Henry W. Gillett

Man forever will err; yet an innate longing desire
Draws the aspiring mind gently toward the truth.

GOETHE.

LOCAL ANESTHESIA

IN

DENTISTRY

WITH SPECIAL REFERENCE TO THE MUCOUS AND CONDUCTIVE METHODS

A CONCISE GUIDE FOR DENTISTS, ORAL SURGEONS AND STUDENTS

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SECOND AMERICAN FROM THE THIRD GERMAN EDITION, THOROUGHLY REVISED, WITH ADDITIONS

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PREFACE.

When the first edition of this book in English was offered, a great deal of conservatism toward local anesthesia was expected on the part of the American dental profession. Such conservatism would not have been without justification, as both the agents and the technique employed in local anesthesia were decidedly unsatisfactory, even dangerous, before the advent of novocain-suprarenin and the perfection of the methods of injection, as devised chiefly by Braun and so ably adapted to dental practice by Fischer.

The rapid exhaustion of the first edition, the demand for demonstrations of novocain-suprarenin anesthesia—without which the program of a dental society meeting is no longer considered complete—the enthusiastic essays appearing periodically in our dental journals, the invitation recently extended to Dr. Fischer by representative American dental institutions to deliver lectures and give demonstrations of this specialty, and the study clubs subsequently formed here and there for the further promulgation of his doctrines among the profession, all seem to be convincing proofs that genuine interest has been aroused in local anesthesia with novocain-suprarenin for dental practice. In fact, it is not too much to say that this method is in a fair way to become routine practice in America as surely as it has for some years been a faithful standby in European dental offices; and it is being more and more universally adopted in general surgery for operations in which a few years ago only general anesthesia would have been considered feasible.

As in all dental operations, uniform and unmarred success can reasonably be expected only when full consideration is given to the physiological and anatomic premises upon which the methods advocated are based, and if the exacting requirements of asepsis are rigorously observed in the minutest detail.

The present American edition (the second) is based upon a new German edition (the third). In the revision no pains were spared to condense and revise the text, and to incorporate many changes and improvements based upon the most authoritative knowledge and the best and most practical procedures. The instrumentarium and the technique of making accurate and safe solutions have been improved and simplified, and the methods and points of injection have been even more fully elucidated in text and pictures. Special attention has been accorded the subjects of isotonia, asepsis, and conductive anesthesia, which latter method has become that of predilection with all skilled operators. As far as it seemed fitting, other means and methods of local and general anesthesia have received consideration.

The German text has been liberally translated, and numerous additions of a practical nature have been made. This has been done with the full consent of Dr. Fischer, to whom the editor is indebted for many memorable hours of discussion and tokens of personal friendship in the preparation of this volume. Grateful acknowledgment is made to Mr. A. F. Tilly for his aid in the proof-reading; the editor has received untiring assistance from his wife.

The publishers, Messrs. Lea & Febiger, have again spared no effort or expense in the technical execution of this book. The profusion of illustrative material, to which some notable additions have been made, should prove a most valuable feature.

R. H. R.

PHILADELPHIA, 1914.

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PART I.

MODERN LOCAL ANESTHETICS AND THEIR APPLICATIONS.

PAIN.

FROM time immemorial the problem of the prevention of pain has engaged the attention of practitioners of the healing art, and among its branches surgery especially has striven to effect the removal of that which constitutes the most serious handicap to its beneficent endeavors. To dentistry—which from a small scion of medicine has developed into an independent science—is due the honor of introducing the inestimable boon of what we know as "general anesthesia;" while the further aspiration for the attainment of the supreme goal, *i. e.*, local anesthesia, has engaged the earnest coöperation of both surgical and dental sciences.

In dental operations, which are so extremely painful as compared with other operative interventions, the desire to diminish or to abolish the sensibility of the teeth is especially justified since the general enervation resulting from modern civilization is daily increasing. Moreover, dental disease has been assuming such alarming proportions that all possible means of inhibiting this universal scourge deserve to be seriously considered.

Pain is a phenomenon wisely instituted by Nature. To use Goldscheider's words: "Pain makes us realize that some external danger is threatening which we may still avoid, or that harm has already

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been done to the body requiring our care if we would escape more serious consequences. Pain arises as a warning signal whenever we are exposed to such conditions of life as by their continued influence would involve general disturbances to health. Pain appears before or simultaneously with the outbreak of disease, warning man that his body is in a diseased condition and requires care. Pain occasioned by physical or mental fatigue indicates the necessity for rest and recreation. Pain, the symptom of organic disease, imperatively urges the patient to nurse the diseased organ. Pain is the physician's most powerful assistant, whose demands the patient follows in blind obedience, and who saves the physician many a prescription, many an advice as to diet and conduct. Through pain Nature imposes rest even upon the most strenuous; it dictates idleness to the most energetic, and forces the most obstinate to abide by conditions suitable for the diseased body.

"Pain is a harsh but useful law of Nature. But, like all natural laws, it is unyielding in its consistency, blind in its disregard, brutal and cruel. Pain appears not only in the guise of benevolent warning but also in that of troublesome torment. Even in incurable disease, in affections in which the realization of ill health is useless for the patient, inasmuch as no one can control the disease, pain is present, ruthlessly destroying all enjoyment in life without offering any physical advantage whatever by way of compensation. In the most dangerous diseases pain is often absent, thus lulling the patient into a sense of security, only to appear and call for abolition by artificial means after the patient has undergone an operation in order to save his life. Hence it is only proper that we physicians should combat our ally. To wipe out pain entirely is an impossibility, and we cannot and would not do without it, since pain is necessary not only as a monitor in the combat against the hostile powers of matter but also as an inspirer to ethical emotions. For it is chiefly in the reminiscence of one's own pain, both physical and mental, that love and active charity are rooted."

Pain belongs to that order of phenomena which are usually termed conditions or general sensations, such as tickling, itching, hunger, thirst, nausea, and others. They are all distinguished by a high degree of pleasurable or unpleasurable sensation, and do not inform us concerning our environment like the sensory perceptions, but above all attract our attention to the altered state of our own body.

Pain, empirically, can originate only within the radius of the centripetal sensory nerves and the nerves of touch, while the sensations of other sensory nerves are perhaps disagreeable, but never really painful. Sensations of pain and touch, therefore, are different degrees of the same sensation; a light stimulus produces the sensation of touch or pressure, while a stimulus intensified beyond the maximum produces pain. Pain is caused by the increase of a stimulus beyond a certain limit, this stimulus radiating over neighboring nerve plexuses, and being of prolonged duration provided the area acted upon possesses sufficient sensibility. Hence the intensity and the duration of a stimulus exert a decisive influence upon the character of an irritation. If the action of a stimulus is sufficiently prolonged, the sum total of the resulting irritation is probably stored in the sensory ganglionic cells, leading to a consummation of individual stimulative impulses which produce the effect of pain, and at the same time a hyperalgesic condition. Inflammatory pain is probably due to a hyperalgesic condition of the ganglionic cells induced by the prolonged action of a stimulus.

The character of pain may vary considerably. According to Erb, burning pains may arise from an admixture of sense perceptions; pricking pains from localization or expansion; throbbing pains from change in the stimulative process. "The intensity of pain is greatly dependent upon psychic factors, and is the greater the more we abandon ourselves to it, while diversion and will power mitigate even exceedingly unpleasurable sensations. Kant, for instance, is said to have overcome the torture of gout by concentrating his thoughts upon a definite subject. At night, after the continually changing impressions of a day have ceased to occupy the mind, pain is felt all the more intensely." (Mangold.)

Other factors, such as education, character, intelligence, race, age, sex, and general health, exert a considerable influence upon the origin and manifestation of painful affections.

The realization of suffering, in fact, increases in direct ratio to the development of the sensory organs.

Pain, like all other sensations, is one of the functions of the cerebral cortex, in the "sphere of physical sensations" of which the sensory filaments are supposed to terminate. If the tract of fibers radiating from the cortical region is interrupted in the region between the posterior and anterior ends of the thalamus complete anesthesia of the opposite half of the body ensues. The peripheral sensory nerves of the brain and spinal column within the spinal cord, including the gray substance, are to be considered as conductors of painful sensations. The sympathetic nervous system, however, probably does not possess the faculty of conducting pain.

The end organs of the sensory nerves are tuned to certain forms of stimuli, and conduct these farther on to the cerebral cortex, probably in such a way that complicated chemical changes are transmitted from cell to cell.

Stimuli of different quality, *i. e.*, mechanical, chemical, thermal, and electric stimuli, are capable of producing painful sensations in the sensory end organs, or along their conducting tracts. A sensation of pain originating in the cerebral cortex is communicated to the parts of the body lying outside of the brain in such a manner, however, that the pain is not clearly localized but vaguely circumscribed, as is frequently observed in the oral cavity. The irritability of diseased tissue is generally increased, rarely diminished. Acute inflammations in which the increase in blood-pressure plays an important role, tend specially to produce rapid and severe irritations of the sensory nerve plexuses involved, *i. e.*, *hyperalgesia.* On the other hand, local disturbances in nutrition, as, for instance, loss of function in dental pulps and chronic edemas, may produce a diminution of sensation, *i. e.*, *hypalgesia.*

Besides the varied distribution of the sensory nerve plexuses, the function and the situation of an organ bear an important relation to its irritability. Muscles, subcutaneous cellular tissue, tendinous tissue, cartilage, and abdominal organs, for instance, seem to possess but very slight if any sensibility; while the epidermis, the mucosa of the oral and nasal cavities, the urethra, the periosteum, and the perichondrium are highly sensitive; bones and marrow are less so, and the mucosa of the stomach and the intestinal canal from the esophagus downward, the lung and the brain itself, are entirely insensible, as Gasser has convincingly proved and every surgeon knows. This, of course, refers only to direct surgical interference with these tissues, disturbances in which are, as a rule, painfully referred to adjacent tissues of greater sensitivity.

From the beginnings of practical medicine this distribution of sensitive areas throughout the body has been carefully studied, and indefatigable efforts have been made to reduce the sensibility of the tissues by artificial means so as to render operative interventions possible. These efforts tend to produce either abolition of sensibility, *i. e.*, *anesthesia*, or at least inhibition of painful sensation, *i. e.*, *analgesia.* This condition of insensibility is sometimes brought about by Nature itself, when, for instance, normal irritability of the sensory nerves is reduced during profound sleep or in sickness; but it can be produced by artificial means, *i. e.*, narcotics, such as chloroform, ether, etc.; local anesthetics, such as cocain, novocain, etc., or hypnosis.

BRIEF HISTORICAL REVIEW.

Among all peoples and in all eras efforts have been made, more or less successfully, to discover means for the prevention of pain. It was, however, not so much local as general anesthesia which at first appeared desirable, and various agents, especially vegetable extracts, were administered for that purpose. Narcotizing decoctions, such as the mandrake root potion, were frequently given in order to produce a sleep-like state, during which operative interventions could be carried out.

In the year 50 A.D. Dioscorides is said to have made the first attempt to produce a sort of anesthesia by pulverizing the Memphis stone, mixing it with vinegar into a paste, and allowing it to act locally upon the skin for some time before an operation. In this preparation carbonic acid presumably played some role, being liberated in the mixture of limestone and vinegar, and producing cold, thereby effecting a slight anesthesia in the skin area thus treated.

In the Middle Ages local anesthesia seems to have fallen into oblivion, for it was not until the end of the eighteenth century that James Moore suggested that by compressing nerve trunks, or by severing them, analgesic areas could be produced. Owing to the numerous anastomoses of nerves, the effect of Moore's procedure naturally was but a limited one, and the efforts of the investigators of that time were therefore directed to perfecting the methods of general anesthesia.

It was in 1866 that local anesthesia began to receive its due recognition. This was brought about by comparatively successful attempts of Richardson to obtain anesthesia of the skin by means of the ether spray, the application of which, in a limited degree, is considered correct practice to this day. Richardson, who did pioneer work also in the field of general anesthesia, is entitled to special credit in regard to local anesthesia, for he drew attention to the great value of this method, and succeeded in interesting the surgeons of the day in his ideas.

About the seventies of the last century local anesthesia lay dormant until it was awakened into new life by the efforts of Koller, Schleich, Robson, Corning, Oberst, and others. At the Congress of Ophthalmologists held in Heidelberg, in 1884, Koller demonstrated the remarkable anesthetizing power of cocain, which, after its action had been hurriedly tested by many authorities, quickly sprang into general popularity. But the methods of application of this drug were not sufficiently tested, and consequently, especially in anesthesia of the mucous membrane, fatalities frequently occurred owing to the toxicity of cocain, until Schleich and Reclus introduced their method of infiltration anesthesia by means of comparatively very small cocain doses. This method was still further perfected when Braun recommended the admixture of extract of the suprarenal capsule with the anesthetic solution.

Conductive anesthesia (**perineural** or **regional** anesthesia), which is used so successfully today, was first suggested by Halsted in 1885.

Instead of injecting cocain in the vicinity of the tooth to be anesthetized, he injected it near the trunk of the inferior dental nerve. This principle of perineural injection was applied by Kummer and Pernice in anesthesia of toes and fingers.

Medullary anesthesia, which also is very popular today, and which has been perfected by Bier, was known as early as 1885 to Corning, who discovered by animal experiments that the lower extremities became insensible after anesthetization of the spinal cord by injection between the spinous processes of the lumbar vertebræ.

Many investigators, such as Schleich, von Mikulicz, Braun, Kocher, and von Eiselsberg, who have materially contributed to the progress made in this field, have specially sought to do away with the toxic effects of cocain on the heart and the central nervous system which must be reckoned with, despite its excellent anesthetizing action. "In no instance is it justifiable to speak of cocain mixtures as being harmless; in their application, therefore, the greatest care is needed, as the effects of cocain on the entire organism, especially the central nervous system, must be realized constantly. I have collected records of a great many cases in which serious sequelæ from this drug were noted, even disturbances of the functions of the brain in the form of sexual affections." (Ritter.)

