal to each of the numerous pieces of mechanism devised; there is a lack of power, so that the drill stops so soon as it is pressed hard against its work. But for finishing the surface of a plug, or any similar purpose, where much power is not required, both Harrington's erado, and the American pneumatic drill, which is driven by a pair of bellows, are useful instruments.

Lately, however, an arrangement in which the motive power is derived from a treadle has been introduced under the name of Morrison's dental engine, and this appears to possess that power the lack of which is so fatal to the usefulness of the other forms of mechanism contrived for this purpose. To minutely describe the apparatus would take up too much space, but by an ingenious adaptation of spiral springs as a means of conveying the rotatory motion, very great flexibility is given to that end of the long arm on which the drill or rose-head is carried. In this instrument, the difficulty of securing adequate power appears to have

been surmounted, but it has not been sufficiently long in use in this country to speak very positively as to its value.

Removal of Sensitive Dentine.—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, in a recent number of the "Dental Cosmos," 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 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 cavity, and the cavity carefully sealed, preferably by a temporary filling of gutta percha. But as there are other agents which are capable of reducing the sensitiveness of dentine, its use is to be 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 appli-

cation 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 (1). 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 absolutely insensitive to the touch of an instrument.

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.

(1) On Oxychloride of Zinc. C. S. Tomes, in British Journal of Dental Science, vol. xiii., p. 552.

MATERIALS USED IN FILLING TEETH.

Temporary fillings.—There is 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 renders 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 creosote when the nerve is nearly exposed, 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 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 months. In using this compound, a piece 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; this, being a ready solvent for gutta percha, secures its perfect adhesion to the walls. 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; and, where it is protected from the wear of mastication, it is exceedingly durable. This form of filling is particularly useful in those cases in which the teeth, although generally free from pain, will not bear the pressure required for the introduction of a

metallic plug—a condition which will commonly pass away in the course of three or four months, if the cavity be sealed up with the gutta percha. Instances are not uncommon where, after the introduction of a gold filling, the tooth is so painfully sensitive to changes of temperature, that the patient is in dread of either hot or cold beverages, or even of drawing cold air through the mouth. If the gutta percha be substituted, the inconvenience passes off, and the tooth will, at the end of a few months, bear the re-introduction of the gold without any of the preceding discomfort.

Gutta percha is also very useful as an experimental filling, where there is some doubt whether the nerve can be preserved alive, as in the case of the tooth aching, it can readily be removed, even by the patients themselves, should the necessity for their so doing arise.

For *temporary* fillings, the various preparations of zinc oxychloride are exceedingly useful. 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.

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.

As a *temporary* filling, then, it 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, even from the atmosphere, 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.

Permanent fillings.—Passing to the class of metallic substances, which do not undergo very material change in the mouth, we have three different kinds: fusible metals, amalgams, and pure metals.

It is a curious property of certain alloys to have a melting

(1) C. S. Tomes, in British Journal of Dental Science, vol. xiii., p. 552. On Zinc Oxychloride.

point below that of the constituent metals; thus, the addition of cadmium to certain other alloys confers this property in a marked degree.

Several formulæ have been proposed (of which the best known is Dr. Wood's) for forming alloys which melt at a sufficiently low temperature to be applied to a tooth by the aid of hot instruments; but such preparations have found little favour in this country, and I have but little experience in their use.

It may, I think, be assumed as a settled point, that for dental purposes a pure metal, such as gold, or even tin, is in all respects preferable to any mixtures of metals at present known. But there are cases in which the one can be used while the other cannot. The American writers on dental surgery have urged every possible argument against the use of amalgams, and have gone so far as to pass rules for the expulsion from dental societies of members who would not pledge themselves to discontinue the use of mercurial fillings. Yet there are teeth the condition of which is such that gold fillings cannot be inserted with any chance of success, but which, if plugged with a good amalgam, will last for years, and be perfectly effective for a long period.

Common sense will, I think, decide the question whether it is better to have a tooth filled with amalgam, or to lose it at once. It has been urged that the mercury used in making the alloy will salivate the patient. I have never seen a case in which this result was produced, nor do I know of a well authenticated instance, and I think we may fairly conclude that the instances are so extremely rare that they need not influence our practice.

It must, however, be borne in mind that I am not advocating the use of amalgams where pure metals can be used, but I do contend that the former are extremely useful where the employment of the latter is prohibited. Take, as an example, a tooth the crown of which has been hollowed out to such an extent that the introduction of a foil filling

would break down all that remains above the surface of the gum, yet in which the pulp has been calcified and the tooth is free from tenderness. Such a tooth if left to itself will soon crumble away, but if carefully filled with amalgam it may last for years.

Many examples may be found in which these kinds of filling have preserved the teeth in a state of usefulness for long periods, the use of gold at the time the operation was performed, from some cause having been interdicted. It is true the teeth may be stained by the filling, but the presence of a stained tooth is preferable to vacant gums, more especially when situated at the back part of the mouth, and subservient only to the purpose of mastication. This objection, however, can at the present time be scarcely said to hold good. The amalgams now in use do not stain the substance of the tooth as the older preparations did—a property due, I think, to the presence of more or less copper in the compounds formerly employed.

It is not uncommon to meet with cases which support these views in respect to the occasional use of amalgams. Patients sometimes request that such fillings may be removed and gold substituted, but more frequently an officious operator urges the necessity of refilling teeth which have been judiciously and effectively treated. One of two results follows; either the teeth remain as useful as they were before the substitution of gold for amalgam, or, what is very common, the teeth are rendered tender by the operation, and the patient, after more or less suffering from inflammation about the roots of the refilled teeth, is obliged to submit to the extraction of organs which, had they been allowed to remain undisturbed, would in all probability have continued serviceable for years.

I have in my own mouth two wisdom teeth which, three years since, were so much decayed that it seemed hopeless to attempt their preservation. They were extremely tender when brought in contact with hard food, such as biscuit or

crust of bread, and felt as though they would ache before many weeks had passed. I removed as well as I could the carious portions, of course very imperfectly, and filled them with amalgam. These teeth have since that time given me no discomfort: hence I have a right to consider that the use of amalgam has enabled me to retain two teeth which would otherwise have been removed or have fallen into disuse three years ago.

Till within a comparatively recent period it was customary to reduce into filings the ordinary silver coin, mercury was added, and the compound worked up in a mortar or in the palm of the hand until the whole became reduced to a stiff paste. The superfluous mercury was then squeezed out, either by pressing the mass between the thumb and finger or in a fold of chamois leather. After this manipulation the compound is placed in the tooth, and in the course of a few hours becomes quite hard. Although this form of amalgam is bright when introduced, yet in a short time the surface becomes black and the whole body of the tooth by degrees assumes a dark grey colour.

A series of amalgams have been long known as Sullivan's cements, which are in the main composed of copper, but the composition of the several qualities offered for sale has not been described. They are sold in large pill-shaped masses, and the operator is directed to crush in a mortar a sufficient quantity for the case under treatment; and to place the mass in an iron spoon, which is to be held over the flame of a spirit-lamp until globules of mercury appear upon the surface of the fragments. In the heated condition the compound is returned to the mortar, and rubbed until reduced to a paste. It is afterwards squeezed in chamois leather, to separate the excess of mercury, and is then ready for use. These amalgams possess the same objectionable qualities as the one already noticed, but in a less degree, and are therefore preferable.

Precipitated palladium, when rubbed up with mercury,

forms an amalgam which does not stain the tooth although it becomes in the mouth of a dark grey colour. The process of uniting the two metals is a little tiresome. The mercury rolls about in a finely-divided palladium, and at first shows no disposition to unite; but when the combination commences it proceeds rapidly, and is accompanied by the evolution of considerable heat. After the metals are incorporated, no time must be lost before the mass is introduced into the faulty tooth, as the process of hardening proceeds very rapidly. This alloy in the soft state is very plastic, and will take an extremely delicate counterpart of any surface upon which it is pressed, much more so, indeed, than any other form of amalgam with which I am acquainted. The preceding compounds when pressed in the soft state between the thumb and finger, impart a very peculiar grating sensation, a property which the palladium amalgam does not possess.

Dr. Evans introduced, several years since, a compound of cadmium, tin, and mercury, which at first appeared to possess many advantages over all other similarly-constituted alloys. When perfectly set, the colour resembled that of tin, and the degree of hardness was about equal to that metal. These conditions presented great advantages over the hard, brittle, and dark amalgams formerly used, and the new compound was consequently very generally adopted. It was, however, soon found that the cadmium, when used as a filling for teeth, became subject to rapid oxidization. The mass lost its tin-like softness, and became friable, while those portions in contact with the tooth were converted into the yellow oxide, giving to the surface against which it rested a brilliant yellow or orange colour. Hence it happened that the use of cadmium as a basis of dental amalgams was no sooner adopted than abandoned. Attention had, however, been drawn to the subject, and attempts were made to find a compound which would neither oxidize nor assume an objectionable colour.

Mr. Arnold Rogers published, in 1850, an account of an amalgam which he had used for several years with success (1). It was composed of one part of gold, one part of silver, and seven parts of mercury, and required heating before use, much in the same manner as Sullivan's cements. This preparation was not subject to discoloration, but I am told by Mr. Rogers there was some difficulty in obtaining uniform results as regards the degree of hardness of the plugs, and the time required for the hardening when used in the mouth. These difficulties led him to discontinue its use in favour of other formulas which have since been introduced.

Messrs. Ash, of Broad-street, vend an alloy, supposed to be composed of silver, and tin, and a small percentage of gold, to which mercury is added when required for use. And Mr. Robertson, of Birmingham, at about the same date, published a formula, containing similar ingredients. It is composed of "gold, one part; silver, three parts; and tin, two parts." The metals, which must be perfectly free from impurities, are melted together, and run into an ingot, and afterwards reduced into filings (1). To these mercury is added at the time of using, and the quantity required is equal in weight to the filings.

But, although the tissues of the teeth are not discoloured, yet even these preparations become a little dark in hue after they have been some weeks in the mouth. Moreover, they are hard and brittle; hence a preparation capable of retaining the physical properties which Dr. Evans's amalgam possessed at the onset, would be an improvement upon those sold by Messrs. Ash and others.

When required for immediate use, the requisite amount of filings is placed in a mortar, or in the palm of the hand; mercury is added, and the two are rubbed together until a stiff paste is formed. This should be washed, either with alcohol, or (according to Mr. Rogers) with compound spirits

(1) Pharmaceutical Journal, vol. ix., p. 402. 1850.
(2) Ibid., vol. xi., No. 12. 1852.

of ammonia. The first portion of fluid will be deeply coloured, but after one or two repetitions the amalgam will cease to impart any stain to the liquid. The mass may then be dried in a napkin, and after squeezing out all the superfluous mercury, is ready for insertion into the faulty tooth.

In conducting the operation, the cavity should be freed from moisture, and the amalgam may then be pressed firmly in, care being taken that the cavity is thoroughly filled, while none is allowed to project—a precaution that must be especially observed where the gum lies over the margin, and thereby conceals the edge of the orifice. The plug will become perfectly hard in the course of a day, and should, if opportunity is offered, be filed smooth and polished, together with the margin of dentine or enamel by which it is surrounded.

The kind of surface assumed by amalgams in the process of hardening will be considered in connection with the surfaces presented by those parts of gold fillings which lie in contact with the walls of cavities.

A peculiar effect upon the dentine, produced more fully by the copper amalgams than by those at present in use, may be noticed. The blackened tissue against which the amalgam has rested for a lengthened period, is commonly found to be extremely hard, much more so than healthy dentine, and much more so than that which is subjacent. It is often difficult to cut away the discoloured and indurated tissue, but when this is effected the instrument readily operates upon that which is next presented.

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 amalgam at present in use, I undertook an extended series of experi-

(1) C. S. Tomes, on "Physical and Chemical Properties of Amalgams." Transactions of Odontological Society, March, 1872.

ments 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 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 unreliable. It was found 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.

So far as I am aware, no serviceable amalgam which does not contract as it hardens has as yet been produced; Mr. Fletcher has, however, by the addition of both gold and platinum to a silver and tin alloy, succeeded in producing an amalgam in which the total shrinkage is not great, whilst the rapidity with which it sets allows some part of the contrac-

tion to take place before the operation is complete. These amalgams have not been in use for a length of time sufficient to test their actual value in the mouth.

There is, however, another fault possessed by amalgams, which has been lately 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 would seem advisable to use as little mercury as possible in mixing up an amalgam, and it is 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.

As has been lately pointed out by Mr. Makins, in the employment of a semi-fluid amalgam we get an effect analogous to that produced by squeezing a sponge; that is to say, the fluid, in this case mercury, gets forced to the surface, so that the composition of the mass in different parts varies. It is easy to see that this may lead to a vacancy round the edges in two ways: by the absorption of the free mercury back into the contiguous portions of the plug, or by its gradual evaporation.

Gold.—This metal is pre-eminently suitable for the purpose of filling teeth on account of its softness, which renders it possible to get very accurate adaptation to the walls of the cavity, and also on account of its power of resisting oxidation. It has also another valuable property, closely dependent on its softness, namely, the readiness with which it may be

welded at ordinary temperatures. For dental purposes, the gold is presented to us in two forms; the one being gold leaf or foil, the other sponge, or, as it is preferably called, crystal gold. Great purity is an essential, and this can only be secured by refining the gold by the wet method; that is to say, dissolving it in aqua regia, and subsequently precipitating it; the form assumed by the precipitated gold varying greatly with the re-agent used to effect this purpose, and with many other conditions, not well understood.

When the aqua regia solution is precipitated by means of oxalic or sulphurous acids, the gold comes down in a coherent spongy mass of crystalline structure.

Mr. Makins 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's 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 myself.

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 is 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, a favourite form of sponge gold in America. We know it as Watts's American crystal gold, the valuable properties of which have been very strongly put forward by 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 re-

cently 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 adhesive property of the gold.

The instruments fitted for operating with crystal gold differ from such as are required for the introduction of non-adhesive foil, but in most respects resemble those best adapted for adhesive foil.

The working end, instead of terminating like a wedge, is more or less flattened, and cut up into a series of small points or ridges, in the formation of which it is necessary to exercise some little care. The more perfectly formed are the ridges or quadrilateral cones, the more easy will be the

management of the gold. After a little use the edges or points become blunted, and require restoration.

An instrument which presents a working surface of some little size, will be found convenient for introducing the gold into the cavity; but so soon as we have compressed the gold firmly against the wall of the cavity, or upon that which has

Fig. 142. (1)



Fig. 143.



been consolidated, a smaller instrument must be worked over the surface, and ultimately a still smaller one; indeed, a point may be exchanged for the chequered working surface. By the repeated use of a pointed instrument, after a new piece of gold has been added to that which had been previously

(1) Figs. 142 and 143 show forms of instruments for introducing and compressing sponge gold.

introduced, the solidity of the plug is ensured, and a surface favourable for the addition of still more gold is produced.

The character of the surface to which further additions of gold are required is of considerable importance. In the first place, it must be perfectly clean, and free from moisture of any kind; and in the second, it must be rough, either from the impressions of the one or the many-pointed instrument.

Let the surface be made wet by the tongue, or smooth by the burnisher, and no more gold will adhere until it is again rendered perfectly clean and reduced to the rough condition previously mentioned.

Much has been said in praise of crystal gold, owing to the readiness with which the lost half, or even two-thirds of a tooth can be restored by building up in metal a copy of the absent part. When out of the mouth the half or the whole of the crown of a tooth may be reproduced in sponge gold; but in the mouth the operation of restoration is by no means so easy: it is not impossible, but it is generally impracticable. There are few patients who could keep the mouth open for a sufficient length of time, and when they can, the tooth gradually cools down to a lower temperature than the expired breath, and precipitation of moisture upon the metal is the result. The operation may be suspended for a short time, if on recommencing it the gold be wiped dry, and the surface scraped or filed, so as to ensure a clean surface. It is seldom, however, that the result is perfectly satisfactory when the procedure is interrupted; indeed, the restoration of any considerable amount of the crown of a tooth is rarely attended with lasting success. A few show-cases may be produced, but the operation is too tedious, and the ultimate result is too uncertain, to admit of general application.

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, I have come 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 connot 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 adhesive-

ness 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 compresssion. 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 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

(1) G. H. Makins, "On the Union of Metals by Welding." Transactions of Odontological Society, June, 1872.

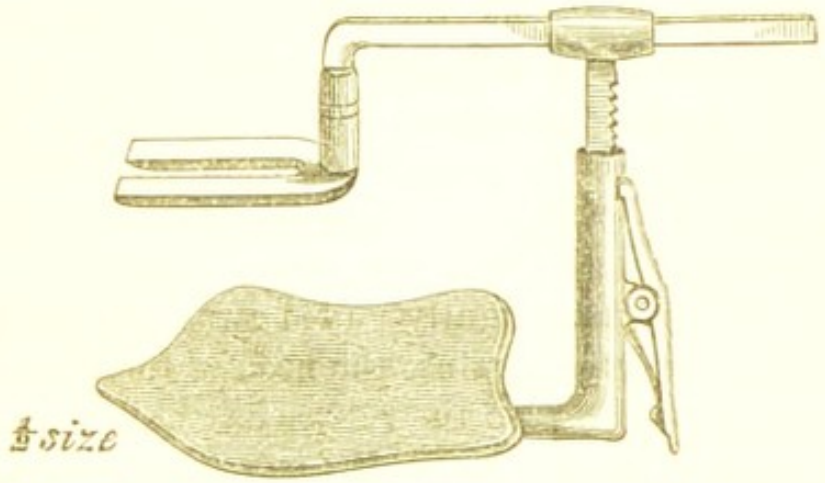
molecular change when kept for a length of time, leading to its assuming a hard, harsh texture.

Before describing the manner of introducing the gold, it will be well to devote a little space to the consideration of the instruments employed, and the methods of keeping the cavity free from moisture.

Methods of keeping the cavity dry.—The most universally applicable appliance for this purpose is a small napkin twisted into the form of a rope; the roll being passed over the crowns of the teeth behind the tooth to be operated on, and held down on either side of it by the operator's fingers. Though it is easy to demonstrate the various ways in which the napkin may be applied, it would be an endless task to attempt to describe them. In employing the napkin in the lower jaw it is generally possible to make pressure over the mouth of the salivary duct, so as to prevent or retard the exit of saliva; when operating 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. 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 duct 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 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.

Fig. 144.



In prolonged operations the napkins are apt to become saturated, and the difficulty of keeping a lower tooth dry is often very great. To meet this difficulty various forms of saliva pumps have been devised.

But the appliance which gives the greatest security against the inroads of saliva is the rubber dam. 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, or by suddenly forcing the handle end of an excavator through the tightly-stretched sheet.

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. 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 upwards, 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.

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.

There are, however, many cases in which the application is exceedingly difficult, and in which the labour and possible failure, after every precaution has been taken, render its use hardly worth the trouble of its adjustment. Minor diffi-

culties 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 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. (1)

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.

For cases in which the above-mentioned measures prove insufficient to retain the rubber, it has been proposed (*loc. cit.*) to use metallic clasps fitted to the teeth, but I have no experience in their use.

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 will result; but where the superficial extent of the disease is limited, it will be better to avoid cutting into the tooth.

(1) Dr. Hodson, in Dental Cosmos, vol. xii., p. 507.

The required space may be gained by the introduction of strips of wood, of india-rubber, or of cotton-wool 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 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. On the whole, the method of slow wedging is safer, and is the one generally adopted in this country. 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. But the most convenient material is india-rubber; this should be employed only in very thin pieces, which may be cut from the solid lump. 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. 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.

Methods of introducing the Gold.—Crystal Gold.—The sponge must be torn up into small fragments, the size of which will be in some degree regulated by that of the cavity. Each fragment, on its introduction, must be thoroughly condensed before we proceed to add another; and this condensation must be done gradually, and at first gently, so as to avoid pulverising the gold. Any attempt to introduce a large amount of sponge, and then consolidate it as a whole, will eventuate in the production of a plug hard on its surface and very soft in its interior. Such results were common before the use of sponge gold was properly understood. The plugs looked very bright and solid on the surface; but their disintegration speedily commenced, and the cavity operated upon, instead of containing a plug of solid metal, was found to be occupied by a more or less coherent mass, so soft that it could be broken up by the finger-nail.

The fragments of crystal gold may be very conveniently picked up and carried to the cavity with plugging forceps, and the condensation may be, to a considerable extent, effected with the same instrument. On page 343, figures of instruments which may be used for the introduction of sponge gold are given, but the most generally suitable forms are the foot-shaped pluggers. As it is absolutely necessary to develop the adhesive properties of the gold to the utmost extent, it is generally advisable to anneal the gold immediately before use. The fragments prepared for use may be annealed by heating them on a sheet of mica over a spirit-lamp, or by passing each piece through the flame as it is

about to be used. Sometimes the one plan, and sometimes the other will be found to succeed best.

Gold Foil, non-adhesive.—The methods in which the gold may be used are various. The leaf may be folded into ribands of suitable length and breadth, and these may be cut up into more or less square pieces; or the whole may be loosely twisted into ropes (Fig. 145).

Fig. 145.



Or, again, the leaf may be cut into four or more pieces, each of which is crushed up into the form of the rope by means of the instrument sold for the purpose, which consists of two sheets of metal, one edge of each of which is turned up so as to form a ledge about one-fourth of an inch deep. The riband or rope is cut into lengths somewhat more than twice the depth of the cavity, and the pieces introduced by means of an instrument with a tolerably large extremity; the middle of each is carried down to the bottom of the cavity, so that the two ends project from its orifice. When the cavity is nearly full, an instrument with a smaller point is used, and one end of each strip carried down to the bottom. When we are unable to introduce any more foil, a sharp wedge-shaped or trocar point is forced into the centre of the plug, so that in the act of perforation the gold is very forcibly pressed from the centre towards the circumference of the cavity. The hole thus made is filled by folding in strips until no more can be introduced. The operation of perforating, and filling the perforations, is repeated until it is no longer possible to make the instrument enter. The success of the proceeding will depend upon the character of the foil employed, that which is destitute of adhesive properties being alone suitable when the foregoing manner of operating is adopted. Had the operation been conducted with adhesive

foil, great difficulty would have been encountered in carrying the folds to the bottom of the cavity when the operation approached completion. Each fold would adhere when it came in contact with the gold already impacted, and if force were employed the instrument would cut through the riband, leaving the orifice narrowed, while the lower portion of the cavity remained undiminished; and unless great care were taken the operation would terminate in the production of a plug very hard on the surface, and soft or porous in the interior—a character of filling presenting a good appearance, but capable of saving the tooth but for a short time. The hardened surface will give way, and the plug either become depressed, or it will fall out. It might be supposed that in filling a small cavity, which in the general sense of the term, though it equals the size of the whole tooth, cannot be very large, the gold foil would be compressed throughout the whole mass of the plug by pressure made upon the external surface. Experience, however, shows that this effect cannot be produced. The foil, whatever its character, becomes condensed immediately under the instrument into a thin, hard scale, which arches over and protects from pressure that which is below. This condition obtains in all the forms of gold available for dental purposes. In no case can a moderate-sized plug be introduced and compressed as a mass—to be effective, the pressure must be applied consecutively to each of the many portions (and these must be small portions) of which the plug is gradually built up. But although we cannot depend upon producing a sound plug, unless it is formed by the gradual addition and compression of small pieces of gold, yet there is a great difference in the qualities of foil in respect to the manner in which they are influenced by pressure. Thus a sheet of the non-adhesive, when made into a ball by rolling between the fingers, may be compressed and adapted to the sides of the cavity with some degree of uniformity throughout the mass; but if adhesive foils be similarly treated, we shall find that the surface against which the plugging instrument

has been pressed is condensed into a hard layer, while that which lies next to the cavity has been relatively but slightly acted upon, and probably, instead of adapting itself, has turned away from the tooth at several points towards the instrument, and become loose in the cavity.

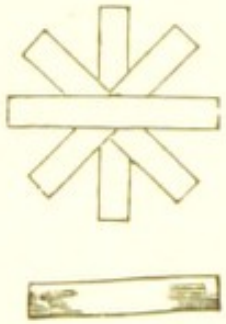
With the non-adhesive foil, a mass after introduction is readily applied to the walls of the cavity, which becomes contracted to an amount corresponding to that of the metal added, until at last the whole space is occupied by gold. But each mass so added, although closely adapted to that already introduced, will preserve its own identity, and on the tooth being broken up, may be separated from those with which it has lain in contact. On breaking up the plug, it will become apparent that the component masses have been held together by a system of packing within a circumscribed space, not by the adhesion to each other of the several portions of which the plug has been built. It is very necessary that this point should be fully understood.

If the operator proposes using the non-adhesive foil, he must proceed upon the principle of packing, and the layers of foil must pass in a direction from the bottom to the orifice of the cavity. The foil may, however, be introduced in other forms than that of a loosely-twisted rope: it may be rolled into a ball of sufficient size to loosely fill the cavity before it is compressed, and when in position perforated with a sharp-pointed conical instrument, of sufficient size to force the foil against the circumference of the cavity. In filling up the central aperture thus produced, the sides of the filling should be forced down. At this stage of the operation we shall have a dense plug immovably fixed upon the floor of the cavity, and rising up the sides to within a limited distance of its orifice. To complete the filling, the careful superposition of layers of adhesive foil is alone necessary. In this manner a plug may be built up in a cavity, two sides of which have been lost, supposing the two remaining walls are strong. For example, a large fissure running across the masticating

surface of a bicuspid, and cropping out upon the mesial and distal sides of the crown of the tooth, may be thus effectively filled.

Another method of manipulation, 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. 146.



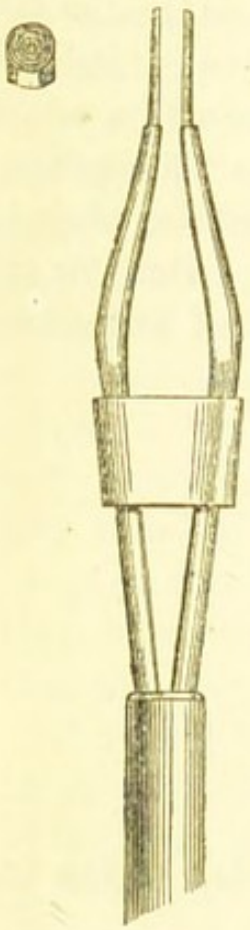
caoutchouc, and picked up by pressing the point of the instrument on the centre of the star.

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 instrument has 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 pro-

Fig. 147. *Fig.* 148.(1)



duced 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.

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. 154.)

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 easier to fill these up by the use of

(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.

stars of gold foil, or of adhesive gold, the heavy numbers of foil answering this purpose admirably.

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.

Some operators, however, generally drill retaining points, not with any view to the retention of the finished plug in

the tooth, but simply in order to securely anchor the first few pieces of gold.

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 lip 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. These 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.

The cavity by one method or another having been filled, and the gold allowed to project slightly from the orifice, the next step towards the completion of the operation will be to reduce the surface of the plug and the margins of the cavity to the same general level, allowing a slight degree of fulness to the central portion of the plug.

This part of the operation will readily be effected by a suitable file, after which the plug may be carefully examined with a sharp-pointed instrument, and should any part be found sufficiently soft to allow of penetration, the aperture must be enlarged and additional foil introduced, after which the file must be again used to reduce any inequalities, and to remove the impressions left by the instrument. We have now to remove, by means of pumice powder or fine silica, applied upon a strip of soft wood, or by a corundum tape, the marks left by the file, and subsequently the surface may be burnished with a little soap. It will be found that the burnisher will facilitate the steps of the operation, if it be used after the file has been abandoned, and again after the application of the pumice powder. Indeed, in many cases the firm application of a burnisher will assist in the con-

solidation of the plug, and in the production of an even surface, before we have recourse to the file, and prior to the saliva gaining access to the surface of the filling.

Perhaps no more suitable place will be found for alluding to the subject of "contour fillings;" that is to say, when a part of the crown of the tooth has been lost, the restoration in gold of its original form. There are few English patients who would submit to the insertion of a contour filling near the front of the mouth, on account of its very conspicuous appearance: the question hence resolves itself into one of utility for purposes of mastication. The advocates of contour filling claim for it that it restores the natural form of the tooth, which is presumably the best possible form, and that by so doing it protects the gum between the teeth. Nevertheless, although it is often advisable to leave the gold convex and projecting to some extent from the cavity, the cases in which a real "contour" filling proves useful are few; and the matter is well summed up by Professor Austen, in the last (tenth) edition of Harris's Dictionary of Dental Surgery, in the following terms: "The majority of them are a useless waste of the skill of the dentist, the money of the patient, and the time of both;" and in another place, "Only let the operator assure himself that he is labouring for the real benefit of his patient, and not degrading his art, on the one hand, by humouring an idle whim of his patient; or, on the other, by making him the reluctant advertising medium of dental ingenuity."

Plugging Instruments.—The form of these, and more especially that of the handles, has been almost infinitely varied. Each operator has his own favourite pattern, and it would be quite impossible, within any moderate limits, to give a complete account of all the varieties manufactured; so that the description in this place must be confined to a few of the more generally useful forms.

To commence with the handles, considerable diversity of opinion exists as to the most suitable form. Many operators

use the instruments constructed for use with the mallet as hand-pluggers (see Fig. 151); Butler's set of pluggers being especial favourites in this country.

For large condensing instruments, or for burnishers, the oval wooden handle represented in Fig. 168 is, to my thinking, the preferable form; it is large enough to be very firmly grasped in the palm of the hand, while the point of the instrument is not far from the thumb and fingers, a matter of some importance where considerable force must be used, as it enables the operator to guard against the point slipping and injuring the soft parts around. Thus, in using a burnisher the thumb may generally be rested on the tooth operated on, or on one of its neighbours, and force exerted in a direction towards the thumb; in this way there is no risk of slipping, and the force applied is both steadier and stronger than when the point of the instrument reaches far beyond the fingers.

In the more simple forms of plugger the shaft is perfectly straight, but there are some cavities which can only be reached by curved instruments. A very useful form is that in which the shaft is bent in a spiral direction to the extent of an eighth or a quarter of a turn, the coil being more or less open or irregular to suit the requirements of particular cases.

For filling the lower teeth, and more especially for reaching distal cavities in the lower jaw, the shaft of the instrument may advantageously be bent at a right angle. For reaching cavities far back in the mouth, the double bend represented in Fig. 149 is serviceable.

There are some few operators who work with perfectly smooth-pointed instruments, but the great majority prefer to use points more or less deeply serrated. These serrations, which should consist of sharp-pointed pyramids, may be cut with a sharp dividing file, and finished with a small three-sided file; but it can be more readily accomplished by a special tool. Such a tool is readily constructed by taking an ordinary reeded scalper, softening it, and converting its longitudinal ridges into teeth by making transverse

cuts with a file; when rehardened to a file temper, it will cut on the softened steel points a series of grooves and edges, which, by an application of the tool at right angles to its former direction, are converted into points. For the insertion of sponge gold these serrations should be very shallow, but for ordinary adhesive gold they may with advantage be somewhat deeper. Much of the ease with which the operation is performed depends on the accuracy with which these points are finished; they should be sharp, and yet leave the gold without clinging, and should not get clogged with the gold. These conditions can only be attained by a high degree of finish, which is, however, reached by several of our instrument makers, as well as by some of the American workmen, whose instruments are all that can be desired.

Fig. 149.



Fig. 150. (1)



As regards the form of the working ends, they may be either flat or wedge-shaped; perhaps the most generally useful of all the forms is that known as the "foot-shaped plugger." The following figure (Fig. 151), taken from one of Butler's pluggers, does not exactly represent a characteristic foot-shaped plugger, which bears a close resemblance to the form of a foot, the shaft representing the leg, and the working surface the sole of the foot.

For perforating a plug of non-adhesive foil, or of cylinders,

(1) A plugging instrument, the blade of which has a spiral curve, adapted to introduce and condense gold foil into cavities situated on the mesial or distal surfaces of the front teeth. A pair, a right and a left instrument, will be required.

an instrument with a sharp point, chamfered like a trocar, will be found most useful; the oval wooden handles are excellent for such a form of instrument.

Fig. 151. (1)



The Americans were the first to bring into every-day practice, though not to originate, the use of the mallet (2), not only for consolidating the plug when finished, but for condensing each piece as it is introduced. It is a most efficient means of thoroughly condensing the gold, and is adopted by a great number of operators; and it is productive of less discomfort to the patient than would have been expected *à priori*.

The mallet should be constructed of some heavy material, a very good form consisting of a head of lead inclosed in a cylinder of German silver, to which is attached a handle about eight inches long. But the use of the actual mallet is, to say the least, very inconvenient in the absence of an assistant; and a variety of automatic mallets have been devised, the majority of which simply repeat, in the form of a blow, that same amount of force which has been already expended on the filling in the form of steady pressure. Inasmuch as the same force is more effective in the form of a tap than in the form of steady pressure, these automatic mallets are advantageous; but the force is generally insufficient, and those which give a blow that is independent of previous pressure are to be preferred.

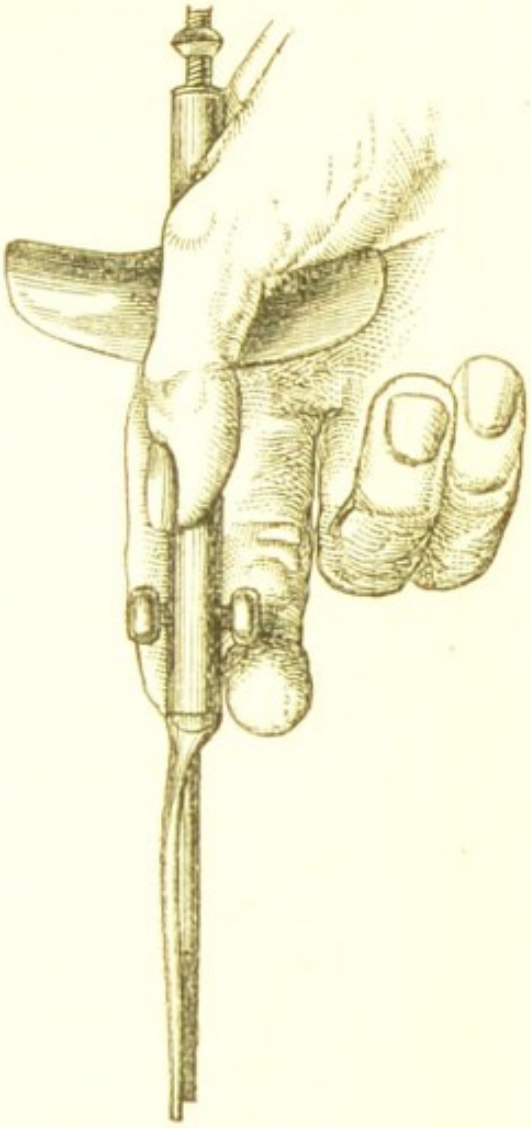
To meet this difficulty, the form of automatic

(1) Mallet plugger made after Butler's pattern.

(2) Dr. Hoffman, of Margate, was many years ago in the habit of consolidating the gold by malleting; in the first instance with the handle of an instrument, and afterwards with a mallet.

spring mallet represented in the figure was devised; the one here figured is not the one most generally useful, but from this drawing the more simple form can be readily understood by a description only. The instrument is held somewhat like a pen, the forefinger lying extended at full length upon it, and directing its movements. In the interior of the shaft is a spiral spring, in the inside of which plays a steel rod furnished on the outside with two ivory balls. The blow is struck by pulling up one of the ivory balls by means of the last joint of the second finger, as seen in the figure. When it has been raised to a sufficient distance, it is suddenly released, by allowing it to slip from the finger, and a blow is given on the filling by the elasticity of the spiral spring. In the instrument ordinarily employed, the serrated points fit into a socket at the lower end, this socket having a play of about a quarter of an inch upwards and downwards; the blow of the central rod which carries the ivory balls (which is, of course, perfectly separate and distinct from the socket-piece) being received on its upper end.