Substitutes were offered, such as eucain alpha and beta (Silex), acoin (von Heyden), holocain (Täuber), tropacocain (Giesel), orthoform, nirvanin (Einhorn and Heinz), anesthesin and subcutin (Ritsert), stovain (Fourneau), alypin, novocain (Einhorn), and others. All these drugs were supposed to possess the anesthetizing power of cocain without its toxicity. Science and industry made unceasing efforts to find an ideal preparation for the purpose of local anesthesia. It was Braun especially who tried to compare the different cocain substitutes in regard to their specific action. He showed that anesthesia is a chemical process, a combination of the anesthetic with the cell elements, *i. e.*, the nerves of the injected area. Contrary to Schleich, he considered the physical factors, such as cooling, difference in osmotic pressure, and direct pressure upon the nerves, as non-essential. Above all, he emphasized that the simultaneous contraction of the bloodvessels in an injected area is an important aid in the intensity and duration of the anesthesia. For this reason he advised combining suprarenal preparations with anesthetics, and this combination has now become absolutely indispensable.

Thus the discovery of the anemizing action of *solutions of suprarenal extract*, which are marketed under the names of adrenalin, renoform, suprarenin, etc., has become of the greatest importance for the further development and perfection of injection anesthesia. The chief property of these preparations consists in their intensifying the action of cocain or its substitutes. When injected in mixture with an anesthetic solution they produce a vigorous contraction of the bloodvessels in the injected area; for this reason not only the absorption of the anesthetic is retarded, but also considerably smaller quantities of the anesthetic mixture produce as deep an anesthesia as that afforded by considerably larger doses of pure cocain or novocain solutions. This is specially true of the combination of *novocain* and *suprarenin*, which latter is now prepared synthetically. This novocain-suprarenin mixture, while equally potent, is less toxic than the combination of cocain and suprarenin, and is therefore given the preference in surgical and dental operations.

Local anesthesia by injection is sure to become soon a common practice in dentistry, owing to the noteworthy work of propaganda for its general adoption. By their researches, Bünte and Moral, Cieszynski, Konrad Cohn, Eckström, Euler, Hübner, Luniatschek, Misch, Möller, Paul, Peckert, Port, H. Prinz, Reinmöller, Reclus, Ritter, Rosenberg, Sachse, Schäffer-Stuckert, H. Schröder, Seitz, Sauvez, Thiesing, Viau, Walkhoff, Williger, Ad. Witzel, and many others, have made valuable contributions toward the perfection of the technique and its adaptation to our special field, and it will be the duty of any historian who may in the future record the development of local anesthesia in dentistry to accord these men full credit for their efforts.

LOCAL VERSUS GENERAL ANESTHESIA.

Before taking up the aims of modern local anesthesia in detail, a few preliminary remarks on the relationship between local and general anesthesia may be in place. The dentist, whose practice concerns a very important but circumscribed portion of the body, is vitally interested in treating and curing the organs intrusted to his care in such a manner that no damage to the entire organism will result from his operations. The question of the relative toxicity of local anesthetics as compared with that of general anesthetics is therefore of greatest interest to him.

It was shown in our brief historical review that the earliest results in anesthesia were obtained in the domain of central desensitization, *i. e., general anesthesia*. The perfection of surgical methods of treatment was so closely connected with efforts to bring about the prevention of pain that these two movements have advanced hand in hand.

In order to perform a difficult and tedious operation with safety, the surgeon has always endeavored to paralyze the nervous centres, thereby completely eliminating the sensation and will power of his patient; in other words, producing general anesthesia. In the fields of minor surgery, ophthalmology, dentistry, and others, in which surgical intervention renders such an aid desirable, investigators have naturally endeavored to evolve methods by which the nerve terminals in a circumscribed area of innervation could be paralyzed, and the surgeon enabled to operate while the patient was fully conscious, *i. e.*, under the influence of *local anesthesia*. By local anesthesia we mean either those measures by which only the terminal ramifications of the nerves in a definite area are influenced, as in *mucous* or *infiltration anesthesia*, or those by which a larger nerve trunk is intercepted directly at its basis, as in *conductive anesthesia*. In *infiltration anesthesia* the nerve terminals are for a certain length of time incapacitated from receiving stimuli, while in conductive anesthesia a particular nerve trunk is prevented from conducting impressions.

The progress of local anesthesia has been accelerated above all by the want of perfect safety to the patient's life which still inheres in general anesthesia. Even if the more accurate method of so-called mixed anesthesia is correctly employed, one fatality in 7558 cases is still to be expected. At the Surgeons' Congress of 1910 Neuber estimated that one fatality still occurred in 2953 cases of chloroform anesthesia. These statistics are considerably swollen by the very many errors that occur in general anesthesia, and the frequently injudicious employment of this method in cases in which local anesthesia is clearly indicated. In minor interventions, such as tooth extractions, the employment of general anesthesia has often brought about the patient's subsequent death. General anesthesia, moreover, requires such preparations as are considered by most patients as decidedly disagreeable, and its induction is often followed by serious after-effects.

Although the operative measures which are connected with the induction of local anesthesia may cause some fear and anxiety, the patient, being fully conscious of all the steps of the entire operation, enjoys the great advantage of not being exposed to any vital danger whatever, owing to the high state of perfection which local anesthesia has reached as compared with general anesthesia. The reported fatalities from local anesthesia have been due almost exclusively to the employment of cocain. The methods of local anesthesia as practiced in interventions in the eye, mouth, nose, ear, and the extremities, undoubtedly involve but little probability of vital danger to the patient, especially if these methods are practised by skilled hands. In the extremely dangerous operations on the thyroid gland, which involve serious interference with the cardiac nerves, and which, when done under general anesthesia, are liable to produce syncope of the heart, it has now generally become surgical practice to employ local anesthesia. In dentistry its application is demanded all the more imperatively as the very nature of the field of operation in every respect indicates local intervention.

A knowledge of the sensibility and the nerve supply of the individual tissues is indispensable. The skin and the mucosa, as well as the periosteum, the pericementum, the pulp, and the dentin are far more sensitive to pain than the muscles. By a careful consideration of these conditions, however, a conscientious and experienced operator will be able to operate painlessly provided the patient faithfully and patiently follows his directions. Here we touch upon a question of great importance in dental local anesthesia, *i. e.*, that of educating the patient to have faith in the operator. Some nervous persons regard the thought of being operated upon under a local anesthetic while fully conscious as far more formidable than the struggle under a general anesthetic, and it requires calmness and discretion on the part of the operator to persuade them to submit to local anesthesia. It is the operator's duty, therefore, to justify fully the patient's reluctantly granted confidence by doing all within his power and skill to perform a perfectly painless operation. If he fails, the patient will lose forever the self-control which he has gained by the operator's mental suggestion, and will in the future swear by general anesthesia. In local anesthesia remarkable results can be obtained by mental suggestion, and in our hospital and private practice we have induced many a patient by such mental influence to submit to a local anesthetic.

In regard to technique, local anesthesia offers the great advantage of rendering the aid of an assistant unnecessary; on the other hand, the presence of a third person, an assistant, a woman attendant, or any responsible witness, is practically indispensable for social and medicolegal reasons. Several cases of sexual hallucinations following the injection of cocain solutions for extractions have been reported in which the operator had difficulty in clearing himself from neglect of this necessary precaution.

"It has therefore been established as a general rule that neither the physician nor the dentist, without urgent reasons, should induce anesthesia when alone, but that an assistant, or at least another person, should be present. The presence of a witness is, indeed, imperative, owing to the additional fact that frequently during the application of anesthetics hallucinations or dreams occur which deceive the patient, and the operator may consequently become involved in a most disagreeable situation. Especially in treating patients below the age of twenty-one great care is necessary, since any operative step which is undertaken without the guardian's permission may possibly be denounced as malpractice. A minor has no legal right to any serious decision, and for surgical operations, therefore, even for the most insignificant intervention in the human body, the consent of the parent, guardian, or legal representative is necessary. Dentists should take the greatest possible care in this respect when a serious oral operation or the induction of anesthesia is involved, and injections of a local anesthetic should never be made in minors without previous agreement. In such cases a plea of professional custom would hardly be accepted, the legal representative's special consent being always required." (Ritter.)

Local anesthesia offers an additional and important advantage over general anesthesia, inasmuch as local anesthetics can be very readily applied and require no lengthy preparation either on the operator's or on the patient's part. This is an extremely valuable feature, especially for ambulatory dental practice, in a big city as well as in the country, in the dentist's office as well as in the patient's home. The production of general anesthesia under difficult conditions or in unsuitable surroundings offers infinitely greater disadvantages, and its final success is incomparably more hazardous than that which can be obtained in dental operations under local anesthesia by a skilled hand almost at any time, in any place, and in almost any patient. To be sure, the dentist must have sufficient experience to cope with any difficulties that may arise in any case; he must be a master in painless manipulation, and be fully proficient in the technique of local injections; he must know exactly the pharmacological and physiological effects of his injecting solution, and, above all, he must be able to diagnose the general condition of each patient in order to treat him according to individual requirements; for there is no doubt that the behavior of the individual organism in absorbing an injected solution must largely determine the operator's method of procedure. The dentist can inject a smaller quantity of solution in greatly anemic or tubercular patients, and reduce the dose of the suprarenal extract, which is dangerous for the heart, without jeopardizing the success of his operation. Such patients will often tolerate only very superficial general anesthesia, and even then they are in constant danger, and pain is only partially abolished. The application of local anesthesia in such cases is far more advisable, since it guarantees perfect success and invariably meets with the patient's full approbation; for it must not be overlooked that with every successful operation we gain friends and advocates of local anesthesia among our patients, who will aid in popularizing a method which is worthy of becoming common practice with all dentists. To what extent general surgery has succeeded in replacing general by local anesthesia may be gathered from Braun's report (see page 107) to which we would draw special attention.

"The production of general anesthesia," Riethmüller writes, "under difficult conditions or in unsuitable surroundings involves infinite disadvantages and risks, and its final success against such odds is altogether too dearly bought when we know that for dental operations local novocain anesthesia can be obtained so satisfactorily. Medicolegally, also, the application of local anesthesia gives the operator the advantage. To cite a medicolegal authority (Kupfer): 'After extensive observations I do not hesitate to maintain that general anesthesia, with the few exceptions enumerated, is unnecessary in operations in the oral cavity, and that, as a medicolegal expert, I should be unable to protect an operator from indictment in case of fatal accident from general anesthesia.' Dental colleges would surely raise the efficiency of their graduates, and more forcibly instil into them the necessity of aseptic methods of operating and the importance of an intimate knowledge of the anatomy of the head, by including a short practical course in local anesthesia in their curriculum. General surgery is rapidly adopting local anesthesia for a great many major operations, and it behooves the dental profession, whose special field by its very nature calls for local intervention, not to lag behind, but unhesitatingly to keep abreast of the foremost modern and efficient methods available."

PRELIMINARY MEASURES IN LOCAL ANESTHESIA. THE OPERATOR'S DUTIES.

After having shown that local anesthesia is not only a most desirable adjunct to the dentist's operative resources but a necessary prerequisite for successful dental practice, the details of this procedure will be considered. While elaborate preparations for the correct administration of general anesthesia are always required, the induction of local anesthesia necessitates only certain measures, which we shall discuss in the following paragraphs:

Anamnesis.—An accurate anamnesis usually can be best and most tactfully secured in leisurely conversation, by which the operator should inform himself about the patient's general physical condition. Special attention is to be devoted to weakly and anemic persons and to patients who are convalescent from serious infectious diseases, such as influenza, also to physically depressed or nervously irritated individuals, and hystericals—all of whom require special care if they are to undergo any operation. In such patients the normal quantity of an anesthetic which may be safely applied in strong and healthy persons is liable to produce more or less serious toxic effects, which, as a rule, can be avoided by injecting a smaller quantity of the anesthetic and by reducing the percentage of the suprarenal extract. By calm self-possession in asking questions, and by kindly persuasion which will dissipate fear, the operator can instill in the patient sufficient composure and confidence to enable him to begin the operation. The patient's composure is of great importance in the first insertion of the needle, which is sometimes technically complicated, and can be accomplished only if the operator has his patient under perfect mental control. Success is assured as soon as the needle is introduced in the desired position. If the patient feels little or nothing of the needle puncture, he will quickly take full confidence in local anesthesia, and remain calm during the rest of the operation, provided the operator is skilful enough to carry his measures to a successful end.

Even if inevitable pain should arise, the patient will be willing to bear it provided the operator has properly advised him of such a possibility. It may happen that deep alveolar strata have not been reached by injection in the mucosa and have remained sensitive, as, for instance, following fracture of a root. Or the operator may introduce a retractor or a scalpel in an insufficiently anesthetized portion of the mucosa, thereby causing sudden pain. To avoid such unpleasant incidents, it is expected of the modern anesthetist that he foresee and consider all imaginable conditions that may arise, and reckon with all the factors that may defeat his object of painlessness. Every operator must be his own severe critic; he cannot afford to overrate his ability and experience, and he should know perfectly well how far he can trust his skill. He must be certain if he is technically able to produce such anesthesia as the conditions may demand, or whether he should take the precaution of notifying the patient in advance of the possibility of pain. This does not necessarily discourage the patient, rather it contributes to inspiring confidence. Such a candid admission, which is scientifically justified, meets with the fuller appreciation the greater the operator's technical skill and manipulative ease, and it exemplifies modesty, which unfortunately has becomes a rare virtue. A certain class of practitioners are in the habit of guaranteeing their patients absolute painlessness, and exploit this fraudulent promise in their advertisements; but such quackery cannot be condemned sharply enough as being unprofessional and unscientific.

A correct reserve on the part of the operator is all the more in place, as, beside preventing pain, he is also obliged to perform the operation, and therefore faces a specially difficult task. Even though the operation be a minor one, he nevertheless has to exhibit great technical ability, alertness in observation, presence of mind, and determination. Thus, for instance, the problem of direct anesthesia of the dentin still remains unsolved, and it requires most delicate and clever manipulation to extirpate successfully so minute an organ as the dental pulp.

Pulse and respiration must also be watched in order that disagreeable accidents which would interfere with the operation, such as dizziness, collapse, spasms, etc., may be recognized by their symptoms and prevented. Experience shows that such accidents occur frequently in patients affected with heart trouble or some other constitutional disease; every dentist therefore ought to be able to make an examination of the heart and lungs by auscultation and percussion, and this requirement should be included in the dental curriculum.

It is out of the question, of course, that a thorough physical examination be made in every case; yet from the patient's history any heart trouble can be recognized, and if the symptoms are in the least suspicious, complications can be avoided by a reduction of the quantity and strength of the injected solution. In dubious cases, of course, the patient's and the operator's interests are best safeguarded by calling into consultation an experienced diagnostician.

After having taken into account the patient's general health, the operator must next consider the local condition of the diseased area, which frequently determines the correct selection of the method to be employed for the prevention of pain. In cases of pericementitis or putrescence, the insertion of the needle and the injection frequently produce severe pain in the mucous membrane, and the anesthetic effect is very unsatisfactory. Here conductive anesthesia is properly indicated, as it is in all cases where anatomic or pathologic reasons specially call for it. The question of efficient asepsis must also be considered, since it is of the utmost importance in local injection anesthesia.

From the foregoing it appears that the operator, who incidentally must be a capable anesthetist, assumes great responsibilities, since by faulty manipulation he may endanger the health, even the life, of his patient and may be held responsible for any damage caused by negligence on his part. As the danger for the patient increases proportionately with the intricate nature of the operative procedure, a perfect mastery of the anesthetic technique is imperatively demanded of the operator. Although the law does not require the presence of a skilled assistant in local anesthesia cases, the operator's responsibility is by no means lessened. Only when proved beyond doubt that he has fulfilled his duty in every respect will he be completely exonerated in case of accident.

It is the operator's further duty to keep an accurate record of the patient, the disease observed, and the therapeutic measures employed. The method of injection applied and the quantity of solution injected must be noted, also any symptoms arising during the operation. Such a conscientiously kept record will prove invaluable in case of unlooked-for accident, as it will substantiate the fact that the operator was fully realizing his responsibility, and will influence a verdict in his favor.

Eroticism.—Sexual affections that may arise in connection with anesthesia are due to the strong general action of the anesthetizing agent upon the central nervous system, which gives rise to a series of lascivious thoughts and conceptions similar to those produced by nitrous oxid anesthesia. In female patients such hallucinations very frequently affect the genitals, and in neuropathic and hysterical persons, though they be fully conscious, persist as real sensations which are wrongly interpreted. That conditions simulating sleep may occur even in connection with local anesthesia the writer has personally noted in one case of novocain injection. In relation to this the case published by Körner should be cited: A woman had been locally anesthetized with ethyl chlorid for the purpose of extraction of a tooth, and though she had remained conscious claimed to have been assaulted during the operation. Owing to the presence of several persons who had witnessed the operation from beginning to end, it was easy to explain this unpleasant incident.

"It is a fact, known to physician and dentist alike, that all anesthetics may produce erotic dreams. This is true not only of the agents employed in general anesthesia but, according to published records and my own experience, also of local anesthetics, especially cocain. One of the first to publish a comprehensive work on cocain anesthesia in operations in the oral cavity was the late Professor Dr. Witzel. He states that in one of his women patients, in whose gums he had injected eight drops of his cocain solution (0.08 cocain), sexual excitement was noted five minutes after the extraction. Shortly after the introduction of cocain in dentistry I applied this agent myself in subcutaneous injections, but abandoned its use after experiencing all kinds of disagreeable accidents, above all syncopes and severe hemorrhages from extraction wounds due to failure of the blood-vessels to contract normally after the injection, also lascivious speeches and gestures, even confused narrations.

"It is only within recent years, since the adoption of the so-called cocain mixtures, that I have readopted such injections in my practice. But even in these cocain mixtures, which generally contain an admixture of adrenalin (suprarenal extract), these symptoms of sexual excitement appear in both male and female patients, especially the latter, and I should therefore advise every operator never, if possible, to administer local anesthetics to female patients in the absence of witnesses. In his recent work on *The Sequelæ and Secondary Effects of Local Anesthetics in Dental Operations*, Dr. Dorn, who is to be regarded as an authority on this subject, agrees with Lewin that the after-effect of cocain anesthesia does not depend upon the quantity of the drug injected, and that, as has been verified by the writer's own experience, even very minute doses suffice to produce secondary toxic effects. Dorn further reports that in women, after the application of cocain, erotic conditions may occur, sometimes even without any disturbance of consciousness, and I can verify these observations, which are very important for the case under consideration.

"Another case reported by Dorn is interesting: A girl, aged twenty years, shortly after an operation under cocain, lapsed into a condition of tremendous excitement, respiration being considerably accelerated, pulse 102, and made voluptuous motions with her lips, without notably reacting upon being spoken to. After having remained in this condition of mental distraction and great excitement for about ten minutes, she gradually regained consciousness, and explained that she had dreamed of her fiancé.

"How closely cocain intoxication and hysteria may be related, and how dangerous this combination may be for the operator, is proved by the following case published by Hentze: A young woman had a tooth extracted in the clinic under local anesthesia. She showed symptoms of cocain intoxication and hysterical fits, but soon recovered and returned home. Soon afterward the assistant, who had been present at the operation and whom she had not known even by name, received love letters from the woman, which remained unanswered. Three days following the operation the patient committed suicide by shooting, after having written to the assistant that she intended to take her life unless she received a reply. It was ascertained afterward that the woman was engaged to some other man." (Ritter.)

These reports of specially dramatic cases serve to emphasize that the presence of a third person, who may be called upon to testify, constitutes a most valuable safeguard medicolegally, if patients should experience sexual affections and accuse the operator of immoral attempts. While such cases are of fairly frequent occurrence in connection with general anesthesia, and local anesthesia with cocain, fortunately only very few such incidents have been observed following novocain-suprarenin injections, which is another strong argument in favor of this method.

AGENTS FOR LOCAL ANESTHESIA.

After these general considerations, the question arises by what means a satisfactory, safe, and effective local anesthesia may be obtained. There are a great number of anesthetics which have been applied in various ways more or less successfully, but few of these deserve serious consideration in view of the severe specifications demanded of an up-to-date anesthetic. Like the narcotics, almost all anesthetics are poisonous to the vital human organism, and their toxic effects upon the general system must therefore be checked by suitable dosage and solution.

PHYSICAL METHODS OF ANESTHESIA.

Anesthesia by Freezing.—The physical methods of anesthesia by freezing and pressure, which were the earliest practiced, are primarily localized in their effects. Anesthesia by freezing is based on the principle of depriving the tissues of as much heat as possible by the application of congealing agents, such as the well-known ether spray, which produces a condition of analgesia in the tissues. Owing to the great loss of heat, the tissues of the living organism are changed into a solid state. The tissue fluids, blood and lymph, being of an aqueous nature, solidify like water during frost, affecting the sensory nerve endings in such a way as to render them incapable of transmitting impressions to the central organ. The sense of touch is thereby affected but little or not at all, so that anesthesia by this means consists not so much in a deadening of the entire complex of senses as in the abolition of the sense of pain, *i. e.*, analgesia.

The epidermis, and to even a greater extent the mucosa, are permeable to gaseous bodies. The gas which is developed upon application of ethyl chlorid to the warm surface of the mucous membrane penetrates the epithelial retiform interstices, the tissue pores and glands, owing to the high pressure caused by the deprivation of the tissues of heat. Anesthesia of the affected nerve elements is thus rapidly produced, but it usually wears off just as rapidly.

Anesthesia by Pressure.—Besides freezing, compression of nerve trunks has long been employed for the production of analgesia of a limited degree. By firmly tying a portion of the body, as, for instance, the arm, the sensation of pain can be notably diminished, yet not completely abolished. In dentistry the simple method of anesthesia by pressure is still applied in obtunding hypersensitive dentin or exposed pulps. The merits of this procedure will be considered in the special discussion of dentinal anesthesia. (See page 119.)

Schleich adopted the principle of physical pressure for the production of anesthesia by completely filling the tissues to be obtunded with an injected fluid, thereby producing infiltration, or artificial edema. The pressure and tension obtained in this way incapacitate the affected nerve filaments to convey stimuli. By employing very weak cocain solutions, Schleich combined physical and chemical effects in his infiltration method. To a limited degree, anesthesia of the mucosa in the alveolar region is based also upon such a combination of the pressure and the chemical action of the injected solution; the latter factor is, however, of decisive importance. The drugs intended for injection have now reached such a high degree of perfection in regard to chemical action that this factor dominates the entire technique of dental local anesthesia.

CHEMICAL METHODS OF ANESTHESIA.

Chemical Anesthetics.—All the anesthetics in more or less general use today represent organic chemical combinations which are applied upon or within the tissues in the form of suitable, generally aqueous, solutions. For the anesthetization of mucous surfaces cocain solutions of high percentages or concentrated novocain solutions are employed, while for injection into the connective tissue dilute solutions are always indicated. The external application of these drugs upon the oral mucosa produces a superficial anesthetic effect, because the lymphatic fluid, which is distributed through the tissue, readily seizes the salts introduced, dissolves them and carries them to deeper strata. This action is greatly favored by the superficial situation of the sensory nerve endings which are distributed closely under the epithelium. The surface tension of aqueous solutions of alkaloidal salts is considerably diminished by the addition of infinitesimal quantities of blood serum, according to the very interesting investigations of Traube.[1] This fact was attributed to the alkaline action of the blood, especially because simultaneous researches upon the influence of various salts upon the surface tension of alkaloidal salts had shown that basic salts, such as sodium carbonate and others, reduce that constant to a marked degree. The rapidity as well as the duration of the effect of mixtures of novocain-hydrochlorid with sodium bicarbonate is considerably greater than that of pure novocain salts, as has been demonstrated by Gros and Laewen.[2]

Solubility in Water.—As the tissue fluids are of an aqueous nature, only aqueous solutions of anesthetics are effective, and the anesthetizing power of these drugs is directly proportionate to their

[1] Biochemische Zeitschrift, 1912, No. 6, p. 470.
[2] Münch. med. Wochenschrift, 1910, p. 2044.

solubility in water. For this reason alkaloids which are very readily soluble in water, such as cocain, eucain, tropacocain, novocain, and others, yield the best results, especially when these have been made into salts such as hydrochlorids, with appropriate acids, in order to increase their solubility in water.

Toxicity.—The toxicity of these anesthetic salts is reduced to a minimum by various measures. The concentration of the solution is restricted to certain limits, and the solution itself reacts in the human system according to certain fixed laws. If the patient is given a solution of appreciable strength by the mouth, a much too rapid and extensive absorption takes place, which is generally followed by severe toxic symptoms. The same quantity, on the other hand, is very well tolerated subcutaneously, and is generally absorbed without any local disturbances. Nevertheless, even in subcutaneous application, the maximal dose, which varies with different salts, must not be exceeded; for most anesthetics, besides their action upon the nerve endings, produce toxic conditions in the central nervous system by way of the circulation. While partly paralyzing the brain and its special centres, they exert an irritating and destructive influence which is the greater the larger quantities are introduced into the blood. Besides, secondary effects may occur which are specific for each drug, so that the conscientious operator has every reason to familiarize himself to the smallest detail with the effects of the anesthetic which he employs.

Cocain and Its Substitutes.—Of the innumerable anesthetics offered in the market, the following should be mentioned: Cocain and its substitutes, *i. e.*, novocain, eucain alpha and beta, acoin, tropacocain, holocain, nirvanin, anesthesin, orthoform, stovain, alypin, yohimbin, and aneson, all of which with a few exceptions have been discarded after having been in vogue but a short time. Cocain, being the original preparation, has tenaciously held its own ground despite the alarming sequelæ which have frequently been observed following its injection. It possesses, however, so many serious disadvantages, above all a specifically high toxicity, that its employment is being limited more and more, greatly to the benefit of suffering humanity.

Toxicity of Cocain.—"Transitory disturbances in brain function, chiefly conditions of excitement, occur in certain patients either very soon or as late as two hours after the introduction of cocain. Some patients chatter with trembling voice, or exhibit symptoms simulating intoxication. Others talk confusedly, and show other symptoms of mental derangement and incoherence. They also experience hallucinations affecting the senses. The excitement sometimes is aggravated to the highest degree. Fits of fury and delirium lasting for days, combined with hallucinations, mania of persecution, etc., have frequently been observed. The delirious attacks may also occur intermittently. In one instance, a woman jumped up from the operating chair in a delirious fit, drank water, and, upon reaching home and retiring to her bedroom, had another spasm, though afterward she could not recollect the incident. During the stage of excitement in another woman, strongly erotic symptoms were observed. The excitement sometimes alternates with depression, which assumes the form of pronounced melancholia associated with delirium of persecution, or of profound apathy such as is generally observed after excessive excitement." (Lewin.)

"It must be kept in mind that the mucous membranes, owing to their great vascularity, absorb the alkaloid more rapidly than any other tissues, especially when the former are inflamed. Generally it may be said that adults can tolerate without untoward effects up to 5 centigrams of a 1 or 2 per cent. solution. In dental operations, however, never more than 3 centigrams should be injected.

"Cocain intoxication is either acute or chronic. As a rule, the first symptoms of an acute intoxication appear within ten or fifteen minutes after the injection, sometimes, however, not until half an hour or three-quarters of an hour afterward. These symptoms are the following: Precordial depression, closely resembling the pain in pulmonary and cardiac oppression, very thin and rapid pulse, pallor of the face, coldness of the extremities, abundant perspiration, high temperature which may rise to 40° C., irregular respiration, disturbance of the digestive tract in the form of bilious vomiting sometimes associated with diarrhea, diminished urination and anuria, which in some cases was observed from twenty-four to forty-eight hours after injection. The psychic disturbances are of a most pronounced character, and manifest themselves in the form of excitement or garrulousness; sometimes the patient sheds tears, or exhibits great anger or fury. The tactile sense is impaired especially in the hands, a prickling sensation sometimes being noticed. Cases of cramps, or symptomatic cocain epilepsy, have been observed, followed by a condition of motor and sensory paralysis lasting several days. Hysterical attacks have also been noted. Cases of death from cocain intoxication have occurred suddenly, in some cases two minutes after the employment of this alkaloid, in others within from half an hour to five hours. While the untoward after-effects are not often fatal, nevertheless the disagreeable secondary symptoms last several hours, sometimes several days. Post-mortem examinations have revealed acute congestion of the lungs. Sometimes numerous small infarcts, also edema of the lungs, inflammation of the cardiac muscle and the dura mater, have been observed, although the last symptom is not quite certain." (Brouardel.)