Fig. 152. (1)

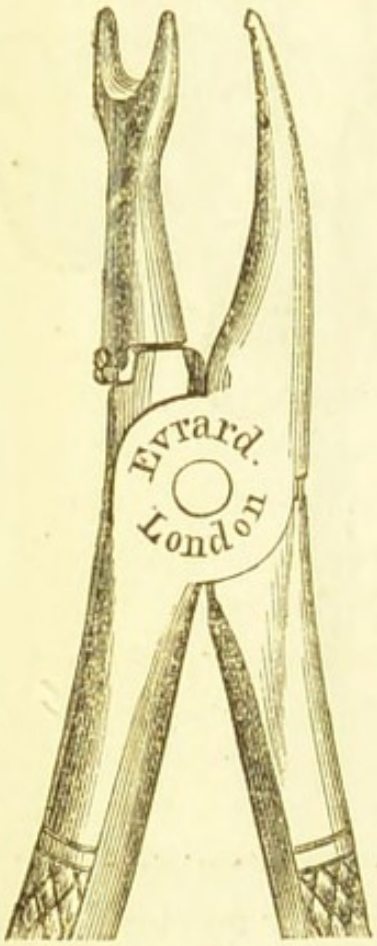


The instrument here figured differs by the socket which carries the serrated plugging-points being made in the same piece of metal as the rod carrying the balls and compressing

(1) Mr. Tomes's spring mallet.

the spring, so that the plugging point is actually raised away from the gold, and is driven down upon it again by the blow of the spring when the rod is released. In addition to this there is a fixed leg, the point of which also is serrated, and which is sufficiently long and thin to enable the operator to spring it away from the striking point. In using this form of mallet the gold is held down by firmly pressing the fixed leg upon it, while blows are given by the second or striking leg at a distance from the first varying at the will of the operator. It is exceedingly useful in cavities in which the gold is disposed to roll, as one side can be securely held down while the other is hammered.

Fig. 153. (1)



The points are changeable, but it adds greatly to the convenience of the operator to have more than one spring mallet, so as to obviate the necessity for changing the point during the progress of an operation.

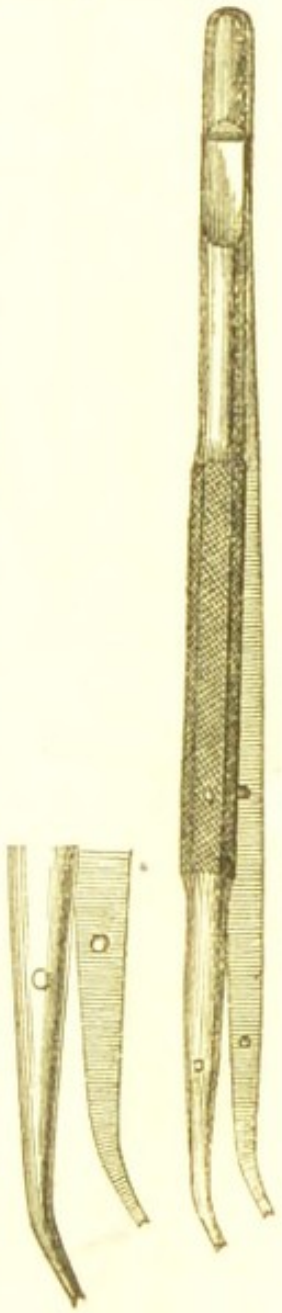
After a very little practice no difficulty will be found in varying at will the force of the blow; the lightest possible tap may be given, or, by drawing up the spring to the utmost possible extent, a blow might be given which would be perfectly unbearable.

The gold having been introduced, the surface is next condensed by the use of instruments of gradated sizes; in interstitial cavities, not very accessible, this is sometimes rather difficult. A most useful instrument, which is far too little appreciated, is the condensing plugging forceps; it is used by grasping the tooth, and squeezing the plug by closing the handles: caution is, of course, required in its use, but in

(1) Mr. Tomes's modification of condensing plugging forceps.

careful hands it is most valuable. A modification which renders more easy their adaptation to the tooth consists in replacing one blade by a rotating crutch ; this adapts itself to the irregularities in the form of the tooth whilst the other jaw acts on the surface of the plug.

Fig. 154. (1)



An instrument which is perfectly invaluable for the introduction of the gold is the ordinary plugging forceps, the points of which are serrated, and when closed resemble an ordinary plugger. The gold may not only be carried to its place by this instrument, but, by closing the jaws, it can be condensed, the forceps acting as an ordinary plugger. For the introduction of cylinders they are indispensable; and they are of great advantage in using either sponge gold or the heavy foils.

When all the gold has been introduced, the excess has to be removed by suitable files. The shapes of these are innumerable, and each one must select for himself that which he prefers; but attention should be called to a most useful form of file for finishing fillings on grinding surfaces: it is like a large rose-head, and is used by revolving it while pressed on the surface of the gold.

The inequalities left by the file may be removed by the use of corundum points held in a suitable pair of forceps. (See Fig. 160.)

The application of pumice or fine silex on a piece of wood will leave a very fine surface, or a piece of Arkansas or of Water of Ayr stone may be used for the same purpose.

The finishing polish is given by means of burnishers,

(1) Plugging forceps.

Fig. 155. (1)

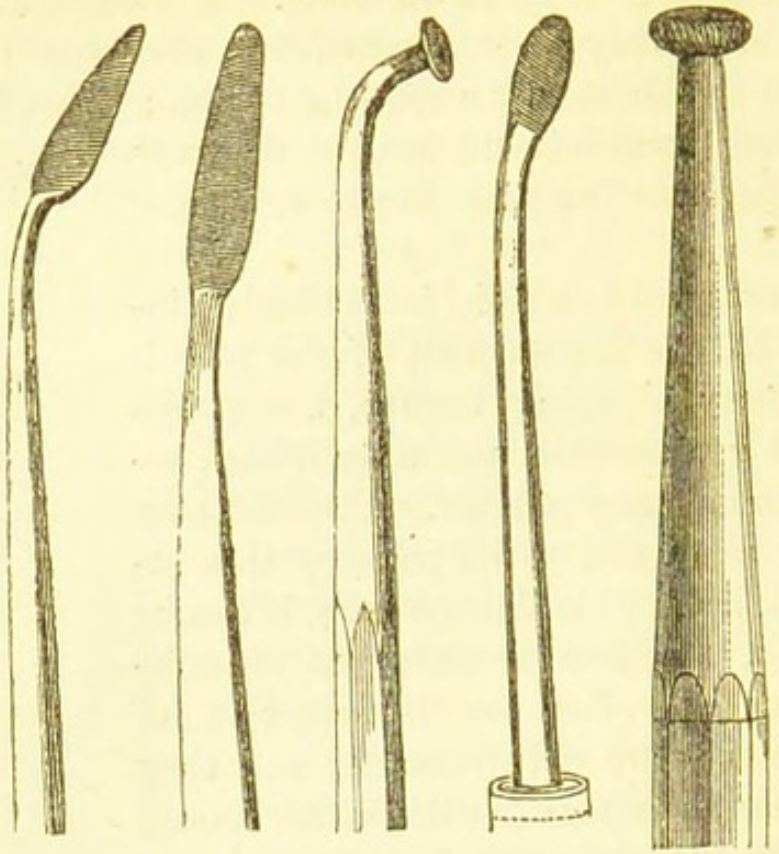
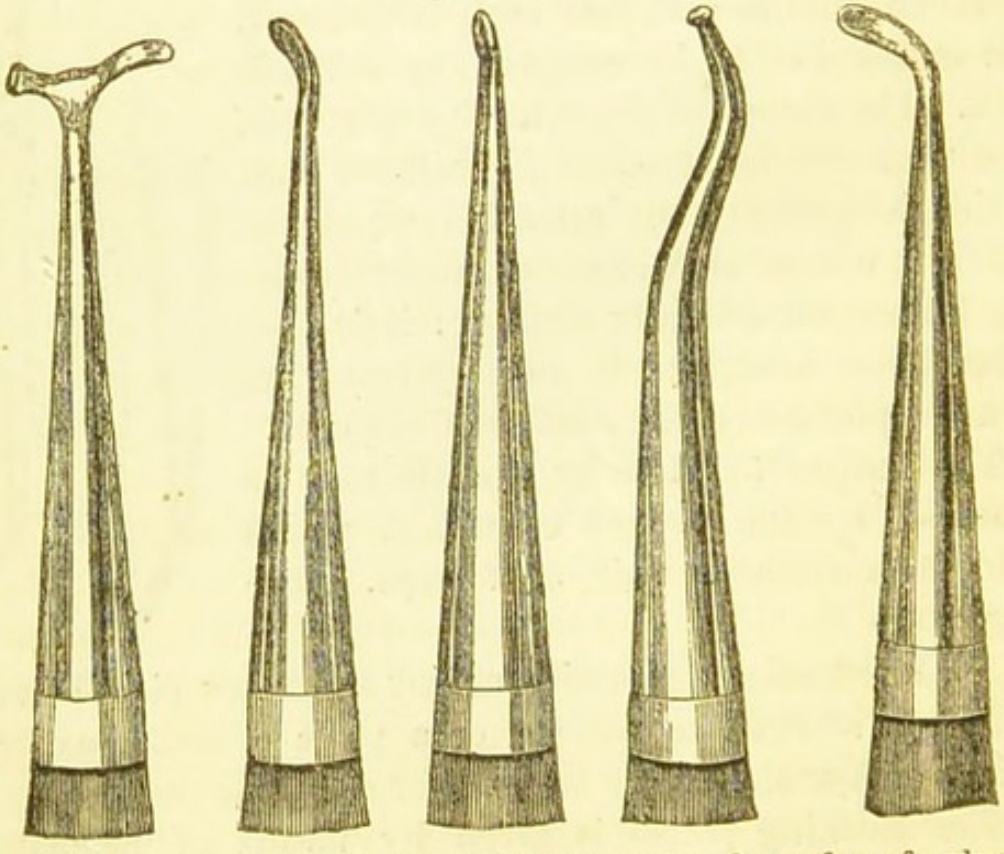


Fig. 156. (2)



(1) Showing several useful forms of file for reducing the surface of a plug.
(2) Generally useful forms of burnishers.

instruments of varied form made of hardened brightly-polished steel. A few forms are here given for illustration, but a great variety of different shapes are in use. (Fig. 156.)

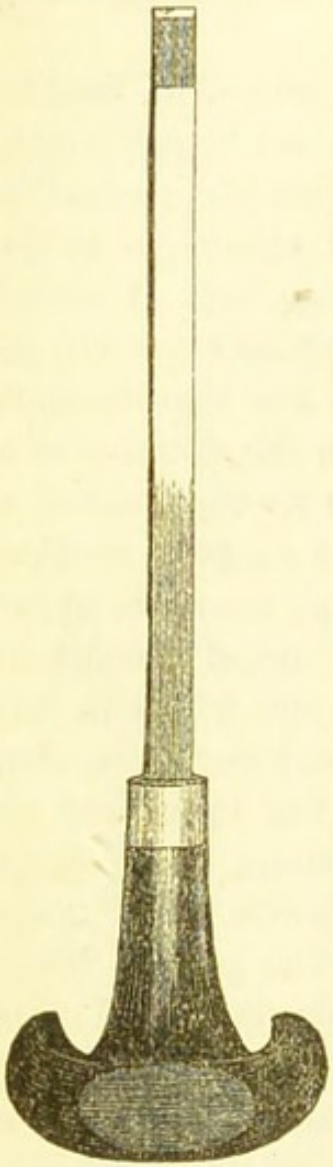
The forceps figured on page 381, which carry a small fragment of dividing file, are often exceedingly useful in filling and filing, whilst a similar pair of lighter make, designed to carry small points made of corundum, will be found very valuable in finishing the surface.

Treatment of Cavities in the Front Teeth.—The facility with which operations on any of the teeth can be performed, is greatly dependent on the means of placing the patient in a suitable position; and great diversity of opinion as to the most convenient form of chair prevails, so that it would perhaps be invidious to name any one maker's pattern as preferable to all others. There are one or two requirements which should, however, be kept in mind in the selection of a chair, and which may be introduced here for the want of a more suitable place. In the first place, the range of vertical motion should be considerable: for operating upon the upper incisors, it is often convenient to have the patient's mouth at or near the level of the operator's eye; and whilst in this position, the head should be able to rest backwards, so that the alveolar line may be nearly vertical. For operations on the lower teeth, more especially extractions, the patient should be placed low, so that the operator's arm is not much raised; few of the chairs in use allow of the patient being placed sufficiently low, Morrison's pattern being, in this respect, the best.

It is desirable that the back of the chair should have a reclining movement independently of the seat, and the head-rest should be so contrived as to allow the patient's head to lie far back, or to rest with the chin upon the chest. By inclining the head to the one side or the other, or by the operator sitting on a stool by the side of the chair, access may be gained to most cavities without the assumption of a very constrained position.

As the teeth are usually in close apposition, it becomes necessary to resort to means capable of producing a sufficient amount of separation to allow of the introduction of instruments. The end may be gained either by the introduction of strips of caoutchouc or of compressed wood between the teeth, or we may cut away the faulty tooth. The selection of means must depend upon the state of the tooth to be operated upon. If the decay has a considerable superficial extent, it will be well to cut away the lingual surface of the tooth with the chisel (Fig. 157), in such a manner as shall leave a V-shaped division between the teeth, without interfering with their external appearance. If the superficial extent of the disease be limited, it will be well to avoid cutting into the tooth, as we should be sacrificing sound tissue. The requisite separation may be obtained by the insertion of india-rubber between the affected and the contiguous tooth. In some cases a sufficient interval will be produced in twenty-four hours, while in others a much longer time may be required.

Fig. 157. (1)



The next step is the removal of the disorganised dentine; but before proceeding to remove the decayed tissue, the condition of the gum with respect to the diseased tooth should be considered. In many cases we shall find the free edge vascular, and descending below the upper margin of the cavity, and perhaps curled into it. When in this state it will be next to impossible to operate without wounding the gum; blood will then flow for some time, and

(1) Straight enamel-cutter.

perfectly obscure the cavity. Formerly the patient would have been sent away, with directions to force cotton-wool saturated with a solution of mastic between the teeth, renewing it from time to time until the gum became forced up out of the way. I believe we owe the following ready and effectual method of at once getting over the difficulty to our American brethren. 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 (Figure 95) 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 we are operating upon the mesial surface of the left central incisor, the tooth may be held by the index finger and thumb of the left hand, the arm having been passed round the head to the left side. In using the excavator, it

must ever be borne in mind that the pulp, though less in size, corresponds very closely in shape to the tooth itself, and although it may be, and often is, altered in shape by the calcification of the part towards which the disease has proceeded, yet the cutting instrument must be used with caution after we have advanced to a certain depth into the dentine; for should the pulp be wounded, the destruction of the tooth may be endangered. Rather than run an obvious risk, it will be better to leave a little discoloured tissue at the bottom of the cavity. From the walls and from the floor of the cavity, on its labial and lingual sides, it may be cut away, as in the latter situation we shall escape the pulp by proceeding behind or in front of it.

Having shaped the cavity in accordance with the directions given when treating upon the subject generally, the part should be cleared of all extraneous matter by directing upon it a stream of warm water, by means of a syringe. The cavity should now be wiped dry with cotton-wool or tissue paper, and its shape very carefully examined. Should any doubt exist as to a proper form having been produced, a little warm wax or gutta-percha may be pressed into it, and a cast obtained. By this simple procedure we shall often discover that had a plug been introduced, the chance of its preserving the tooth for any length of time would have been but slight. Supposing it be found that the walls of the cavity are generally divergent from within outwards, the defect must be remedied. Small hoe-shaped instruments will be found suitable for reducing to parallelism the labial and lingual walls; and a drill, carefully directed so that it shall not approach too closely upon the pulp in the neck of the tooth, will reduce to a proper figure the upper wall of the cavity. The excavator, figured on page 388, will be found very serviceable in preparing the cervical portion of the cavity. After feeling assured that the cavity has acquired a form favourable for the retention of a plug, it must be thoroughly washed out, and subsequently made perfectly dry.

Steps must now be taken for preventing the access of moisture: a roll of cotton-wool, or a small napkin folded into a riband, should be placed between the gums and lips, and brought round upon the palate behind the front teeth. Its position may be maintained by the index and second fingers, or the rubber dam may be applied. The character of gold suitable for the case having been determined upon, and a sufficient quantity arranged upon the operating table within reach of the right hand, its introduction may be commenced, the patient having been previously requested to breathe through the nose.

Fig 158. (1)

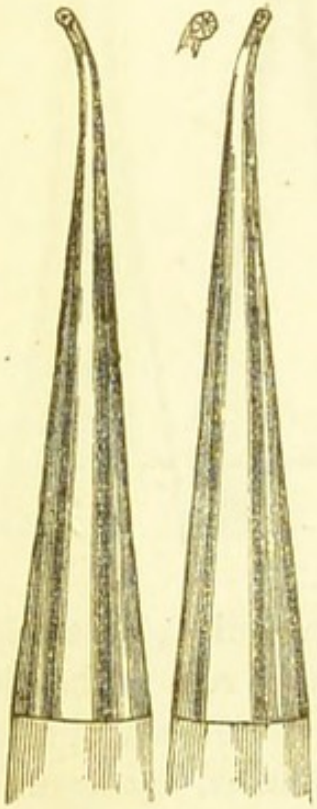


If the cavity be not very large, foil arranged in the stellate form will be found to work advantageously. Two or three stars may be taken up on the point of the instrument and pressed towards the upper wall of the cavity; one after and within the other. The arms of the stars should then be folded inwards, and the whole compressed thoroughly against the upper part of the cavity. Some little care is 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

(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.

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.

Fig. 159. (1)



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 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

(1) 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.

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

Fig. 160. (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.

from the surface of the plug, when chalk may take the place of 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 and harder 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.

A considerable space has been given to the manner of plugging cavities on the mesial surfaces of the left central incisors. The description will, however, apply equally to operations performed upon the distal surface of the right incisors, and to those situated on the distal surface of the corresponding teeth of the left side of the mouth, excepting only that the head should be turned towards the operator, instead of from him. The left hand, too, will be somewhat differently placed. When it becomes necessary for the patient's face to be directed towards the operator, the fold of napkin placed under the lip and behind the teeth may be retained by the thumb in the latter, and the index finger in the former situation.

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 com-

paratively 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.

Cases not infrequently arise in which the walls are all much weakened, excepting only at the upper part of the cavity. If this part can be so shaped as to very firmly retain the gold packed into it, the rest of the cavity may be filled by gold packed adhesively on to that first introduced, very little pressure being made upon the weak walls. Thus it is often possible so to form the upper half of the cavity, that it will firmly retain a ball of non-adhesive gold pressed into it and malleted till it is perfectly hard; sponge gold may then be built on to this till the cavity is full, and thus a satisfactory filling introduced where the walls, towards the lower end, are little else than enamel.

A useful contrivance for making up pellets of non-adhesive gold, consisting of two sheets of zinc, has already been described. By means of this all handling of the gold is avoided, and the adhesive gold will more readily stick to the pellet first introduced.

Cases will arise in which the disease has so far injured the tooth, that instead of finding one, all the walls excepting the

upper are rendered too weak to admit of the application of sufficient force for the introduction of foil, and there is no prospect of introducing a satisfactory gold plug by the method 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 two years, and 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, 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 a 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.

Caries may attack either the lingual or the labial surface of the incisors, and necessitate the adoption of remedial treat-

ment. Natural depressions are not uncommonly found in the enamel on the lingual surface of the incisor teeth, and disease is apt to establish itself in such situations. The cavities which result are generally of a simple kind, and do not require any special description.

When the development of the enamel has been defective, cavities may be produced by disease in those parts where the natural defect is most strongly pronounced, whether it be situated on the lingual or labial surfaces of the teeth. If submitted to treatment at a tolerably early period, the hole is usually characterised by greater breadth than depth, and its shallow walls slope outwards.

The cavity, after the mere removal of the disease, may be compared to a saucer—a form incapable of retaining a plug with any degree of certainty. The first step in the proceeding must be the reduction of the walls to a vertical position by the use of a small, sharp excavator, and it will be well, when the cavity is very shallow, to produce a slight degree of undercut. In selecting the materials for forming a plug, foil and crystal gold may be taken with advantage. Three or four thicknesses of foil, sufficient to line in an even layer the surface of the cavity, should be first introduced; small fragments of sponge gold may then be added, and thoroughly compressed, one after the other, until the resulting plug stands higher than the general level of the tooth. Or if a groove be cut at the upper and lower portions, or at its two sides, as may happen to be most convenient, foil may be packed securely into each of these places, and the plug completed by filling up the central space between the portions first introduced by some form of adhesive gold, the latter acting like the keystone of an arch.

After removing the superfluous gold with a file, the surface of the plug should be examined with a sharp-pointed instrument, and any defect made good. This having been done, and the instrument marks filed out, the surface may be further improved by rubbing it with Water of Ayr or a slip

of Arkansas stone, together with the surrounding enamel, should that be rough and broken in character. The operation will be completed when the surface of the gold has been polished either by the use of chalk or the burnisher. Cavities of this character may often be rapidly and effectively filled by the use of small pieces of heavy gold foil.

Another description of cavity in the front teeth remains to be noticed. A narrow transverse slit produced, I believe, in the first instance, by the tooth-brush, is sometimes found immediately above the terminal edge of the enamel, deep in the centre, but cropping out on either side, with the walls diverging outwards. To reduce such a groove into a form for receiving a plug, the upper and lower walls must be slightly under-cut, and at the two extremities the groove should be deepened by the use of a drill so as to form a cavity. If the operation be properly conducted, the groove or slit will be converted into a trough, the sides and ends of which will, if not under-cut, at least be perfectly vertical. The operation of filling may be conducted in the same manner and with the same materials as in the preceding example.

In the treatment of cavities in the canine teeth, the directions which have been given in respect to the incisor teeth are equally applicable, both as regards the manner of operating and the materials used.

Treatment of Simple Cavities in the Bicuspid Teeth.—Any part of the crowns of the bicuspid teeth may be attacked by decay, but the mesial and the distal surfaces are the situations in which it is most frequently developed. Supposing the mischief to have occurred on the mesial surface of the second bicuspid on the right side of the mouth, the operation will be commenced by cutting away the enamel from the mesian edge sufficiently to expose the cavity, and to admit of the introduction of instruments employed in the subsequent stages of the operation. The radiate direction followed by the enamel fibres must be

borne in mind, otherwise the removal of that tissue will be attended with greater difficulty and greater inconvenience to the patient than necessary. The most suitable instrument is the flat chisel-shaped enamel-cutter, the edge of which, on commencing the operation, should be applied in a direction parallel to the course of the alveolar line, and gradually changed to a rectangular position with the disappearance of the part undergoing removal. The excision of the carious tissue will now be effected without difficulty; and having advanced thus far, it will be advisable to introduce the wooden wedge between the teeth in the manner described at page 377. The gum having been pressed up against the alveolus, the cavity may be reduced into the required form without fear of embarrassment from a wounded vessel. Care must be taken to remove all the affected tissue from the upper part of the cavity. This may be accomplished with a drill, but the position of the pulp must be borne in mind, for instruments of this character, when in good order, cut rapidly, and if a proper direction be not observed, the pulp-cavity will be opened. In producing parallelism of the sides of the cavity, the hoe-shaped excavator will be found very useful, as will, also, the round-ended excavator here figured; and several sizes and forms of these should be at hand, some of which are constructed to cut by a drawing, others by a pushing motion. If this part of the operation has been conducted with success, an oval cavity will have been produced, the walls of which converge slightly from within outwards, more especially the upper wall, the margin of which will be covered by the wedge, thus producing a shallow cavity, a temporary side being formed by the wood. The head of the patient should be thrown back into the position

Fig. 161.



similar to that described as the most convenient for operating on the front teeth. Instructions having been given in reference to keeping the mouth open, to breathing through the nose only, the teeth and gums should be wiped dry. After placing a fold of linen between the lips and gum, and another on the lingual side of the tooth, the cavity should be thoroughly dried with tissue paper or cotton wool, or any other convenient material. The thumb and forefinger will be employed to keep the folds of linen in place, and to raise the lip out of the way. If the flow of saliva is very abundant, a slip of adhesive plaster(1) resembling court-plaster, may be placed upon the lingual and labial surfaces of the gums, and allowed to extend a short distance over the tooth. After being held in position by the linen, it adheres firmly to the gums, and perfectly excludes the saliva from finding its way between the teeth or the rubber dam applied. A sufficient quantity of gold having been prepared, its introduction may now be commenced. It will be desirable to have a large piece of non-adhesive foil, loosely folded or crinkled up between the foil-folding instrument described at page 384, to lie against the margin of the upper cavity. This must be carefully introduced, and thoroughly condensed by the plugging instrument against the upper wall; for this purpose foot-shaped pluggers (Fig. 151) are very useful. The forms shown in the accompanying figures will be found suitable for the purpose.

If this, the first part of the operation, has been successfully performed, the gold will be firmly fixed in the upper part of the cavity, and the most difficult part of the operation accomplished. We have now to fill what may be regarded as the secondary cavity. This may be done by adding successive pieces of adhesive gold, taking care that

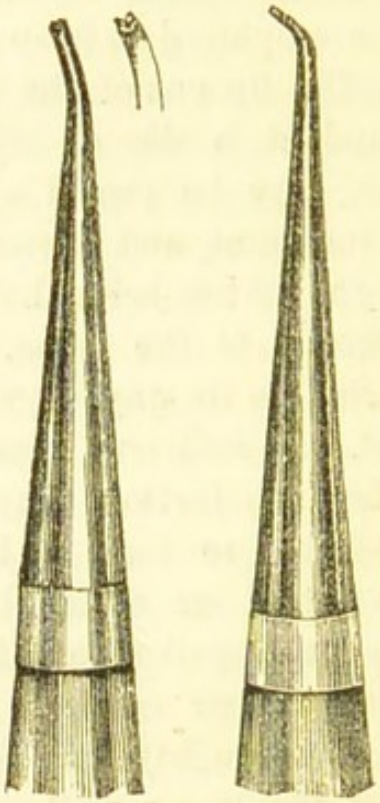
(1) The plaster, and the method of using it, were described before the Odontological Society, and the account was published in the first volume of the "Transactions." It is made by coating gutta-percha membrane with gelatine, thus rendering the one surface adhesive, while the other is quite impervious to moisture.

each is thoroughly adherent to, and condensed upon, its predecessor, and that each is laid on with some degree of evenness. If the latter caution is neglected, on completing the operation it will be found that the plug is perfectly solid in the centre and porous at the sides—a faulty con-

Fig. 162. (1)



Figs. 163 *and* 164.



dition which it is difficult to remedy without commencing the operation anew. In order to guard against the occurrence of this error, it will be well to test the plug from time to time with a square-pointed or a wedge-shaped perforating instrument. It may be necessary, when the lower wall is approached, to change the instrument in favour of one the blade of which is more bent upon the shaft (Fig. 164), in order to ensure the gold being carried to the bottom of the

(1) Figs. 162-3-4 show instruments having the same general character, the first being adapted for introducing the gold, whether foil or sponge; the second and third for the condensation of the plug.

cavity. It has been assumed that the first portion of the plug was formed of foil moderately adhesive only, and that in the subsequent steps of the operation gold possessing the highest degree of adhesiveness was used. As good, and perhaps a better result would have been obtained had the crystal gold been used, providing the cavity had been first lined with a thin layer of foil. There are those who in all cases employ the non-adhesive foil used upon the wedging system, and I have seen plugs so made that cannot be objected to; but I much prefer the use of a material which, when consolidated, forms one solid mass.

Fig. 165. (1)



When no further addition of foil or crystal gold can be added, an instrument having a broad convex surface cut up into conical points (Fig. 165) will be found useful. It should be pressed firmly on the surface of the plug with a rolling motion. The gold will thus be reduced to a comparatively level surface. The presence of the wedge will protect the gum from injury during the process of filing to a level surface the plug and the surrounding tooth substance; the wedge should therefore be retained in its position until that part of the operation is completed. It is necessary that a free interval should be left between the teeth, in order that food and other matter should be readily removed. If an error is committed, it will be in the too sparing, rather than in the too free use of the file. It only remains to complete the plug by polishing in the usual manner.

If the cavity be situated on the distal, instead of the mesial surface of the tooth, or upon either of those surfaces in the bicuspids of the left side of the mouth, the steps of the operation will be the same as in the case already described, excepting as regards the position of the patient's head. The

(1) Shows an instrument with an expanded extremity cut into minute cones.

face must be turned a little towards or from the operator, as may suit his convenience.

In forming the upper edge of the cavity, when the decay has reached the level of the gum, it is often very difficult to get a smooth, satisfactory margin; and even when it has appeared to be all that could be desired, it not infrequently happens that the enamel splits off during the introduction of the gold. The enamel at this part of the tooth is naturally very thin, and readily parts from the dentine; hence it is perhaps desirable, when the cavity extends very nearly to the point where the enamel terminates, to carry it a little beyond it, so as to get rid of this fragile piece of enamel, and obtain a cavity the cervical wall of which is bordered by cementum. It is rare for caries to originate in the cementum; and it is the opinion of many American operators of repute, that the cervical wall had better be composed of cementum than of enamel.

It is often a matter of difficulty to introduce the gold beneath the enamel and dentine which bound the cavity towards the masticating surface of the tooth; if the plug is not perfectly solid at this part, the tooth will give way over it during mastication. A method which is often very serviceable, consists in altogether cutting away this wall of the cavity with an enamel-cutter. In this way a cavity is formed having only three walls; in order to securely retain the plug, which forms a part of the masticating surface of the tooth, the cavity must be made somewhat wedge-shaped, both from above downwards and from without inwards, the largest portion being, of course, at the cervical wall and at the floor of the cavity—or, at least, what would have been the floor, had not the masticating wall of the cavity been removed. The whole cavity is thus easily accessible to straight instruments; and by commencing with a piece of non-adhesive, and completing the filling by pieces of adhesive foil, most satisfactory results may be obtained.

American dentists have lately introduced a plan of filling

these interstitial cavities by the aid of "matrices;" these consist of polished plates of metal introduced between the teeth, so as to serve as a temporary fourth wall to the cervical portion of the cavity; they are removed either when this part of the cavity is filled, or are allowed to remain until the whole plug is completed.

Treatment of Simple Cavities in the Upper Molar Teeth.—It will not be necessary to enter minutely into all the details connected with plugging the molar teeth, as the account would be but a repetition of that which has already been described in connection with the operations upon the more anterior teeth. The differences only need be pointed out.

The head of the patient should be well thrown back, and placed at a height to suit the convenience of the operator.

Fig. 166. (1)



If the disease be situated upon the mesial surface, the tooth should be freely cut away, in the manner recommended in the treatment of bicuspids when decayed in the corresponding situation. The rubber dam will render great assistance in preventing the tongue from bringing moisture to the tooth, and also in rendering it unnecessary to change the folds of a napkin, which sometimes becomes saturated during the operation.

In condensing a plug upon the masticating surface, the accompanying form of instrument will be found serviceable (Fig. 166), more especially if the cavity be situated in the second or third molar.

When the distal surface is attacked by decay, the enamel-cutter must be freely used, and the tooth cut away until, on the commissure of the lips being drawn back by the first

(1) Showing an instrument for introducing adhesive foil or sponge gold into cavities in the masticating surface of the upper molars.

and second finger of the left hand, the cavity can be seen. The operation of plugging is far too difficult to admit of being successfully performed in a cavity which is out of sight. It will consequently be sometimes found necessary to reduce the tooth to a greater extent than would have been needed, had the disease been situated on the mesial surface of the tooth. In the introduction of the gold the instrument will enter the cavity at the angle formed by the distal and labial surface of the tooth, when situated on the right side of the mouth; and in order to afford the requisite space, this angle of the tooth must be reduced to a greater extent than that situated near the lingual surface. But if the operation be on the left molar, it will be found advantageous to submit the latter angle to a considerable amount of reduction. In either case, however, we must to a considerable extent be governed by the course taken by the disease, and the extent of injury it has produced.

Fig. 167. (1)



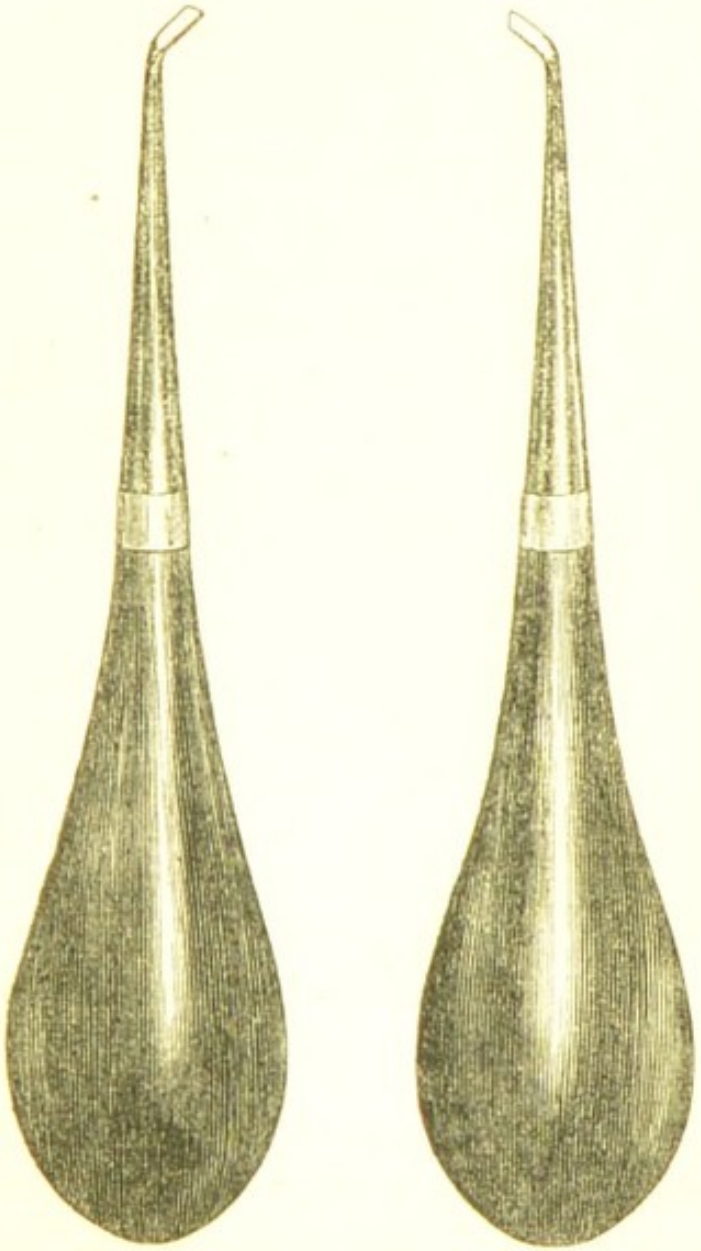
The preparation of the cavity must be proceeded with upon the same general plan as that already described, and the instruments used in plugging the bicuspid will be equally suitable for the molar teeth. In consolidating the surface of the plug, the accompanying form will be found suitable.

For cavities situated on the labial surface of the upper molars, a pair of instruments, right and left, somewhat of the forms given in the figure (Fig. 168), will be found serviceable. With the head thrown back, and the face turned to the right or left to suit the case, and the commissure of the lips drawn back, the cavity can be readily reached with the instrument, and a twist

(1) Showing an instrument suitable for the introduction of crystal gold, or for finally condensing the surface of a foil-filling situated in the distal surface of an upper molar or bicuspid tooth.

given to the blade will enable the operator to force the foil upwards and backwards, without allowing the shaft of the instrument to interfere with the teeth and lips of either jaw.

Fig. 168. (1)

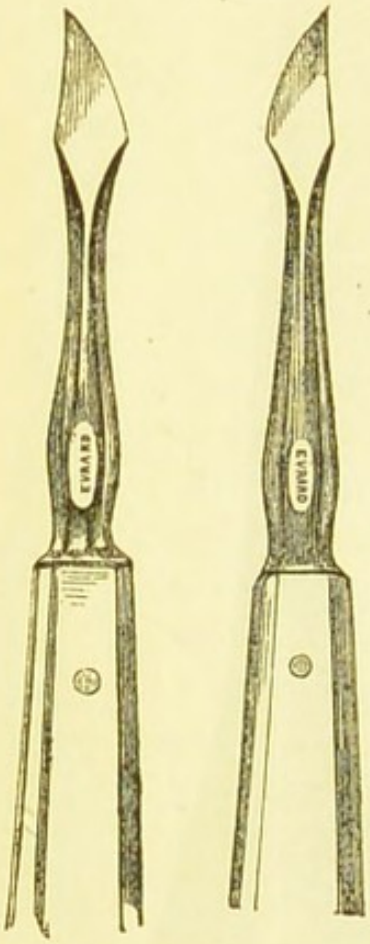


No one will be found to question the superiority of gold over other filings, but there are cases in which the crown is so hollowed out that the tooth is reduced to a mere shell, quite incapable of withstanding the force necessarily em-

(1) Right and left instruments for introducing foil into cavities situated upon the labial surfaces of the upper molar teeth.

ployed in the introduction of foil or sponge gold. In the treatment of a case of this kind, we shall do well to use amalgam. The tooth may not last for any great length of time, but should it be rendered serviceable but for a twelve-month, the interest of the patient will be better served than if the tooth had been broken down in an abortive attempt to make a gold plug.

Fig. 169. (1)



Again, there are those who will not submit to the prolonged operation entailed by using gold. They become so restless that the formation of a sound plug is rendered almost impossible; and seeing that a good amalgam is more likely to save the tooth than a defective gold plug, it will be wiser to use the former material. The slight discoloration which may ensue is in the molar teeth of minor importance. Gutta percha might be used, but it does not render the support to the fragile tooth that is afforded by the hardened amalgam, the surface of which will endure for years uninjured by mastication.

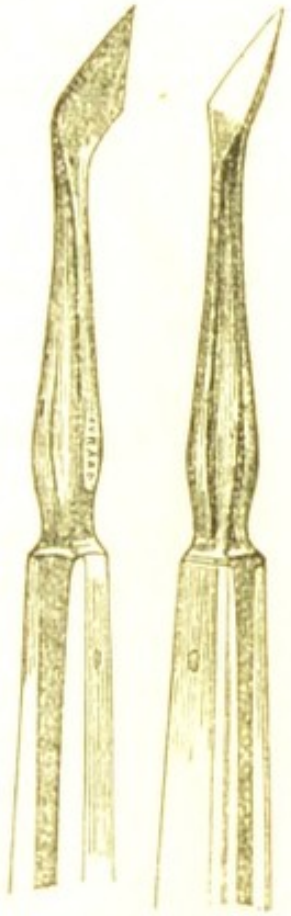
Treatment of Simple Cavities in the Teeth of the Lower Jaw.—In operating upon the lower teeth the proceeding will be varied as respects the position of the patient, the form of the instruments used, and the precautions necessary to exclude the intrusion of the saliva from the part under treatment.

The enamel-cutter will be called into requisition, but the straight chisel-shaped instrument so useful in the upper, fails

(1) Right and left sabre-bladed enamel-cutters, suitable for operating upon the mesial or distal surface of the bicuspids or first molars of the lower jaw.

to meet the requirements of the operation in the treatment of teeth of the lower jaw. The subjoined forms will be found better suited for the purpose. For removing the mesial or distal surface of the canines, bicuspids, or first molars, instruments the blades of which are sabre-shaped, and in a straight line with the shaft, will be sufficiently suitable, but the corresponding surfaces of the second and third molar teeth cannot be conveniently reached by straight instruments. For the latter teeth the blade should be placed at an angle of forty-five degrees with the shaft, and the cutting edge formed by a chamfer from the under in one, and from the upper surface of the blade in a second instrument; and enamel-cutters, the blades of which are bent at right angles, will prove very useful.

Fig. 170. (1)



In the preparation of cavities in the lower teeth, the same general rules given in respect to the subject generally must be observed. It matters not where the cavity is situated, the plug will soon fall out, unless the form is suitable.

Prior to the introduction of the gold in cavities situated in the mesian or distal surface of the lower incisor or canine teeth, the wedge should be inserted, and ample precautions should be taken for the exclusion of the saliva. If the rubber dam be not employed, after placing the head so that the face is turned sufficiently upwards to allow the saliva to flow towards the throat, a strip of the impervious plaster may be placed upon the lingual surface of the gums and teeth, and between it and the tongue a tolerably thick fold or rope of

(1) Enamel-cutters, with the blade placed at an angle with the shaft; the one being brought to an edge by a chamfer from the upper, the other from the under surface of the blade.

linen. A corresponding fold may then be placed between the lip and gums, the two being retained in position by the thumb and forefinger of the left hand brought round the head of the patient, these two folds being composed of a single napkin, twisted into a rope-like form, and carried over the crown of the teeth.

The cavity having been rendered perfectly dry, the gold may be introduced with instruments similar to those used in conducting the like operations on the corresponding upper teeth. Cavities in the canines may perhaps in some cases prove exceptional, and require similar management to that which will be subsequently described as applicable to the treatment of the contiguous bicuspids.

Fig. 171. (1)



In filling cavities situated on the mesian or distal surface of the last-named teeth, the spiral-bladed instrument may be employed with advantage, the gold being introduced from the labial side of the tooth. When the distal surface of the right teeth is under treatment, the operator should stand to the right, and a little behind his patient; and on the side, but slightly in front, when the corresponding part of the left bicuspids is operated upon—the patient in the former case leaning his face to the left, in the latter towards the right side. Those instances in which the crowns of the teeth are reduced to a considerable extent on the lingual side, in consequence of the disease having encroached upon the masticating surface, as well as upon the neck, will allow the foil or sponge to be introduced from above more advantageously than from the side. The plugging instrument should have a short blade,

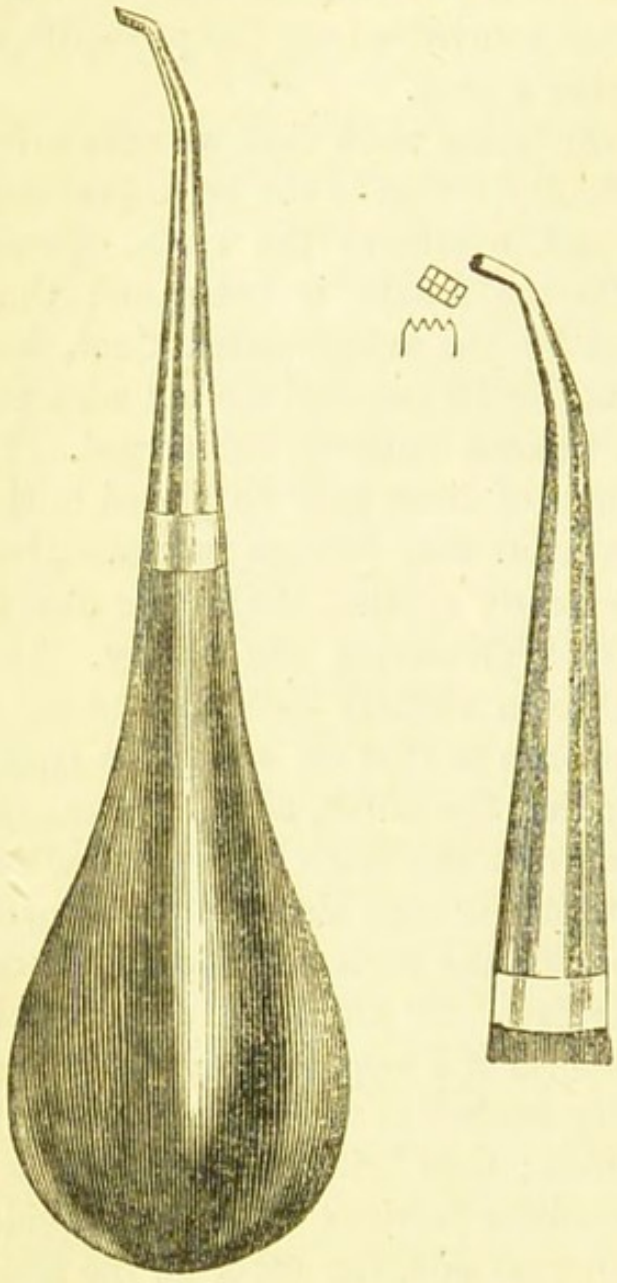
(1) An instrument used for condensing the surface of the gold inserted either on the distal side of the right, or the mesial side of the left bicuspid. An instrument resembling the one shown in the figure is well adapted for condensing the surface of the gold.

bent nearly at a right angle, and the shaft itself should also be slightly bent in the same direction, at a distance of about three-eighths of an inch from the blade. The two curves will enable the blade to hook over the crown of the tooth and enter the cavity. The gold having been introduced, the subsequent stages of the operation involve only the proceedings usually adopted in completing a plug.

It is in operating upon the molar teeth that we encounter the greatest amount of difficulty, owing to the large quantity of saliva which collects and overflows the teeth. Some patients can swallow while the mouth is open, and thus from time to time get rid of the accumulated fluid, but others cannot; and if means for its removal are not adopted, the crowns of the teeth become entirely submerged. To overcome this difficulty, folds of linen may be placed in the mouth, and renewed so soon as they become saturated, but wherever it can be conveniently applied, the rubber dam is the most effectual means of protecting the cavity. The patient's head should be thrown slightly back, and turned a little towards the side opposite to that on which the faulty teeth are situated, in order that the saliva, when the amount is not excessive, may flow from the teeth under operation. A small patch of adhesive plaster may also be placed upon Steno's duct, which opens upon the surface of the cheek near the first molar of the upper jaw. Or after rolling a napkin into a rope, bend it in the form of a loop, and lay the curved portion over the masticating surface of the molar posterior to the cavity about to be filled; then bring the two ends outwards, allowing the intermediate portions to lie by the sides of the teeth, one on the lingual side, the other on the labial side of the teeth. If the operation is on the right side of the mouth, the twisted napkin can be retained in position by the thumb and second finger of the left hand brought round from the back of the head. If a fold of linen be placed between the cheek and the upper teeth, some pressure may be made against the orifice of the parotid duct, and will tem-

porarily close it. With a little management, we shall succeed in keeping the tooth under operation dry for a sufficient length of time to enable the gold to be introduced. When the operation is on the left side of the patient's mouth, the arrangement will differ only in the position of the left hand, which will then be in front; the thumb will rest on the labial, and the second finger on the lingual side of the teeth. By using the second finger for the retention of the napkin, the first is left free for assisting in the guidance of the instrument, or the adjustment of the napkin, should it become displaced: and the use of such an instrument as Hawes's duct and tongue compressor will save the operator's fingers much fatigue. If the flow of saliva be excessive, a small fold of linen may be placed behind the incisor teeth, and when saturated, renewed with the right hand, while the left keeps the napkin which surrounds the faulty tooth undisturbed.

Figs. 172 *and* 173 (1)



(1) Instruments constructed with a double curve for filling cavities in the masticating surface of the lower molar teeth; the former being suited for ordinary foil, the latter for adhesive foil or sponge gold.

If the cavity under treatment be situated upon the masticating surface, an instrument presenting a double curve will be found to meet the requirements of the case (Fig. 172). The curve of the shaft carries the instrument over the contiguous teeth without the handle being inconveniently raised. After the gold is introduced, another form of instrument will be found useful for condensing the plug (Fig. 174), which, being exposed to wear, cannot be too hard.

Fig. 174. (1)



The shaft is bent almost in the shape of the letter S, and when used descends from the lower border of the closed hand, the blade terminating in the working surface being in a vertical position. It is necessary to support the jaw of the patient with the left hand.

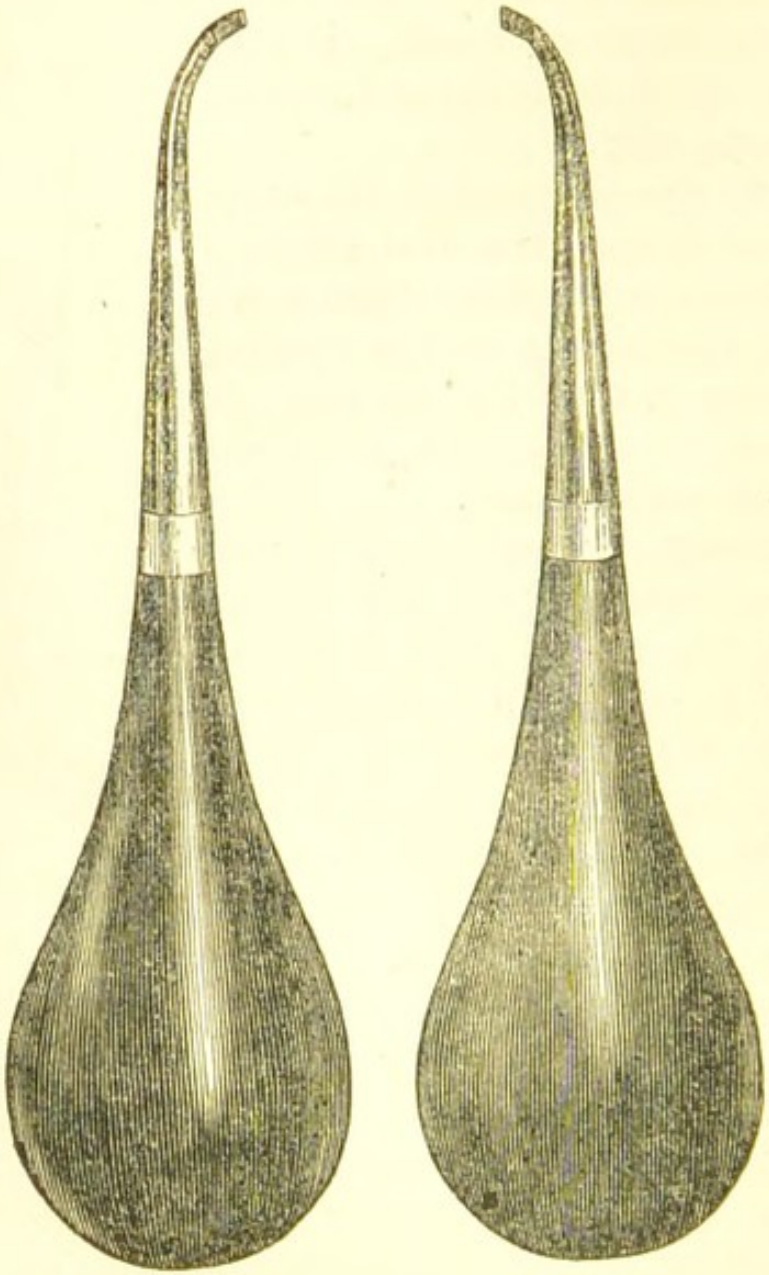
For operating on cavities in the labial surface, a double-curved instrument, similar as respects the blade, but with the curve in the shaft in a different direction to those last described, will be found very serviceable. When in use, the shaft will be nearly parallel to and a little above the crowns of the lower teeth, the blade descending, and the working extremity directed obliquely downwards and backwards (Figs. 175, 176). By adopting this form, the operator is enabled to keep in view the lower margin of the cavity during the packing of the foil—the part in which the plug is most frequently defective, and consequently requiring the greatest care in its construction.

The most troublesome cases to treat with success are those

(1) An instrument for compressing plugs introduced in the masticating surface of the inferior molars. The handle is grasped with the blade passing downwards from the lower border of the closed hand.

in which the disease is situated on the distal surface of the lower molars, more especially when the cavity is small, and confined to the neck of the tooth. The free use of the

Figs. 175 *and* 176. (1)



enamel-cutter is required, and it is often with great difficulty that the crown of the tooth is sufficiently cut away to enable

(1) A right and a left double-curved instrument, for introducing foil into cavities on the labial surfaces of the lower molars.

the cavity to be reached. A good quality of steel, well tempered, is required to enable the operator to cut through the sound enamel of molar teeth, more especially when, as in lower molars, the position is unfavourable; for filling such cavities cylinders will very generally prove the most convenient form of gold.

In describing the treatment of caries, the observations have been confined to those cases in which the pulp of the tooth has not been involved in the disease—cases in which the cavity to be treated has been simple. The more complicated forms of the disease remain for consideration. They will come under two divisions; first, those cases in which the pulp is exposed, but not obviously diseased; secondly, those in which the pulp-cavity is laid open, and the pulp diseased or dead.

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 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 directly 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 foil, folded six or eight times upon itself, 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 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, the quill-horn, 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 part 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. To follow out these indications, the exposed pulp should be protected by an artificial covering, which, while it protects, will at the same time keep the pulp within its natural limits, and defend it from sudden changes of temperature.

In adjusting the cap, some little time and attention must be given in order to secure its taking a level bearing upon a surface which may be, and frequently is, uneven; and it should also, if practicable, fit to the walls of the cavity with sufficient tightness to secure the retention of its position during the introduction of the gold or other material.

Before, however, we proceed to fill the cavity, it must be

determined whether the plug is to be regarded as a temporary or a permanent one. Should the treatment prove successful, the exposed portion of the pulp will, in the course of a few months, become calcified, and the aperture in the cavity stopped from within by a layer of secondary dentine. Assuming this process to have been effected by nature in a tooth that has been permanently plugged over a cap, it is quite possible that the filling will preserve the tooth for an unlimited period, but it is far more probable that a plug introduced under such circumstances will, after a time, fail, and the failure perhaps may not be discovered until the crown of the tooth is all but lost. Had the filling been regarded as temporary, the tooth would have been examined after the lapse of six or eight months, the temporary plug removed, and a gold filling introduced under circumstances far more favourable than obtained when the operation was complicated by the presence of a cap and general tenderness in the tooth.

So much uncertainty, however, was found to follow on the capping of exposed nerves, that the practice fell into some disfavour, but it has again been revived in a somewhat modified form, and meets with fairly successful results. In the place of using a protective cap of quill, or other hard, unyielding substance, it is now usual to lay over the point of exposure a very small piece of cotton-wool soaked in thymol or carbolic acid, or a drop of collodion containing carbolic acid. Over this a filling of gutta-percha, or, I think, preferably, zinc oxychloride, is inserted and allowed to remain for some months. Some writers advocate the direct application of the zinc oxychloride to the exposed surface of the pulp; but I prefer to protect the point of exposure by one or other of the substances mentioned. In many instances where the exposure of the pulp is very small, or where some softened dentine remains, forming an insufficient protection to it, a layer of zinc oxychloride may be put over it and allowed to harden; this is cut away on the next day,

excepting over that spot where its presence is desirable, and the rest of the cavity filled with gold.

Although the preceding plan often meets with success, as a general rule, I believe it is wiser to employ a temporary filling, which may be advantageously composed of zinc oxychloride. Mr. Thomas Rogers, in an elaborate paper (1) (to which I must refer the reader for a fuller account of all that relates to this subject), makes the following statement:— "As I consider it to be a matter of great importance to avoid as much as possible all irritation to the tooth in this delicate condition, I fill over the cap with amalgam."

Whether amalgam (in which case it would be well to use an amalgam that hardens imperfectly)(2), 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. Or the crown of the tooth may be so much injured that, even

(1) Transactions of the Odontological Society, vol. i. Mr. T. A. Rogers "On Capping the Exposed Pulp."

(2) Ibid., vol. iv., new series. Mr. C. S. Tomes "On Amalgams."

if the pulp were capped, the introduction of a plug would be attended with risk of breaking down the shell. The patient may be unable to return to you, or to obtain the assistance of a dentist for some years to come. On the occurrence of circumstances such as those enumerated, the protective system of treatment must be abandoned. Instead of striving to save the pulp, means must be adopted to bring about its destruction. The most effectual, and at the same time safest, manner of accomplishing this end, consists in passing a very fine and flexible broach through the opening in the pulp-cavity up the fang of the tooth. When the further progress of the instrument is arrested by the diminished size of the cavity, a rotatory motion should be given to the broach. The effect will be to cut off the pulp in the root of the tooth at the most constricted part of the canal, and, consequently, of the pulp itself. This treatment is applicable to single-rooted teeth only, and even in these the operation is sometimes attended with great pain, owing to the difficulty of passing the broach to its proper destination. Whatever instrument be used, it should be at once boldly thrust home: little or no more pain is given by such a procedure than by a mere touch, and indecision on the part of the operator involves prolonged suffering to the patient.

By destroying the pulp, we convert the once simple into a compound cavity, the one part being formed by the pulp-cavity, the other by the cavity produced by the primary disease.

The two cavities have now to be regarded as one, and steps must be taken to reduce it to a suitable form for the reception of a plug. The canal in the root, after the withdrawal of the pulp by a spirally-twisted broach, or preferably by one of the barbed instruments constructed for the purpose (1), should be enlarged with a drill, and the distinction

(1) Broaches for destroying and withdrawing the pulp should be very fine, elastic, and flexible, otherwise the capability of following the curved course necessary for the effective performance of the operation will not be obtained.

between the two cavities destroyed by graduating the walls of the outer into those of the inner cavity.

There appears to be some difference of opinion as to the time at which a tooth can be most safely plugged after the pulp has been removed. There are those who consider that the cavity should be filled with cotton-wool and mastic, and the tooth allowed to remain unmolested until any irritation that may supervene upon the destruction of the pulp has completely subsided.

The experience derived from my own practice has led me to arrive at a different conclusion. In the cases which have proved most successful, the canal in the root has been filled immediately on the cessation of the hæmorrhage, and the operation completed on the same or a following day. When this course has been followed, irritation of the alveolar membrane of the socket has seldom arisen; but when from any cause the permanent filling of the root has been postponed for some days, a certain amount of irritation has come on, the tooth becoming slightly raised in the socket, and painful when pressed upon. In some instances, the unfavourable symptoms have gradually passed away; in others, the tooth has been lost.

The different results consequent upon the two modes of treatment may be explained upon the assumption that when the permanent filling is used, the ingress of oral fluids is perfectly prevented, and the accumulation of anything more than a very minute amount of coagulum impossible; whereas, when cotton-wool only is employed, the permeation of saliva is not rendered impossible, neither is the collection of a relatively larger amount of coagulum guarded against.

The consequences which follow the laceration of a soft

Fine watchmaker's broaches, reduced to a soft spring temper, are commonly used; but a more effective instrument may be made by taking a firm watch-spring, and grinding it down until a square-sided broach is produced. If in a second the temper is slightly lowered, the point may be twisted to the extent of three or four turns.

tissue will, *cæteris paribus*, generally be proportioned to the amount of surface injured. In the case of a tooth, the sectional area of the pulp near the end of the root is so small, that its division in a healthy subject will not be followed by inflammation, unless the injured part is subsequently exposed to irritation. But should the saliva find access, or a large coagulum collect in the vacant cavity or in the interstices of the wool, and decompose, the lacerated surface will become inflamed, and the disease will extend from the remnant of pulp to the periosteum of the root and socket.

There are other methods than that just described of destroying the pulp; and in cases where the use of the broach is attended with difficulty, owing to the position of the opening in the pulp-cavity, or to the tooth having more than one root, they are to be preferred. The use of escharotics for destroying the pulp can no longer be looked upon as a novel mode of treatment. The practice has stood the test of time, and may be regarded as one of many great improvements in dental surgery matured during the present generation. Ruspini, in a pamphlet published in 1797 (1), mentions destroying the pulp, and subsequently filling the cavity, but the operation was not generally adopted, and its details and results worked out, until within the last twenty years. It

(1) Ruspini, in his "Treatise on the Teeth," the eighth edition, published 1797, makes the following statement: "Whenever caries appears it must be opened with a masterly hand to the very bottom. If in doing so the chord of the tooth is discovered, the operation will prove painful; but still it must be destroyed, either with an instrument, or with the actual cautery, or some caustic liquor.

"We ought to be very attentive in the operation; for if we do not utterly destroy the said chord, but only prick it, the most raging pains will succeed, together with an inflammation, and the inevitable necessity of drawing the tooth.

"When a tooth by the loss of its chord is become insensible, it must be filled with lead or gold, in order to prevent any acid or saline particles from getting through the hole where the chord went into the socket, to hurt its delicate membrane; for then there would be no means of redress but by drawing the tooth; hence all the care that had been taken, and all the pain that had been endured to render the tooth insensible, would then be of no avail."

is singular that a principle the soundness of which had been fully established for the best part of a century in the operation of pivoting, should not have been applied to the preservation of teeth the crowns of which were but partially decayed. Every one knew that after the removal of the pulp, a piece of gold wire might be passed up the healthy root of a front tooth, for the purpose of supporting a new crown, but it did not occur to those who practised pivoting that the crown of a tooth could be preserved by an operation conducted upon the same principle. It is not, however, very difficult to see how the fact was overlooked. The gold pin was not introduced for the purpose of preserving any portion of the faulty tooth, but was regarded as purely subservient to the support of a new crown, in the place of that which had been too far injured to render its retention desirable.

There are several general rules which may be laid down in respect to the selection and the application of escharotics. The first in point of importance is, that they should not be employed when there is reason to suppose that the peridental membrane is diseased, and for the following reason. It seldom happens that inflammation external to the root arises, excepting as an extension of disease originating in the pulp, during the progress of which both the pulp itself and the canal in the fang become considerably enlarged. Consequently the action of the caustic may not be limited to the pulp, or if it be, that portion which is allowed to remain will be in a diseased condition, and capable of keeping up the morbid action in the alveolus.

The second rule to be observed is, that no more of the escharotic should be applied than will be sufficient to produce the required effect. For if an excess be used, it is more than probable that the action will extend beyond the required limits, and produce inflammation of the peridental membrane. The third rule is, that the application should not be continued over a longer period than is necessary to ensure the destruction of the body of the pulp. If allowed to remain

for a long time in the tooth, it may permeate the dentine and affect the peridental membrane; whereas, if the body of the pulp be dead, the degree of sensibility of that which remains in the roots is so much lowered that it may be withdrawn without occasioning any considerable amount of pain. By observing this precaution we ensure the removal of the caustic, and leave the pulp at the point of rupture in a much more favourable condition for healing than if it had been saturated by the escharotic.

The fourth rule is, that escharotics should not be applied to a tooth, with the view of destroying the pulp, unless the fang is fully developed, and the aperture through the extremity of the root reduced to its ultimate size. In young subjects the canal in the root of a tooth is very large generally, but more especially at the terminal portion, and the pulp maintains a corresponding size.

The expediency of destroying the pulp by means of an escharotic having been determined on, the substance best fitted to produce the effect must be selected. The mineral acids, nitrate of silver, chloride of zinc, and many other substances possessing caustic properties, have each in turn been used. Arsenious acid has, without giving rise to a greater amount of pain, been found to act with more certainty, and in less time, than any other agent. The certainty of its operation is so great a recommendation that arsenic is almost invariably employed in preference to any other description of caustic. The extremely active character of this substance as a poison led me some years since to prefer chloride of zinc, which, although less certain, is a less dangerous agent to employ in the mouth. At that time the minimum amount of arsenic capable of producing the required effect had not been determined, and several cases had come under my notice in which sloughing of the gum and the loss of the tooth followed its use, though it is probable that this sloughing of the gum was due to a careless application of the caustic. More extended experience has cleared away many doubts as

to the advantages offered by this mineral, which has now taken its place among the most useful of the agents at the disposal of the practitioner.

The twenty-fifth of a grain of arsenious acid, reduced to a fine state of division (a dose which, if swallowed, would be productive of no injury), is sufficient, when properly applied, to destroy the vitality of the pulp of a large molar tooth. Some practitioners prepare a compound, made by grinding together equal parts of arsenic and morphia, the narcotic being added for the purpose of mitigating the pain produced by the corrosive action of the mineral substance. In my own practice, I prefer to use the arsenic alone, and applied in the following manner: a small ball of cotton-wool, scarcely larger than a pin's head, is formed on the end of a fine broach, and dipped into creosote. The arsenic is then taken up on the saturated wool, which, thus loaded, is carefully placed in contact with the exposed portion of the pulp, and retained in position by the introduction of a second piece of wool saturated with a solution of mastic. The application is rendered yet more certain by taking up a little arsenious acid on the blunt point of an instrument which has been moistened with carbolic acid or glycerine, and applying this to the pulp before introducing the wool.

When the cavity is situated in the masticating surface of a tooth, the application is readily effected, but if it be upon the median or distal surface, a little more caution is required, otherwise the arsenic may find its way to the gum, and produce, if not permanent mischief, a considerable amount of temporary discomfort.

The introduction of the second piece of cotton will, if the movement be not guarded against, force towards the gum that which is charged with the escharotic. In order to prevent such shifting of position, a small piece of wool should be laid between the teeth, close upon the edge of the gum. The charged cotton may then be placed in position, and the wool provided for its retention introduced. The patient

must be directed to avoid masticating upon the tooth, or disturbing the application by any other means, even though the pain it occasions should be severe. Both the intensity and the duration of the pain produced by the destructive action of arsenic upon the dental pulp are inconstant to a degree for which the recognisable differences in the cases fails to account. One patient will tell you that the application produced no pain, another that the toothache was most severe, and lasted for ten or twelve hours, while a third will describe the pain as moderate in degree, and of a very bearable kind.

It is remarkable that the application of arsenious acid to a tooth which has previously been aching severely is seldom followed by much pain; perhaps this may be due to a pulp in a state of inflammation being more readily destroyed than one in a comparatively healthy condition. The more free the exposure of the pulp, the less pain will, as a rule, be experienced: there is no condition productive of such severe suffering as a mere pin-hole exposure of the pulp through which the arsenic passes only in sufficient quantity to act as an irritant; the result is that the pulp swells, a hernial protrusion is forced through the constricted orifice, and the aching and throbbing are almost unbearable. It is in a complete exposure of the pulp, and an effectual application of the escharotic, and not in the admixture of drugs such as morphia with the arsenic, that we must seek to obviate suffering during the destruction of the pulp.

Fig. 177. (1)



A small opening into the pulp-cavity may be advantageously enlarged by the use of the instrument here figured: from its shape it has the advantage of not slipping abruptly into the pulp, as would be the case were a rose-headed drill or a broach employed to enlarge the

(1) Drill for opening the pulp-cavity.

orifice; moreover, the instrument in question cuts with a very small amount of pressure.

After the lapse of from twelve to thirty-six hours—depending on the size of the tooth and the extent of surface exposed to the action of the escharotic—the whole of the cotton-wool may be removed, and the effects of the application ascertained. If the result has been favourable, the sensitiveness, before so great, will have entirely passed away. On passing an instrument into the pulp-cavity, slight bleeding may follow, but the patient will not complain of pain, unless the effect of the instrument has been to compress the whole contents of the pulp-cavity. Should the pulp, however, on examination, be found in an acutely sensitive condition, it may be concluded that the ingress of the arsenic has been prevented, either by the aperture into the pulp-cavity being extremely small, or by a mass of secondary dentine lying against the opening. But whatever cause may have retarded the operation of the escharotic, the application must be renewed, and a further time given. The required effect having been produced, the whole of the decayed dentine should now be removed, and the opening into the pulp-cavity sufficiently enlarged to allow the pulp to be withdrawn entire. This part of the operation may generally be effected by a fine broach, hooked at the end, or by a twisted flat broach of the kind already described, or by the barbed nerve extractor here figured. The operator must be prepared to meet with occasional difficulties, owing to the presence of masses of secondary dentine within the substance of the pulp. They are sometimes so large and irregular in shape, perhaps dipping down into the

Fig. 178. (1)



(1) Instrument for removing the nerves

fangs, that their withdrawal occupies some little time, the pulp becoming broken down by the operation. In such cases the contents of each fang must be drawn out separately. Although the body of the pulp has become insensible, more or less pain will be felt when the pulp situated in the roots of the tooth is broken across at or near the orifice by which it passes into the alveolus; but the pain subsides immediately. Should slight hæmorrhage follow, the operation may be suspended for a few minutes, by which time the bleeding will have ceased.

If the treatment has been successful, the pulp-cavity of the body and of the roots of the tooth will have been cleared of their natural contents. The further treatment will consist in filling first the roots (when practicable) with gold, then the pulp-cavity, and lastly the external cavity. The necessity of filling the roots has been strongly insisted on by the American writers, and there can be no doubt of the advantage which results, supposing the canals to have attained a certain magnitude. But when the root is small and its cavity too minute to admit a fine broach, it may be left without the fear that any evil consequence will ensue. In a first molar of the upper jaw, for example, the anterior and palatal roots should be filled, but the posterior root is commonly traversed by a canal too small to render filling necessary.

Some doubt has been expressed as to the practicability of filling the roots of teeth, and no doubt the operation is tedious; but when sufficient time is given very little difficulty is experienced. In front teeth it is simple enough, and in the back teeth it must be rendered simple, otherwise the result will be imperfect. The crown of the tooth must, in fact, be cut away until the pulp-cavity is fully exposed and its continuation in the roots brought within the reach of an instrument. It will in most cases be found desirable to enlarge the canal with a broach. The question constantly suggests itself as to what extent the enlargement shall be carried, and to what depth. The determination of these

points will depend upon the peculiarities of the case under treatment. The object of the enlargement is to facilitate the operation of plugging. In some instances it may be dispensed with, in others it must be carried to a considerable extent. Thus, when the canal is large at one part of its circumference, and reduced to a mere slit at another, it will be advisable to reduce it to something approaching a regular outline. In respect to depth, the enlargement may be carried with advantage to the point beyond which a fine broach will not pass in the natural state of the root.

Having fully prepared the cavity, both in respect to its form and removal of extraneous matter, and protected the tooth from the influx of saliva, the cavity must be made perfectly dry by passing into the roots cotton-wool rolled upon a broach.

We may now proceed to pack in the gold by one or other of the following methods.

Roll round a broach which will readily pass to the bottom of the canal a small amount of foil, firmly, but not so tight but that the broach can readily be withdrawn. The gold may then, while upon the broach, be pressed to the bottom of the cavity; withdraw the broach a short distance, and again return it, using sufficient pressure to consolidate the gold, which will be carried down before the instrument. After thus forcing in the first tube of foil, the process must be repeated again and again until the root is filled.

In the place of the tube of foil, very narrow ribands may be used, but the operation is more tedious, and does not possess any advantage over the method already described; if ribands be employed, they may be advantageously cut from No. 60 foil, leaving them but little wider than the instrument which is to introduce them.

A third method consists in taking three or four thicknesses of foil, and cutting therefrom very small square pieces, which are one by one introduced upon the point of the

broach, and consolidated. Or a piece of soft annealed gold wire may be inserted into the fang.

Some little attention must be given to the instruments employed for this delicate operation. If an ordinary four-sided broach is used, the temper must be reduced to that of a spring, otherwise it will snap off during the operation, a portion probably remaining in the cavity. I have known this accident happen in several cases, and a portion of steel has unavoidably been allowed to remain in the tooth, without any evil consequence becoming immediately developed.

A preferable instrument may be made either from a piece of steel wire, or by grinding into a cylindrical shape a strip taken from a clock spring. The extremity, if left flat, will carry the gold to the bottom of the cavity more readily than it would do were an edge or point produced. The curved course which the broach is required to take renders elasticity absolutely essential, and in no way can this be obtained more readily and more certainly than by adapting to our purpose a piece of watch or clock spring.

The root or roots being plugged, the subsequent part of the operation does not vary from that of making an ordinary plug, excepting that the cavity in the tooth is unusually large, and will therefore occupy a greater length of time than would be consumed in filling a simple cavity. If a large molar, either of the upper or lower jaw, be the subject of treatment, the compound cavity, even after the roots of the tooth are filled, may be so deep that difficulty will be encountered in packing non-adhesive gold so as to form a single plug. In such cases it is well to first fill perfectly the pulp-cavity, and then to proceed to make the more external part of the plug. It is a convenient practice to fill the roots with gold, and the crown of the tooth with some temporary filling, postponing the completion of the operation for a fortnight or more, so that should any alveolar irritation arise, the removal of the plug may be readily effected.

When the foregoing operation is carefully performed, the result is generally very satisfactory, the tooth being reduced to the condition of one upon the root of which a new crown has been fixed by a pivot. In each the connection with the living tissues is limited to the external surface of the root; and in one, as in the other, inflammation of the dental periosteum may ensue soon after the operation, either if care be not observed in its performance, if the periosteum be diseased, or if the patient be in a bad state of health when the operation is performed.

It must, however, be borne in mind, that we have been treating of those cases only where the pulp has been exposed during an operation. The presence of disease in the dental periosteum will therefore be rare, and the source of failure may consequently be looked for in the general state of health of the patient, or in the manner in which the operation has been performed. I can call to mind several instances of failure in my own practice which were consequent upon a certain portion of the pulp having retained its vitality and held its place unobserved in the tooth. In one case an upper molar became very sensitive to changes of temperature, sensitive when pressed upon, and slightly loose. It was removed, and, on examination, the pulp in the posterior distal root was found to have retained its vitality and to have become inflamed. In one instance an upper bicuspid became very painful. After removal the pulp on the one side of the compressed cavity was found to have escaped the broach and retained its vitality. In each case the source of failure lay in the incomplete destruction and removal of the pulp.