By a long series of carefully conducted experiments Sikenberg[1] has proved, contrary to recent teachings, that adrenalin injected simultaneously with or after cocain does not reduce the toxic effect of the alkaloid. Equal doses of cocain with or without adrenalin had the same effect, the lethal dose also being the same. The anesthetic effect of cocain is by no means intensified by the addition of adrenalin, and the same quantity of cocain is required no matter whether adrenalin is added or not.

The limit of concentration of a non-toxic cocain solution cannot be accurately determined. Cases have been observed in which more than 2 grams of cocain were tolerated without serious sequelæ, while very low doses of 1 cgm. have proved fatal. In regard to toxicity, it is essential to note whether strong or weak doses of solution are employed, also whether the drug is applied to the mucosa or subcutaneously. But even in subcutaneous injection the alkaloid may accidentally enter a vessel directly and reach the circulation, so that a large quantity of the poison is conveyed to the brain in a relatively short time.

[1] Archiv f. klinische Chirurgie, vol. lxxvii, No. 2.

The absorption of the solution takes place much more rapidly in highly vascular tissue, such as the oral mucosa, the periosteum, etc. Cases of cocain intoxication after minimal doses must be attributed to idiosyncrasies.

Cocain is a pronounced protoplasmic poison. It immediately retards the ameboid movements of certain cells, and inhibits diapedesis of the leukocytes. Cocain furthermore acts as a specific toxin upon the nerves, kidneys, and heart; diseases of these organs, therefore, constitute a contra-indication to this drug. It is also contra-indicated in anemia, chlorosis, neurasthenia, nephritis, heart disease, physical debility of old age and convalescence.

It was only natural that, after these numerous unfavorable experiences with cocain and its solutions, the writer joined such investigators of note as Braun, and others, in a thorough examination of the substitutes for cocain. Of the cocain mixtures which are still in use, eusemin, for instance, continues to enjoy great popularity. In a prospectus eusemin is called the "ideal local anesthetic, first, because of its sterility; second, because of its non-toxicity; third, because of its effect as proved by experiment and practice." Regarding the second point we must protest, for at present there exists no entirely non-toxic local anesthetic, least of all should any solution that contains cocain be represented as non-toxic.

Moreover, the preparations marketed in ampoules are somewhat untrustworthy, according to recent opinions, because their stability is a limited one. For this reason, freshly made solutions are absolutely preferable to all stock preparations. At any rate, all cocain preparations should be shunned, no matter how carefully compounded.

Substitutes for Cocain.—After an experience with injection anesthesia extending over ten years, we feel justified in making a statement which characterizes the present status of the question of solutions. Cocain, even in infinitesimal doses, may have toxic secondary effects, as Biberfeld, Lewin, Dorn, and Ritter have confirmed, and eusemin is no exception to this rule, as we have ascertained by experiment. Like Lewin we must assume that "the after-effect of cocain anesthesia does not depend upon the strength of the dose applied," but the patient's physical and mental condition plays an important role. This latter factor may be so preëminent that even an ordinary dose of novocain, although seven times less toxic than cocain, may produce slight toxic symptoms, as has been proved in several reported cases.

That novocain, on the other hand, is a complete substitute for cocain has initially been affirmed by Braun. We can but fully endorse his excellent discussion of this subject, after having employed novocain to the fullest extent in dental practice, and do not hesitate to emphasize that cocain preparations must be banished from injection anesthesia, and novocain adopted as the most suitable anesthetic up to date. Port, for instance, in over 300 injections of a 1 per cent. novocain solution, has not observed one single case of intoxication, while he noted several unmistakable instances of intoxication in an equal number of control injections of cocain, one of which was serious.

In view of the glaring advertisements of various anesthetics which are shrouded in more or less mystery, it is about time for us to emancipate ourselves from the manufacturer's tutelage and to go our own way, which has been clearly indicated by unselfish investigators. In the hands of an operator who has learned to master the technique of injection, novocain solution will never be found wanting. Most cases of failure are undoubtedly due to a lack of technical skill, as has been freely admitted by many dentists who have learned or practised local anesthesia in our clinic. For this reason an elaborate description of the technique of injection is offered in this volume, as this feature is really much more difficult than may appear at first glance.

Novocain, as has been stated, is the leading substitute, and owing to its numerous advantages is being more and more generally introduced in dentistry. It has already found its place in surgery, and seems to be destined to supplant cocain entirely. Fortified by an extensive experience with anesthesia by novocain solution, we shall therefore speak chiefly of that preparation, and refer to cocain and its application by way of comparison only, since, as Braun says, "cocain has become obsolete in surgery, and is no longer used. The drug houses, of course, will continue to make the old preparations as long as there is any demand for them."

Quinin and Urea Hydrochlorid Compounds Contra-indicated.—Certain quinin compounds, Riethmüller[1] writes, have within recent years been employed for the production of local anesthesia in minor surgery, and the combination of quinin and urea hydrochlorid has received quite some discussion among the dental profession to whom this combination has been offered under proprietary names. A great many untoward sequelæ, however, have been produced by its use hypodermically, such as local hemorrhage, oozing, extensive sloughing, abscess, continued fever, swelling, gangrene, and tetanus.[2] Boiling of quinin for the purpose of sterilization not only produces deterioration of the drug chemically, but materially impairs its therapeutic efficiency. H. Prinz[3] scrutinizes the value of this anesthetic compound, and reaches the following damaging conclusions: While it is true that quinin and urea hydrochlorid is not poisonous in the doses in which it is injected for local anesthesia purposes, yet, since it reacts strongly acid, it severely damages the tissues in the injected area, edema and induration being the usual sequelæ. The injection is more or less painful, and the mixture interferes with the progress of wound-healing. The excessive length of duration of the anesthesia, and the paralysis persisting from several hours to several days, is most disagreeable and often alarming to the patient. If applied in concentrated solution to the mucous surfaces, this compound is only sparingly absorbed, and very little anesthesia is produced. Besides, its most persistent bitter taste renders its use undesirable for this purpose. "From the foregoing we conclude that quinin and urea hydrochlorid, when employed as a local anesthetic in dental operations, possesses no advantages as compared to novocain. While, *a priori*, its non-poisonous nature indicates safety, this safety is only relative, as it refers to larger doses. The small dose of novocain necessary for the average dental operation may be considered a safe dose."

[1] Dental Cosmos, February, 1913.
[2] Ibid., February, 1911, p. 253; October, 1913, p. 1061; November, 1913, p. 1196.
[3] Ibid., January, 1911.

NOVOCAIN AND ITS SOLUTIONS.

Secret Preparations of Local Anesthetics.—While a great many local anesthetics with fancy names and of secret or only partly disclosed composition are in the market, it is significant to note that within the last year a few of the most popular are being manufactured with novocain as their active anesthetic principle instead of cocain as formerly. These ready-made secret solutions are not very stable, unless they contain strong preservatives which are highly irritating to the tissues. Moreover, as Riethmüller writes, "the large majority of these preparations should be shunned by any practitioner who respects the scientific standard of his profession. From a merely practical point of view it should be remembered that the price of these proprietaries is too high in comparison to their efficiency, and the mystery in which the manufacturers shroud the composition of their products puts the operator at a great disadvantage medicolegally in case of suit for damages following any accident."

For the selection of an anesthetic, the following principles have been laid down by Braun:

1. The local anesthetic must be less toxic than cocain.
2. It must not cause any tissue lesions.
3. It must be soluble in water, and its solutions must be sterilizable.
4. It must allow of combination with suprarenal preparations.

Novocain.—Novocain fulfils these requirements. It was discovered by Einhorn in 1905. It is a white powder, readily soluble in water in equal proportions. The salt crystallizes in alcohol in the form of small needles which melt at 156° C. It dissolves in the proportion of 1 to 1 in water, forming a neutrally reacting liquid. In cold alcohol it is soluble at the ratio of 1 to 30. The solutions can be heated up to 120° C. without undergoing decomposition. After suprarenal extract has been added to a novocain solution the mixture should be boiled for a short time only, as the active principle of suprarenin loses its effect by continued boiling, and the drug itself is decomposed.

Novocain has the same action on the peripheral sensory nerves as cocain. A 1.5 per cent. solution is fully sufficient to anesthetize within ten minutes even large nerve trunks.

"The 1 per cent. novocain-suprarenin solution serves almost all purposes and is most suitable for general practice. . . . Without fear of toxic secondary effects, 1.25 gram novocain, *i. e.*, 250 c.c. of a 0.5 per cent. solution, or 125 c.c. of a 1 per cent. solution, and more, can be injected. If a 2 or a 4 per cent. solution is employed, a dose of 0.8 gram novocain, *i. e.*, 40 or 20 c.c. of these solutions respectively, should not be exceeded; for injections into tense and highly vascular tissue, such as the gingivæ, a lower dose will suffice. On the whole, little attention need be given to the dosage of novocain, unless an attempt is being made to operate under local anesthesia in an all but hopeless case that presents an enormous operative field. To this feature of novocain the remarkable progress of local anesthesia is in a large measure due." (Braun.)

Systemic Effects after Absorption.—The systemic effects after the absorption of novocain are hardly noticeable, neither circulation nor respiration being influenced. The heart action is not affected. From 0.15 to 0.2 gram, when injected subcutaneously in rabbits, produces hardly any change in the tracings of blood-pressure and respiration as registered by the kymograph. Novocain does not produce mydriasis, disturbances in accommodation, or increase in intra-ocular pressure. Its low toxicity can easily be demonstrated by comparing the lethal dose of novocain with that of cocain or stovain per each kilogram of body weight in different animals.

The comparative lethal doses of these drugs, when injected subcutaneously, are per kilogram body weight: In rabbits, novocain, from 0.35 to 0.4 gram; cocain, from 0.05 to 0.1 gram; in dogs, novocain, 0.25 gram (not yet lethal); cocain, from 0.05 to 0.07 gram. The minimal lethal dose in rabbits per kilogram body weight is 0.73 gram of novocain when injected subcutaneously in a 10 per cent. solution.

Effects of Novocain.—Novocain solutions are absolutely non-irritant. Even if 20 per cent. solutions or the pure powder are introduced into fresh wounds, not only no untoward symptoms whatever are observed, but the local inflammation is reduced, as we have been able to demonstrate. Solutions can be boiled any number of times without disintegration. The toxic effect of novocain is relatively light. In very high doses tonicoclonic spasms, together with opisthotonos, great agitation, accelerated and shallow respiration, are noted. The maximal dose for subcutaneous injection is 0.8 gram. Novocain is seven times less toxic than cocain, and three times less toxic than its other substitutes.

Novocain has a transitory vasodilator effect, but is fully equal to cocain in its anesthetic power. The unfavorable vasodilator action of novocain is counteracted by combination with suprarenal extract; in fact, its anesthetizing power is considerably enhanced by this admixture.

Another great advantage of novocain, which Riethmüller wishes to emphasize, lies in the fact that it is not a habit-forming drug. This is of vital importance when we remember that many an unfortunate victim of the cocain habit has been started in this fatal practice by the application of cocain by well-meaning dentists or rhinologists. Since the legislatures of several states of the Union have placed the ban upon the sale of cocain and cocain mixtures except upon a physician's prescription, the exemption of novocain from such laws is a matter of momentous interest to the dentist.

Consequently, as Braun has declared, novocain is "an ideal anesthetic which can not only be substituted for cocain in every case, but considerably enhances the safety of local anesthesia owing to the possibility of safely injecting much greater quantities of a strongly active anesthetizing solution."

Opinions Regarding Novocain.—"We must emphasize that our experiences fully coincide with those of Braun, Hainecke and Læwen. The results of 255 observations have proved that novocain is a non-irritant, rapid and intensely effective local anesthetic, which produces no toxic secondary effects, no irritation or necrotic symptoms. Novocain does not impair the action of suprarenin in the least, and can be well sterilized. We have arrived at the conviction that novocain at present is the only known agent fit to take the place of cocain in surgery, and we can warmly recommend it for use in medical practice." (Danielsen.)

"A résumé of our clinical experiences shows that novocain represents a non-toxic and superior substitute for cocain for the purpose of local anesthesia by injection in the tissues, its maximal dose is 0.5 gram, it allows of an ideal combination with suprarenin, and produces absolutely no irritation." (Liebl.)

Novocain-suprarenin.—"The effect of suprarenin, far from being impaired by novocain, seems to be enhanced by this drug, as my very first tests have shown and numerous subsequent investigations have corroborated. The anemia which follows novocain-suprarenin injection is much more pronounced than when a pure suprarenin solution or a cocain solution containing an equal amount of suprarenin is employed. Independently of my observations, Dr. Biberfeld had noted the same curious fact. The combination of novocain and suprarenin, and the behavior of these two drugs toward one another, is of great advantage in local anesthesia, inasmuch as only very small quantities of suprarenin are needed to intensify the local anesthetic action of novocain to as high a degree as is peculiar to cocain-suprarenin solutions. These small admixtures of suprarenin also retard absorption and thereby render the anesthetic action purely local and limited to the place of injection. The power of these novocain solutions in regard to intensity, duration, and extension of anesthesia is at least as great as that of cocain solutions. All the operations described in my book can equally well be performed with novocain as with cocain solutions. For infiltration and conductive anesthesia, novocain in combination with suprarenin is the most suitable agent." (Braun.)

Suprarenin.—Suprarenin is derived from the suprarenal gland and possesses the specific property of contracting the walls of the capillaries and small bloodvessels within an injected area. The toxic effect of the injected anesthetic solution is thus minimized and its absorption retarded while, at the same time, anemia is produced so that the field of operation remains unobstructed by parenchymatous hemorrhage. In former years, suprarenal preparations were secured from the suprarenal glands of sheep and oxen. Synthetically prepared suprarenin, however, is much purer, less toxic, and more stable than the organic product.

Suprarenin is a grayish-white powder, slightly soluble in water, and readily soluble in dilute acids. It is the most powerful of all chemical substances thus far known, being active even in a dilution of 1 in 100,000. Its toxicity is therefore relatively high, and more than 0.5 mg. should never be injected in one dose. The toxic symptoms produced by suprarenin consist chiefly in palpitation of the heart, oppression, and difficult respiration.

Suprarenin has no anesthetizing power, but, as has been said, produces contraction of the small bloodvessels and capillaries. A solution of 1 to 1000 seems to be most favorably indicated for injection.

Contraction of the bloodvessels occurs also when suprarenal extract is applied locally to the mucous membranes, or injected into the tissues.

Suprarenin, according to the findings of Kochmann and Esch[1] has the property of preparing the nerve tissue for the reception of the local anesthetic, in about the same manner as a mordant is applied in the dying industry for rendering the cloth more receptive of the dyestuff.

Adrenalin, a suprarenal preparation of English manufacture, is mixed with a small quantity of chloretone for the purpose of rendering the solution more stable. This effect of chloretone, however, has been disputed by B. Müller, who found that chloretone impairs the action of adrenalin.

Stability of Suprarenin Solution.—Even synthetic suprarenin is stable only to a limited degree after the bottle has once been opened; for this reason the transferring into another vessel of the quantity required in every case, as recommended by Seidel, seems impracticable. In private practice it is best to make a fresh solution from tablets, as cases present themselves. "The very convenient tablets," as Braun writes, "are preferable to any other form of dispensing alkaloids used for medical purposes. This is especially true of unstable drugs like suprarenin which, in dry tablet form, keeps for a long time."

[1] Deutsch. Zahnärztliche Wochenschrift, vol. ii, p. 65.

For injection, a slightly acidulated sodium chlorid solution is used as a base to which suprarenin is added in the concentration of 1 in 1000. Even fractions of 1 mg. of suprarenin suffice to produce anemia in a very large operative field, if the anesthetic mixture has been introduced in sufficient quantity and evenly distributed in the tissue, *i. e.*, along the periphery of the area to be operated upon.

If synthetic suprarenin is exposed to light for some time, the originally clear solution undergoes a reddish, later a yellowish, discoloration. Any slightly discolored solution is unsuitable for use, as the toxicity of the drug is considerably increased by the chemical changes which produce the discoloration.

Biberfeld has ascertained that synthetic suprarenin is also clinically equal to the organic product. In my opinion, however, the organic product generally exhibits greater toxicity than the synthetic preparation.

Action of Suprarenin.—Suprarenin is dispensed and used in physiological salt solution. If applied externally upon the mucous tissue, the solution produces anemia within from one-half to five minutes; if injected hypodermically, in from fifteen to thirty seconds. The anemia is complete as soon as the originally pink mucous tissue has assumed a pale, whitish shade. The action of the solution extends only within a radius of from 1 to 2 cm. After the anemia has disappeared, primary dilatation of the bloodvessels ensues, until gradually the vascular walls return to their normal condition.

Toxicity of Suprarenin.—Suprarenin may exhibit an intensely toxic action if introduced into the circulation in excessive quantity or concentration. The toxicity is greatest when the drug is injected intravenously, viz., directly into the blood. According to Batelli, its toxicity is forty times greater when it is injected intravenously than when it is introduced subcutaneously. Even the doses employed for dental purposes sometimes produce untoward toxic symptoms, such as palpitation of the heart, acceleration of pulse, dizziness, fainting, and collapse, especially if stale solutions are employed. This danger is reduced to a minimum if a fresh solution is prepared from tablets, while solutions made with liquid suprarenin are always risky.

The maximal dose of suprarenin may be said to be 10 drops of a 1 to 1000 solution of the synthetic preparation.

The size of the drops is measured by a standard pipette. Seidel justly emphasizes accuracy in the size of the drops, after having shown that 3 c.c. of synthetic suprarenin furnished 36 drops with a dropper, 93 with a pipette, and 45 with the original bottle. Organic suprarenin differed in this respect from the synthetic product, the same quantity yielding 34, 73, and 25 drops respectively. It is important to avoid the sudden introduction of a large quantity of the drug into the blood. Even a 1 to 1000 solution is extremely efficacious; hence, when injected as admixture to an anesthetizing solution, suprarenin should be used in more dilute form.

The Standard Pipette.—Dr. Schönbeck has endeavored to design a so-called standard pipette which would be most suitable for practice. He made the interesting observation that all the standard pipettes, as bought from various apothecaries, furnished drops of different sizes, proving that there was no uniform standard pipette. We have figured that 1 c.c. of 1 to 1000 synthetic suprarenin should be divided into 32 drops in order to insure the normal dose of suprarenal extract. This requirement is fulfilled by Dr. Schönbeck's so-called "Tested Standard Pipette."

Seidel has recently suggested a small instrumentarium for the preparation of fresh novocain-suprarenin solutions, in which a pipette of dark glass and with double cover is included. This pipette, when being held vertically, yields 31 drops per 1 gram of 1 in 1000 suprarenin. Two drops of suprarenin added to 3 c.c. of a novocain solution give the average dosage of 0.00002 per 1 c.c., as indicated by Seidel.[1] With every dropper it must be ascertained "how many drops per 1 c.c. it produces. Unless this precaution is taken, dosage by drops is absolutely unreliable." (Braun.)

No Tissue Lesions from Suprarenin.—A fortunately rare danger consists in postoperative hemorrhage, which has been observed in reaction to the abnormal vascular contraction followed by hyperemia, especially after tooth extractions. Suprarenin by its extremely local

[1] Deutsch. Monats. f. Zahnheilkunde, 1911, p. 889.

action most effectively retards the process of local circulation, and, in some cases, may endanger the dental pulp. This danger, however, does not seem to exist with the now generally adopted dosage of our injecting solutions, as Euler and Scheff have recently proved by experiment. The latter found that novocain-suprarenin solutions do not in the least disturb either the vitality of the teeth anesthetized or that of the approximating teeth, "provided the perfect vitality of the pulp before application of the drug has been established beyond all doubt." (Scheff.)

Suprarenal extracts, especially suprarenin-Hoechst, are marketed in the form of 1 in 1000 solutions ready for use, to which a slight trace of hydrochloric acid has been added for the sake of stability, or in the shape of compressed tablets of 1 mg. each. One of these tablets is calculated to be added to about 50 c.c. of a 2 per cent. novocain solution. The combination tablets E and G, however, which contain novocain together with the proper small percentage of suprarenin, are far more practical. While in ready solution suprarenin keeps for a short time only, it remains unchanged for a long period in the dry tablet form. Since the sterility of these tablets is not always uniform and certain, solutions made from tablets must be sterilized before use. Braun recommends the addition of a trace of hydrochloric acid to the normal saline solution in which the tablets are dissolved, *i. e.*, 3 drops of dilute hydrochloric acid to one liter of normal saline solution.

In his opinion, the dosage of suprarenin is of little importance in local anesthesia, because the dilutions of 1 in 100,000 and of 1 in 200,000 will not produce any systemic effects. Hospital internes are employing considerable doses in collapse due to infectious diseases, *i. e.*, as much as 6 mg. per day, even 24 mg. per day. (Kirchheim.) The doses required in local anesthesia may therefore be considered innocuous as long as a pure and fresh preparation, preferably one made from tablets, is employed.

The concentration of the suprarenin in the anesthetic solution, however, is of importance, as it determines the intensity of the local effect of the anesthetic and the duration of anemia. This anemia should never be so pronounced as to interrupt the circulation of the blood completely. Excessively strong suprarenin may cause gangrene, especially in arteriosclerotics. Generally, however, the doses indicated above produce no untoward action whatever in the tissues.

In patients with heart disease, in children, and in the aged, it is advisable to reduce the concentration of the suprarenin by adding to one tablet E a little more of the Ringer solution (see page 163), 1 c.c. of which gives a 2 per cent. novocain-suprarenin solution when one tablet E is dissolved in it. The excess of Ringer solution also reduces the novocain contents, and a less toxic solution is obtained, but the anesthetizing power of the solution is still more than sufficient, as innumerable practical cases have shown. The tablet G, which yields a 1.5 per cent. novocain-suprarenin solution is even less toxic, though quite efficacious when dissolved in a greater quantity of Ringer solution.

THE INJECTING SOLUTION OF NOVOCAIN–SUPRARENIN.

The Injecting Solution.—Novocain-suprarenin solutions which are intended for injection must always be of the purest quality; they must be crystal-clear and not contain any admixtures; nor must they have come in contact with any impurities during the process of preparation. Toxic secondary effects may occur if the solution has not been sufficiently protected from light and heat and subsequent decomposition, which is evidenced by the flocculent appearance of the solution.

The quality of an injecting solution is also generally evinced by its behavior toward the living organism. It should penetrate the tissue cells without producing any lesions in the way of distention or contraction. This property of a solution is called isotonia.

Isotonia.—Every body cell is protected from the tissue fluids by a semipermeable membrane which regulates the interchange of the fluids between the cell contents and the cell environment, *i. e.*, maintains metabolism. If the fluids within and without the cell are of the same consistency, if their percentage in salts is the same, then isotonia or equal tension is present. If, however, the percentage in salts in the environment of the cell exceeds that within the cell, then there is a tendency to equalization. Since, however, only water, not salts, diffuses through the plasmatic membrane, the salts, on the other hand, have a tendency to absorb the water from the cells, the water leaves the cells, causing a contraction; or, if the reverse is the case, *i. e.*, the cell environment is deficient in salts, a distention of the cell ensues. The power that regulates this interchange is called osmotic pressure. Cell disturbances are caused by difference in concentration, *i. e.*, difference of osmotic pressure on either side of the cell membrane. If, then, a solution is injected which does not conform with the amount of salts in the tissue, the cells are either contracted or distended. The absorption of the injected solution is retarded and a pathological condition ensues which often assumes the form of edema. *Hypertonic solutions*, *i. e.*, those rich in salts, and *hypotonic solutions*, *i. e.*, those poor in salts, may, in unfavorable cases, produce necrosis of the tissues, especially when they contain highly toxic drugs such as cocain.

Non-isotonic Preparations.—Numerous solutions in the market not only contain admixtures of highly toxic drugs but also lack sufficient neutrality; in other words, they are not isotonic but heterotonic, if we may use this term, as has been proved by the writer's former assistants, Buente and Moral. Hemolysis of the human blood corpuscles was produced by the following drugs: Bernatzik's solution, Wilson's anesthetic, Krause's world anesthetic, adralgin, Winter's anesthétique local, Bönnighausen's local anesthetic "corona," subcain (which induced the formation of methemoglobin), nalicin, andolin, udrenin, Pohl's *a–c* subcutaneous tablets, phenyphrin (which also induced the formation of methemoglobin), orthonal, Ritsert's simplex subcutin, Witte's local anesthetic, dolorant (producing incipient hemolysis), Schröder's analgesic, and dolantin.

In contrast tō these, novocain penetrates the tissue cells, the red-blood corpuscles, etc., without producing any irritation; it in nowise impairs the hemoglobin, and permeates even the nerve substance, so that its anesthetic effect is fully developed.

The injected fluid rapidly enters the circulation. As one circulation is completed in the human body within twenty-seven seconds, the injected fluid reaches the heart and the central nervous system within about thirteen seconds. This explains the extraordinarily rapid action of toxic agents when injected into the organism.

Harmless solutions, such as the novocain-suprarenin solution advocated, are very readily excreted by the urine and the perspiration, so that untoward effects of a local (edema) or general nature need not be anticipated.

Besides the above-mentioned conditions, an injecting solution must fulfil the following requirements:

1. The solution should not be detrimental to the blood or the tissue cells.

2. It should not alter the hemoglobin.

3. It should not produce any distention or contraction of the cells or hemolysis; it must be isotonic. Its freezing-point must be about $-0.55°$ C.

4. It should contain an accurately determined average amount of the anesthetic.

5. It should not react acid.

6. It should be free from unnecessary or harmful admixtures.

Addition of Thymol.—The addition of an antiseptic for the purpose of greater stability of the solution has been abandoned on the strength of the clinical experiences of the last two years. The admixture of thymol as formerly recommended may produce a more or less painful irritation during the injection of the solution. In my opinion, and according to recent observations, this pain is not uniform, and even if it is present its intensity is minimal. A great many practitioners still adhere to the addition of thymol, as it does not produce any tissue lesions. Fresh solutions made from tablets, however, do not require any admixture for the purpose of greater stability, so that thymol can be omitted without any detriment to the solution.

Temperature of the Solution.—The temperature of the solution should correspond as nearly as possible to that of the tissues. The farther we deviate from this optimum temperature, especially on a downward scale, the greater is the likelihood of irritations resulting. Injections of very cold or hot (above $+55°$ C.) solutions produce serious tissue lesions, usually followed by extremely painful infiltrations. The latter occur also when the solution is not quite sterile, or when the admixtures, especially the suprarenin, have undergone alteration or decomposition.

Recent investigations of Moral have shown that temperature has a pronounced influence upon the anesthetic power of the solution, which should be injected at body heat. Solutions of that temperature have proved to be most satisfactory. This condition can be easily brought about in making a solution from tablets. After boiling, the solution is quickly drawn into the syringe and injected, as it then has the optimum temperature.

Ampoules.—For the requirements of daily practice it seemed expedient to dispense novocain-suprarenin in ampoules so as to offer the solution ready for use in convenient form. Our experiences with these ampoules, however, induce us to give the preference to solutions freshly made from tablets, for the present at least. The ampoule solution decomposes more quickly, and its stability depends upon the conditions of temperature and light under which it is preserved. Although it is possible to market stable ampoule solutions if all precautionary measures are strictly observed, the manufacture of these solutions is variable and uncertain. Besides, suprarenal extract is not stable for any length of time when in liquid union with novocain.

In medicine, nevertheless, thousands of ampoules are being used daily. We are continually conducting experiments with ampoules, and do not hesitate to confess that, as soon as it becomes possible to eliminate all imperfections, the ampoule solution will be the ideal of convenience for innumerable practitioners. We have employed preparations which were twelve weeks old and over, and upon opening found the solution crystal-clear and no less perfect in regard to anesthetic power than a freshly prepared solution. The process of manufacturing ampoules, however, is not as yet generally perfected so as to guarantee their durability absolutely; especially the technique of sealing the sterile contents of the ampoule by fusing the neck seems difficult and uncertain, and even first-class laboratories sometimes market ampoules which are unsuitable for use after a very short time, because they are not hermetically sealed. It is probable, however, that the experiments toward improving the technical procedures of sealing ampoules and testing each one in a vacuum will shortly lead to satisfactory and fully reliable results. The small glass splinters which may be produced in breaking the neck of an ampoule, do not seem to constitute a weighty contra-indication, and no untoward consequences from this source have ever been reported. In short, an improvement in the manufacture of ampoules will soon prove their eminently practical value.