In respect to the general health, some little caution should be observed in the selection of the cases for filling the roots and the pulp-cavity. It will be wise to avoid the operation in those who present the strumous diathesis, more especially where it is coupled with great sensibility of the teeth generally. Persons who are liable to neuralgic pains in the head

and face are unpromising subjects, and we can scarcely expect a very favourable result where the gums are in an unhealthy condition.

The occurrence of a small and unimportant chronic gumboil, coming and going with little or no inconvenience, must be placed amongst the results which may follow the destruction of the pulp and the subsequent filling of the pulp-cavity. In respect to the root itself, changes, I believe, commence from the time of the operation, and proceed, more or less slowly, until the tooth is lost. In pivoted teeth the root sometimes becomes enlarged, but more commonly suffers a diminution of bulk. In a case which came under my notice, the pivot had been exposed by absorption on one side of the root; in another a sufficient amount to ensheath the gold pin only remained. Again, if we take the roots of teeth which, after the loss of the crown, have had the pulp-cavity sealed up by secondary dentine, we shall find that either additions of cementum have been made to the surface, or that the surface has been gradually wasted by absorption. In many cases there will be ample evidence to show that the two actions have alternated. Ultimately the waste exceeds the repair, the root is shortened, loses its implantation, the socket disappears, and the tooth, after the lapse perhaps of some years, falls out.

In the place of filling the fangs with gold, cotton-wool saturated with carbolic acid may be used; the results are, for a time, at all events, very satisfactory, though eventually the carbolic acid seems to disappear, and in some cases the wool becomes saturated with discharge, and then a gumboil is the inevitable result.

Other methods of treating an exposed pulp than those already described have been proposed, and for a time found favour. Mr. Hullihen described an operation which has since received his name. It consists in drilling a small hole through the neck of the tooth into the pulp-cavity. The perforation is made either under the free edge or through

the gum, a short distance above its terminal margin. The cavity produced by caries is then filled permanently, leaving the artificial perforation open. But as this operation relates to the treatment of diseased pulp, its further consideration may be postponed.

Some few years since it was proposed to char the exposed surface of the pulp by electric cautery, with a view of destroying the exposed portion preparatory to the introduction of a plug. In my own practice the advantages derived from this mode of treatment were very questionable, and the operation was therefore abandoned.

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 materially 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. 179. (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 Society," (2) to works on Histology, and to the previous publication of the author. But

(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.

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 has been doubted. Several preparations, however, in my own possession demonstrate the fact 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 are enclosed in tissue which has not a well-pronounced con-

centric 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 blood-vessels. The new bone has, in fact, been moulded around the portions of the 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. This close resemblance in the two tissues, when developed, renders it desirable that some account should be given of the manner in which the former is developed.

Close to the surface of the bone lie peculiar granular cells, much larger than those outside them, to which the name of "osteal cells" was formerly given, whilst German writers speak of them as "osteoblasts."

These "osteoblasts" make their appearance wherever bone is being developed, whether in cartilage, in membrane, or in periosteum; in point of fact, it is held by Rollet[1] that the development of bone differs in no respect in these dissimilar situations, so that the cartilage may be regarded as little else than a convenient support to the developing bone.

No bone is in any case formed till after the appearance of this "osteoblast" tissue; and Rollet believes that the osteoblast cells are not modified cartilage cells, nor cells derived from these latter by a process of proliferation, but that they are essentially a new growth. At all events, the layer of osteoblast cells does not gradate into the structures outside it, but is so distinctly marked off that it almost assumes the character of an epithelium.

If we harden a tooth in chromic acid, and subsequently

(1) A. Rollet. Art. "On the Connective Tissues." Stricker's "Handbook of Human and Comparative Histology."

decalcify and cut it transversely through the fang, we meet with the following structures from without inwards. On the outside is the outer part of the periosteum, consisting of decussating fasciculi of connective tissue; internal to this is a layer to which the name of "cambium" has been sometimes given, consisting of roundish cells with processes. These lie in a reticulum made up of cells which give out a small number of homogeneous transparent processes; by the inosculation of these processes a network is formed, which has been well figured by Dr. Lionel Beale. (1)

Between the reticulum and the fully-formed cementum lies the osteoblast layer, consisting of much larger cells, which are often provided with fine processes. The transparent homogeneous processes already spoken of as forming the reticulum may be seen in many places passing in through the osteoblast layer, and may be traced passing without interruption into the matrix of the cementum. As the osteoblasts form a continuous layer, and are very numerous, it is obvious that only a small percentage of them ever form lacunæ, or otherwise retain their individuality. As the process of calcification goes on the outlines of individual cells and of the trabeculæ of the reticulum become lost in the general transparency of the matrix, only a cell here and there remaining as a lacuna.

The explanation of the formation of bone lacunæ from the osteoblasts given by Henle and Dr. Lionel Beale, which has been substantially accepted by Waldeyer and Rollet, seems to accord best with the appearances observed.

The deposition of calcareous matter, and that change which immediately precedes it (so as to produce the "formed material" of Beale), takes place from without inwards. Thus we might picture to ourselves each calcifying osteoblast as enclosed by hard structure, like an egg-shell, continuous deposition taking place on the inside till the central cavity was obliterated. At the same time, the contiguous

(1) "On the Structure of the Simple Tissues."

osteoblasts become fused together by their exteriors, so that their individuality is absolutely lost. In a certain number, however, this entire obliteration of the central cavity does not take place; but the calcification advancing with some degree of irregularity towards the centre, leaves tracks of uncalcified matrix, and, finally, stops short of obliterating the central cavity. Thus the centre of the osteoblast comes to be occupied by a space from which fissures radiate; in fact, a "lacuna." Although for the purpose of description this central portion has been described as a "space," it must not be forgotten, that in the first instance it is not hollow, but is perfectly filled by the uncalcified matrix, and that in it originally lay the nucleus of the osteoblast (germinal matter of Beale). Thus, by staining with carmine the nucleus may often be defined in a developing tooth of a calf, lying in the stellate "lacuna," but the nucleus soon disappears; and in the dry state the lacuna is really a space, as its contents dry and shrivel up.

And just as calcification may fail to obliterate the centres of all the osteoblasts, so it may fail to obliterate their external contours; when these are visible around lacunæ, we have the so-called "encapsuled lacunæ," or nests of osteoblasts.

The various views which have been entertained regarding the formation of the lacunæ and canaliculi have been concisely stated by Dr. Sharpey, *op. cit.*, p. 158. He observes, that "they are generally supposed to be derived from the shells of the soft tissue involved in the ossification by some sort of metamorphosis which has been variously conceived. Some suppose that the cells become the lacuna, and send out branches (like the pigment cells) to form the canaliculi (Schwann [1]). Others think that it is not the cell but its nucleus that undergoes this change, and that the substance of the nucleus is afterwards absorbed, leaving the lacuna (Todd and Bowman [2])." The nucleus described by Todd and Bowman is identical with that which has been called the granular cell, and from which the authors held the lacuna to be formed. "Henle ([3]) thinks that the lacuna is a cavity left in the centre of a cell which has been partially filled up by calcification, and that the canaliculi are branched passages, also left in consequence of the unequal deposition of the hard matter,

(1) "Mikroscopische Untersuchungen." (2) "Physiological Anatomy."
(3) "Anatomie Générale."

as in the instance of the pore cells of plants." "It rather appears to me as if the lacunæ and canaliculi were little varieties left in the tissue during the deposition of the reticular fibres, as open figures are left out in the weaving of some artificial fabrics (but not within a cell, as Henle imagined), and that thus the apposition of the minute apertures existing between the reticulations of the lamellæ gives rise to the canaliculi." "At the same time it seems not unlikely that a cell or a cell nucleus may originally lie in the lacuna or central cavity, and may perhaps determine the place of its formation." Hassall (1) agrees with Schwann, while Gerber (2) and Bruns (2) appear to hold the views of Todd and Bowman. With the exception of Dr. Sharpey, the above-named authorities may perhaps differ more in the use of terms than in matter of fact. The appearances would at first view seem to justify the opinion expressed by Dr. Sharpey; but a careful examination of the tissue during its development, the unquestionable fact that in the development from cartilage the granular cell becomes converted into a lacuna, together with the circumstance that lacunal cells are frequently found in the Haversian canals and cancellated structure, especially in the bones of old subjects, and at times imbedded in the structure of the bone, have left no room for doubt in the authors' minds that the lacunæ are formed from special nucleated cells, in the manner described in the text.

Further details of the appearances observed in ossification may be found in the following extract from a paper in the Royal Society's Transactions (3); the osteal cells there spoken of are equivalent to the osteoblasts of later writers, while the differentiation between osteal and "lacunal" cells exists only in so far as they are the same elements in a different stage of calcification (see page 427).

"If the advancing edge of a parietal bone be taken either from a human fœtus or a fœtal lamb, and the pericranium and dura mater be carefully removed from their respective surfaces, we shall find the growing bone still invested with soft tissue both on the outer and inner surface, which is prolonged from the free edge. When examined under a favourable light this tissue will show differences of character in different parts, varying with the distance from the bone at which the observations are made. Thus, if attention be directed to the part farthest removed from the bone, it will be seen that the membrane-like mass is composed of oval cells with slight prolongations from the extremities, which are frequently arranged in the form of bands of fibrous tissue. Dr. Sharpey has observed that the membrane into which the bone extends is like fibrous tissue in an early stage of development, and this obser-

(1) "Microscopic Anatomy of the Human Body," p. 310.

(2) "Allgemeine Anatomie."

(3) "Observations on the Structure and Development of Bone." By John Tomes, F.R.S., Surgeon-Dentist to the Middlesex Hospital; and Campbell De Morgan, Surgeon to the Middlesex Hospital.

vation is strictly true when confined to the part indicated, but the analogy ceases as we extend our examination towards the bone. Here in the place of cells with elongated processes, or cells arranged in fibre-like lines, we find cells aggregated into a mass, and so closely packed as to leave little room for intermediate tissue. The cells appear to have increased in size at the cost of the processes which existed at an earlier stage of development, and formed a bond of union between them. Everywhere about growing bone a careful examination will reveal cells attached to its surface, while the surface of the bone itself will present a series of similar bodies ossified. To these we propose to give the name of *osteal cells*, as distinguished from lacunal and other cells.

"In microscopic characters the osteal cells closely resemble the granular cells of temporary cartilage; so closely, indeed, that the latter, when detached from the cartilage, could not well be distinguished from them. They are for the most part spherical or oval in form, and lie on the surface of the growing bone in a crowded mass, held together by an intervening and apparently structureless matrix. Here and there we find a cell which has accumulated about itself an outer investment of transparent tissue, and has, in fact, become developed into a lacunal cell destined to become a lacuna.

"The process of growth may be thus described. In the meshes of the fibrous tissue on the surface of the bone, *osteal cells* are developed and gradually take its place; a few cells become developed into lacunal cells; the earthy salts are added, and concurrently lacunæ and canaliculi are formed; we then have bone presenting the usual characters of that tissue. In bone developed in the foregoing manner, we find the canaliculi not merely extending to the surface of the cell-wall, or anastomosing with the canaliculi of lacunal cells lying in contact with it, but extending freely in all directions, and passing through or amongst the ossified cells, and establishing rich plexuses of anastomosis. Indeed, we see the boundary of the original lacunal cells only in those cases where the lacunæ have but few, or are entirely devoid of canaliculi. It would appear to be a law, to which there are few, if any, exceptions, that when anastomosis is established between adjoining lacunæ, the lacunal cells blend with the contiguous parts, and are no longer recognisable as distinct bodies. The process by which the cylindrical bones are increased in diameter is in all essential points similar to that described as pertaining to the growth of flat bones. Similar osteal and lacunal cells are present, but the relative amount of the matrix is greater; moreover, the osteal cells have a disposition to assume a linear arrangement corresponding to the direction of the laminæ of the contiguous bone. In these lines the cells are placed so close to each other as to leave but little room for intervening tissue, but between the lines an appreciable amount may be recognised. This appearance, however, varies in different specimens. In one the cells predominate, in another the transparent tissue is the more abundant. Generally the younger the animal the greater will be the amount of the intervening transparent tissue, and the smaller the number of the osteal cells. But in all cases, whatever the age of the subject, or from whatever part of the skeleton the specimen be taken, the cells and the intermediate tissue become blended in the process of ossification, and the whole presents a uniform granular appearance, excepting in the instances in which lamination is strongly developed, or in those which have been noticed in the previous part of the paper. We frequently find portions of bone where the osteal cells, lacunal

cells, and intermediate tissue are so perfectly fused together that neither can be recognised, but in their place we have a minutely granular mass, divisible only into lacunæ and canaliculi and the tissue in which they lie imbedded."

The foregoing description of the formation of bone or cement, may, with but little modification, be applied to the development of an exostosis. Mr. Shelley's (1) paper being the only one with which I am acquainted that gives the microscopic appearances associated with exostosis, may be here quoted.

"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

(1) "Transactions of the Odontological Society," vol. i.

on the periosteum also partake of the latter character, being tough and less vascular.

"Examined by the microscope, 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 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."

On comparing the statements made by Mr. Shelley with those contained in the previous extract, it will be seen that there are no essential points of difference recognised in the mode of formation of bone and cementum. In each case cells are produced, the individuality of which becomes lost in the process of calcification, together with the fibrous matrix.

In the soft tissue which connects the root of a tooth with the walls of the socket, Mr. Spence Bate considers that two distinct structures may be traced—the peridenteum of the tooth and the periosteum of the bone. The former he regards as a dermal tissue, the latter as belonging to the internal or osseous system, and states that "however closely in juxtaposition the two may approximate, they still hold their

relative connection widely apart."(1) The cementum he regards as a production of the inner surface of the peridenteum, and as in no way connected with or dependent upon the periosteum of the socket, the two membranes being incapable of ossific union; a statement which he considers is justified by the fact that the root of a tooth, although the subject of exostosis, never becomes anchylosed to the jaw. Had periosteum alone intervened between the tooth and the socket, an osseous union would, it is assumed, have occasionally taken place.

By the "peridenteum," Mr. Spence Bate appears to mean Nasmyth's membrane (cuticula dentis) on the crown, and the external layer of cement on the roots, which, as I have elsewhere shown (2), are continuous with one another, and are to be regarded as incomplete cementum. It is perfectly impossible that the "peridenteum" can build up fresh cementum, as it has itself undergone that metamorphosis which Dr. Lionel Beale describes as change into "formed material," and the period of its activity is passed; it is only, so to speak, waiting for the fuller deposition of calcareous salts to itself become perfected cementum.

If we except this youngest layer of cementum, which is neither vascular nor soft, there is nothing like a differentiation into soft tissues belonging to the tooth and others belonging to the socket. Hence some other explanation must be sought for the fact that anchylosis, which is the normal condition in most reptiles, does not take place in the human subject; indeed, the mere fact that it takes place in reptiles who do possess what Mr. Spence Bate calls a "peridenteum," is a sufficient answer to this hypothesis.

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

(1) "On the Peridental Membrane in its relation to the Dental Tissue." By C. Spence Bate, Esq.—"British Journal of Dental Science," vol. i.

(2) Quarterly Journal of Microscopic Science, 1872.

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. 180. (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 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

(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.

appear only after the patient has undergone great suffering from supposed idiopathic tic-douloureux, a complaint for the relief of which patients have 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. A case which followed this course came under my treatment six years ago, and it is scarcely eighteen months since the last tooth was removed. 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.

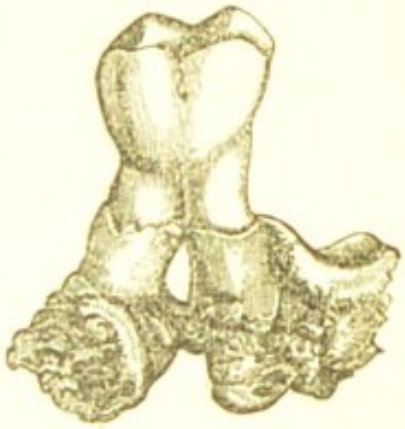
The sympathetic affection may, however, in a few rare examples, extend to a derangement of the whole nervous system. Two cases have occurred under my own observation, in which epilepsy was consequent upon diseased teeth, the most prominent feature being exostosis of the roots, which will be described at a future page.

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 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.

Fig. 181. (1)



Through the kindness of 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 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

Fig. 182. (2)



(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 Mr. Martin for the use of this specimen.

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 alternation 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 takes place later may go so far as to

eat into the dentine, after removing the whole thickness of the cement; examples of absortion 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 the osteogenous tissue, it seems most probable that the same osteoblast cells are capable of effecting the absorption and subsequently becoming calcified.

Fig. 183. (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.

NECROSIS OF THE TEETH.

When a part or the whole of a tooth has lost its vitality, the condition is expressed by the term necrosis. The disease involves the death, but not necessarily the decomposition, of the dead part, the tissues of which become discoloured, but are seldom softened.

The term is no doubt associated in the minds of many practitioners with that state which is attended with discoloration of the whole of the crown of the affected tooth. But the discoloration of a dead tooth is, strictly speaking, an accidental and by no means necessary coincidence. It depends, in the first place, upon the pulp losing its vitality when its vessels are filled with blood, and upon the ultimate decomposition of the blood-globules, and the solution of the colouring matter in the fluids present. These permeate the dentine, and impart to it a permanent stain, the discovery of which is looked upon as an infallible indication that the tooth is dead. The loss of the normal colour is obviously a mere consequence of the death of the pulp under certain circumstances, and a consequence which takes some time to develop.

The depth of the stain will also be varied, the variation depending upon the age of the patient. The younger the subject, the larger and more vascular will be the pulp, and the deeper the stain produced by its decomposition. In old people, on the contrary, the pulp is relatively small, and the discoloration of the tooth consequent upon its death is but slight, and may, in fact, be altogether wanting. The dis-

coloration may in some cases be removed by treatment with bleaching agents, after the pulp-cavity and canal have been thoroughly washed out.

Chloride of lime, chloride of soda, chlorinated soda (Labarraque's fluid), and oxalic acid, have all been recommended for this purpose. Whatever agent is used, the canal should be closed at the apex by a pledget of cotton, the bleaching material introduced on wool, and sealed up in the cavity for thirty minutes or an hour, and after a sufficient effect has been produced, thoroughly washed out again.

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 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 decomposition 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. I believe that the cementum becomes 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. Generally the cementum is greatly

reduced by absorption, and even the dentine in many cases suffers also.

I remember a case in which seven front teeth lost their attachment to the socket, excepting where the nerves and blood-vessels entered the root, without the vitality of the pulp having been sacrificed or the gums absorbed.

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.

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 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.

In respect to the treatment of either partial or complete

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.

Fig. 184. (1)



I have seen many cases of absorption in permanent teeth, where the waste has so far reduced the root 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 central incisors, one after another, became loose, and fell out, on the younger side of forty,

(1) Permanent central incisor, the root of which has been absorbed: from a specimen placed at my disposal by Mr. Alfred Canton.

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 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, an upper central, at the age of fifty, 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, 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.

Fig. 185. (1)



The fact that the walls of the pulp-cavity resisted the absorbent action with greater force than any other part of the dentine, accords with what we may observe takes 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 socket by a bristle which had made its way up the empty pulp-canal. The process of absorption having been discussed in connection with the shedding of the temporary teeth, it need not be again entered upon.

Fig. 186. (2)



(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.

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 and retarded in their eruption than any other 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. 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 in 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 manner in which the latter result is brought about requires some explanation.

It has already been stated that absorption is effected by a vascular papilla, which advances in front of the moving tooth. In those cases in which decay arises in a cavity so produced, the papilla has been situated but a short distance within the margin of the gum, and the cavity consequently becomes exposed to the fluids of the mouth when the latter parts shrink down to a lower level.

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.

Fig. 187. (1)



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

(1) Canine, of which the front and sides of the neck are deeply grooved.

thoroughly protected from 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; this condition has only been, so far as I know, met with in the upper jaw, and in the mouths of those who have suffered from prolonged ill-health. In a patient lately under my care, the enamel had been removed in irregular-shaped patches from the upper incisors and canines, 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.

Fig. 188.



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 conclusive 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 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.

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 con-

(1) Transactions of the Odontological Society, June, 1870.

siderable 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 not serve to account for all the cases.

Absorption cannot 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 nidus for fermentation, may provide an acid solvent.

Dr. Magitot (1) regards the grooving of the necks of the teeth as the result of caries, which has tended to spontaneous 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. 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.

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(1) Recherches sur la Carie des Dents. Paris, 1871, p. 513:—"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 '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 passées à l'état de guérison spontanée ou caries sèches."

DISEASES OF THE PULP.

No portion or organ of the body, either in health or disease, can be independently considered. Whether an inflamed eye or a diseased tooth form the subject of inquiry, it must be borne in mind that neither can exist but as one of many parts which collectively form the body; that the healthy condition of an organ is due to a corresponding state of the whole organism, and more especially to a sound condition of the organs in its immediate vicinity, or with which it is closely associated; and that a state of disease may be consequent upon, or even a symptom of, a disordered state of a neighbouring part of the body. On the other hand, a diseased condition originating in an eye or a tooth, may induce sympathetic affections even in remote organs, and in doing so may seriously disturb the general health. It is necessary that the mutual dependence of the various organs upon each other should be fully acknowledged by those who restrict themselves to special branches of practice, and who naturally feel a strong tendency to isolate and place in an independent position, and to give an exaggerated importance to, the diseases of the one organ or set of organs to which their attention is more especially directed.

These observations admit of application to practitioners of dental surgery, who are strongly tempted to regard local conditions without reference to the general constitutional state, of which they may be but an indication. The remedies which he finds most effective are local in their application and effect. It is only when the character of the disease is

somewhat vague, as in the group which is about to be considered, that the attention is called to the general condition of the body.

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 slight pressure upon the crown or upon the neck of the tooth, while the walls of the pulp-cavity are free from injury. In such cases the patients will complain that the tooth is incapable of bearing with comfort the pressure exercised in mastication. Careful examination usually leads to the detection of caries, or to 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 indication of structural change in the sensitive teeth. The disordered state may depend upon some other tooth, which, although itself free from pain, may produce sympathetic irritability in other teeth; 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, 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 it is quite 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 pulp. 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; there are some few

for whom it is next to impossible to successfully perform the operation of filling.

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 solutions 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 results thus obtained indicate pretty clearly that we shall not be wrong in attributing a considerable share of the hyper-æsthesia to the dentinal fibrils, and the conclusion is still further justified by the fact that if we excise the surface

which has been acted upon by the nitrate of silver, the newly-exposed surface will exhibit the condition of sensibility, which the application of the escharotic removed from that which was cut away. If the attempt to show that an irritable state of the pulp when connected with a damaged state of the crown of the tooth is preceded by, and consequent on a similar state of the dentinal fibrils, has been successful, there will be no great difficulty in establishing a strong ground for assuming, that when the teeth become irritable in consequence of causes acting through the system, that, so far as the teeth are concerned, the state of irritability is situated in the pulp itself.

The supervention of inflammation of the pulp, independent of exposure, has been alluded to as an occasional result of irritation. But it more commonly happens that the diseased condition of the dental tissues is allowed to progress, the pulp-cavity is laid open, and the exposed pulp then passes into a state of disease, acute or chronic, as circumstances may determine. If, however, the disease in the crown of the tooth be successfully treated, the state of irritability will by degrees pass away, and the tooth will be restored to a state of comfort and usefulness.

Irritation, if long continued, is usually, but not constantly, productive of certain changes in the pulp itself, 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. 189). Or the calcification of the pulp may be limited to the production of a

Fig. 189. (1)



(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.

patch of dentine added to the wall of the pulp-cavity (Fig. 190, and Fig. 191).

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 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. It must also be remembered that small isolated calcareous globules are to be found in perfectly healthy developing teeth (see page 283).

Fig. 190. (1)



Fig. 191. (2)



Treatment.—When the irritability of the tooth is consequent upon the presence of simple caries, our aim must be to introduce a permanent 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.

(1) Section of a tooth, showing the local thickening of the wall of the pulp-cavity, consequent upon irritation produced by advancing caries.

(2) Bicuspid in which a formation of secondary dentine has failed to obviate perforation of the pulp-cavity.—From Tomes's "Lecture on Dental Physiology and Surgery."

The sensitiveness will, however, in the majority of cases, gradually subside; in others, we shall be required to remove the metallic plug, and substitute a non-conducting material. The prepared gutta-percha 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 condtion. 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 other agent has in my hands been 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, unless the ailment has a constitutional origin, when it must of course be treated by remedies which operate through the general system.

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 awhile certain substances, such as sugar, or salt, or acid matters, when lodged in the tooth, occasion considerable uneasiness, which is, after awhile, 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 the suffering does not necessarily subside, but the character of the pain will be changed. The throbbing ceases, and in its place a dull, heavy pain, with a feeling of tension, is left. The tooth feels too long, and is, in fact, raised in the socket from thickening of the dental periosteum, consequent upon inflammatory action extending from the pulp to the soft tissue which connects the root of the tooth to the socket, indicating the commencement of an alveolar abscess. If the tooth be allowed to remain in the mouth without adopting remedial treatment, the pain after awhile usually subsides, and the elongation and tenderness of the tooth gradually pass off. The pulp-cavity, on examination, will be found to contain decomposing fragments of the dead pulp, or particles of food, from which will be emitted a peculiar phosphatic odour, an indication that the pulp-cavity of the tooth has been opened, and become the receptacle of a secretion discharged, either from a portion of living pulp, or from the surface of an alveolar 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 aperture in the pulp-cavity, will, to some extent, govern the intensity of the pain consequent upon inflammation.

The *treatment* of acute inflammation of the dental pulp must be regulated by the stage at which the disease has arrived when relief is sought, and the general condition of the crown of the tooth and of the surrounding parts. If there is reason to believe that the inflammation has not extended to the alveolar periosteum, remedial treatment may be adopted with a fair chance of success; but should it be found that the pulp of the tooth is passing into a state of disorganization, and that suppuration in the socket has commenced, the removal of the tooth offers the only certain and speedy means of terminating the disease. If from any cause that operation is rendered objectionable, the pain which attends the process of suppuration may be mitigated by the use of decoction of poppy-heads held in the mouth, and by making a free opening over the root of the tooth, so soon as pus is formed. One or two leeches applied to the gum will oftentimes be attended with advantage, but I have not uncommonly been disappointed in the result. The remedy has aggravated, rather than alleviated the suffering, and the formation of pus and its subsequent escape have not been materially hastened. The treatment of alveolar abscess will, however, form the subject of a future section, and the treatment for the preservation of a tooth so affected will be there discussed.

If, however, the disease be limited to the pulp, we have yet to consider whether the crown of the tooth is in a sufficiently good state to render its preservation desirable, or whether, in the case of a front tooth, the root should be saved to support an artificial crown, secured by means of a pivot. In deciding these questions, the general state of the gums, the idiosyncrasy of the patient, and the condition of the tooth in respect to the state of development of its roots, must be taken into account.

If the gums are in a thickened and unhealthy state, or if the patient be liable to neuralgic pain about the face and jaws, or should there be reason to suppose that the roots are not fully developed, and the aperture at the extremity of each root contracted to its ultimate size, it will be well to remove the tooth. In the absence of any disqualifying condition, we may adopt a plan of treatment for the preservation of the tooth. That plan will consist in the application of an escharotic for the rapid destruction of the pulp, with the view of filling the pulp-cavity, and making good the injured portion of the tooth by means of gold, or some other material. Arsenic, when applied in the manner already described, will be found to be the best agent for bringing about the result. The pain produced by the disease is seldom increased by the arsenic; indeed, it is not unusual for the violent throbbing to be almost immediately exchanged for a dull aching sensation, which passes away in the course of four or five hours.

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 whole substance 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 an organ of secretion ; purulent or serous fluid is poured out from its surface, the amount and character of the discharge varying with the general health of the patient, and the degree of irritation to which the diseased part has from time to time 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 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 for assuming that the process of formation is arrested in the comparatively healthy portion, although the exposed surface of the pulp be inflamed. But there seemed some reason to doubt whether the exposed surface could undergo calcification. Mr. Arnold Rogers has recently placed at my disposal 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. 192) 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 the unsuccessful operation, and afterwards calcified.

Fig. 192. (1)



There is no evidence to show that secondary dentine can be formed in any other tissue than dentinal pulp. In the 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 or-

(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.

ganized tissue. Had it been otherwise, the pulp would probably have been injured and ultimately destroyed by mastication.

I am not acquainted with any case 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.

Fig. 193. (1)



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 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.

Treatment.—The same general principles that were stated in respect to the treatment of acute must be acted upon in the management of chronic inflammation of the pulp. Remedial measures offer but a very small chance of success if the disease has extended beyond the limits of the pulp, and

(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.

it would be useless to attempt the preservation of a tooth, the crown of which could not be rendered effective, by filling, unless, perhaps, in the case of a front tooth, the root of which it may be desirable to preserve. In polypus of the pulp, preservative treatment will usually fail, owing to a coincident enlargement of the aperture at the extremity of the root, and to a morbid condition of the vessels and other tissues to which that aperture gives passage.

If, however, the disease is strictly limited to the pulp, and the symptoms also are strictly local, the chances are in favour of success, if the patient will submit to the necessary treatment. The pulp may be destroyed by arsenic or other means, and the cavity filled; but the strong tendency shown by the pulp to form secondary dentine, and thus shield itself from further injury, should, if possible, be taken advantage of, even though the proceeding may involve a much longer and more troublesome course of treatment than would be required if the pulp were at once destroyed. The preservation of a portion of the pulp, and consequently of the vitality of the dentine, renders the tooth much less liable to attacks of alveolar abscess than it would have been had the former part been lost. In adopting this course of treatment, we must address our remedies to the exposed surface of the pulp with the view of arresting the discharge to which, when in a state of chronic inflammation, it gives origin. The daily application of camphorated spirits of wine, or of a solution of mastic in spirit upon cotton-wool, will, if persevered in, produce the desired effect in the majority of cases. At first the cotton, when removed from the tooth, will be strongly tainted with the peculiar phosphatic smell, but the intensity of the odour will gradually diminish, and after a time altogether disappear. The part of the cotton which has been in contact with the pulp, at first stained by the morbid secretion, will, when the discharge ceases, no longer show any mark of discoloration. Another method of treatment, equally

effective, and in my hands more satisfactory, as it requires a less expenditure of time and less frequent renewals of the remedial agent, consists in the application of a soft mass, composed of tannin, mixed with gutta-percha reduced to a gelatinous consistence, with chloroform. The astringent properties of the tannin act in arresting the discharge, while the gutta-percha holds it together, and ensures its contact with the pulp. Although the soft plug will last for some days, it by degrees wastes away; still the renewals are required less frequently than when the cotton and spirit are used.

But the agents of most value are pure carbolic acid and thymol; they should be applied on a small pledget of wool, and sealed up in the tooth by a larger pledget dipped in a solution of some one of the resins used for the purpose.

The treatment having been commenced, the remedial agents, whatever they may be, must be applied uninterruptedly, otherwise the chances of a successful result will be but poor. It is useless to apply an astringent one day, and on the next leave the cavity open and the pulp unprotected.

It will be apparent that where the aperture in the pulp-cavity is large, any kind of soft plug would, under very moderate compression, adapt itself to and bear painfully upon the exposed surface of the pulp. To this circumstance, and to the want of perseverance on the part of the patients when the teeth admit of preservation, may be attributed many of our failures in the treatment of cases which at the onset promised favourably. Assuming that a successful issue may be obtained, we shall have great difficulty in foretelling the time that the case will be under treatment. I have known instances in which all signs of discharge from the pulp ceased within a fortnight; but I have also met with many examples which were quite uncontrollable either by alcoholic solution of resins or by

astringents, or indeed by any kind of treatment short of the actual destruction of the pulp itself. No doubt this uncertainty as to the result is in part due to the difficulty with which the diseased structure is seen, and the state of disease appreciated.

The actual cautery, applied by means of the battery, at one time obtained a certain amount of favour. Some eighteen years since I tried the white-hot wire in the treatment of a considerable number of cases, but failing to produce any permanent advantage, the use of the battery has, up to the present time, been abandoned. As a means of destroying the whole body of the pulp, it is more pain-producing than arsenic, and less complete in its action, owing to the difficulty which attends the introduction of the wire into the pulp-cavity of the body and roots of the teeth.

Those who advocate the use of the heated wire direct that the exposed surface of the pulp shall be charred, an operation by which a secreting surface is reduced to a dry, hard scale, and therefore for the time deprived of its secreting power. The tooth is now to be plugged, inclosing the burnt tissue; for if we do not proceed to plug the tooth, the eschar will be thrown off, and will leave behind a secreting surface. There will, in fact, be a recurrence to the same state of things that obtained prior to the application of the cautery. But if the tooth be at once plugged, will the eschar separate in the manner which eschars usually separate, that is, by suppuration; or will it detach itself by desquamation? If the treatment be successful, the detachment of the burnt tissue must be effected by the latter process, or it must remain in connection with the living tissue. In the cases treated by myself, the suppurative process was set up, the attendant inflammatory action extended to the periosteum, and the teeth were consequently lost. It is possible that there are conditions under which the treatment by electric cautery will be attended with

advantage; but it is difficult to recognise them, and in the absence of precise knowledge, the operator is forced to abandon the use of an agent the indirect result of which he is unable to predict, and this practice has gradually fallen into complete disuse.

When the exposed pulp has ceased to discharge, the sooner the cavity in the tooth is sealed up the better. In conducting the operation, care must be taken both to avoid compressing the pulp and subjecting the tooth to an unnecessary amount of manipulation. The force necessarily employed in producing a gold plug, and the rapid conducting power of an amalgam plug, render each objectionable. The disadvantage which attends the use of the latter may be overcome by capping the pulp with a non-conducting substance. A better result will, however, follow the introduction of a gutta-percha plug. In this material, as prepared for dental purposes, we have a perfect non-conductor of changes of temperature; it is readily applied, perfectly excludes food and saliva, and is easily removed should symptoms of inflammation of the pulp come on. A plug so formed must be regarded as temporary in its effect. It will last for many months, or even one or two years; but so severe a test of its durability should not be tried. It is in some cases easier, and indeed better, to use zinc oxychloride as a temporary filling; it is less durable, but that is no objection, and it can be inserted with less disturbance of the covering of the pulp; but this latter must be carefully guarded against contact with the zinc salt. If, after the lapse of three or four months, the tooth is free from all signs of abnormal susceptibility, the gutta-percha should be removed for the purpose of substituting a permanent plug. It is well not to hurry the final operation, but rather to re-introduce gutta-percha when there is tenderness or any other indication which would throw a doubt upon the capability of the tooth to bear the insertion or the presence of a metal plug.

Although every reasonable precaution be adopted, a certain number of cases, which at the time appeared perfectly successful, will, after the lapse of three or four months, fail. The tooth unexpectedly becomes tender, a feeling of tension comes on, soon to be succeeded by throbbing pain, the usual indications of acute inflammation of the pulp. Either the plug or the tooth must be removed. If the former course be taken, the pulp may be destroyed with arsenic, supposing the disease to be altogether within the substance of the tooth, proceeding in the same manner as in the treatment of acute inflammation of the pulp.

In old age the pulp, to some extent, shrivels, and becomes the seat of various degenerative processes. Thus the arteries and veins become indistinguishable, and their coats are kept rigid and distended by irregular calcareous depositions upon them. Thrombosis of the vessels occurs, and the clots often disorganise, so that crystals of cholesterine are found in them. The nerve trunks at the same time undergo fatty degeneration, and the odontoblast layer loses its distinctive characters.

These same results may follow upon irritation of the pulp, even in young people; indeed, when a portion of the pulp has been lost by suppuration, it is usual to find that the remainder has undergone degeneration to a greater or less extent, a fact which serves to explain the painless disappearance of such pulps.

INFLAMMATION OF THE ALVEOLAR PERIOSTEUM.

The inflammatory affections to which the lining membrane of the sockets, or the intra-alveolar periosteum (1), of the teeth is liable, admit of division into the following groups :—

The first will include 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.

Local inflammation involving the sockets of one or two teeth, and dependent upon a local cause, will come under the second division.

The causes of periostitis about the jaw are various; thus it may be set up by the inhalation of phosphorus fumes, and ultimately give rise to phosphorus necrosis. Or it may arise in a scrofulous person; or, again, as a result of syphilis or rheumatism. In any case effusion of serum takes place between the bone and the periosteum; this may be absorbed, or soften down into pus, or become organised into fibrin, and this fibrin again into true 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 fibrin to organise in the former

(1) This term is used to distinguish the periosteum which lines the sockets of the teeth from that which covers the outer walls of the alveoli.

disease, and as a consequence of this necrosis is much 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 scrofular 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.

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 mineral 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 Dr. Watson as occasionally producing ptyalism. Preparations of gold, of copper, of antimony, and arsenic; also castor-oil, digitalis, iodide of potassium, 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 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-powdered 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 appa-

rently 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.

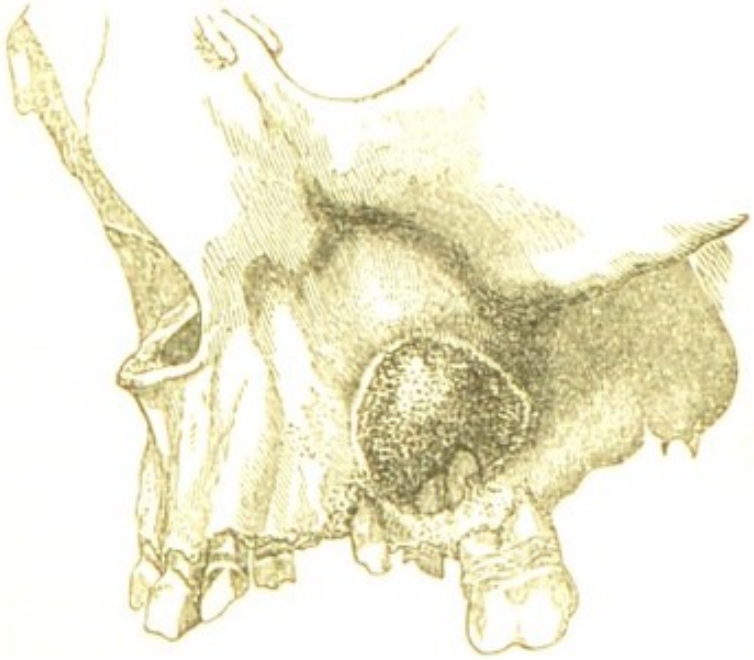
The inflammatory action usually sets in with feelings of slight uneasiness and tension, sensations which excite a strong desire to press by the opposing teeth, or to shake with the fingers, the affected tooth in its socket. Slight, steady pressure of the fang into the jaw gives relief, but the uneasiness 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 noticeable 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. 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.

Fig. 194. (1)



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 the gum, or a perforation is made in the wall of the alveolus, through which the contents of the abscess pass into the sub-

(1) An upper jaw in which the effect of alveolar abscess in excavating the bone is shown.

stance 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 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

(1) Transactions of the Odontological Society, 1858, p. 53.

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 having been 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 formed pus gravitating down the neck, a second opening lower down resulted, and finally two sinuses opening below the clavicle were established.

And even death may ensue from these abscesses; thus M. Robert (1) records a case in which abscess around a lower wisdom tooth was followed by necrosis, and purulent infiltration of the side of the neck, from which the patient's death resulted.

Extensive alveolar abscess not uncommonly results in partial necrosis of the bone, and as a consequence death has been known to ensue in several instances, but these can be more appropriately treated of 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 buccinator 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

(1) Conférences de Clinique Chirurgicale. Paris. 1860.

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 becomes 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. The separation of the two parts is, however, 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 accom-

panied 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 separation of the inflamed tissue 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, and often does, extend to the periosteum of the body of the jaw, and if not speedily subdued, 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 great 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.

Treatment. — The pulp-cavity and fangs should be thoroughly cleared out, and a dressing of carbolic acid or thymol introduced, and renewed every day. 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 our best remedy. If adopted at a sufficiently early stage, it seldom fails to produce relief, and frequently cuts short the disease. One or two leeches should 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. In that case, the tooth should be removed, and if there is reason to suspect that pus is lodged in the substance of the gum, the part should be freely incised.

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 may become 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 awhile increased, arising, 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 pedget 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, even in the worst cases, may be looked for within an hour or two.

If from any cause the removal of the tooth be inexpedient, 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 fang. It is easy to distinguish by touch when the instrument reaches the fang, and the operation gives far less pain than might have been anticipated.

Previous to making the incision, the gum may be painted over with the following solution—

℞. Tinct. iodin. (double strength),
Fleming's tinct. aconit. āā,

and the track of the incision afterwards sponged out with strong carbolic acid; it need hardly be added that the tincture of aconite must not be applied near a raw surface, or the poisonous effects of this very potent drug might be

manifested; the more so as the susceptibility of different persons to its action is very various.

When the more active symptoms have subsided, a small fistulous opening will remain for the exit of the pus, unless the fluid finds its way to the surface through the fang. It is quite possible that the coats of an abscess situated in the dilated alveolus may embrace the necrosed extremity of the fang, 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. But I do not think this event is common, neither would its occurrence be expected, when it is considered that the fangs of teeth admit, under pressure, of a slight degree of motion.

Chronic Inflammation of the Dental Periosteum, limited to the alveolar membrane of one or two teeth, excepting in its 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.

The inflammation may, however, take a more active form. We shall then have pus secreted from the surface of the diseased tissue, and granulations may spring up from the margin or from within the socket.

Thus 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 it 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 connection 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 being encircled with a red line, neither of which symptoms is constant.

This bulbous state of the dental membrane (often termed fungous) is occasionally found in connection 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.

NECROSIS OF THE JAWS.

The death and ultimate separation of portions of the alveolar margins are, 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. 195. (1)



Thus, in a case recently 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

(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.

surface. This was found 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 a 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 (see page 182), 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.

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 operation 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. Thus, 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 pyœmia, 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.

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,

(1) Deutsche Vierteljahrschrift, 1872, as quoted in "Monthly Review of Dental Surgery," vol. i., No. 2.

(2) Conférences de Clinique Chirurgicale. Paris. 1860.

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.

(1) Holmes's "Dictionary of Surgery," vol. iv., p 39.

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 Mr. Paget quotes an instance where it was induced by the inhalation of phosphorus fumes as a quack remedy for nervous depression; and Mr. Heath (*op. cit.*, p. 115) quotes Grandidier to the effect that a case had 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.

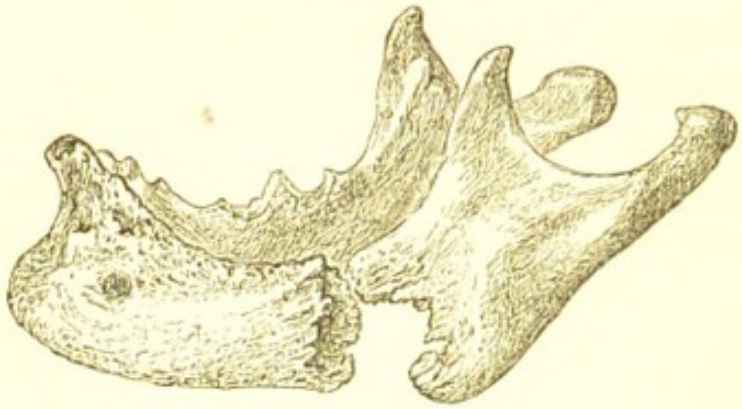
This form of necrosis is, perhaps, the most severe of any which is met with; its symptoms do not markedly differ from those of necrosis induced by other causes, save in their severity.

The swelling of the soft part 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 terminate 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. 196. (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 disease renders the avoidance of drugs, as far as possible,

(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.

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 is stated by Mr. Salter 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. Whilst the disease is in the stage of periostitis, threatening

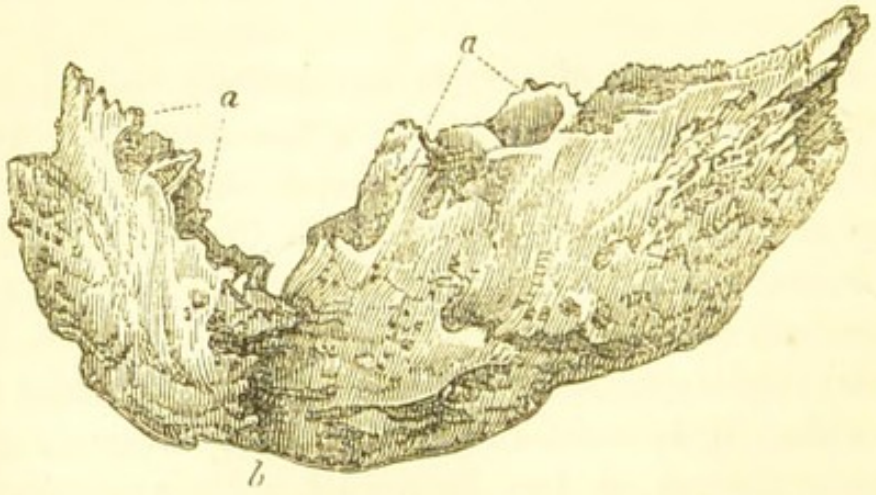
(1) "Lehrbuch der Allgemeinen und Specialen Chirurgie."

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. 197. (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 fistular 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.

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 (2) has, however, met with an example of new formation of bone, which he considers could not have been derived from periosteum.

Mr. Salter (3) 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."

(1) Medico-Chirurgical Transactions, vol. xxvii., p. 432.
(2) St. Bartholomew's Hospital Reports, vol. i.
(3) Holmes's "Dictionary of Surgery," vol. iv.

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.

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 affecting 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.

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. The loss of implantation is not unaccompanied with changes in the teeth themselves. The roots are destitute of cementum, and become translucent, like white horn, and retain that character when perfectly dried, differing in this respect from teeth in a normal state, the roots of which, when deprived of moisture, are perfectly opaque. In the one the opacity is due to the drying-up of the dentinal fibrils, and the consequent empty state of the dentinal tubes; in the other the fibrils are in a more or less perfectly calcified condition, and are incapable of shrinking up when the moisture is withdrawn from the tooth; hence, in the absence of tubular interspaces in the substance of the dentine, its transparency is necessarily preserved. With these concurrent changes, it is difficult to determine which takes precedence, and whether they hold the relation to each other of cause and effect. The evidence is greatly in favour of the assumption that the consolidation of the dentine in the root of the tooth in an aged subject, is the precedent condition lowering the vitality of the tooth, and to a certain extent reducing it to the state of a foreign body, and that the socket and gum are gradually absorbed as a consequence of the ebbing vitality of the part to which they are subservient. This view, I think, holds good when

the phenomena are seen in those who have passed the middle period of life, and also in certain other cases; but a question may be raised as to its validity on the ground of want of conformity to those cases in which the crowns of the teeth are lost, and the roots thereby deprived to a great extent of their life, and yet the absorption of sockets and gums does not follow. I believe, however, the difference of result is due to a variation of the conditions. In cases of absorption of the alveoli, the roots of the teeth are almost destitute of cementum, whereas in the roots of teeth around which the sockets and gums are preserved, the cementum is also retained. Examples illustrating this condition will be found in young or middle-aged patients whose teeth have decayed and broken off close to the edge of the gum, the level of which is for a certain time preserved. Sooner or later, however, the edge of the alveolus recedes, and is followed by the gum.

There are other conditions than those already enumerated under which the teeth may lose their sockets. A case recently came to my notice in which, 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 previously described; indeed, the cause of the malady was too obscure to admit of recognition.

Absorption of the alveolar processes may be more partial than in the cases previously considered. The outer or the inner plate only may disappear. The accompanying illustration is taken from a preparation in which the labial plate corresponding to the upper front teeth has been removed.

Indications of a similar change in other parts of the jaws are shown, but the amount of loss is comparatively trifling.

The more prominent or out-standing teeth are those the sockets of which are most liable to become absorbed; teeth, the roots of which are but thinly covered by bone and soft

Fig. 198. (1)

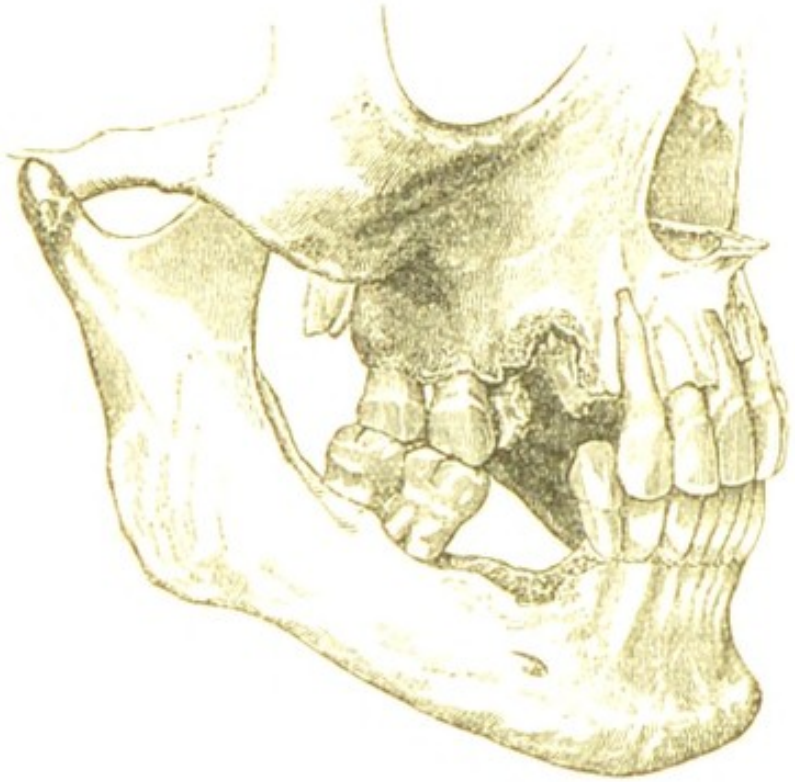


Fig. 199. (2)



(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. (This figure was omitted at p. 67, where the upper maxilla from the same subject is inserted.)

parts. This fact is shown in the case figured. The right upper canine has lost the whole of the anterior wall of its socket, while the contiguous lateral incisor, which lies back, has retained the corresponding part of the alveolar investment. The canine teeth being the last of the front teeth to take their position, are subject in a contracted jaw to stand 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 is 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 it is to the occurrence of alveolar absorption, without the precedence or accompaniment of obvious disease in the soft tissues which clothe the socket, that attention has been directed. The frequent use of a hard tooth-brush will hasten the wasting of an out-standing 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 firm.

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 almost always a thin ring of hard, dark tartar, invisible unless the gum is forced away from the tooth. 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 fang 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 intimately connected 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.

All those teeth which have become hopelessly detached from the periosteum should be removed, as there appears to be some tendency to the extension of the disease from an affected tooth to its neighbours.

The hard, dense tartar which encircles the neck of the tooth beneath or at the level of the edge of the gum should be carefully removed; not because it is, as has been supposed by some, a cause of the disease—it is a secondary deposit, and could never have got there without pre-existent disease—but because it is a source of irritation.

If there is much discharge, the sulcus between the tooth and the gum should be touched with a fragment of solid zinc chloride, and the patient directed to wipe it out with a camel-hair brush at least once a day, the brush being charged with a solution of zinc chloride gr. v. ad ℥j., or with phénol sodique, a convenient substitute for which is subjoined—

℞. Acidi carbolici, ʒj.
Liq. potassæ, ʒj.
Aquæ ad ℥j.

Or, if an astringent seem desirable, the following will be found very efficient—

℞. Glycerini acidi carbolici,
Glycerini acidi tannici, āā ℥ss.

If there be much congestion of the gums, they may be freely lanced, and frequently painted with tincture of iodine (double strength).

In some few cases much good may be done, but as a rule the results of treatment are very unsatisfactory.

In the absence of an obvious cause of mischief, we can but direct that the patient should use a soft tooth-brush, employ a moderately astringent dentifrice, take care that the teeth are well cleaned, and, at the same time, avoid irritating the edges of the gums by unnecessary friction.

The use of a piece of stiff twine will be found very serviceable in deciding whether or not a loosened tooth should be extracted; if it can be passed up nearly to the apex of the fang, on half or more than half the circumference of the tooth, the chance of its again becoming firm is very small.

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.

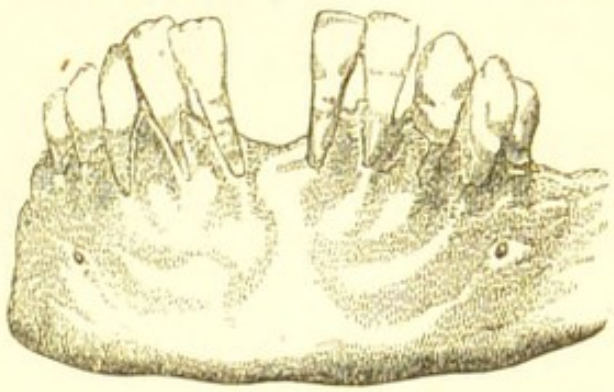
After the luxation of a tooth, the socket in young and middle-aged subjects is to a certain extent filled up from the bottom by the development of bone. This process, which, after the loss of a tooth, is reparative, becomes destructive when the action is set up in the socket of a sound tooth. The tooth 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. A nodule of bone

as large as a pea is often seen projecting from the lingual surface of the lower jaw, and little or no inconvenience is felt from such growths, even when as large as the half of a nut; and many instances have come under my notice in which

Fig. 200. (1)



corresponding growths have sprung from the labial surface of the sockets of the molar teeth of the upper maxilla. 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 (2).

Otto Weber (3) 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: 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

(1) 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 Mr. Saunders's collection.)

(2) An excellent example of numerous exostoses, studded over the alveolar border of the jaw, is given in "Atlas zur Pathologie der Zähne" von Heider und Wedl, Plate xv., Fig. 138.

(3) Otto Weber. "Lehrbuch der Allgemeinen et Specialen Chirurgie."

to disappear after the extraction of the teeth; a course which should, therefore, always be tried. But, as a general rule, no treatment but excision of the morbid growth will be of any service; and this becomes necessary when the mass, from its size or position, causes much inconvenience. Owing to the excessive hardness of some of these exostoses, their removal is often attended with more difficulty than was at all anticipated. A Hey's saw will generally be found the most suitable instrument 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. The 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 or the greater part of the gums and alveolar processes, has been observed: for the opportunity of examining one of these cases I am indebted to 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 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 (1). A fairly characteristic case which occurred in the practice of 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.

Fig. 201. (2)



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 (3) article. At the fifth week after birth, 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

(1) 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, 2nd edition, 1872, p. 194.

(2) From a model of the upper jaw of Mr. Syme's case.

(3) "A System of Surgery," by Timothy Holmes, M.A., 2nd edition, 1870. Art. "Diseases of the Teeth," vol. iv., p. 342.

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

Fig. 202. (1)



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.

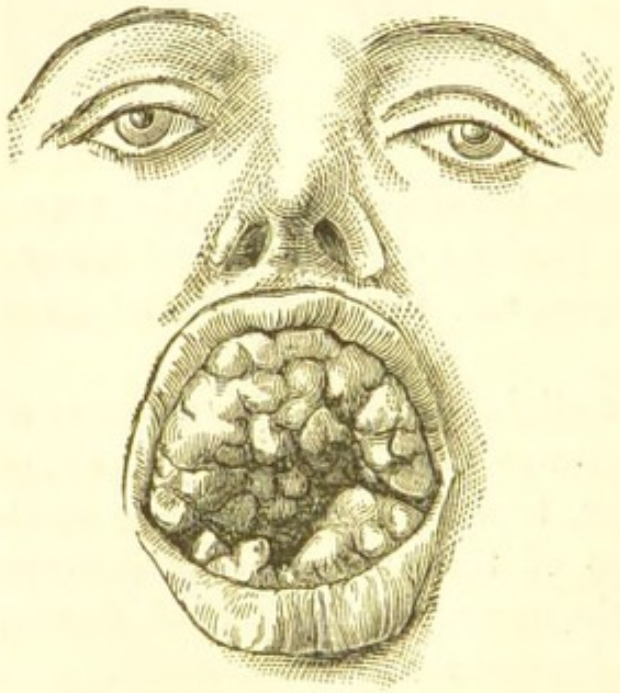
There was a slight tendency to recurrence of the growth. In structure it was found to consist of hypertrophy of the alveolar border, together with immense thickening of the fibrous portion of the gum, and an exuberant growth of papillæ. In the upper jaw it extended three-quarters of an inch forwards 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.

(1) From a plaster model of the upper jaw of Mr. Pollock's case.

The fangs 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 hard and thick 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.

Fig. 203. (1)



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

(1) From a photograph of Mr. MacGillivray's case.
(2) "Australian Medical Journal," August, 1871.

account and figure are taken. It is noted that the gums 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 had 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.

In most, though not all of the cases, the disease appears to have been first noticed at a very early period—in fact, is probably congenital. It does not of necessity interfere with the development of the teeth, although they are concealed

by its rising up round them: in Mr. Pollock's case, related by Mr. Salter, it is noticed that the teeth were of unusually large size, and were developed somewhat before their normal time.

It does not appear possible to certainly connect this disease with any constitutional taint; for though in Mr. Canton's, Dr. Gross's, and Mr. Pollock's cases the children were strumous and of defective intellect, in Mr. MacGillivray's case the patient was otherwise perfectly healthy.

HYPEROSTOSIS.

The maxillary bones appear to be the usual 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.

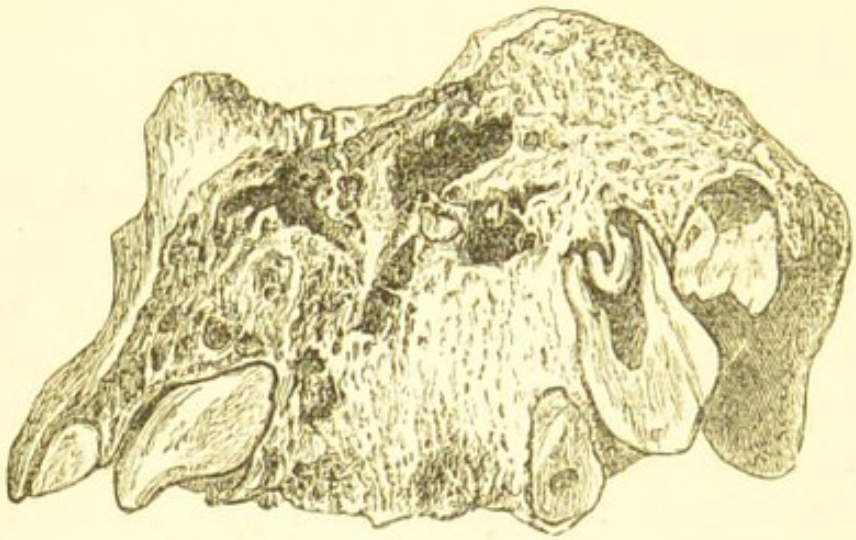
The disease consists in an interstitial growth and alteration affecting the whole substance of the bone, and not merely its surface: in its progress the whole bone becomes enlarged; the antrum, and eventually also the nasal cavities, obliterated: it goes on to encroach on the orbit till the eye is destroyed 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 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 this case the disease was first noticed at the age of three months, when the left side of the face was found to be enlarging. The left eye became closed at the age of six, and the enlargement steadily

(1) "Diseases and Injuries of the Jaws," 2nd edition, 1872, p. 132.
(2) Transactions of the Pathological Society, 1866, p. 245.

increased till the boy reached the age of twelve, when the left upper maxilla was removed by Mr. Heath; the integu-

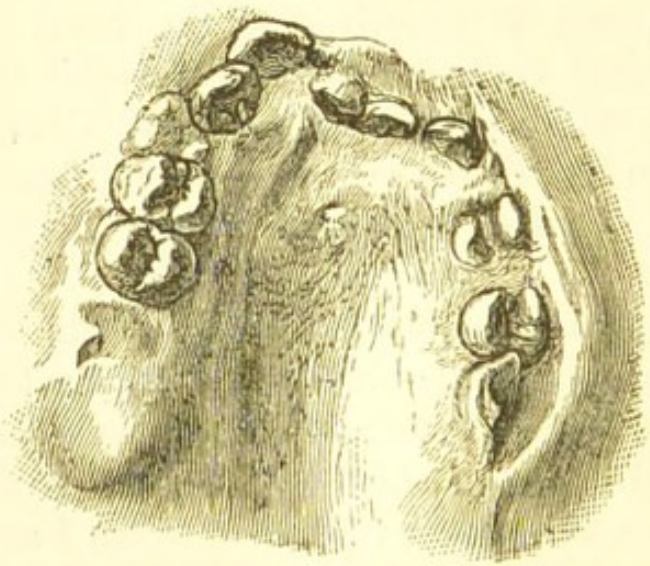
Fig. 204. (1)



ment having, however, shared in the hypertrophy, great deformity still remains.

A model of the mouth (Fig. 205), taken before the opera-

Fig. 205.



tion, shows that on the right or healthy side the permanent incisors, canine and bicuspids, are in place; while on 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.

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 of 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.

DISEASES OF THE GUMS, Etc.

Stomatitis.—Inflammation affecting the mucous membrane of the mouth is far more common during early childhood than at any later period.

Dr. West, in treating upon inflammation of the mouth (stomatitis), says: "Inflammation of the mouth is an occurrence by no means confined to the period of teething, but it comes on in children of all ages, assumes very different forms, and leads to very different results in one case from those which characterise it in another. The mucous follicles of the mouth are the chief seat of the disease in one case; the substance of the gum in another, and that of the cheek in a third. In the first (follicular or aphthous stomatitis), the affection issues in the formation of several small ulcers, which heal eventually of their own accord; in the second (ulcerative stomatitis), an unhealthy process of ulceration destroys the gums and denudes the teeth, but it is tardy in its advance, and tends to a spontaneous cure; while in the last (gangrenous stomatitis), mortification involves all the tissues of the cheek, and spreads with a rapidity which remedies fail to check, and which is arrested at last only by the patient's death." (1) Although each of the foregoing forms of disease has a constitutional origin, and for the most part fall under the treatment of the surgeon, yet they sometimes come under the notice of the dentist.

Simple Stomatitis (*Erythematus Stomatitis*) is charac-

(1) "Lectures on the Diseases of Infancy and Childhood." By Charles West, M.D. Third edition.

terised 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.

Aphthous (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 ℥iij.

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, 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 the 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.

The malady originates in the front part of the mouth, and it is only in severe cases that it extends back 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 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; 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 power, 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 recognised, the ulcer should be utterly destroyed with fuming nitric acid; not a moment should be lost, as, if gangrene has once fairly set in, the case is almost hopeless. But, unfortunately, the access of the disease being unaccompanied by suffering, it is seldom observed until it is too late. The free application of nitric acid should never be neglected; recollecting the rapidity and the almost certain fatal result of the malady, the surgeon must not hesitate to destroy the affected tissues widely. Disinfectant washes should be diligently used, and the child's strength kept up by the free administration of stimulants.

Some practitioners use concentrated hydrochloric acid, in the place of nitric acid, for destroying the sore, and consider that it gives more satisfactory results.

Active 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 further pressed. 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 occur-

rence 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 indications that these conditions are about to appear—that the patient will in a few hours be salivated. The state of gum I am about to describe is, in fact, a premonitory sign of ptyalism, for should it appear, and the mercury be immediately discontinued, yet salivation will come on. The sign is this:—the adherent portion of the mucous membrane of the gums assumes an opaque white colour, contrasting strongly with the non-adherent portion, which preserves its natural hue or becomes more red. The free edge of the gums is moveable, but that part which lies over the edge of the alveoli is firmly tied down to the periosteum; and as the edges of the alveoli present a festooned line, so the whitened mucous membrane presents corresponding undulations. Again, where the mucous membrane is loosely reflected from the gum to the cheek, the natural colour is preserved. The whiteness of gum is produced by an increased secretion of epithelium, which, from being thicker and more opaque than in the healthy state, renders the colour given by the vessels to the subjacent tissue less apparent.

The surface of the mucous membrane, when deprived of epithelium, is studded over with innumerable small conical elevations or papillæ. The thickened epithelium is readily rubbed off the tops of the papillæ, while it retains its full thickness in the intervening depressions; hence, if closely inspected, the gums will not be seen to present a uniform white hue, but a mottled aspect.

With the increased thickness there is a decrease of tenacity between the scales that form the epithelium, for the surface may be much more readily rubbed off than when in its natural state.

This curious and useful premonitory sign of coming ptyalism was, I believe, first noticed, and its value pointed out, by Mr. Corfe; at all events, he was the first to draw

my attention to the fact, and I am not aware that it had been previously described. Since, however, Mr. Corfe mentioned the result of his observations as to the constancy of the sign, I have verified for myself its presence in all cases of salivation that have come under my notice; and from these the foregoing account has been given.

When the condition of mercurial salivation is fairly established, the gum and palate become markedly swollen, as does also the tongue, so that it is deeply indented by the teeth. The breath becomes intolerably offensive, and the mouth can only be opened with difficulty.

In bad cases ulceration and consequent hæmorrhage occur; sloughing and necrosis of the bone may supervene. 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.

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.

Chronic Inflammation of the Gums.—This form of disease is very common in the middle and later periods of life, and when once established, is apt to prove obstinate.

Although in the first instance the gums alone appear to be the seat of the disease, the alveolo-dental periosteum, after a time, becomes involved in the morbid process. The surface

of the gums becomes minutely nodulated, and the secretion of epithelium increased, so that the spaces between the teeth are filled with the creamy or cheese-like substance made up of cast-off epithelium; the papillæ are abnormally prominent, while the substance of the gum is generally thickened.

The festooned outline of the edge of the gum is speedily lost, the free edge becoming thick and rounded. The morbid process may extend over the whole mouth, or be symmetrically developed on the two sides of the mouth, as will be the case when it is dependent on constitutional causes; or it may be confined to the vicinity of two or three teeth, in which case the cause is probably local.

When dependent on general causes, it affects the vicinity of sound equally with that of decayed teeth, and it has been regarded as identical with the natural process of absorption of the alveoli in advanced age; as being, in fact, an evidence of premature old age.

The pain attendant on this malady is inconstant, both in degree and in character. In some cases but little uneasiness is complained of, unless during eating; whilst in others the patient is rarely free from pain. The pain may be strictly local, or it may take the neuralgic form, and recur with great regularity at the same hour every day; but it is, on the whole, rare for pain to be complained of until the sockets of the teeth have been in part destroyed, and the alveolo-dental periosteum involved in the disease.

If it runs its course unchecked, purulent matter is discharged from between the gums and the necks of the teeth, and the breath becomes excessively offensive, often having a peculiar odour very characteristic of the disease. Then the alveolar processes become involved, and may be affected in two opposite ways: the processes may be increased in thickness by the addition of porous bone to their outer surfaces, or they may be rapidly removed by absorption; in either case the teeth are speedily lost—the periosteum becoming detached from the roots. Owing to this detachment of the

periosteum, tartar is apt to be deposited in small nodules on the bared fang; this is not, however, a cause of the disease, as has been supposed by some writers, but is a consequence; though, undoubtedly, the presence of such extraneous matters in the socket will keep up and aggravate the morbid action.

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 treated. 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, as they will never become refixed, and in their mobile condition serve to keep up irritation. Certain American authors lay great stress on the removal of the tartar deposited far down on the fangs, and describe instruments specially made for this purpose. So far as it is practicable, this should be done; but when a tooth has lost its attachment to the alveolo-dental periosteum for a considerable portion of its length, it is better to extract it.

The distance to which this separation of the tooth-fang

has reached, may be ascertained by passing a piece of silk twist down by the side of the tooth: this is sufficiently stiff to pass down until arrested, while it is too soft to effect any further separation of the parts.

In the earlier—or, indeed, in any stages of the disease—the strongest tincture of iodine is often very serviceable, and may be repeatedly applied; it will be found to be absorbed by these spongy, congested gums to a far greater extent than by firm, healthy gums.

Various astringents may be used; none, however, is much more effective than tannin, which may be applied either as a powder, or in the form of the pharmacopœal glycerinum acidi tannici.

When there is much purulent discharge welling up between the gums and the necks of the teeth, the sulcus there found should be thoroughly cleansed, and fused chloride of zinc passed round the necks of the teeth. This may be done by melting it on the end of a fine silver probe, or a fragment of the actual stick may be applied; or, failing these methods, a morsel of cotton saturated with the solution produced by the deliquescence of the salt may be used.

The application of phénol sodique (sodic phenate) in the same manner tends to check the discharge; and the fœtor of the breath may be corrected by washes of the same, in the proportion of a teaspoonful to a tumbler of water.

In the place of using the impure French preparation, which has an unpleasant taste and smell, I commonly employ the following formula—

℞. Acidi carbolici, ℥j.
Liquoris Potassæ, ℥j.
Aquæ ad ℥viij.

Touching the edges of the gum with a stick of nitrate of silver sometimes sets up a more healthy action.

There is a singular modification of chronic inflammation of the gums, in which, instead of becoming thickened and

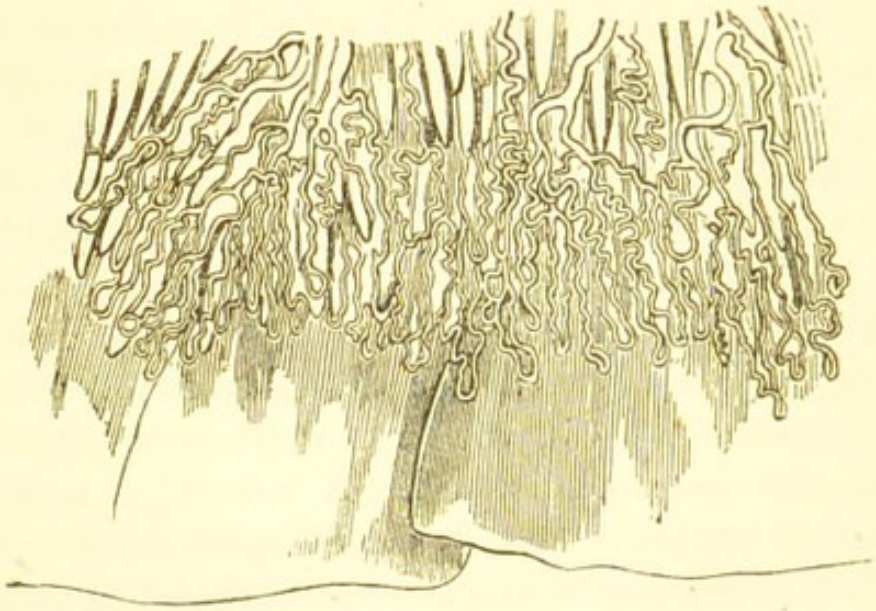
irregular on the surface, they seem rather to decrease in size, assume a very smooth and polished surface and mottled aspect; at the same time the disease may extend over the surface of the hard palate. The malady is attended with acute intermittent pain, which may be confined to one side of the mouth, 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 the 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, and the vessels which, in their looping and inosculations, form so interesting an object when subjected to microscopic examination, become, if not more numerous, greatly lengthened and dilated. I am 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 illustration on the next page 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.

Fig. 206. (1)



In scurvy the gums are greatly affected; the appearance 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 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.

(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.

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.

The mucous membrane of the cheek is liable to ulceration caused by the irritation of jagged decayed teeth; and it may become so indurated by constant irritation as to, in a measure, simulate epithelioma. Mr. Berkeley Hill has pointed out that, in syphilitic patients, the mucous membrane of the cheek where exposed to friction becomes swollen, pale and sodden in aspect, and elevated into whitish ridges or patches. There is often a slight ulceration at the apex of the ridges, and they cause great discomfort to the patient, being especially irritable when rubbed by a jagged tooth.

Gummata may also occur in the substance of the cheek, though they rarely do so.

ULCERATIONS OF THE TONGUE.

Although it would be inconsistent with the purpose of the present work to enter at any considerable length into the subject of diseases affecting the tongue, it is very desirable that the dental surgeon should be familiar with the characters of ulcerations occurring in the mouth, seeing that some are, whilst others are not, dependent on the irritation of ragged and diseased teeth.

A very slight roughness of natural or artificial teeth will suffice to cause a superficial ulcer in a person predisposed to such ulcerations, which are very common amongst the dyspeptic: they come and go rapidly, are shallow and sensitive, and have very bright red edges; a touch with nitrate of silver generally suffices for their cure.

But ulcers of far more formidable appearance may be produced by ragged teeth; ulcers with an exceedingly foul, shreddy surface, pouring out an offensive discharge, and sometimes extending deeply into the substance of the tongue.

Although not surrounded with the hard base characteristic of epithelioma or syphilitic ulcers, the surrounding tissue will be in some degree hardened by infiltration with inflammatory exudations; and more rarely, an ulcer dependent simply on a ragged tooth may closely simulate epithelioma, by having sharply-defined, hardened edges, and a firm, comparatively clean surface.