The closing of ampoules with small rubber disks is to be discountenanced, because the sulfur compounds in rubber imperil the stability of a solution containing suprarenin admixture. This has been shown by the decomposition of suprarenin in bottles closed with rubber stoppers; since these have been substituted with glass stoppers, suprarenin solutions are more uniform and stable.

Those practitioners who employ ampoule preparations of reliable manufacture should proceed as follows:

Ampoules must be kept as aseptic as every other instrument used for injection. The unbroken ampoule contains a sterile solution, yet its outer surface is by no means sterile. It passes through many hands, is packed in ordinary cotton, and should therefore not be used without having been previously sterilized. The operator is cautioned not to nick the neck of the ampoule with a file in order to break it more easily. This measure invites sepsis, and is absolutely unnecessary, even dangerous. From the file numerous infectious bacteria are introduced into the sterile solution after the neck is broken. Ampoules are best sterilized by carefully washing some half dozen in a weak solution of carbolic acid or lysoform, drying and preserving them in a covered glass jar or tray of dark violet color containing 70 per cent. alcohol. When needed, an ampoule is taken from the alcohol with sterile pincers and laid between sterile gauze or cotton, the neck is broken in the gauze while inverting the ampoule—an easy procedure—the mouth is carefully exposed, and the contents are drawn out through an iridio-platinum hypodermic needle which has previously been sterilized by passing through an alcohol flame.

Dr. Schönbeck has made interesting experiments in order to ascertain whether in the customary process of opening an ampoule with the beaks of nippers or by holding it in a clean napkin, the sterile solution can be infected, and to what degree. In these tests the outer surface of the ampoule which contained a sterile solution was not previously sterilized. In all cases the solution was found to have been infected in the opening process. It remained sterile only when carefully manipulated in the manner described.

Tablets.—Since the preparation of novocain solution from the powder, with suprarenin added in drops, is not sufficiently reliable and uniformly practicable in daily practice, the use of tablets as in general vogue in surgery is given the preference.

Sterility of Tablets.—Braun bacteriologically analyzes every year the novocain tablets of a certain drug firm, and finds them always sterile. Some time ago Hoffmann reported that, on analyzing tablets from another drug firm, he discovered that over one-half contained bacteria. Professor Riesel, upon Braun's instigation, analyzed numerous tablets of the first make, all of which were found sterile. Nevertheless there is a possibility of tablets occasionally containing bacteria.

Upon investigation it appears that novocain tablets will keep for years if protected from light and humidity. Failures are due to other causes, such as lack of cleanliness, use of sodium chlorid solution contaminated with bacteria, or rinsing of the syringe with lysol or soda, which causes decomposition of the suprarenin. The physiologic salt solution employed in dissolving these tablets must be absolutely free from soda as this precipitates alkaloids and decomposes suprarenal preparations. In reference to this phenomenon Peuckert says:

"It was a matter of great importance to find an effective and reliable method of sterilization for these tablets, and Braun, after continued experiments, soon arrived at a practical result. He recognized that the source of decomposition of suprarenin solution invariably lies in traces of alkalies present in the dissolving media, due partly to the alkalinity of glass, partly to other causes. If suprarenin solution is boiled in absolutely non-alkaline sodium chlorid solution or in non-alkaline distilled water, or sterilized by steam, in a non-alkaline glass vessel which has been previously treated with hydrochloric acid, the solution retains its color and full power. These precautions not being feasible in an average dental office, the absolutely accurate work of a chemical laboratory is required. In our operating rooms, where lots of soap and soda are used, it is impossible entirely to prevent alkaline traces from getting into the solutions; this difficulty, however, can easily be overcome by other means.

"To one liter of the physiologic salt solution to be used in dissolving the tablets, 2 drops of official dilute hydrochloric acid are added. Solutions made from novocain-suprarenin tablets in this slightly acidulated salt solution may then be either boiled or sterilized in steam without losing any of their power. The greater stability of this solution is evident, as no red discoloration at all occurs, or, if any, only after prolonged standing.

"No physiologic effects from this added tinge of dilute hydrochloric acid can be noted after injection, especially no tissue lesions. On the other hand, the hydrochloric acid suffices to neutralize the alkaline traces which may be present in the salt solution or in the glass vessels employed, and which invariably remain in syringes and needles boiled in soda solution, even if these are rinsed in water or sodium chlorid before use."

For operations in the mouth Braun dissolves in 25 c.c. of salt solution one tablet containing 0.00016 borated suprarenin in a dilution of 1 to 150,000. Of this 0.5 per cent. novocain solution he has safely injected up to 150 c.c., containing 0.00096 gram suprarenin, viz., more than the maximal dose, which is given as 0.5 mg.

During the 1912 meeting of local anesthesia experts, held at Münster, it was the consensus of opinion that a freshly made solution of novocain mixed with suprarenal extract immediately before use was most desirable, and Seidel showed a procedure which, according to his claims, guaranteed the purity of the solution. But even Seidel's method offers no absolute certainty that the two component parts of the solution, especially the suprarenin, will keep fresh and undecomposed for more than a few days. Even such a simple solution as physiologic sodium chlorid, though preserved in specially constructed stock vessels (see Fig. 1), will not remain sterile for more than two or three weeks. How much less can we then reasonably expect of the stability of such a delicate substance as suprarenin? The best chemical works invariably warn in their suprarenin circulars in emphatic terms that the stability of sterile suprarenin solutions is best guaranteed by preserving them in the original bottles, saying: "Pouring into dropping-bottles, etc., is contra-indicated."

Braun also, who undoubtedly has had widest experience in the question of solutions, says: "The tablet method is the simplest and most reliable. Outside of large surgical institutions it is the only one which should be recommended. Practitioners should never have solutions of alkaloids made by an apothecary and keep them in a medicine chest until needed. An incalculable lot of damage has been done by such practice." The argument advanced against the tablet method, viz., that it does not allow of modification of the suprarenin admixture, is untenable according to Braun's statement that "the dosage of suprarenin in the infinitesimal doses in which it is employed in local anesthesia is fairly immaterial. These greatly diluted doses must be regarded as absolutely innocuous, provided a pure preparation and fresh, unaltered solutions are used."

Following the Münster meeting I have made thorough experiments in order to ascertain whether Seidel's method of making a solution is superior to the tablet method or not, and I have come to the conclusion that the advantages of adding the suprarenin to every solution made are defeated by the disadvantages inherent in this procedure. In the first place, it is very difficult in daily practice to draw the suprarenin solution into a pipette under all necessary precautions; moreover, the suprarenin becomes easily contaminated by the influence of air, light, temperature, dust, etc., every time a few drops are poured out. Chemists themselves admit that "the stability of suprarenin solution depends upon a great many contingencies which cannot be avoided or controlled even with utmost care. Suprarenin in solution does not keep any length of time, but in dry tablet form, even in combination with novocain, it remains unaltered for a long time." (Braun.)

For these reasons it does not seem advisable to adopt Seidel's method of preparing the solution in private practice, because it permits of new sources of error. Braun's perfect results with the tablet method in major surgery fully justify its adoption in dentistry. Following Braun's lead, and convinced by our own experiences, we must pronounce the solution made from tablets as the best and safest procedure for dental work. If we wish to individualize our dosage, we simply add 2 tablets E to 3 c.c. or 4 tablets to 5 c.c. of Ringer solution, instead of adding 1 tablet E to 1 c.c. of Ringer solution. Since, in doing so, we simultaneously reduce the dosage of novocain, we lessen the toxicity of the whole solution, and are in position to avoid failures or untoward secondary effects while retaining the full anesthetic power of the solution. In all cases where an untoward effect of the injection is feared, as in delicate and anemic patients who are subject to fainting, the stasis bandage illustrated in Fig. 9 can be advantageously employed. In thousands of cases of this kind this stasis has prevented untoward symptoms. I also fully agree with Braun that as long as the large doses of suprarenin which are employed in major surgery, and in comparison with which our dental doses are infinitesimally small, have not produced any alarming symptoms, as a perusal of the literature on this subject has shown, there is no reason to demand a modification of the suprarenin admixture in every individual case.

To make absolutely sure, I have made additional practical comparisons to ascertain whether the reduction of the suprarenin by dissolving the tablets in a quantity of liquid larger than normally intended, is really too great, as Seidel maintains, and have found that this is not the case. Aside from theoretical considerations, practical experience has proved that the diluted tablet solution is fully efficient, as can be verified by controls. In order also to test Braun's contention that the doses of suprarenal extract employed for dental purposes are so small as to be innocuous, I have employed 1.5 per cent. and 2 per cent. novocain tablets in Ringer solution, without reducing the suprarenin dosage, in about 500 cases of patients with delicate constitution, serious heart disease, arteriosclerosis, etc., and have not observed one single case of intoxication. In these cases, to be sure, the stasis bandage was employed.

After the investigations described, I fully agree with Braun that as long as the solution, and the injection, etc., are made correctly, the hair-splitting finesses which Seidel indulges in are of no practical significance for dentists. In short, the tablet method as advocated by Braun is superior to all others and most suitable for dental practice, where further modifications of the solutions are uncalled for, and will merely complicate matters.

The Solution, its Composition and Preparation.—Various concentrations of novocain solutions, viz., from 0.5 to 2 per cent., have been recommended for dental purposes. Personally, I have contended for years that it is best to keep the concentration of the novocain as well as the suprarenin as low as has been found practical in the large average of cases. In delicate adults and in children we have had excellent results with 0.5 per cent. novocain solutions, and I am still convinced that the 1.5 per cent. novocain-suprarenin solution is successful in all ordinary and even in the most complicated cases. This is also attested to by the recent reports of Braun, Adloff, and others, who find a 1 per cent. solution always satisfactory, and warmly recommend this concentration. To cite Braun: "I admit that in minor ambulatory surgery it is desirable to have only one solution with which every operation can be made, and that is the 1 per cent solution."

If I have, nevertheless, advocated the 2 per cent. concentration, this was done because it is not the concentration of the novocain so much which determines the toxicity of the solution as the suprarenin. The 2 per cent. solution can be generally recommended for dental practice without hesitation, so long as it is understood that the concentration limit of 2 per cent. must never be exceeded, while, with some experience, a practitioner may find it practical to reduce the dosage. I would certainly make a plea that the advocates of the 2 per cent. solution should not refrain from trying out the 1 per cent. and 1.5 per cent. solutions, which they will surely find fully successful after some trials. The efficacy of the solution depends upon its proper composition, perfect isotonia, and sterilization before injection. The isotonia of a solution and its optimum rapidity of absorption in the tissues are insured by the addition of from 0.65 to 0.92 per cent. chemically pure sodium chlorid. For the 1.5 per cent. novocain solution, a NaCl content of 0.7 per cent. seems best indicated.

Addition of Calcium Salts.—Professor Gürber, Director of the Pharmacologic Institute of Marburg University, has for years been making experiments regarding the behavior of calcium salts added to the injected solutions. Upon his instigation chiefly I have substituted a modified Ringer solution for the normal salt solution, and clinical evidence has shown that the addition of calcium salts is absolutely innocuous, and most favorably influences the process of absorption of the solution in the tissues. In this respect a considerable improvement has been noted as compared with simple sodium chlorid solution, and further tests have suggested also a theoretical proof of this observation. Calcium undoubtedly has an important function. A trace of calcium suffices, for instance, to increase the vital function of the leukocytes, the salts of calcium being of prime importance in phagocytosis and in resistance to infectious diseases.

Calcium chlorid 0.05 per cent. produces a stimulation in phagocytosis of about 22 per cent., 0.1 per cent. $CaCl_2$ one of 45 per cent., while 0.25 per cent. $CaCl_2$ decreases again the phagocytic action of the leukocytes.

Owing to its easy oxidability, calcium does not occur free in nature, but in the form of calcium ions it probably plays an essential part in the chemical and electrolytic processes in the organism. Its oxid, again owing to its great affinity for acids, occurs in the body only in form of a salt, while the calcium salts in turn seem to combine with various proteids.

Of special significance in this question of the action of calcium salts upon the cells and tissues is the fact that besides the calcium ion no other substance is capable of increasing the phagocytic action of the leukocytes. Hamburger has thus ascertained the following phenomena:

1. If the heart of a turtle, which in a moist medium will continue to beat for a long time, is immersed in a pure sodium chlorid solution, the beats cease immediately. Sodium chlorid, therefore, evidently

exerts a toxic action upon the heart. If, however, a minute trace of calcium is added, the heart at once begins to beat again.

2. If a trace of calcium is added to a sodium chlorid infusion the collapsing human heart almost immediately begins to work more vigorously, and the blood-pressure rises higher than it would if simply a sodium chlorid infusion were used.

The presence of calcium ions counteracts the toxic influence of pure sodium chlorid solution and stimulates the heart action. From these observations internal medicine has adopted the practice of adding calcium to every infusion.

Although pure sodium chlorid solution apparently does not exert as pronounced a toxic action upon the phagocytes as upon the heart and intestines, nevertheless a slightly toxic untoward effect is demonstrable, according to Sticker, the phagocytic power of the leukocytes being impaired. Calcium therapy also plays a surprisingly important role in infectious diseases, since calcium ions, if added to a vaccine, have a stimulating action upon the functions of the heart and the leukocytes, as for instance in diphtheria, pneumonia, and especially in tuberculosis. It has long been known that workers at lime-kilns who continually inhale liberal quantities of dust from burned and slaked lime rarely suffer from tuberculosis. In febrile conditions, the antipyretics administered by no means counteract the usually concomitant diminution in the alkalinity of the blood (Klemperer), but here again calcium therapy is employed to greatest advantage, being a purely physiologic, hence natural, method of treatment free from untoward secondary effects.

In connection with these findings, the Viennese scientists, Chiari and Januschke, have ascertained that soluble, neutral calcium salts exert a remarkably antiphlogistic action. According to Leo it seems certain that "the calcium ions in the human organism serve as solidifying agents, and their presence is indispensable especially in the enzymotic processes leading to the coagulation of fibrin and casein. The observation that only infinitesimal quantities of calcium are necessary to produce the coagulation even of large quantities of blood or milk seems to explain why such minimal quantities of calcium as are conducted to inflamed tissues by the circulation following subcutaneous injection can exert such a marked effect."