The inflammatory action may extend to the whole floor of the mouth, causing great œdema and difficulty in swallowing or in speaking. The diagnosis of these ulcers is generally 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.

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, proceeding to ulceration in the course of three weeks or a month.

When it ulcerates, portions of the induration appear to slough away, so that the edges, themselves more or less indurated, overhang the cavity: the form of the ulcer is irregular, and its edges smooth. It secretes a scanty discharge, hardly to be called pus, and has a sloughy aspect.

The free administration of iodide of potassium will speedily cure most syphilitic ulcerations, unless the patient be very cachectic: large doses of sarsaparilla often act very beneficially in such cases.

So fully amenable to the influence of iodide of potassium are gummata and syphilitic ulcerations of the tongue, that the effect of the drug may be greatly relied on as a diagnostic sign in doubtful cases.

Epithelioma affecting the tongue is a disease far from rare: like the syphilitic ulcer, it commences by induration, ulceration being a subsequent stage, which in the case of the syphilitic form ends in the destruction of the indurated mass, but in the case of epithelioma is marked by ever-extending induration beyond its edges.

The base of the ulcer is greyish, or sometimes red; the discharge is very scanty, and the growth of the patch is attended with considerable pain.

The edges are hard, generally everted, and lobed; they are often of a peculiar red, polished appearance, and are sometimes fissured or nodulated. When the disease has lasted long, the sub-maxillary lymphatic glands become enlarged, but the period at which a correct diagnosis is of vital importance is then passed.

Epithelioma is most likely to be confounded with syphilitic 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 dorsum of the tongue than on its edges; is often remarkably flat and regular in form, and is seldom found in young persons: the contrary is true of syphilitic ulcer.

The latter is remarkably free from pain or tenderness, though of great extent and depth; its edges are not nodular, and its progress is rapid; moreover, its ready amelioration under the administration of iodide of potassium will often serve to confirm a doubtful diagnosis.

Sir James Paget (1) describes a very extensive form of ulceration due to tubercle, which is very rare, and of which I have personally no experience. These strumous ulcerations present a marked resemblance, in their course and appearance, to strumous deposits proceeding to suppuration and ulceration elsewhere in the body.

(1) "Medical Times and Gazette," 1858.

TUMOURS OF THE GUMS.

Several varieties of tumour are met with in the mouth, springing either from the gums themselves, or from the subjacent 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. 468); 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,

(1) Dr. E. Magitot. "Mémoire sur les Tumeurs du Périoste Dentaire," p. 58, and figs. 7, 7*a*.

although frequently associated with this disorder. Tumours so situated are very liable to be forced against, and injured by, the ragged edge of the tooth which has led to their growth; and the injured part may become painful, more especially if the wound ulcerates. The patient is 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 escharotics.

When the gum between two teeth which have been successfully filled becomes diseased, a different course must be adopted. The roots of contiguous teeth usually diverge in their passage into the jaw, and a second divergence is produced by cutting away the sides of the crown. This leaves a constriction at the point where the excision of the tooth or teeth terminates. It is when the gum rises above this part that it becomes troublesome. Our aim must be to reduce the gum by pressure, or by the use of an escharotic, to its normal position—to a level with the constriction formed in the manner described, or even a little below it. The mere reduction of the gum to its normal limits will not of itself be sufficient to effect a cure; the pressure must be continued until the disposition to advance is overcome. I should think the electric cautery would be useful in accomplishing the first part of the operation. In my own practice I have used sulphate of copper, or have had recourse to pressure only; potassa cum calce made into a thick paste with glycerine is an excellent escharotic for any such purpose as this; it is, I think, the least irritating, and in all respects the best for use in the mouth.

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 by a small and flattened pedicle, or by a broad base. The submucous fibrous tissue, or the soft tissue contained in the Haversian canals of the bone, usually affords the site of the disease, which in its growth carries before it the superjacent 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.

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 submitted, 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 very rarely occur (1).

Such, then, are the general characters of epulis. As regards the structure of these tumours, several varieties may be noted: first, those which are composed of fibrous tissue intermixed with fibro-plastic 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 (2), 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

(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.

(2) Transactions of the Pathological Society, vol. viii., p. 380.

be embedded 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 absorption, 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 (Fig. 207).

Fig. 207. (1)



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; two examples of this are given by Mr. Heath (2).

(1) Epulis which has been laid open to display the stump of a tooth which lay in its centre. From Tomes's "Lectures on Dental Anatomy and Surgery."

(2) "Injuries and Diseases of the Jaws," 2nd edition, p. 193.

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 the disease 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 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 the most formidable-looking cases of epulis, it is only the alveolar portion of the jaw which is involved.

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, in which local hypertrophy of the papilla 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," occuring in the vicinity of carious teeth.

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.

The cases which have come under the notice of the author, amounting only to three or four in number, have been successfully treated by the local application of powdered tannin to the surface of the tumour.

TUMOURS OF THE HARD PALATE.

The commonest cause of tumour on the hard palate is abscess dependent on a lateral incisor tooth, though other teeth do occasionally give rise to it.

It is also a situation in which syphilitic nodes may occur; 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, occuring in the practice of Mr. Cock, has been put on record by Mr. Salter.

Fig. 208. (1)



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 figure, where a molar tooth has been erupted in the median line of the palate.

(1) From a plaster model in the museum of the Odontological Society.

THE SALIVA AND SALIVARY CALCULUS.

The fluid ordinarily found in the mouth is a mixture of the secretions of several different glands, and its chemical and physical properties vary according as the products of the one or the other preponderate. For the purpose of description, it will be convenient to consider separately the products of the secretion of the salivary glands, and those of the oral mucous membrane.

The most abundant source of saliva is the parotid gland, which pours out a clear fluid free from viscosity, of alkaline reaction, and a specific gravity about 1006. It has one peculiarity which is not shared by the saliva furnished by the other glands: when left to itself for a few minutes it becomes turbid, from the deposition, in a crystalline form, of carbonate of lime. This fact serves to explain the enormous accumulations of tartar which are often seen opposite to the orifice of Steno's duct; another reason why deposits at this point attain such a great size being that the parotid alone of the salivary glands is constantly pouring out its secretion, independently of the stimulus of food.

The parotid gland is subject to the influence of the fifth nerve, and hence is often stimulated to hyper-secretion in cases of neuralgia (see Neuralgia), being supplied by a branch from the auriculo-temporal nerve (Bernard). The submaxillary saliva is very viscous, so that on standing it sometimes becomes quite gelatinous, but it does not deposit carbonate of lime, though its reaction is alkaline. Its secretion is poured out in response to the stimulus of food, and hence is almost entirely absent during fasting (1).

(1) E. Magitot. "Études et expériences sur la Saliva." Paris, 1866.

The sublingual gland pours out a viscid fluid, rich in the "ptyalin" of Berzelius, also alkaline.

In addition to the products of these several glands, we have the "buccal mucus;" according to the experiments of A. Bernard (1) and of Dr. Magitot (*loc. cit.*), 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 necks of the teeth, or 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 so 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.

(1) "Leçons de Physiologie," vol. ii., p. 121.

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 sulphocyanate of potassium are also met with in saliva.

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 an 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 this cause 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 of 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 to the consideration of which we shall return in connection with the subject of Dental Caries, merely noting here, that the deposition of tartar composed of carbonate of lime is almost unknown where this condition of mouth exists.

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.

Simon says, "Tartar on the human teeth consists of earthy phosphates, epithelium-scales, a little ptyalin, and fat; and when examined under the microscope, there are seen abundance of pavement epithelium and mucous corpuscles: and, in addition to these, numerous long acicular bodies and infusoria of the genera vibrio and monas."

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 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 a 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. The tartar is not an active corrosive agent, producing the destruction of the fang, as some dentists have supposed, but its presence is consequent on the death and denudation of the latter.

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 fangs 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 surface, they should be polished with pumice-powder on a piece of wood, after the tartar has been removed by suitable steel instruments.

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.

ODONTALGIA.

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 does 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 hyper-æsthesia 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.

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 conditions 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 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.

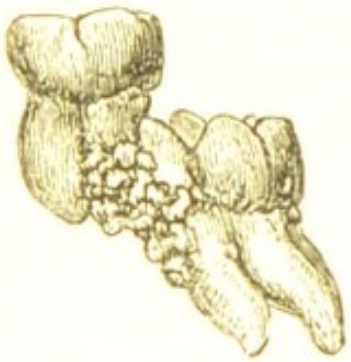
The treatment of toothache is, obviously, when possible, to remedy the cause.

Acute inflammation of the nerve rarely comes into the hands of the dental surgeon for treatment, as it has commonly 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 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

Fig. 209. (1)



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, the most hopeful cases being those in which the pain is due to chronic inflammation of the pulp.

(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.

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.

NEURALGIA.

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.

When pain is felt in a tooth, we describe 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 the localised pain in the tooth, we speak of it as "Neuralgia." 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

(1) Trousseau. "Clinical Medicine," vol. i. "On Neuralgia." New Sydenham Society's Translation.

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 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 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 the one least often affected in

(1) "Neuralgia and its Counterfeits." F. E. Anstie, M.D.

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 confined 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 recently been described by 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 affected a permanent cure, and in all produced great alleviation of the symptoms.

There is a form of neuralgia, named by Trousseau, *epileptiform 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

(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.

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 almost always 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 (1) 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 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, and 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.

(1) "Archives of Dentistry," vol. i.

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 neuralgia is possible without much 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, 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 Dr. Anstie, is not, I think, difficult to find; and it rests in this, that the most typical cases of neuralgia, as 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 and beberine. 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 commonly avert the paroxysm.

With the exception that diseases of the teeth very rarely set up a 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 over-work: 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 accordingly 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 it 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 (page 565).

Various alterations in the fangs of teeth may give rise to neuralgia: Figs. 210 and 211 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. 210); and in the other (Fig. 211), the end of the fang has been

Fig. 210.



Fig. 211.



Fig. 212.



partially absorbed, and left roughened and 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

(1) Transactions of the Odontological Society, vol. iii.

detected by making the patient bite upon a hard substance with each tooth in succession (Fig. 212).

A fang which is a source of great irritation may become covered over with healthy gum, and so effectually concealed 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 never 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. 211.

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 at advising 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 affecting 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

(1) Wedl. "Pathologie der Zähne," 1870, p. 351.

some few cases are the real sources of neuralgia. He points out that in caries, inflammation of the tooth-pulp is accompanied by degeneration of all the nerve-fibres; whereas in neuralgia only a few nerve-tubes are thus affected; and that in this difference between the two conditions, the reason why neuralgia may follow on the extraction of an aching tooth is to be sought.

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 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 neuralgia. 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.

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 travel 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; and from an article contributed by Mr. Salter to Guy's Hospital Reports (Third Series, vol. xiii., 1867).

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 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 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 54); 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) Asbburner, 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 faceache, 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 pain in the uterus, and even of actual abortion, have been brought about by dental irritation; and that such should be

(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.

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 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.

In another patient strabismus of three years, and ptosis of a fortnight's duration, were found to depend on carious upper molars, and were cured by their removal: the patient was an adult (*loc. cit.*).

A case of excessively severe neuralgia is related by Fox, in which only fluids could be taken, on account of any touch upon the teeth bringing on a paroxysm. Profuse salivation and ptosis were present. The ptosis disappeared two days

(1) "Lancet," Jan. 22, 1859.

after the removal of a carious upper molar, but the case was not cured until all the remaining teeth had been extracted. The roots were affected by exostosis.

Disordered Nutrition. — The nutritive functions do not always escape participation in the disturbance set up in neuralgia of the fifth nerve, which are 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.

Mr. Hilton (1) has 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 lower carious 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. 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 b

(1) Lectures delivered at the Royal College of Surgeons. "Lancet," 1861.

caused by diseased teeth. Dr. 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 cases reported are too numerous to give in this place, but an abstract of a few of the most interesting will serve to give a sufficient 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, 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 of the one coincident with the access of 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 (*op. cit.*) 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

(1) Wedl. "Pathologie der Zähne," p. 355.

blindness wholly disappeared, though he could not distinguish what very small objects were.

Dr. Emmeuch ("Dublin Medical Free Press") suffered for fourteen years from congestion and lachrymation from one eye, and photophobia, these symptoms being aggravated by unsuitable diet; the symptoms began to amend and soon disappeared after the extraction of a carious tooth.

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 product 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.

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, figured at page 220; 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 affords a convenient method of arrangement, and will hence be followed in this place.

In order to understand the origin of these pathological products, it is necessary to clearly keep in view the normal

(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.

process of tooth formation. At an early stage, a future tooth is represented by a mass of submucous tissue, which has, as it were, risen up to meet the inflected process of oral epithelium 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 fang, 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 contains no calcified tissue, but only a structure identical with that of fibrous or fibroplastic 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

(1) "Traité des Tumeurs," p. 300. Paris, 1869.

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 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 some two years since 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 fibroplastic tumour, and its recurrence was confidently predicted. Up to this time, however, no sign of recurrence has 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 suface 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.

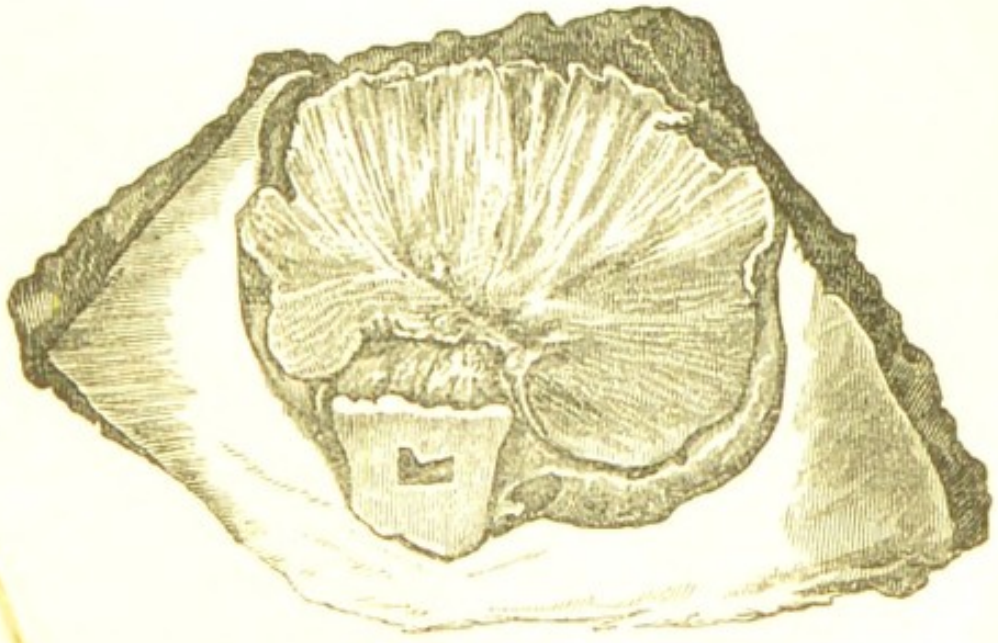
Odontomes of the second class (odontomes odontoplastiques), require somewhat more detailed notice; at the date of their origin the dentine germ is covered by a layer of odontoblasts, more or less completed, but dentine has not yet been formed. Consequently, when the bulb has become the seat of an irregular outgrowth, a mass is produced containing

(1) "Pathologie der Zähne," 1870, p. 129.

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 has 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. 213. (1)



(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.

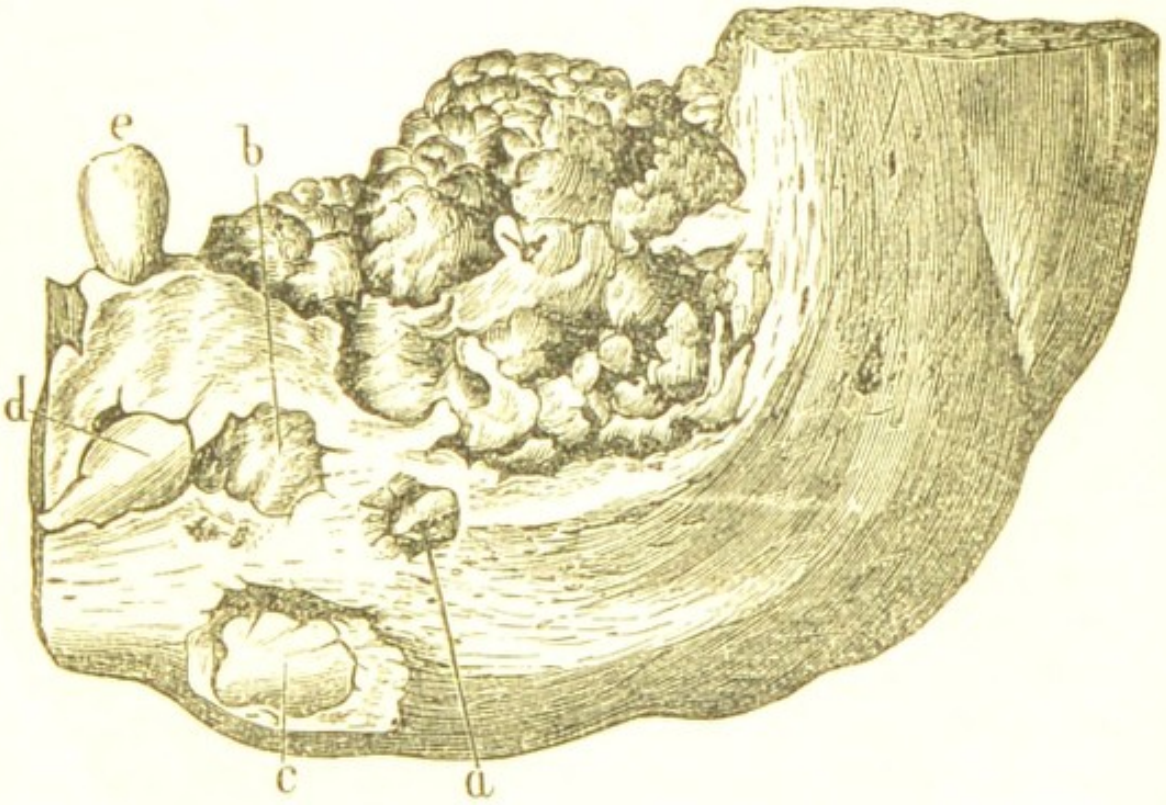
In this case the second molar of the lower jaw was represented by an irregularly flattened mass, composed of enamel, dentine, and a bony tissue thrown together without any apparent regularity. The wisdom tooth was held down beneath this most extraordinary mass. The nature of the case not having been 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 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.

Fig. 214. (1)



The patient in whom this odontome occurred was aged twenty, but disease of the jaw had first been remarked at the

(1) *e*, first bicuspid; *d*, second bicuspid; *c*, first molar; *a* and *b*, portions of the mass which protrude through the bone.

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 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 (1), a mass occupying the whole space 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 (2), and figures taken from models of the 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. 216 was made from a very

(1) Prof. C. Wedl. "Pathologie der Zähne," 1870, p. 125.
(2) "British Journal of Dental Science," 1862.

similar odontome, and will serve to exemplify the usual structural characteristics of these growths. It is traversed

Fig. 215. (1)



by parallel vascular tracts (*a*), which here and there dilate into pouches, or branch out into several divisions; from these vascular tracts the dentinal tubes radiate with considerable regularity.

Fig. 216. (2)



(1) From Heider and Wedl's "Atlas zur Pathologie der Zähne." *a*, smooth enamel-coated surfaces; *b*, nodules of enamel.

(2) Section of an odontome. From Heider and Wedl's Atlas.

Globular masses are in places very abundant, and at the peripheries of the several systems of dentinal tubes irregular spaces abound. In some parts enamel is continued far down 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.

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 fangs. 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

Fig. 217. (1)



in the fangs is well illustrated by the accompanying figure. The crown is perfectly colossal, though it retains in a measure

(1) Natural size. From Heider and Wedl's "Atlas zur Pathologie der Zähne."

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 whole mass may be altered by subsequent outgrowths of the pulp. This form of odontome is far more common than 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.

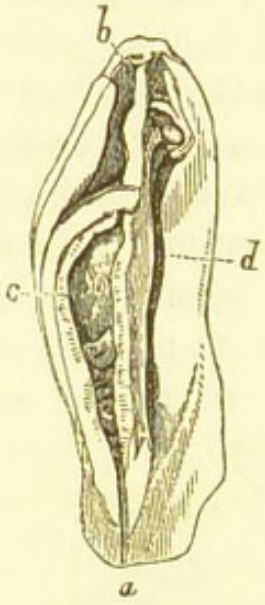
Fig. 218.



A similar specimen has been figured by Mr. Salter, in his 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 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.

Fig. 219. (1)



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 continuous 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

(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*.

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. 220.



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 very rare, only four or five cases having been recorded. Of these one is in 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,

(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.

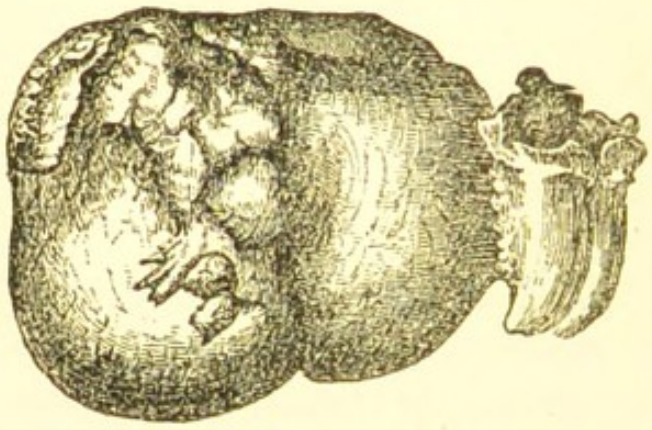
(3) "Atlas zur Pathologie der Zähne," von Prof. Heider und Prof. C. Wedl. Leipzig, 1868. Taf. ii., Figs. 28 and 29.

and described and figured in the Transactions of the Society (1), 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.

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. 221.



The whole mass came away on an attempt being made to extract the decayed tooth which formed the anterior portion of the growth.

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 represented of its natural size, is seen to be attached to and to surround the root of an upper molar tooth.

(1) Transactions of the Odontological Society, vol. iii., p. 335, J. Tomes; and 2nd series, vol. iv., p. 81, Charles S. Tomes.

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,

Fig. 222.



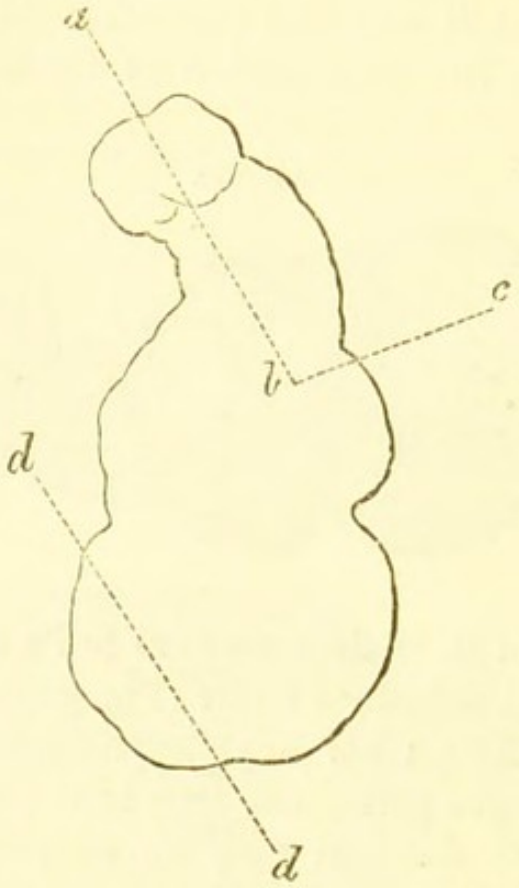
renders each and all of these views as to its nature untenable. As is seen in the subjoined figure (Fig. 224), the fangs of the tooth are not dilated nor hypertrophied, but are of rather small size: at some point, not seen in the section, there has sprung from the dentinal pulp an outgrowth, which has 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. 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

(1) Holmes's "Dictionary of Surgery" (*loc. cit.*).

osseous structure. At the part marked *d d* the dentine shell was entirely absent.

Fig. 223. (1)



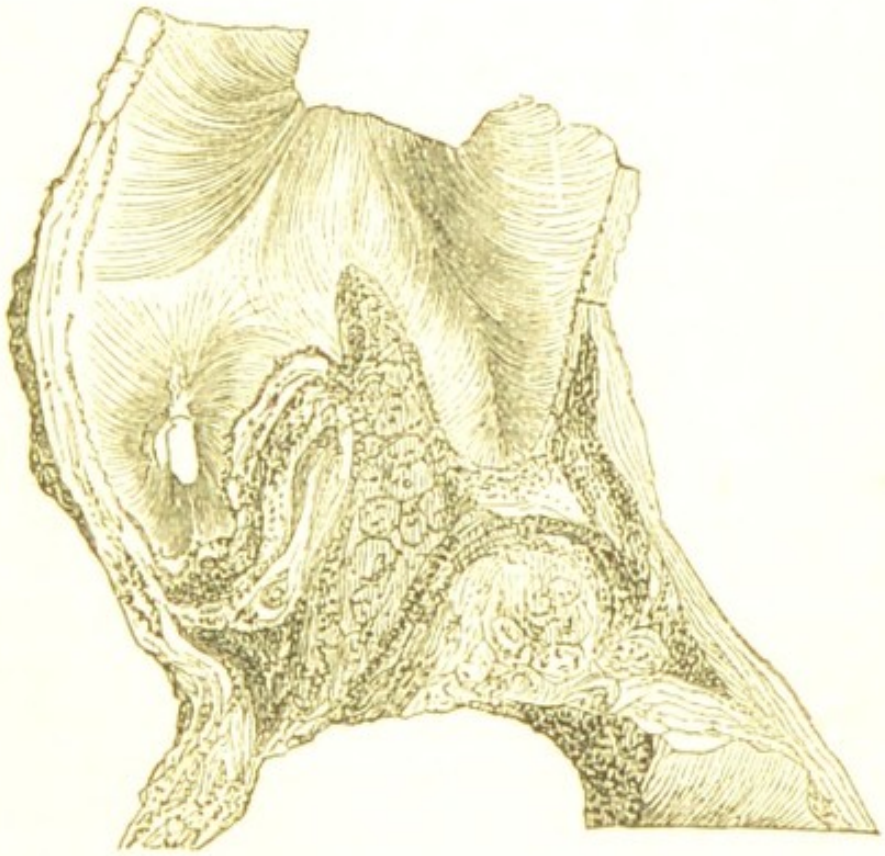
In the specimen at the College of Surgeons the only section which has been made is at a part of the mass nearly corresponding to the line *d d* in the specimen here described; so that its relation with the tooth fang is purely a matter of conjecture: and in the one figured by Heider and Wedl nothing of its relation to the fangs is shown. For this and other reasons (2) the proposed name "hypertrophied 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

(1) Diagram showing portion of the sections made.

(2) See Odontological Society's Transactions, vol. iv., pp. 81 and 103.

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;

Fig. 224. (1)



or it may become absolutely solid, as appears to be the case in the specimen in the museum of the College of Surgeons. The 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

(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.

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. 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 making any external incision, portions of the bone overlying it being removed with a Hay's saw, or by bone-nippers and a gouge.

The removal of the mass will be followed by subsidence of all the symptoms, and the large cavity left in the bone will very speedily contract and fill up, leaving no permanent gap behind.

Tumours containing confused masses of tooth-structure have been met with elsewhere than in the jaws; and although, so far as I am aware, no instance of this has (with the exception of ovarian cysts) been met with in the human subject, it is not impossible that some case may arise, so that the subject deserves passing mention here. In one instance a confused mass of dental tissue was removed from below the ear of a horse; and in another the body of the sphenoid bone was found to be the seat of a tumour containing dentine.

DENTIGEROUS CYSTS.

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 was 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 recognised, it is more than probable that some were lost.

After the lapse of six months, all swelling of the jaw had 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.

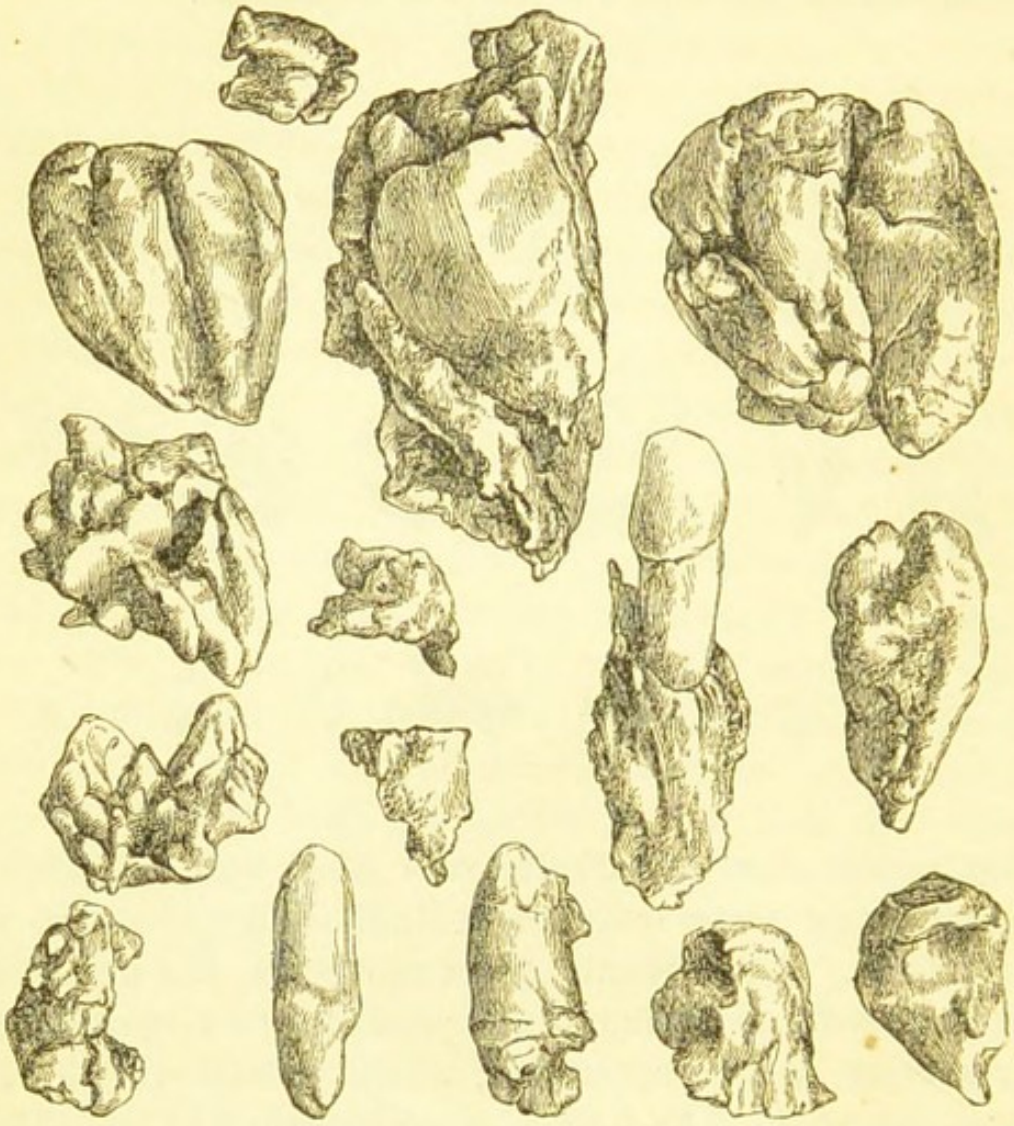
Fig. 225.



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 the next 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 healthy condition, and all deformity disappeared. The teeth absent from the mouth were the central and lateral incisors, the canines occupying their usual position.

Fig. 226. (1)



The masses of tooth substance removed are in the museum of the Odontological Society (spec. 442), and a more full 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

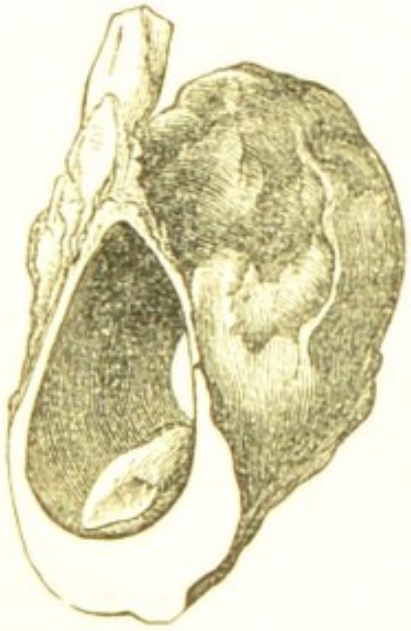
(1) Contents of dentigerous cyst. Mr. Mathias's case.

teeth, but often only one tooth, which commonly belongs to the permanent set, though there are cases recorded of cyst 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 (*cf.* p. 196).

But in a certain number of cases these retained teeth cause 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

Fig. 227. (1)



canine tooth lying horizontally. In this case a 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

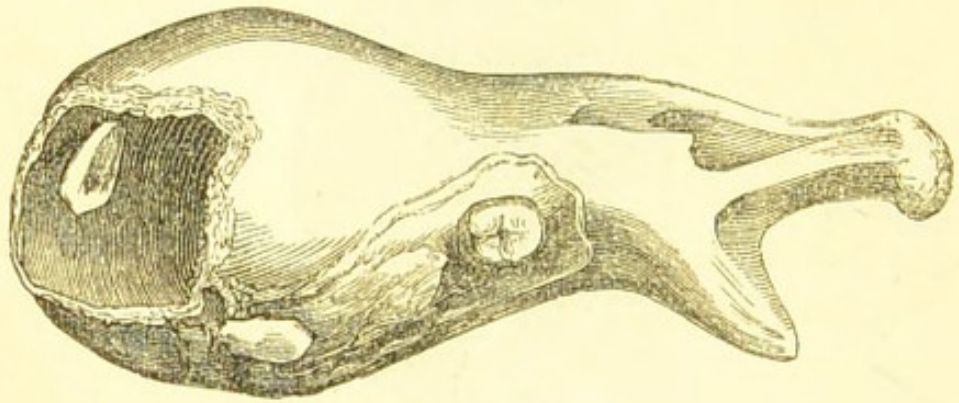
(1) Cyst of the lower jaw, containing a canine tooth. M. Maisonneuve's case.

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. 231; or it may become infiltrated by earthy salts, without definite structural arrangements.

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.

Fig. 228.



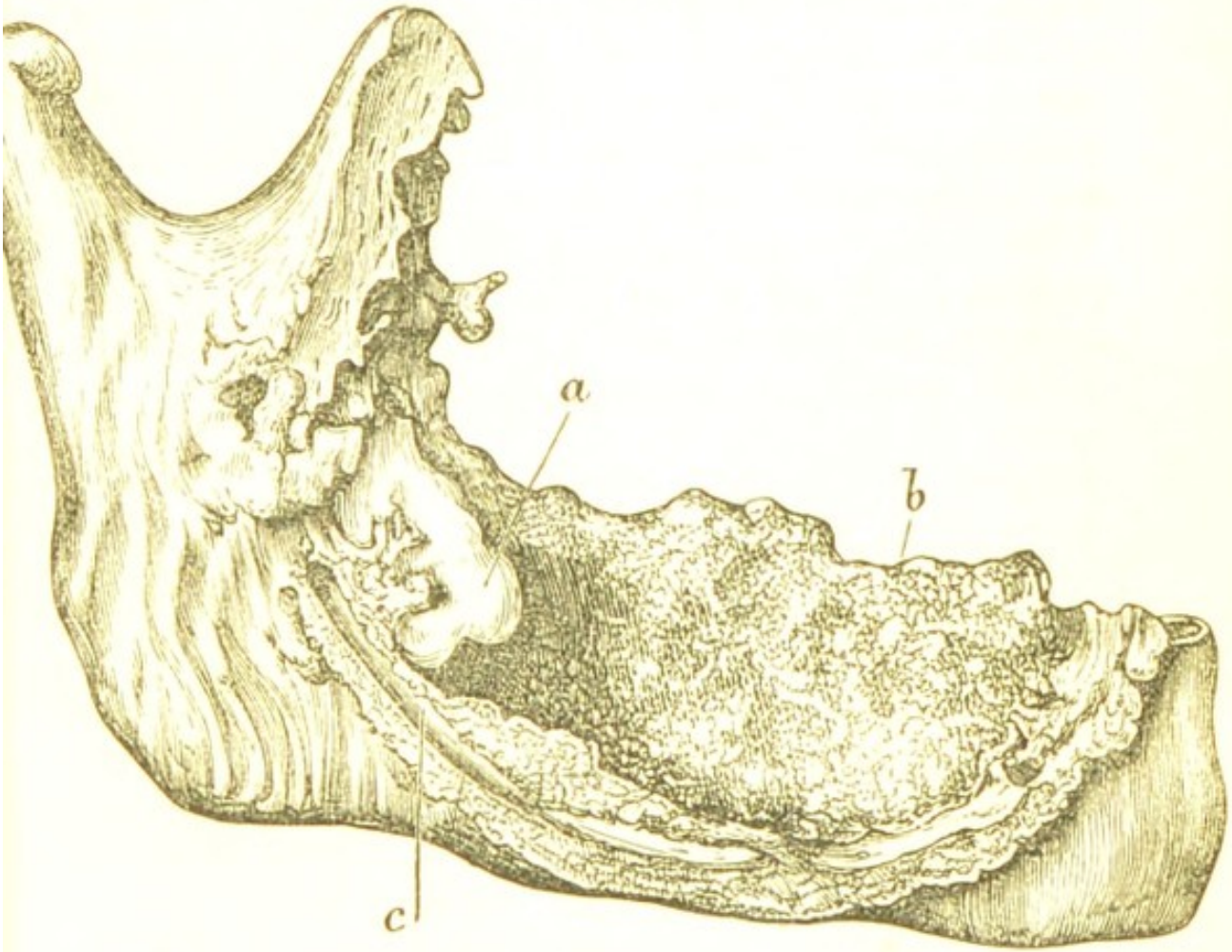
As a general rule, the cyst appears to give rise to a distinctly localised enlargement of the bone; but in some instances, as in the very remarkable case recorded by Mr. Fearn (1), the whole jaw was expanded by a separation of its internal and external plates, extending from the ascending ramus on the one side, to a point beyond the symphysis on

(1) "British Medical Journal," August 27, 1864.

the other. The figure of this jaw here given is borrowed from Mr. Heath's "Diseases and Injuries of the Jaws," where a very comprehensive account of dentigerous cysts is to be found.

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

Fig. 229. (1)



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

(1) 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.

of course, had the true nature of the case been recognised, 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 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. 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 fangs, 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—

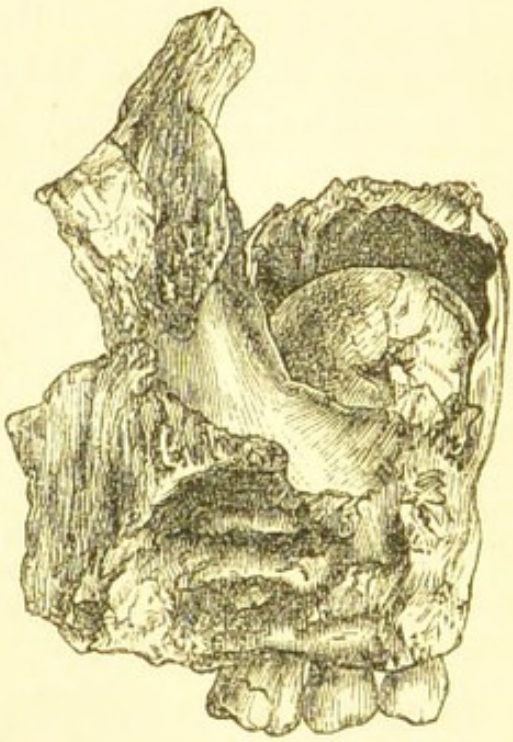
Fig. 230.



"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 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 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.

Fig. 231. (1)



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

(1) Dentigerous cyst which has invaded the antrum, and has subsequently become calcified.

plates of the palatine process of the upper jaw. There is a preparation belonging to Mr. Cartwright, at present 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, being elsewhere free of the walls of the antrum. The cyst contains a supernumerary tooth.

But a yet more remarkable 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. Now, as neither the bone nor the tooth showed any evidence of their tissues being abnormal, and as the presence of a tooth in an unusual position does not of necessity lead to disease around it, the difficulty of giving a rational account of the origin of this and similar cases becomes almost insurmountable, unless we recognise the occurrence of conditions such as those described. But the difficulty of explanation is at once removed if the collection of fluid between the enamel and the tooth-capsule be admitted as a condition that may arise, under some circumstances, in the case of teeth which lie deeply buried in the jaw.

Before, however, any explanation can be accepted as final, further observations are required.

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.

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 fangs 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 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 (1) 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 membrane 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.

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

(1) Transactions of the Odontological Society, 1862.

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 chloroform, 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 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, 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.

DISEASES OF THE ANTRUM.

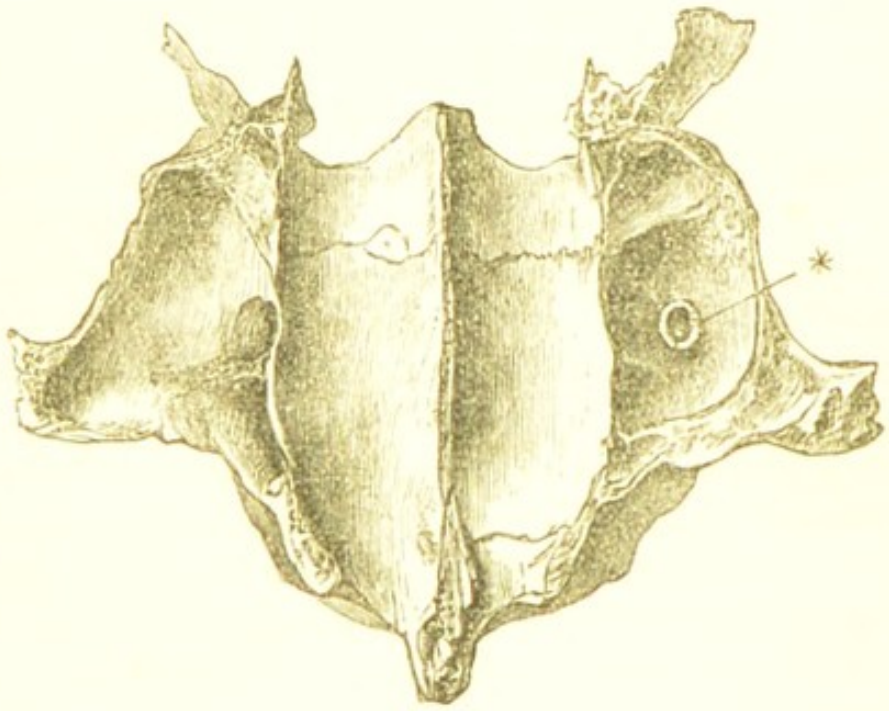
The maxillary sinus is liable to become the site of various new growths, the consideration of which does not fall within the province of this volume: but the malady with which it is most frequently affected being traceable to the influence of diseased teeth, it is indispensable that the dental surgeon 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.

The 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.

Fig. 232. (1)



By the burrowing of an alveolar abscess through the substance of the bone, teeth which do not ordinarily come into very close relation with its floor may cause abscess in the antrum; thus, amongst the out-patients of the Middlesex Hospital I lately saw a case where extraction of a loose and painful central incisor gave exit to a quantity of excèedingly offensive pus; a probe passed through the vacant socket entered the antrum through a canal as large as a goose-quill;

(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.

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.

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.

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.

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, 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, even after the cure of the empyema, and necessitate an operation for its removal.

When there is any doubt, an exploratory puncture should be made; it is not likely to lead to any bad results, and may prevent the surgeon from falling into a very important blunder. For this purpose 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. Of course this can only happen when the cavity is incompletely filled with fluid.

Malignant growths seldom remain long confined to the antrum, but speedily pass out from it into the surrounding parts.

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 very commonly 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 ensues, 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 (*loc. cit.*) 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, enor-

mous 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 Galenzowski, 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 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 carious 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 (O. Weber).

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 which 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; and 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 restore a healthy condition, a stimulating injection composed of a weak solution of chloride or sulphate of zinc, or nitrate of silver, may be used; in obstinate cases tincture of iodine has been advantageously applied.

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 necessary to keep the opening permanently patent.

Dentigerous and other cysts of the antrum have already

been noticed in a former chapter, and need not be again 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.

CLOSURE OF THE JAWS.

It will sometimes happen that the dental surgeon will be consulted in cases of trismus.

By far the most frequent cause of inability to separate the jaws is spasmodic action of the masseter and pterygoid muscles, which is commonly a reflex action due to the irritation set up by diseased teeth. 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. Dr. Gross, of Philadelphia, enumerates 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, &c., 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 asthritis. Or, lastly,

it may be due to the pressure of a tumour, especially one occupying the parotid region.

Gangrene of the cheeks, &c., 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. Where it seems possible to give relief by division of cicatrices within the mouth, every endeavour must be made to restore the natural sulcus between the teeth and the cheek, and to get this covered by mucous membrane. This has been successfully done by the use of silver shields, capping the teeth and passing down outside the alveolar borders, so as to prevent adhesions forming at this point. In the opinion of Mr. Heath (*op. cit.*, p. 349), the formation of mucous membrane may be thus induced, even where no remnant of it had escaped destruction.

Anchylosis of this joint is not of common occurrence; it has been met as a result of injury, and sometimes it appears to be idiopathic.

(1) "Injuries and Diseases of the Jaws," p. 337. Second edition, 1872.

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. In such a case, failing all endeavours to force the mouth open with screw gags, or other such appliances, a false joint may be established by division of the ascending ramus as high up as it can be reached.

MECHANICAL INJURIES OF THE TEETH.

Abrasion.—When, from the loss of teeth, the process of mastication falls upon a reduced number, considerable injury may arise from the wearing down of their crowns, more especially if the antagonism of the upper and lower series be deranged. The crown of a tooth may be cut down, excepting at one side, where a sharp edge of enamel may be left standing, or a lower tooth may strike obliquely upon its antagonist, and gradually cut away its side, even to the extent of perforating the wall of the pulp-cavity.

A sharp and ragged edge of enamel, projecting above the general level of a tooth, should be carefully reduced with a fine file; for, apart from the injury that may be inflicted upon the tongue or the lips, the tooth itself may eventually be injured. Sooner or later the projecting part will be broken off, and very likely carry with it a considerable portion of the tooth. In the front teeth, this accident is very liable to arise if a thin and ragged edge of enamel is allowed to remain.

After the file has been used, the surface should be rendered perfectly smooth by a slip of Arkansas or other suitable stone.

Another form of *abrasion* is that which is occasioned by the action of the tooth-brush on the necks of the teeth, or upon such parts as are but indifferently protected by the enamel or by the gum. The teeth become very gradually indented by highly-polished transverse grooves.

The occurrence of such grooves has been, by many writers,

supposed to be independent of a mechanical cause. They have attributed the loss of substance to erosion, using the term as expressive of a sort of ulceration, much in the same sense as it is employed in "erosive ulceration."

Fig. 233. (1)



But in many cases which have come under my own notice, the grooving could be attributed to the action of the tooth-brush, or to mechanical action in some other form. The more prominent teeth are almost invariably the most deeply cut, or teeth in which the enamel is obviously defective. Again, in a right-handed person the teeth on the left side of the mouth suffer more than those on the right side, and in left-handed people the converse holds good. The groove is always on the labial surface, and on such parts of that surface as are exposed to the action of the brush.

Treatment.—A groove having been produced, we can but direct the patient to avoid those causes which have been instrumental in its production. But in guarding against the extension of the mischief, we must be careful to caution the patient against running into a still greater evil. The use of hard brushes and gritty tooth-powder should be avoided. The teeth must, however, be properly cleaned, otherwise the polished surface of the indentation will be lost, the exposed dentine will be acted upon by the fluid of the mouth, and caries will be established.

(1) An instrument for holding a small piece of Arkansas or other stone used in rendering smooth the surface of teeth which have been filed, or fo rubbing down the surface of a gold plug preparatory to burnishing.

FRACTURE OF THE TEETH.

The teeth, from their exposed position, and from the office they are destined to fulfil, are liable to be broken. The amount of injury will vary from the slight chipping of the edge to the fracture through the pulp-cavity, or through any portion of the root.

When the loss 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 of the blow, but to the sudden closure of the jaws. 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.

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 at once be extracted; and the rule will apply 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 success. Even in the bicuspids of the upper jaw, and more especially in the first bicuspid, the application of a pivot is not always admissible. 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.

As a rule, the roots of the incisors and canines only should, other circumstances concurring, be preserved; and preservation even of these will not in all cases be desirable. If, for

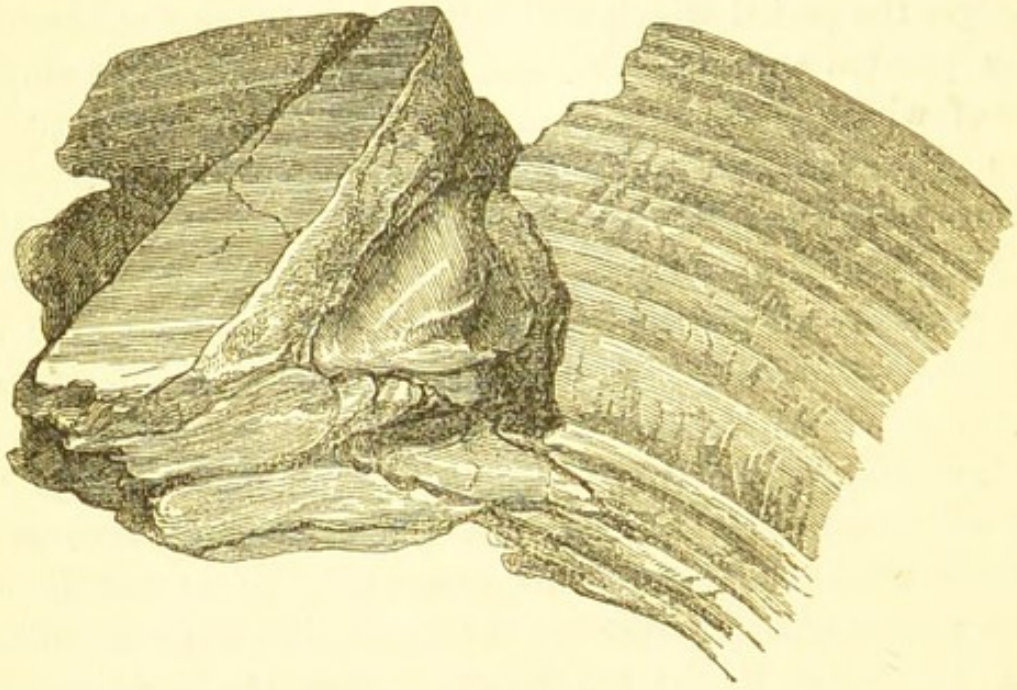
instance, a lateral incisor be broken off at or before the age of thirteen, and the root be immediately removed, the canine will come forward, and in a few years fill up the space; or if the accident occurs at a later period, in a mouth crowded with teeth, a similar result would follow the operation. 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 intevene 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.

The treatment of roots situated at the back part of the mouth, from which the crowns have been broken, must depend upon the indications presented. If a root is free from pain, and firmly fixed in the socket, but little advantage will be gained by its extraction, unless the neighbouring teeth would come together, and fill up the space. Hence the age of the patient and the present state of the jaw with regard to crowding of the teeth must be our guide; but very commonly the tooth is so painful from the nerve being exposed that the patient will urge its removal.

Hitherto fractures extending through the exposed portion of a tooth, or extending through the crown into the root, have been considered; occasionally the injury is situated within the socket. The tooth, after the accident, remains loose and painful; it is eventually removed, and the precise nature of the injury is revealed. Supposing the tooth had become by degrees less painful, and had regained its firmness, the

accident would be forgotten, and the attention might not again be directed to the tooth. The refixing of the loosened tooth would be regarded as a proof that the injury fell short of an actual fracture of any part of the tooth. Such a solution of the question would, no doubt, in the great majority of cases, be strictly correct, but there is good reason for doubting its invariable accuracy. Mr. Saunders has in his collection an incisor which shows the marks of a reunited fracture

Fig. 234. (1)



extending across the root near the junction of its terminal and middle third. A description, with a figure of this tooth, has been published (2). Professor Owen has described and figured an instance of reunited fracture in the tusk of a hippopotamus (3). The preparation in my own collection, from which the preceding illustration is taken, is of great interest,

(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.

(2) "Lecture on Dental Physiology and Surgery."

(3) "Odontography."

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 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 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 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; 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

Fig. 235.



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 469.

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, which should be always watched for after the infliction of a blow (see Necrosis of Teeth), or 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 a canine 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.

For the purposes of practice, the dislocation of teeth may be divided into—partial dislocation, or the mere loosening of teeth; complete dislocation, or the absolute removal of teeth from their sockets; and dislocation accompanied with injury of the alveolar processes.

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 I have recently seen an instance where a patient 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.

There is abundant evidence to show that a tooth thus displaced 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.

But I am not aware that there is any authenticated instance of the pulp retaining its vitality; so that I should be inclined, were such a case to present itself to me, to drill

through the crown down the pulp-cavity, and fill the latter with cotton-wool steeped in strong carbolic acid; this could be withdrawn from time to time, so as to give vent to any discharge which might have accumulated in the alveolus.

With this ample evidence in favour of the opinion that the membranous connection of teeth to their sockets may be renewed even after the teeth have been removed from the mouth, there need be no hesitation on the part of the dental surgeon in returning teeth accidentally dislocated to their sockets, if the teeth themselves are free from injury and the alveoli have escaped material damage. Failure in this mode of treatment may arise, and in patients who are out of health, or in whom the gums are in a morbid condition, success would scarcely be expected; but in healthy subjects the preservative treatment will generally be attended with success.

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.

But at best the union is an imperfect one, and the tooth will be extremely liable 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 fang setting in.

In cases which come under the third division—cases in which the accident is accompanied with a considerable amount of injury to the alveolar processes, any attempt at the restoration of the tooth would prove unsuccessful. The teeth, if retained within the mouth by the adhesion of a small portion of the gum or the periosteum, should be removed, together with any detached pieces of bone which may be found in the soft tissues.

In view of the firm union sometimes obtained after a tooth has been accidentally knocked out, attempts have from time

to time been made at "replantation of teeth." It should have been mentioned in the section relating to alveolar periostitis that experiments have lately been performed by Mr. Coleman, following in the steps of Mitscherlich and others, in which carious teeth were extracted and replaced, after scraping off the thickened and diseased periosteum.

The results, however, are not such as to render it an advisable operation; and Mr. Sercombe has lately 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 fang was found to have almost disappeared. Such seems to be the usual termination of cases of replantation.

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. They are 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 unmistakeable: crepitus, mobility of the fragments, and irregularity of the teeth being the prominent indications.

After a severe fracture very profuse suppuration often ensues, and 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 is 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 necessary.

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, 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 of the upper jaw are uncommon, and displacement is not by any means invariably present. There is

generally little 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.

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 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.

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 operation of pivoting is only generally applicable to the incisors and canines of the upper jaw, the nerve should be extirpated by a nerve-extractor, rather than by the use of an escharotic.

The operation, then, is commenced by removing, by means of the saw, the cutting-forceps, or the file, down to the level of the gum, such portions of the crown of the faulty tooth as may still be standing. The choice of instruments will depend upon the condition of the part to be removed. When the neck of the tooth is strong and sound, the saw may be entered upon each side to within a short distance of the pulp, and the operation of excision be completed with the cutting-forceps. If the latter instrument only were employed, a risk of shaking the root in its socket, or of splintering it within the gum, would be incurred. If, on the other hand, the neck of the tooth has been encroached upon by caries, or the crown has been broken off near the margin of the gum, the cutting-forceps and the file only will be required, or perhaps only the latter instrument.

The exposed surface of the root must now be cut down with a half-round file to the level of the gum, and even a little below its free edge. The next step in the operation will consist in reducing the pulp-cavity to a perfectly cylindrical canal, which should be extended to within a short distance of the extremity of the root. To effect this purpose a five-sided broach may be used, but I have found a half-round drill preferable. The latter cuts freely, produces a very true hole, and at the same time follows the course of the pulp-cavity. Several sizes of such instruments will be required, the smaller for commencing, the larger for completing the perforation. From time to time the depth of the hole must be gauged, otherwise the drill may be carried to too great a depth. I have known the broach passed through the root of a tooth into the alveolus.

The root having been prepared, a new tooth must be selected, corresponding both in shape, size, and colour to the one which has been lost. The choice will lie between a natural and a mineral tooth. If the former be taken, the fang must be removed, and the cut surface of the crown fitted with great accuracy to the exposed surface of the root destined to support it, an operation which can be readily accomplished with a file, the process of fitting being carried on either by using a cast taken of the root and adjoining teeth, or by frequent trials in the mouth. The root having been prepared, and the new crown fitted, the pivot must now be selected. Two substances are used—wood and gold, and the choice between them will depend upon the condition of the root. If the canal is necessarily large, the wood pivot will be preferable; if it be of moderate size, the gold should be selected. This question having been determined, the pivot must be so placed in the crown, that when passed into the canal of the root the new tooth will stand in the required position. To ensure this result the canal in the crown must be made to correspond accurately with that in the root. In order to ascertain the position the pivot should hold in the

crown, a thin layer of softened bee's-wax may be attached to the cut surface of the crown, which should then be pressed into its destined place. By this proceeding the precise spot for the canal will be learned, and the size will be determined by the character of the pivot about to inserted.

But the most convenient method of ascertaining the direction of the canal in the root is to take an impression with a small impression-tray constructed for the purpose; it consists of a tray of such a width as to cover about three teeth, through the centre of which slides a wire: this wire is first pressed up into the drilled canal, and the impression-tray then pressed home; when the wax has sufficiently hardened, the tray and wire are withdrawn together.

If wood be selected, a piece of hickory, filed or cut into a cylindrical form, and passed through a draw-plate, in order to produce compression of its fibres, and to reduce it to a uniform size, will be found to possess sufficient strength and durability. A cylindrical hole, the size of which should correspond with that through which the wood has been passed, must now be drilled in the crown. Within the hole one or two shallow circular grooves may be cut with a fine excavator. The wood pivot is now pressed firmly into the crown, and reduced to a length corresponding to the depth of the canal in the root. We have now to press the wooden pivot fixed in the crown up the canal in the root of the tooth, until the fitted surfaces come in contact, and the operation is completed. The wood, on imbibing moisture, swells and holds the crown very firmly attached to the root, so firmly that, were their detachment attempted, some care would be required, or the root would leave its socket before the pivot was withdrawn either from the crown or the root of the tooth.

Had a gold pivot been employed, the manner of proceeding would have been varied in the following particulars. A screw must have been cut within the canal in the new crown, and a corresponding thread upon the pivot. The two having been

firmly screwed together, the projecting portion of the gold pin should be made slightly rough, and surrounded with a very thin layer of floss silk. In this condition the pin is passed with a firm and steady hand into the canal of the root to which, by the addition of the silk, the pin is accurately adapted.

Had a mineral tooth been selected, the process of fitting would have been conducted with the emery-wheel instead of the file, and the gold pin attached to the crown by means of soft solder. Teeth of this description are also specially made for receiving a wooden pivot, and are fixed in the mouth much in the same manner as a natural tooth.

Although the crown of a tooth can be fixed upon a sound root with sufficient firmness to give to the patient a sense of security, while it answers the purposes of articulation and the restoration of personal appearance, yet it will not be able to withstand constant collision with an antagonistic tooth. A sound front tooth, when submitted to more than its legitimate share of pressure, is usually forced out of position, and a pivoted tooth would necessarily be still more readily displaced. To avoid this obvious source of injury, the newly-added crown must be so arranged that the opposing tooth, on closing the mouth, will press upon it but lightly, or fall short of contact. Ordinarily this result may be secured by grinding away the lingual surface, but in certain cases the teeth of the opposite jaw close in a manner that would necessitate the reduction of the new crown to an extent which would render it unserviceable.

Fig. 236. (1)



Rather than reduce the strength of the crown of the tooth, whether natural or mineral, beyond the proper limits, it will be better to use a flat mineral tooth. The operation will consist in adapting a small gold plate to the surface of the prepared

(1) Shows in profile a flat mineral tooth, mounted upon a gold plate, fitted to the root of a tooth, with the pivot destined to pass into the canal of the root, soldered to the gold plate.

root, in soldering the gold pivot to the plate, and soldering the flat tooth, previously backed with gold, to the outer margin of the plate. When this method of operating is adopted, the tooth may be placed quite out of the way of its antagonist, which, if necessary, may be allowed to close upon the exposed surface of the gold plate which lies over the lingual portion of the root.

Several modifications of the foregoing manner of fixing pivoted teeth are practised. Some practitioners screw into the root a gold tube, into which the pivoted crown is fitted by means of a split pin ; this method has the advantage of the pivoted tooth, being readily removable, whilst it is rendered sufficiently secure by the elasticity of the split pin. Some American dentists, instead of screwing such a tube into its place, merely fit it in, and fix it by making an adhesive gold filling round its lower end, having previously drilled a cavity of suitable shape in the root. This adhesive-foil filling may be extended from around the tube over the whole exposed surface of the root, so as to protect it against further decay.

Some practitioners, when using a gold pin, coat this thinly with hickory : the wire has a screw thread cut upon it, and is screwed into a piece of hickory, which is subsequently trimmed down to the proper size.

Yet another method is to fill the canal in the root with a wooden plug ; drill a small hole in the plug, and then force in a pointed pivot-wire carrying the tooth ; but this manner of procedure is not so generally available as the others.

The operation of pivoting, when undertaken under favourable circumstances, and carefully performed, produces a very satisfactory result. Unfortunately, however, we are not always in a position to form a just appreciation of the attendant circumstances. In the majority of cases the patient suffers no further inconvenience than that which attends the operation ; but instances occasionally arise in which inflammation is set up in the alveolus, the gum becomes enlarged, and the face swells. Great pain, at first

limited to the alveolus of the pivoted tooth, afterwards diffused over the neighbouring parts, attends the progress of the disease, and severe constitutional symptoms are not always wanting. Eventually, suppuration is established within the socket of the pivoted tooth, and the pus finds its way to the surface; but the disease sometimes assumes a more active character, and spreads over a larger surface than an ordinary alveolar abscess. In one case tetanus and death followed the operation of pivoting (see p. 591).

In another case an epulis was developed with considerable rapidity in consequence of the irritation set up by pivoted teeth.

With a view to avoiding these consequences, it is always preferable to tightly fill the canal with mastic and wool, and wait for a few days to see what will be the result of absolutely closing up the canal. Where the nerve has been extirpated by an instrument, it is unusual to get any irritation; but where the nerve has died spontaneously, it is by no means unusual for an alveolar abscess to be threatened.

As the pivot-wire does not reach up to the apex of the fang, and it is, of course, undesirable to leave any vacant space above it, it is better to fill the apex of the fang with gold where the nerve has been lately extirpated, or with cotton-wool and carbolic acid where it has died spontaneously. In every instance care must be taken not to form a piston in the pulp-canal by which air or fluids might be forced out through the apical foramen.

The possibility that unfavourable symptoms may arise, renders it necessary that the patient should be requested to return, should the pivoted tooth become painful. If it is found that the alveolar periosteum is becoming inflamed, one or two leeches should be applied to the gum, and the new crown removed, if the pivot can be readily withdrawn. But if the disease has advanced to suppuration, it will be well at once to remove the root before the sockets of the neighbouring teeth become involved. Generally, however, the inflam-

mation, if taken at the onset, may be controlled, and the tooth saved by local bleeding and the administration of an aperient.

Should there be reason to suppose that unfavourable symptoms may arise, it will be advisable to fix the pivot in a manner that will admit of its ready withdrawal, and refix it when all chance of mischief has passed away.

THE OPERATION OF EXTRACTION.

In a previous work (1) the comparative merits of the key instrument and of the forceps were fully discussed, but the universal adoption of forceps since that time has rendered it quite superfluous to again enter upon the question.

I have no reason to change the opinions then expressed in respect to the construction and the manner of using these instruments, neither have I any great additions to make to my former description. Under these circumstances, the following description, with the accompanying illustrations, must in the main correspond with that devoted to the same subject in my Lectures.

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

(1) "Lectures on Dental Physiology and Surgery." 1848.

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 they are 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 above the terminal edge 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. I am inclined to think that the tendency is to use forceps with handles both longer and larger that 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 preferable 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 intended for removing the back teeth.

But, the less complex the various curves made by the instrument are, the more easy will it be to direct the force applied to the tooth with precision.

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. By the use of forceps so adapted to the forms of the necks of teeth, they may be removed in the least possible time, and with the least possible pain to the patient; moreover, no further injury to the gums and alveolar processes need be inflicted than must necessarily result from the forcible separation of a tooth from its attachments. 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 fangs 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. For removing teeth which are not decayed down to the gums, the ends of the jaws should be slightly rounded; but when the root only remains of a tooth, rounded ends are the more convenient, as that shape is more readily introduced between the fang and the inclosing alveolus. 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 fang 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 fangs 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. 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 the last (tenth) edition of Harris's "Principles and Practice of Dentistry" (by Professor Austen, 1871), it is said "the use of the gum-lancet should generally precede the application of either the forceps or the key," and its use is strongly advocated in the succeeding sentences. 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 different-shaped teeth require forceps shaped to them. It will be necessary, therefore, to describe partially the teeth, and then the forceps individually, in order that the peculiar shape of each instrument may be understood. Before doing so, however, I should state that 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 fangs, 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.

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. 237. (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 they are very small indeed; at other times they are almost as large as the central incisors. It will be advantageous, therefore, to have different sizes of instruments from which to select.

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 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 maxilla. When the tooth is grasped

(1) Forceps adapted for the removal of the incisor teeth of the upper jaw.

it must be forced outwards, the movement accompanied with the slightest possible degree of rotation, and, when it is felt to yield, draw it upwards and outwards.

Fig. 238. (1)



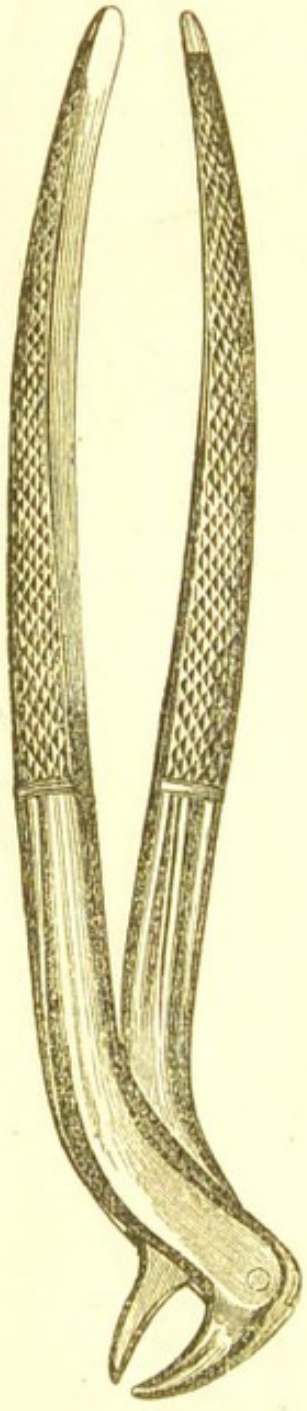
The cuspidati of the upper and lower jaws require for each a pair of forceps made upon the same plan as those for the removal of the incisors, except that they must be larger and rather stronger. Those for the cuspidati of the lower maxilla should, like forceps for the incisors of the lower jaw, have 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, whether in the upper or the lower jaw, may be detached from their membranous connection with the jaw by a rotatory movement, and will then leave the socket readily.

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.

(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.

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 fangs laterally compressed, and are placed in an unbroken line with other teeth of like-shaped fangs, the only available movement will be at right angles with the line of the alveoli, and in the direction of the greatest diameter of the fangs. This motion may be obtained whether the forceps employed be straight or rectangular, like Fig. 247 ; but with an instrument of the latter shape the movement must be effected by rotation of the wrist, with a motion upwards. The centre of the rotatory movement will be either at the extremity of the jaws of the instrument, or else in a line with the handles of the instrument and wrist. Force applied in this manner would seem to be given at great disadvantage, and much expended on the alveolus ; there inflicting injury, which, although in the vast majority of cases it may not be complained of by the patient, prevents the mouth from so speedily recovering from the operation.

Fig. 239. (1)



(1) 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 first applied in a direction outwards and at an angle to the dental arch. The tooth should be moved outwards and inwards, and then drawn downwards. 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 not to draw it out; and that if the force be continued in this direction with the hope of removing the tooth, that it will probably be broken off.

The bicuspids of the lower jaw have more conical fangs 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.—The molars of the superior maxilla have three fangs—two external, one internal. Of the two external fangs the anterior is the largest, and is placed in a plane slightly external to the posterior fang, which is both shorter and smaller. The third, the internal fang, is thicker and of greater length than either of the others, and is situated opposite to the posterior external fang, and the space between that and the anterior external fang. The divergence of the fangs 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 fangs, 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 fang. 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 difficulty of using it. The handles should have a general curve in the opposite direction to the jaws.

The molars of the superior maxilla have the two external fangs parallel to each other in their direction in the alveoli. The internal, which is not only the largest, but the longest also, diverges from the two preceding fangs, 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.

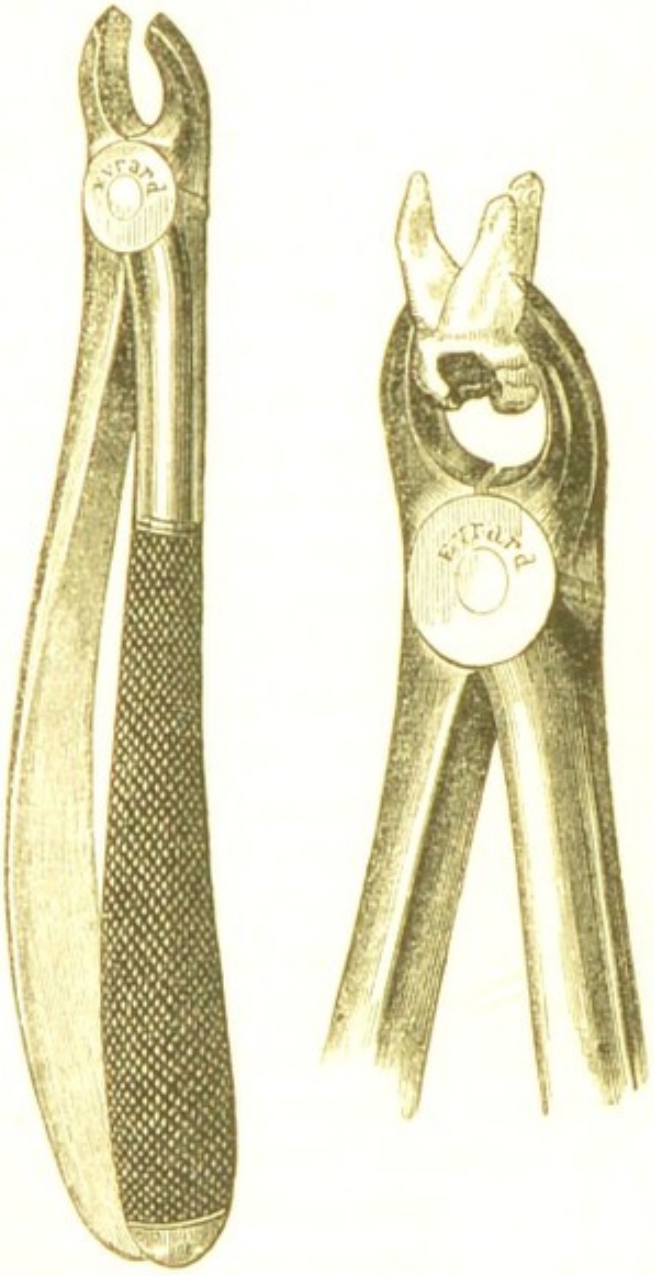
In removing these teeth, then, the tooth being firmly grasped at its neck, the first motion should be very slightly inwards, to disengage the fangs from the external alveoli. The force should then be directed downwards and outwards in the direction of the internal fang. If these precautions be observed, 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 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.