Leo has made control tests of the antiphlogistic properties of calcium salts in pneumococcic and other infections, all of which proved positive. The selection of the bacteria in these tests was immaterial, "since the action of the calcium salts is not directed against the phlogogenic organisms themselves, but these salts serve to strengthen the resistance of the tissues against the influence of phlogogenic organisms without influencing these directly." Leo has shown that small quantities of calcium chlorid, viz., 1 c.c. of a 2.5 per cent. solution, can be injected hypodermically in man without producing local or systemic lesions. In inflammations of mucous membranes, as in the mouth, Leo recommends rinsing with 2 per cent. calcium solution.

From the above brief account, the importance of calcium salts in our special field becomes evident. It is only natural that we should utilize the wonderful properties of the calcium ions in the hypodermic injection of anesthetics in order to limit to a minimum the possible sequelæ of injections. In every injection we produce a tissue lesion by the insertion of the needle; the tissue itself is inundated with a foreign fluid, and a temporary change is produced in the metabolism by the elimination of the sensory organs. Under normal conditions, and if all necessary precautions have been taken, this condition of the tissue is usually, though not always, tolerated with impunity, the solution is fully absorbed, and the temporarily altered tissue quickly resumes its normal function. In cases of acute inflammation or suppuration, however, the elimination of sensation is not tolerated so indifferently, absorption seems retarded, edema forms frequently, and even after-pain may occur. In such cases the sodium chlorid base as formerly employed seems to approach the ideal, though even then the untoward secondary effects described could not always be entirely avoided despite perfect technique, solution, and diagnosis. The calcium chlorid base, however, as we are now employing it in the form of the Ringer solution, has proved superior to the pure sodium chlorid base, in fact, ideal for local injection. The calcium salts in combination with the other salts insure surprisingly perfect absorption even in the most difficult cases, increase the penetrating action, and, in surgical cases, contribute materially to rapid and uneventful wound healing. Rinsing with 2 per cent. calcium chlorid solutions favorably influences and accelerates healing in the oral mucosa; lime water should, therefore, be given a thorough trial in all inflammatory conditions of the mouth. The advantages of the calcium chlorid base are so convincing, and clinically so evident, that it is surprising the Ringer base has not long been tried in connection with local injections, considering the fact that for quite some time all infusions have been prepared with an admixture of calcium. Why should we cling to the time-honored "physiologic salt solution" in interventions which necessitate the direct inundating of the tissues with foreign solutions? Everyone will agree that the sodium chlorid solution is by no means cognate to the cell and strictly "physiologic," since it lacks an important constituent which the cell requires for normal metabolism. These constituents—namely, calcium chlorid, potassium chlorid and sodium bicarbonate—have been determined by Ringer several years ago. Of these salts I have omitted the sodium bicarbonate as being an extremely unstable body. This omission is in no way detrimental to the effect of the solution, because, for the improvement of absorption, calcium chlorid is of chief importance.

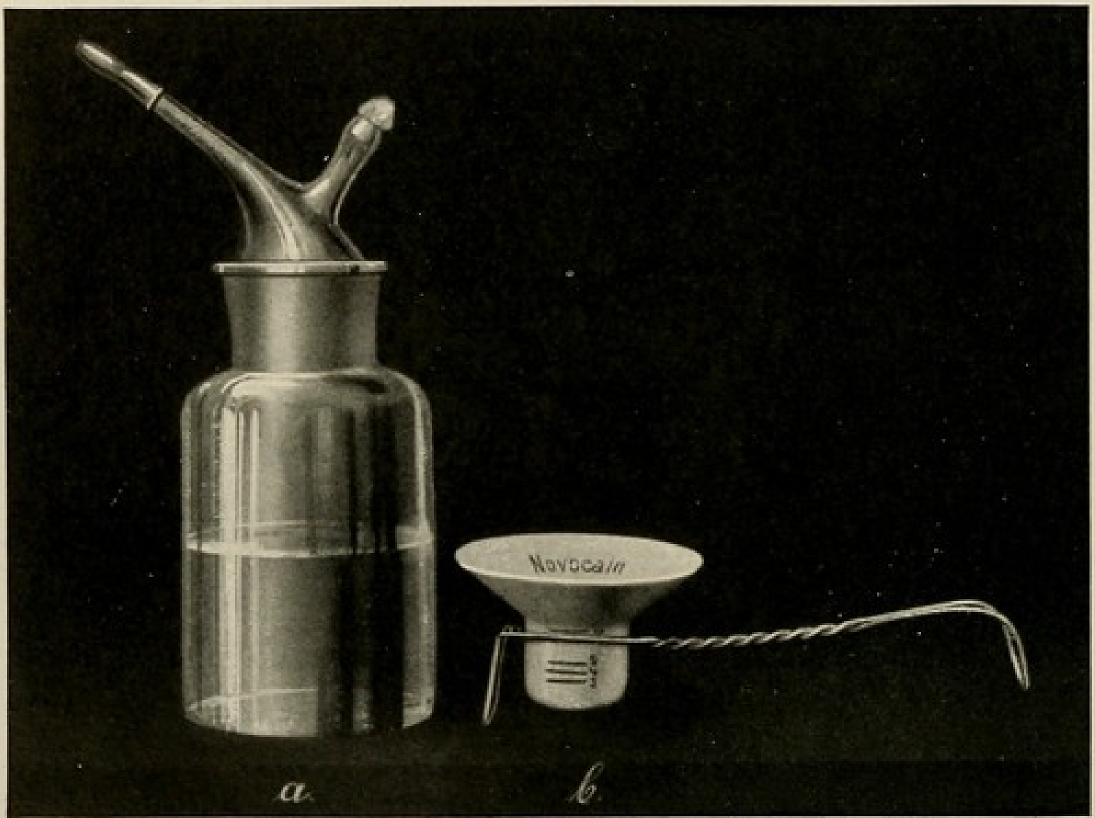
Since the summer of 1912 we have combined all imaginable percentages of local anesthetics with Ringer solution, and have noted in all cases an improvement both in the anesthetic action and the after-effects as compared with pure sodium chlorid solutions of these anesthetics. In severe purulent conditions, in which the sodium chlorid solution used to produce edema, after-pain, and disturbances in the healing process, all secondary effects were either surprisingly trivial or entirely absent. In simple injections, as a rule, no untoward sequelæ were observed.

It seems questionable whether the addition of sodium bicarbonate and potassium sulphate, which have been advocated chiefly for the purpose of better utilization of the free novocain base and reduction in the concentration of novocain, will ever prove to be practical. As compared with calcium chlorid additions, these substances are inclined to have an irritating action upon the tissues.

From these considerations I would advocate a novocain solution of the following composition:

Novocain	1.0 or 1.5 or 2.0
Sodium chlorid	0.5
Calcium chlorid	0.04
Potassium chlorid	0.02
Sterile aqua destillata	100.0
Synthetic suprarenin (1 to 1000)	0.002

Fig. 1



Flask for Ringer solution and porcelain cup for preparing and sterilizing novocain-suprarenin solution.

Preparation of the Solution.—The solution is best made from novocain-suprarenin tablets and a Ringer stock solution. The instrumentarium required for this purpose consists of a stock flask (see Figs. 1 and 11), which serves for the preservation and gradual consumption of the Ringer solution under sterile conditions, and a small test-tube, graduated to 8 c.c., both made of Jena glass. The test-tube rests upon a secure wooden stand and is held with a pair of tweezers while boiling the solution. The stock flask holds 50 c.c., and is constructed in such a manner that, without removing the glass stopper, the desired quantity can be poured off through a tapering glass nozzle, air being admitted through a small side opening which is sealed with a wad of cotton. After this stock flask, together with the rest of the instrumentarium, has been sterilized in boiling distilled water for ten minutes, it is filled with the following modified Ringer solution:

Sodium chlorid	0.5
Calcium chlorid	0.04
Potassium chlorid	0.02
Aqua destillata	100.0

The correct proportions of this modified Ringer solution are best insured if the operator makes it himself from the Ringer tablets manufactured by a few reliable drug firms, 5 of these tablets dissolved in 50 c.c. of aqua destillata giving the correct solution.

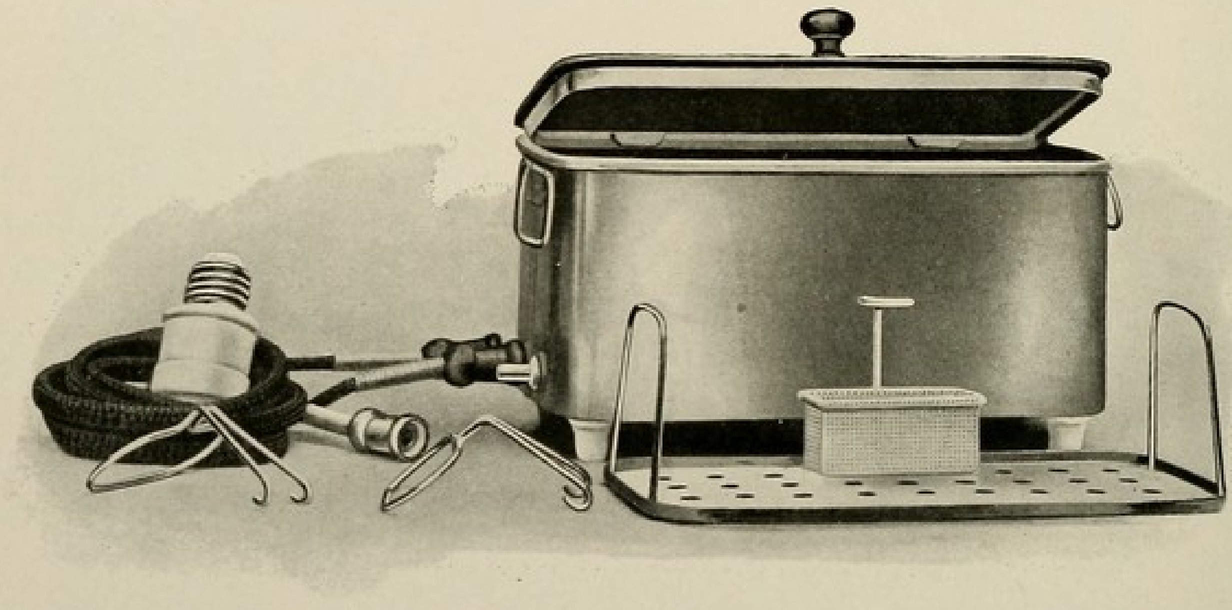
The filled stock flask is closed and its contents are boiled for ten minutes in a distilled water bath, preferably in a small electric boiler (see Fig. 2) which is best suited for disinfection in local anesthesia, and must always be fed with distilled water. In order to prevent the stock flask from breaking during the process of sterilization, it is best to tie around it a sterile mouth napkin. Electric sterilizers, which are so constructed that the heating element dips into the water, are unsuitable for this purpose. In regard to the use of distilled water, Riethmüller[1] writes:

"It goes without saying that only aqua destillata should be used in making up a solution. Boiled water is by no means sterile; moreover, it may contain quantities of alkalies, these varying in different districts, which detrimentally affect the solution, as will be indicated by a pink or rose discoloration. Even the aqua destillata as bought in pharmacies is by no means reliable, as everyone familiar with the slipshod methods by which it is made—usually in the darkest spare

[1] Dental Cosmos, February, 1913.

corner, and frequently by none too careful or skilled clerks—knows very well. It frequently contains bacteria that have been introduced from the air or the dust collected on the large bottle in which it is kept, and on close scrutiny is often found to have particles of dust, filter paper, or even hair, suspended in it. The acquisition of a small filter apparatus will therefore prove a boon to the conscientious operator, and in a busy and clean practice will soon pay for the initial investment, especially since aqua destillata must be used for the sterilization of the instrumentarium employed in connection with local anesthesia.

FIG. 2



Electric sterilizer.

"It is a fact known to every chemist that glass, which is more or less strongly of an alkaline nature, is dissolved by cold and hot water, and these traces of alkali, however minute, seriously affect the stability of suprarenal preparations. Some operators for this reason employ only the scientifically manufactured brown non-alkaline glassware of the Jena glass works. How sensitive to alkalis the suprarenal preparations are is strikingly illustrated by a report of Dr. E. Paul.[1] He found that, four weeks after purchase, the contents of an unopened

[1] Deutsch. Zahnärztliche Woch., February 10, 1912.

bottle of suprarenin manufactured by a reputable drug firm had become turbid.

"For reasons similar to those given in favor of the preparation of aqua destillata by the operator himself, the purchase of prepared Ringer solution is undesirable. The purchased product often contains impure drugs in incorrect dosage and slight traces of soda. A purchased Ringer solution should always be tested for alkaline traces; if present, the alkalis must be neutralized by the addition of one drop of one-tenth dilute hydrochloric acid, which compensates at the same time for the alkalinity of ordinary glass containers and prevents the catalysis of oxygen in the anesthetic solution, either of which unfavorably influences the suprarenin."

The Ringer solution is best filtered into the stock flask through sterile filter paper. All the salts in the solution must be chemically pure. The quantity of Ringer solution required in a given case is poured out into the previously sterilized test-tube of Jena glass after removing the little glass hood from the nozzle. This method prevents the invasion of microörganisms from the surrounding air almost entirely, and insures the sterility of the solution for a longer period of time. The poured-off quantity should always be slightly greater than is absolutely needed, because in boiling a small fraction of the solution is lost by evaporation. The test-tube is grasped with the tweezers, and the Ringer solution boiled for a few seconds over an alcohol flame. The use of a Bunsen gas burner is not advisable, as the combustion is not always perfect, and undesirable particles of soot are carried into the solution and deposited upon the iridio-platinum needle in sterilizing.

Into the hot Ringer solution, the novocain-suprarenin tablets are thrown with sterile pincers, 1 tablet E in 1 c.c. of solution giving a 2 per cent., 1 tablet G in 1 c.c. of Ringer solution giving a 1.5 per cent. novocain-suprarenin solution. After adding the necessary number of tablets, the solution is once more raised to boiling-point, and the hot, closed test-tube is set upon the wooden stand at an angle of 45 degrees. The sterile syringe, through which hot distilled water has been drawn several times, can now be conveniently filled by drawing up the solution through the iridio-platinum needle, which has previously been passed through the alcohol flame. The solution, which has in the meantime cooled to body temperature, is at once injected.

The Hoechst Farbwerke Co. are now marketing small graduated porcelain cups of two sizes, holding 3 and 10 c.c. of solution respectively, with convenient metal stands and handles, which are extremely practical for preparing the tablet solution, and appreciably simplify the instrumentarium (see Fig. 1).