In the third molars, or dentes sapientiæ, of the upper jaw, though the fangs 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 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

Figs. 240 *and* 241. (1)



(1) Forceps for removing the superior molar on the right side of the mouth. In the second figure the instrument is shown embracing a tooth.

upper wisdom teeth is made with two nearly rectangular curves, like those of the plugging instrument represented in Fig. 149: 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 purpose, perhaps, but the obliquities of position and conformation render it quite impossible to adapt the jaws of one 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. 242, but with the handles curved to fit the hand; but in

Fig. 242. (1)



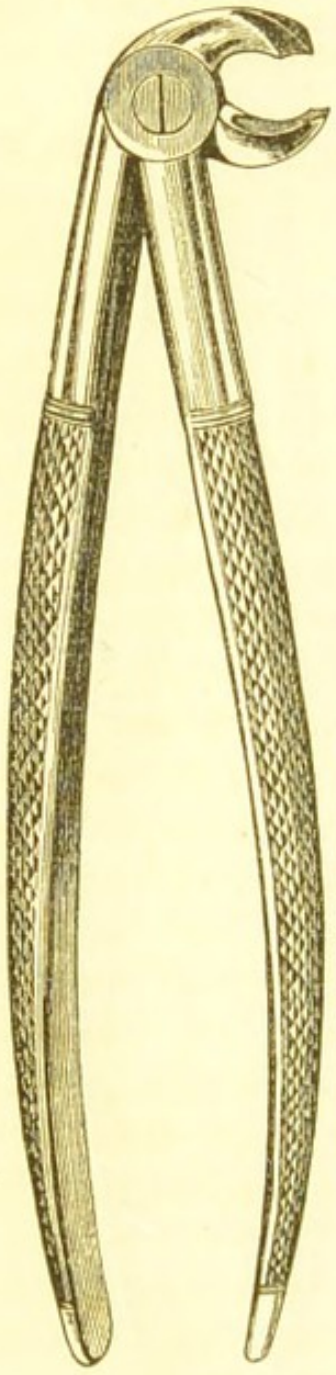
Fig. 243. (2)



(1) Forceps for the removal of molar teeth of the lower jaw.
(2) Forceps, the jaws of which are placed at a right angle.

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. 243).

Fig. 244. (1)



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. 242 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 it 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. 244), 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.

(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.

The old adage, that the best workmen are known by the fewness of their tools, if true in former years, falls short of the truth in modern times. The best work is produced by those who have at their disposal the most perfect mechanical appliances; and it is so in the practice of general and special surgery. Those who have the best-made and the most perfectly adapted instruments, will, other circumstances being equal, operate with the greatest success.

A deviation from the normal form is exceptional in any member of the dental series, excepting 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 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 fangs 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.

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 the instrument with the jaws bent downwards at a right angle be selected, the dentist in removing the tooth from the right side of the 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 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. If the tooth be upon the right side, and hawksbill forceps (Fig. 243) be selected, the operator will stand behind the patient, his left arm passing round the head, and the thumb and fingers being applied as before. In

operating upon patients when under the influence 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-fanged 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-fanged 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 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. 245. (1)



Fig. 246. (2)

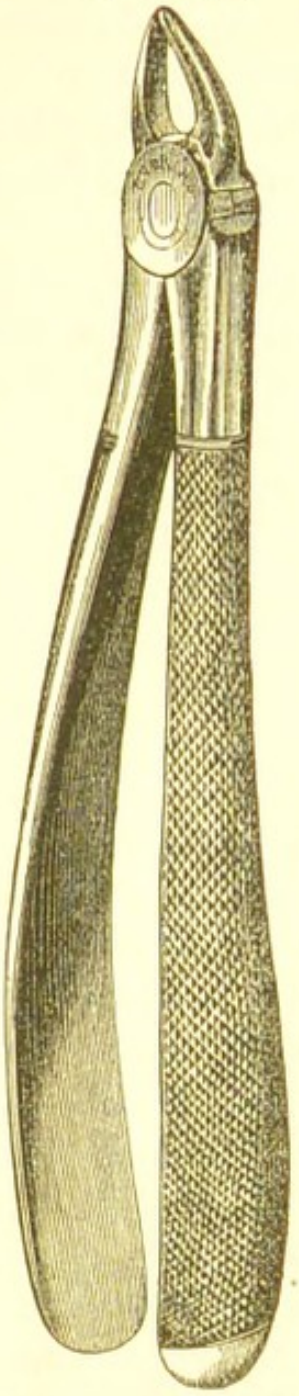
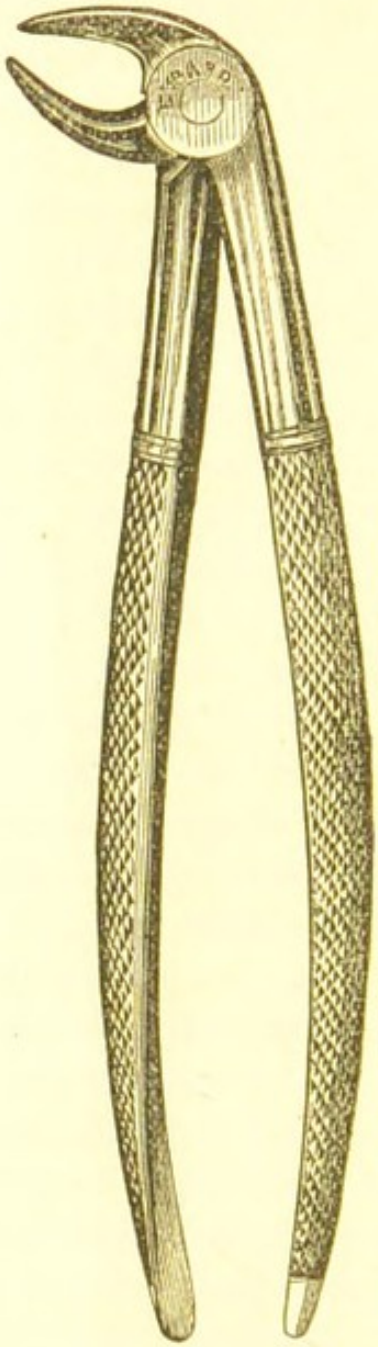


Fig. 247. (3)



(1) Forceps for removing the roots of single-fanged teeth situated in the front part of the upper jaw.

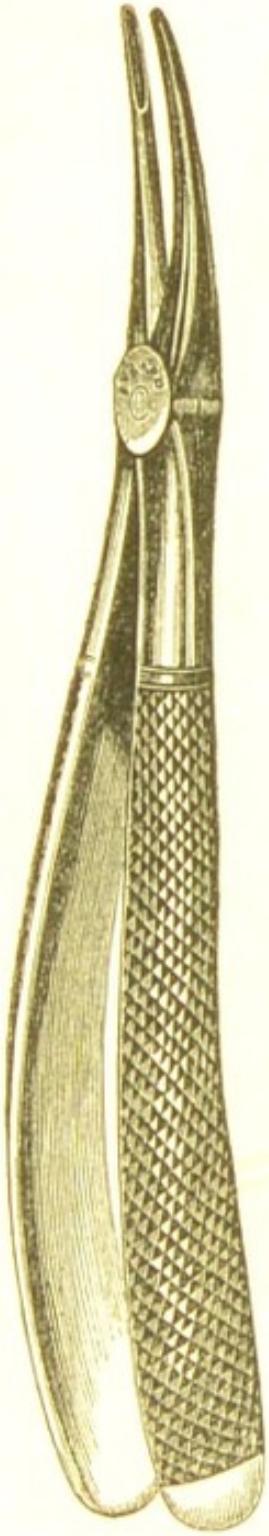
(2) Forceps for removing the detached roots of the upper molar or bicuspid teeth. The jaws of the instrument are slightly curved upwards, and the handles in an opposite direction, in order to enable the operator to reach the back part of the mouth.

(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. 244.

Fig. 248. (1)



Fig. 249. (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 (compare Fig. 149), are very valuable for removing upper stumps.

application to stumps situated in different parts of the mouth. Of these varieties the succeeding illustrations will afford examples.

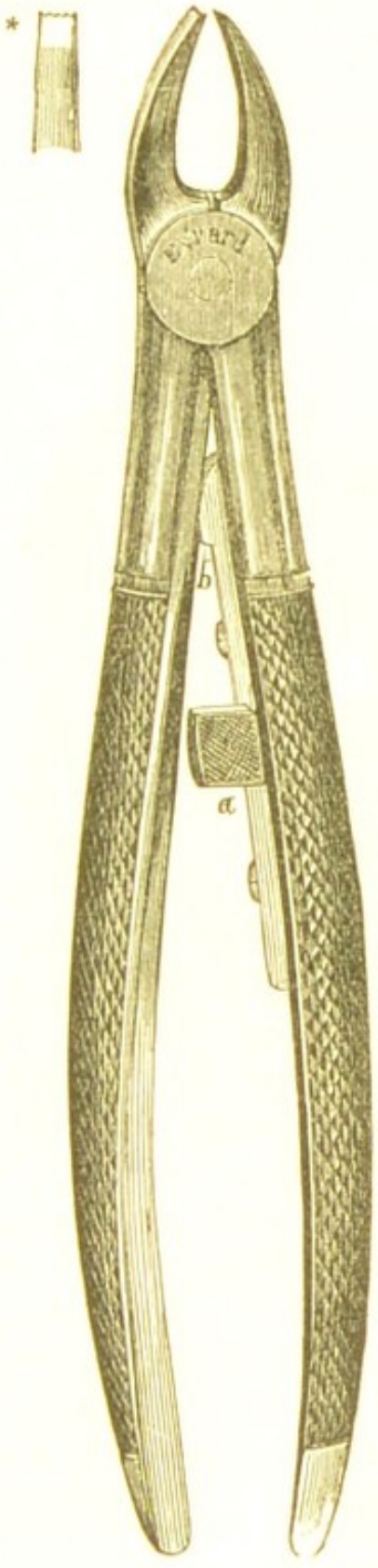
The edges of the blades having been rendered moderately sharp, they should be closed lightly upon the stump, and then forced between it and the edge of the alveolus. In many cases simple pressure will carry the instrument to a sufficient depth, but in others a slight amount of rotation will be found 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 has devised an instrument, shown in the accompanying illustration.

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 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 more readily removed by a more

Fig. 250. (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 grooved surface of the wedge, which rests against a similarly grooved surface on the handle of the instrument.

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,

Fig. 252. (1)

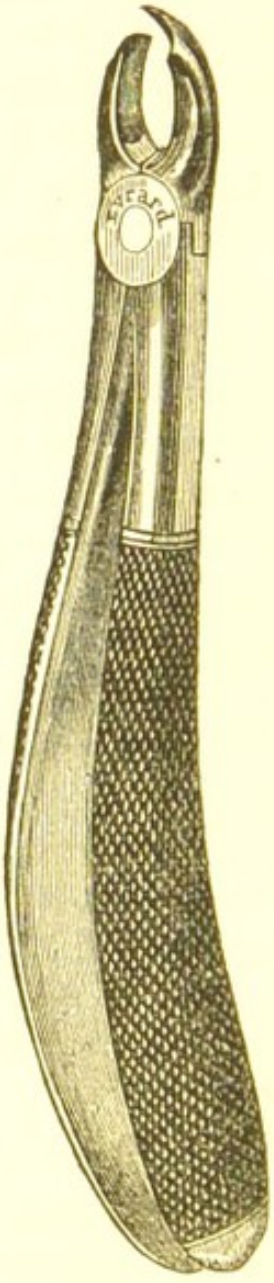
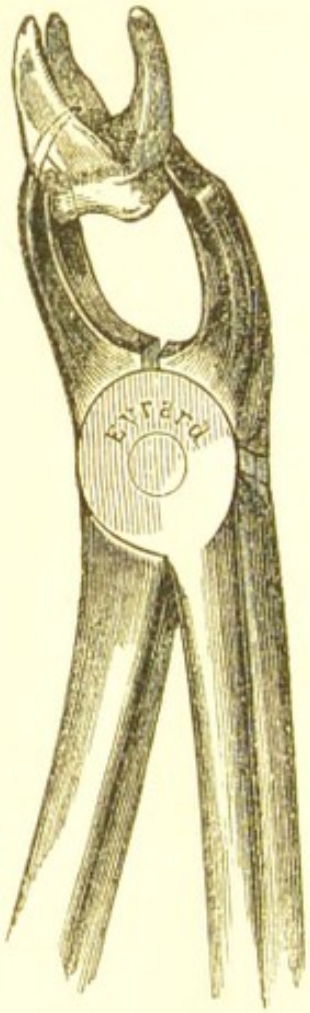


Fig. 251. (1)

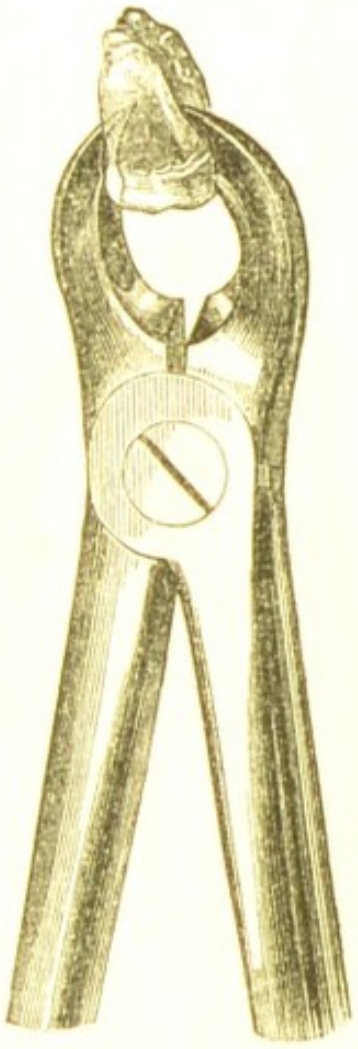


(1) Forceps for removing upper molar teeth, the crowns of which have been broken off, while the connection between the three roots has been preserved. The peculiarity of the instrument consists in the production of a tapered prolongation of the outer jaw, capable of passing between the labial roots of the tooth. In the first figure the jaws are shown embracing a crownless tooth, in the second the instrument only is shown.

the gum may be torn, and the patient will be subjected to unnecessary pain.

It is in the extraction of connected roots of the first molar teeth that forceps constructed upon the foregoing principle are more especially useful. In the upper wisdom teeth the position and number of the roots cannot be ascertained. They are frequently connate, and may be treated as simple roots. Even the second molars sometimes depart from the usual form; if, therefore, any difficulty is experienced in introducing the labial blade of the forceps, its use had better be abandoned in favour of a more simple instrument. 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. 245 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. 256) 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

Fig. 253. (1)



(1) 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.

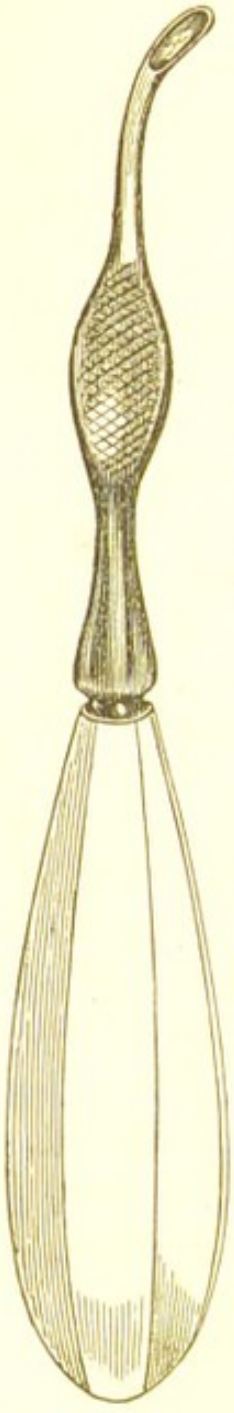
Mr. Harding, in which the external blade is replaced by a vertical cutting edge.

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.

Fig. 254. (1)



Fig. 255. (2)



The most generally useful instrument for extracting the roots of teeth has yet to be mentioned. There is scarely a root, or even a tooth, which

(1) Shows an elevator of the most simple description, with the blade hinged to shut into the handle.

(2) A curved elevator, proposed by Mr. Thompson.

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. Figs. 254–5–6 show three of the more useful forms of the instrument, the two straight, the other a curved elevator. 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 rotatory 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. 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 fangs, 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.

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. 256.



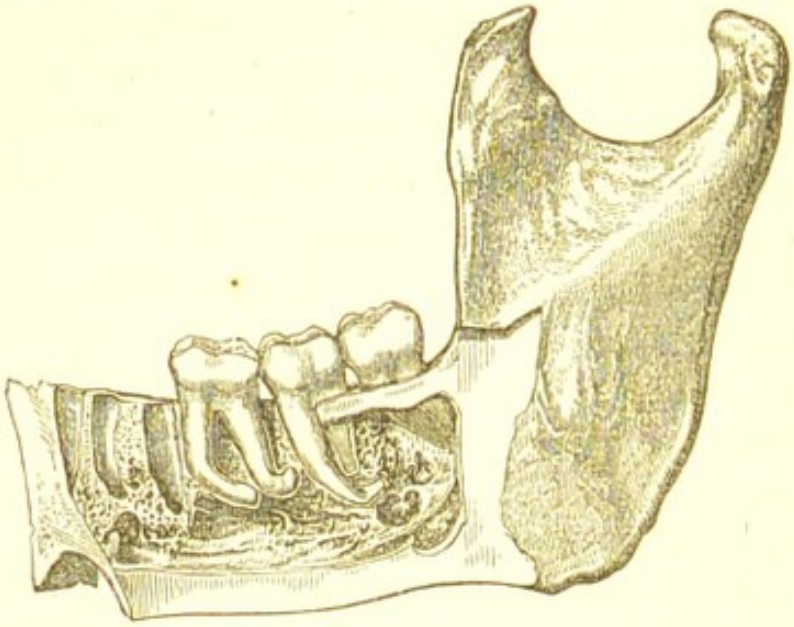
The spear-pointed elevator represented in the accompanying figure is by far the most generally useful form, and is quite large enough for any purpose. Sometimes, however, owing to the inability of the patient to open the mouth widely, it may be difficult or impossible to reach a lower wisdom tooth with 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.

In treating of the extraction of teeth, it has hitherto been assumed that the operator will encounter no unusual obstacle, and the difficulties which sometimes arise in the progress of the operation have been reserved for separate consideration.

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. 257).

Fig. 257. (1)



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 should it have been connected with an alveolar abscess, its

(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.

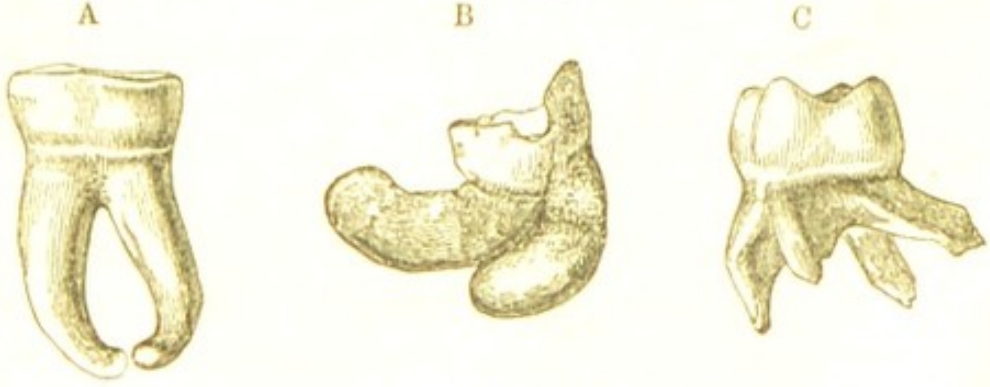
removal will not be attended with difficulty. The digging out—if the expression be allowed—of the terminal third of a sound and firmly-attached root is productive of great pain and a considerable amount of injury to the alveolus: but the presence of the root, if undisturbed, is very rarely indeed followed by any inconvenience.

In the example figured (Fig. 257), 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.

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

Fig. 258. (1)



shown; the tooth with the convergent, and that with the four

(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.

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 occurrence 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. 259. (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 unusual difficulty, and the operator is still further embarrassed when the crown of the tooth so circumstanced is broken off on a

(1) Shows a first bicuspid of the upper jaw, with three distinct roots.

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, Mr. Cattlin pro-

Fig. 260.



poses to cut away with a small trephine a portion of the outer plate of the alveolus. The root when thus exposed is readily dislodged by an elevator.

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 the 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 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

(1) "British Journal of Dental Science," vol. xiv., p. 160.

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 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

Fig. 261.



(1) Transactions of the Odontological Society, new series, vol. iii., p. 138.

alveolar periosteum have been for some time inflamed, but I do not know that any precautionary measures can be adopted.

Temporary teeth are, as is also 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.

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.

A remarkable case has been recorded by Tierlink, in which dilatation of the pupil and impaired vision followed upon the

extraction of a bicuspid tooth; these symptoms disappeared on extract of opium being placed in the vacated socket. A very common sequela of tooth extraction is exfoliation of the edges of the alveolar process; this is always liable to happen where there has been much suppuration preceding the extraction of the tooth, and it is particularly liable to happen where unusual force or protracted attempts have been made use of to dislodge the tooth. Hence it is very common after the removal of impacted wisdom teeth, and it can in no way be attributed to want of skill on the part of the operator.

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 it 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 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 examinining 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 done. 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 tight to prevent the mouth from being opened. The use of escharotics in the treatment of hæmorrhage is attended with this great 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.

If the use of some other hæmostatic is required, I should give the preference to persulphate of iron, and at the same time administer large doses of gallic acid with sulphuric acid internally. Or purgative doses of sulphate of soda may be given, to be followed by large doses of T. ferri perchloridi; the pil. plumbi cum opio is likewise valuable in checking hæmorrhage.

In more obstinate cases it may be necessary to have recourse to a mechanical apparatus for producing pressure.

Dr. Roberts and Dr. Reid of Edinburgh have each described instruments for effecting compression. The pressure is obtained by a movable bar suitably bent, supported upon a frame which is fixed to the lower jaw, or to the head, just as the seat of hæmorrhage may be, in the upper or lower jaw. By these mechanical appliances the pressure may be graduated and maintained without taxing the efforts of the patient.

In the absence of such an apparatus, a plate in metal might, in the course of an hour or two, be struck to fit the surface of the gum, or a piece of shellac moulded to the required form. The plate should, of course, extend beyond the bleeding surface, and fit closely to the mucous membrane, upon which it must be firmly pressed by means of pledgets of lint retained in position by pressure.

In one of the fatal cases recorded, it is noticed that the oozing took place from the whole surface, but this may, probably, have resulted from the use of escharotics. In this case the carotid was eventually tied, without success in arresting the hæmorrhage.

Whenever the patient has previously suffered from excessive hæmorrhage, consequent on the extraction of a tooth, until all bleeding have entirely ceased, the case should not be lost sight of; and I often adopt the precaution of placing matico plugs in the sockets without waiting for the necessity to arise: giving the patient directions to have them removed on the second day. I have not found this plan to sensibly retard the healing of the gums.

ANÆSTHESIA.

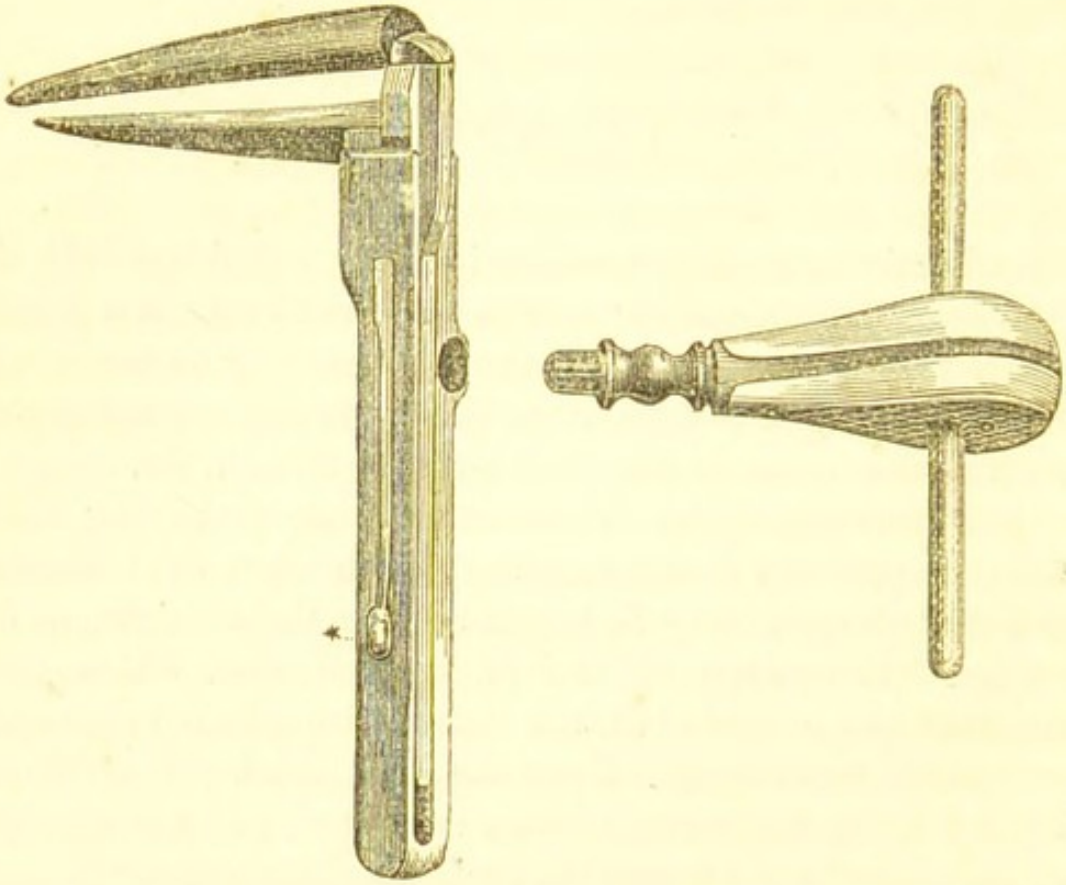
The administration of anæsthetics does not fall within the province of the dental surgeon as such, and hence is a subject beyond the scope of the present volume. There are, nevertheless, some few points with which he is directly concerned, such as the means of propping open the mouth, &c.

For operations under chloroform, the accompanying useful form of speculum for opening the mouth when the lower jaw is forcibly closed, 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 the spring catch. The construction of the instrument will be readily seen on referring to the figure (Fig. 262).

The advantages attendant upon the use of nitrous oxide are, however, so great, that the use of chloroform for any but the most severe and protracted cases has been all but abandoned. As the duration of the anæsthesia is so short, it is necessary to prop the mouth widely open before commencing the inhalation.

For ordinary cases the spring gags, manufactured in vulcanite, answer the purpose admirably, but sometimes it is

Fig. 262. (1)



difficult or impossible to find a place in the mouth in which they will rest securely, and yet be out of the operator's way.

The very 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, for-

(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.

tunately, 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 it must not be forgotten that fatal results have, in several cases, ensued from the passage of foreign bodies into the larynx or trachea, during the administration of nitrous oxide. A tooth stump may pass through the larynx into the trachea, and even down into the bronchi, and be afterwards coughed up without any ill result ensuing; but this is an exceptionally fortunate accident, and fatal mischief may be set up by this same cause. Death has also occurred from the gag, or portions of it, finding their way 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.

The subject of general anæsthesia, as induced by the inhalation of the vapour of chloroform, or of ether, or of nitrous oxide gas, does not call for lengthy discussion in these pages, inasmuch as, since a patient under the influence of any anæs-

thetic agent demands the undivided care and undistracted attention of the administrator, the operator should never administer such agent single-handed; so that the exhibition of anæsthetics forms no part of the duties of the practitioner in his capacity of dental surgeon. The agents capable of producing anæsthetic effects have taken their place among the many substances used by the surgeon; and in the works devoted to materia medica and therapeutics their respective merits are fully discussed. Nevertheless, it may not be out of place to say a few words with reference to the last-mentioned anæsthetic, nitrous oxide, which, on account of its great safety, has, in dental operations, almost entirely superseded chloroform.

In order to secure the best results, the patient must be instructed to breathe deeply and regularly, and especially to breathe *out* thoroughly; and the most absolute quiet must be maintained both during the inhalation and during the period of recovery.

Both operator and administrator should keep out of sight, so as to avoid any disturbance of the patient's mind during the period of semi-consciousness. The gas may be most conveniently administered from the wrought-iron bottles into which it has been compressed, a Cattlin's bag intervening between the gas-bottle and the face-piece. The modification of the face-piece of Mr. Clover's chloroform apparatus, which is in general use for the administration of nitrous oxide, is, upon the whole, the most generally available form which has been introduced.

A liberal supply of gas should be kept up, and it is advantageous to have the pressure in the bag always considerably in excess of the atmospheric pressure, as this will diminish the risk of the admission of air in consequence of the face-piece not being everywhere perfectly adapted to the skin.

The spring gags, at one time so much in vogue, are exceedingly convenient; but, since an accident has happened from the fracture of one, it is, I think, preferable to use gags made

in one piece, which are far less likely to break; if they are carefully adjusted, there is very little chance of their slipping out of place and allowing the mouth to close.

When several teeth are to be removed at a single inhalation, the operator should commence with those farthest back in the mouth, and with lower before upper teeth, as by so doing the view of the teeth to be removed is less obstructed by the bleeding from the socket of those already extracted.

The passage of an electric current through a tooth about to be extracted, has been proposed as a means of producing local anæsthesia. Many practitioners engaged in experiments with the view of determining the value of the agent, but the results hitherto recorded have not been sufficiently uniform to warrant the conclusion that the electric current has been found generally available for producing local anæsthesia in dental operations. The electric current may, like the process of congelation, prove serviceable in exceptional cases only; and as it has been found that the advantages which may result from the use of the one or the other must, in each instance, be determined by experiment, the great inconvenience attending the application of a cold sufficiently intense to produce congelation, and the increased pain which is frequently produced by the electric current, have, after the novelty of the methods had passed away, induced the dental surgeon to abandon their use.

APPENDIX.

THE PATHOLOGY AND ETIOLOGY OF DENTAL CARIES.

THE literature of this subject is now so profuse, and the opinions advocated are so diverse, that it has seemed inadvisable to burden the text with a summary of them; whilst, at the same time, so much of the dental surgeon's time is occupied in combating caries and its effects, that a manual of dental surgery which passed over this branch of the subject in silence would be manifestly incomplete.

The actual appearances observed have been already described (p. 294, *et seq.*), and it will suffice to allude to certain additional characters in connection with the theories which they influence. 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 action.

Those which regard it as wholly and entirely the effect of 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, Fox, T. Bell, and others held this opinion, and it has of late years been revived by Neumann and Hertz.

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 (see page 298) 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, even putting aside the apparent impossibility of these changes going on in such a tissue as dentine, this theory has so much evidence against it, and so little in its favour, that it need not detain us longer.

Hertz ("Virchow's Archiv.," Bd. xli.), however, 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.

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. 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 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. 296), which seems to be due to 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. Chirurg.," 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.

In the first edition of this book, the opinion that the thickened

sheaths were to be regarded as the restored outlines of formative cells was expressed, and it was said that there was a difficulty in explaining the appearance on the supposition that a solvent fluid had gained access through the canals, and penetrated to a varying depth around them (p. 297). But now that the resistant nature of Neumann's dentinal sheaths is known, this difficulty—which lay in the fact that the immediate surroundings of the tubes were the last to disappear as caries progressed to the disintegration of the tissue —no longer exists. Some such explanation as the following may very possibly be the true one: a solvent fluid, gaining access to the tubes, effects the decalcification, complete or partial, of the matrix immediately round the tube; as the refractive index of the dentinal sheaths differs little, if at all, from that of the surrounding decalcified matrix, they are not visible on transverse section; but, on account of the great power of resistance, they ultimately become isolated by the wasting away of the matrix around them. And, although, so far as I am aware, no one has been successful in precisely imitating the microscopic characters of dental caries by the action of dilute acids out of the mouth, this is hardly to be wondered at when we recollect the complexity of the conditions to which a tooth is exposed in the mouth.

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.

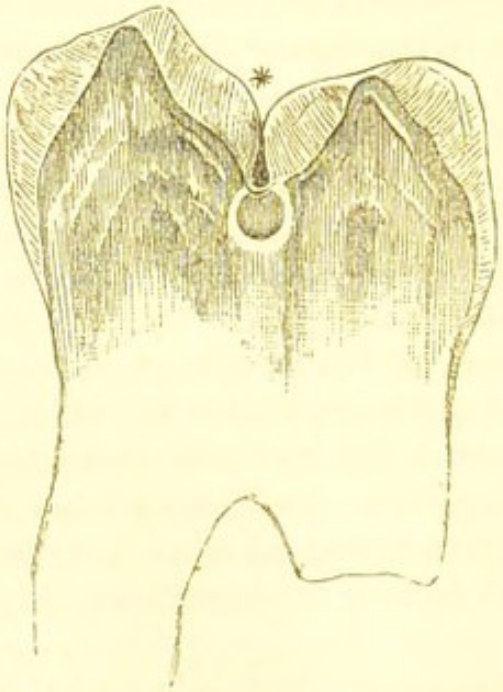
Seeing that the character of caries, in its destructive processes, at least, have been repeatedly met with in human teeth worn as artificial substitutes, and also in hippopotamus ivory placed under similar circumstances, it must be admitted that there is an over-

whelming body of evidence to show 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.

Zone of Transparency.—It has been mentioned in the body of this work that a halo-like zone of translucent dentine is very generally seen surrounding commencing caries, as is shown in the accompanying figure.

Fig. 263. (1)



(1) Shows a transparent zone of dentine, removed a short distance from and surrounding that which is undergoing decomposition consequent upon caries.

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 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 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 translucency was due to the exclusion of air from the tubes by the calcification of the fibrils; and inasmuch as the matter is still one of uncertainty, those passages have been allowed to remain in the text with but slight modification, although a good deal may be said on the other side of the question.

In favour of the view that the dentinal fibrils become calcified, several arguments may be adduced; one is its *primâ facie* probability—we know (*cf.* p. 273) 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 shown by

actual chemical analysis to be far 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 pigmented 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 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 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 be absolute proof of vital action; for, as has already been mentioned (p. 281), albumen out of the body is able to form combinations with calcareous salts which have a definite structure. From the preceding observations it will appear that, inasmuch as no characteristic appearances can be found to distinguish caries, as occurring in living, from that attacking dead teeth, it seems that the hypothesis of vital action in any way modifying the disease must be abandoned *in toto*, and dental caries cannot, strictly speaking, be said to have any "pathology;" so that we may at once pass to the consideration of its etiology.

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 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 tartrate, 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.

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 is found not only upon the surface, but in the dentinal canals, and probably has 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 accom-

plish 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.

By Mr. Bridgman ("Transact. Odontol. Soc.," vol. iii.) 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 has to a great extent escaped criticism.

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 undue ascendancy over the 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 (*op. cit.*, p. 380). 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	4,399	2,273 upper	
		2,126 lower	
Second molars	3,615	1,675 upper	
		1,940 lower	
Third molars	1,924	899 upper	
		1,025 lower	
Total		Upper 13,136	20,000
		Lower 6,864	

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	
Canines	515	445 upper	
		70 lower	

(1) Wedl's "Pathology of the Teeth," p. 399. Translated by W. Boardman, M.D., and edited by T. B. Hitchcock, M.D., D.M.D. 1872.

First bicuspids	1,310	940 upper 370 lower
Second bicuspids	1,310	810 upper 500 lower
First molars	3,350	1,540 upper 1,810 lower
Second molars	1,736	690 upper 1,046 lower
Third molars	360	220 upper 140 lower

Analysis of 2,638 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.

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 wide-spread 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 are constantly shed out, 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

([1]) "Traité de la Carie Dentaire," p. 60. 1867.

indigenous, but freshly imported into a country, appear to suffer in an exalted degree.

Amongst the anthropological series of the Paris museums 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 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

(1) *Op. cit.*, p. 65.

(2) Transactions of the Odontological Society, new series, vol. ii.

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.

One link in the chain of evidence is as yet wanting; no one has hitherto succeeded in artificially producing all the histological characters of caries in teeth which have been submitted to the action of reagents out of the mouth; nevertheless, sufficient data exists for arriving at a tolerably accurate estimate of the nature of dental caries.

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, the buccal mucus, probably, 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 (page 537).

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