In order still further to reduce the possibility of introduction of microörganisms from any source, the editor has constructed a stock flask for the Ringer solution, (see Fig. 11) and has otherwise modified the Fischer instrumentarium as described in detail on page 91.

If novocain-suprarenin solution is prepared by the procedure above indicated, it will always be fresh and crystal clear, possess body temperature, and fulfill all reasonable requirements of an anesthetic solution. If one wishes to reduce the concentration, 2 instead of 3 tablets E in 3 c.c., or 4 tablets E in 5 c.c., or, for still greater reduction, 2 tablets G in 3 c.c. of Ringer solution are employed. The ease with which solutions can be modified according to the operator's judgment and the requirements of the case, is demonstrated in the affixed table:

TABLE OF MODIFIED SOLUTIONS.

Quantity of Ringer solution.	Number of tablets.	To make a concentration of
2 c.c. of Ringer solution	1 tablet E	1.0 per cent.
3 c.c. " "	2 tablets G	1.0 "
2 c.c. " "	1 tablet G	0.75 "
3 c.c. " "	1 " E	0.7 "
3 c.c. " "	1 " G	0.5 "
4 c.c. " "	1 " E	0.5 "

As a precaution, freshly made solutions should always be protected immediately from light by a cover of ruby-colored glass, unless the entire quantity of solution is used at once. A solution which after standing for more than thirty minutes is no longer entirely clear should never be used. Even the slightest discoloration indicates decomposition of the suprarenin and renders unsafe the sequelæ, though not the effect of the injection. It is far better to make several fresh solutions than to use one that has been standing for some time. We always use up the quantity calculated for a case, and prefer to make several fresh solutions rather than employ a stock solution. This precaution has been fully justified by the invariability in the certainty and safety of our results.

Factors in a Successful Injection.—Failures are not due to the solution only. As we have seen, to render an injection perfect in all its phases many factors are to be considered individually. To recapitulate briefly: solution, glassware, syringe, needles and field of operation must be absolutely sterile; the solution, moreover, must be of optimum composition; the normal and pathological anatomy of the field of operation must be given due consideration; and last but not least, the technical execution of the injection must be governed in every case by a correct interpretation of the conditions presented. In addition, the physical constitution of the individual patient must be subjected to a rigid examination. Is it a wonder, then, that the criticisms of local anesthesia vary so greatly, when, owing to the complicated nature of the technique—which, however, after some practice becomes simple routine—the neglect of one single postulate suffices to impair the desired effect and to produce partial or total failure, which unskilled and careless operators are usually too prone to attribute to the anesthetic solution itself?

Compound Tablets of Novocain-suprarenin and Sodium Chlorid Contra-indicated.—For the purpose of simplifying the preparation of isotonic solutions, several drug houses are marketing compound tablets of novocain, suprarenin, and sodium chlorid. In tests of a great many of these tablets from different manufacturers, Riethmüller has found that they give discolored solutions within a very short time after purchase, especially when the tube has once been broached, proving that the composition of novocain-suprarenin and sodium chlorid is very unstable.

Mixtures of Novocain and Peptones, and Novocain and Hydrogen Dioxid Contra-indicated.—Experiments have been conducted by Fichot in collaboration with Billard[1] with combinations of novocain with

[1] Dental Cosmos, January, 1913, p. 105.

from 2 to 10 per cent. of Byla's peptone, for which more rapid anesthesia, quicker cicatrization, and absence of all idiosyncratic symptoms are claimed. These claims, which have not yet been substantiated, are counteracted by the fact that no guaranty can be had regarding the sterile character of peptones, which are an extremely favorable culture medium for bacteria; at the same time, sterilization of the novocain-peptone mixture by boiling is impossible. While it is true that a few cases of idiosyncratic sequelæ following novocain-suprarenin injection have been reported, yet they are far less numerous than with cocain, and the symptoms are considerably less severe and alarming.

The objections to the combination of novocain with five-volume solutions of hydrogen dioxid, as indicated by Marmouget of Bordeaux and advocated by Mahé and Vanel[1] of Paris, are even greater, owing to the unstable and treacherous nature of hydrogen dioxid, the use of which is becoming more and more restricted in medical and dental practice. The advocates of this method themselves, who have made only a very limited number of practical tests, do not seem to be over-confident, and state that for deeper injections, and especially for conductive anesthesia, the combination of novocain with suprarenin is far preferable.

Braun's Experiences with Novocain and its Solutions.—The most enthusiastic champion of novocain solution, H. Braun,[2] of Zwickau, published in 1910 a comprehensive treatise on the employment of novocain in surgery. From this work it appears plainly that novocain is most extensively used in major surgery, especially in small doses, viz., in 0.5 per cent. and 1 per cent. solutions.

The statements made in the recently published third edition of his text-book fully coincide in all essential details with our own experiences. This thoroughly revised new edition shows especially that Braun, in contradistinction to certain dental writers, does not consider advisable any essential modifications in the preparation of the solution

[1] Dental Cosmos, January, 1914, p. 124.

[2] Beiträge zur klinischen Chirurgie, 1910; also F. Peuckert, Further Contributions to the Application of Local Anesthesia and Suprarenin Anemia.

and the technique of its injection. It is most gratifying that these views of the past-master in local anesthesia can be maintained unmodified in our dental practice.

Braun has indicated four different solutions, the weakest being 0.25 per cent., the strongest, 2 per cent. novocain. Solutions 1 (0.25 per cent.) and 2 (0.5 per cent.) are employed when thick layers and extensive areas of tissue are to be infiltrated. Solutions 3 (1 per cent.) and 4 (2 per cent.), which contain correspondingly more suprarenin, serve for conductive anesthesia proper. Braun, for the sake of simplicity, employs as few solutions as possible, and preferably only one form of tablets. He also endeavors to restrict the use of the high per cent. solutions (3 and 4) as much as possible. "We have generally substituted the 1 per cent. for the 2 per cent. solution, injecting a little more of the former than we employed originally." Hence Braun uses in the main only two, namely, the 0.5 per cent. and the 1 per cent. novocain solutions. "The 1 per cent. novocain solution suffices for tooth extractions, also without exception for the conductive blocking of large nerve trunks."

Application of Local Anesthesia in Surgery.—The wide adoption of local anesthesia in surgery, promoted by a suitable technique of injection, is characterized by the following passages in Braun's report: "Of 10 complicated cases of fracture of the skull two were operated upon under local anesthesia; also two skull trepanations were performed under local anesthesia for suspected abscess of the brain, and in one case for removal of a bullet from the brain. Peripheral injection of the field of operation with 0.5 per cent. novocain-suprarenin solution is a superior means of reducing hemorrhage in cranial operations. It supersedes all other aids recommended for this purpose, is much more effective, and permits of the performance of cranial and cerebral operations with a minimum of hemorrhage and anesthesia. All these advantages cannot be underestimated, nor can they be attained by any other similar procedure.

"One operation which we now perform exclusively under local anesthesia is that for empyema of the frontal and the ethmoidal sinuses. It is possible to make all operations on the frontal sinus, the chiselling away of the entire anterior and inferior walls, Kilian's radical operation, Barth's operation, opening into the ethmoidal sinuses, probably also into the sphenoidal sinuses. The field of operation is completely anesthetized and so anemic that the operation can be carried out much more easily, neatly, and rapidly than under general anesthesia.

"We prefer local anesthesia even in resection of the maxilla, since the admixture of suprarenin sufficiently guarantees the intensity and duration of the anesthesia. By inducing scopolamin slumber we are enabled to do away also with the unfavorable psychic impression of the operation upon the patient.

"The blocking of the superior maxillary nerve in the sphenomaxillary fossa has been accomplished in 5 cases successfully and without any difficulty. The point of injection is found, upon palpation, to lie closely posterior to the inferior process of the malar bone, whence the needle is advanced inwardly and upwardly, its point reaching the maxillary tuberosity immediately back of the zygoma. Gently groping along the surface of the tuberosity, the needle easily advances, and, in a depth of from 5 to 6 cm. meets the superior maxillary nerve in the sphenomaxillary fossa. The patient immediately feels a slight pain radiating into the maxilla. The syringe is then attached to the needle, and under slight backward and forward motion of the needle from 5 to 10 c.c. of a 1 per cent. novocain solution are injected. The injection can be executed easily and safely. Anesthesia in the whole area of the superior maxillary nerve ensued in all cases almost immediately after the injection.

"Of 7 cases of resection of the maxilla, 2 had to be subjected to general anesthesia owing to excessive extension of the tumor. The other 5 were operated upon under local anesthesia.

"The course of operation under local anesthesia is quite different from the usual. No interruptions of the operation as needed for the continuance of general anesthesia are required, and the operation can be completed in a minimum of time. Owing to the anemia from the suprarenin, the continual inundation of the field of operation with blood is avoided, and the few bleeding vessels can be quickly and conveniently compressed. The unobstructedness of the operative area permits of operating accurately and neatly. If blood flows into the pharynx, the patient is always able to prevent its aspiration, all reflexes being maintained. The patients' condition after the operation is most favorable; they leave the operating table perfectly well and rarely have to be put to bed. Owing to the effect of scopolamin, they frequently have little or no reminiscence of the operation. It is not saying too much that, owing to the employment of local anesthesia and suprarenin anemia, resection of the maxilla has lost all its terrors. Local anesthesia in this operation is not only equivalent to general anesthesia but far superior."

Major operations on the tongue also can be performed under local anesthesia. Braun undertook even more complicated operations, performing extensive extirpations of glands, temporary separation of the maxilla, and removal of maxillary bone fragments under local anesthesia. The anemia produced by the suprarenin greatly facilitates the technical execution of such operations. He also mentions 3 cases of carcinoma of the tongue and the floor of the oral cavity which were operated upon under local anesthesia.

Advantages of Local Anesthesia in Surgery.—"Local anesthesia has been charged with being too complicated, therefore unsuitable for extensive clinical practice. This, however, is unjust. Schleich's infiltration anesthesia, to be sure, was complicated, since the scalpel had to aid the syringe continually, and even then no satisfactory anesthesia could be obtained. The patients became restless, began to complain, and often general anesthesia had to be resorted to in the end. The operations were thereby unduly prolonged, and the patients as well as the operator were greatly disappointed. Not so with the modern method of local anesthesia. All injections are made before the operation, if desirable even before sterilization of the field of operation. The injections require no longer, usually a much shorter time, than the production of general anesthesia. If several operations have to be made in succession, the assistant can make the injections in a separate room shortly before termination of the preceding operation, so that no time whatever is lost. If the correct technique is employed, there is no need for long waiting. After completion of the injection, we immediately prepare ourselves for the operation, and this preparation requires but a short time if aseptic gloves and long-sleeved aseptic operating-coats are worn. In the meantime the field of operation is sterilized. If the operation is begun within from eight to ten minutes following the injection, complete anesthesia will have been established. In large surgical institutions the saving in assistants and anesthetists afforded by the routine practice of local anesthesia is a considerable one.

"Since the patients retain consciousness, and a continual conversation can be carried on between operator and patient, disturbing movements of defense, if the anesthesia is temporarily superficial, can be prevented, and the patient is able to coöperate in making minor changes in position, etc., without the assistance of a third person." (Peuckert.)

This most favorable report speaks so eloquently for the employment of local anesthesia in major surgery that it is surprising that dentistry, being a specialty of minor surgery, has not yet definitely and unconditionally adopted this practice. As Braun expresses it in a personal letter: "In surgery cocain has become obsolete since the introduction of novocain, and is no longer used. The old drugs such as cocain are, of course, still being sold by supply houses as long as there is a demand for them." This proves beyond all further argument how fully justified is our demand that novocain be substituted for cocain.

The investigations of Braun also show that a considerable reduction in the concentration of the novocain solution is indicated in local anesthesia. In the normal solutions Nos. 1, 2, and 3, as above recommended, this desideratum has been taken into account. Just as the 1 per cent. novocain solution employed by Braun has yielded remarkably good results, so solutions ranging from 0.5 to 1.5 per cent. when adapted to individual cases in dental practice, guarantee full success, depending, of course, to a great extent upon the technique of injection and the precautionary measures employed.

In a recent work which appeared in 1912,[1] Braun published an

[1] Ergebnisse der Chirurgie u. Orthopädie, 1912, vol. iv.

additional report of clinical experiences with local anesthesia, which is no less favorable. Also in the recently published third edition of his *Text-book on Local Anesthesia* he reiterates his unconditional adherence to the principles of local anesthesia as formerly pronounced by him.

While local anesthesia originally was specially indicated in minor surgery and in emergency cases only, it is gradually gaining a firm foothold in major surgery, as appears from the following reports of various hospitals:

	Year.	No. of operations.	General anesthesias.	Local anesthesias.
Heidelberg Surgical Clinic (Dr. Narrath) . .	1906	1917	1633	218
	1907	1936	1377	426
	1908	2070	1460	559
	1910	2303	1583	632
Stettin Municipal Hospital (Dr. Hesse) . .	1908	1762	1364	199
	1909	1940	1294	413
Zwickau Charity Hospital (Dr. Braun) . .	1908	1529	1078	375
	1909	1542	995	489
	1910	1811	1029	727
Berlin Charité (Dr. Axhausen)	1910	1600	....	240

Owing to the absence of irritation and toxicity, novocain has superseded cocain almost everywhere; for instance, in Germany, England and her colonies, South America, and Russia. In France, also, novocain has been introduced in place of cocain by Reclus in 1911. To cite Piquand: "Novocain, at the present time, appears to be the most efficient local anesthetic. Its extremely low toxicity permits of injecting large doses without danger, and of performing complicated operations which would be extremely difficult under cocain. The only possible objection to novocain, *i. e.*, the short duration of the resulting anesthesia, is eliminated by the addition of minimal quantities of adrenalin, which produces a remarkable prolongation and intensification of the anesthesia without materially increasing the toxicity of the anesthetic."

Braun's experiments regarding the addition of sodium bicarbonate to the solution for the purpose of reducing the concentration of the novocain have shown that "this solution possesses no essential advantage over the ordinary normal salt solution with novocain."

It is almost impossible to fix the maximal dose of novocain because, as Braun remarks, the toxicity of this agent depends as much upon the concentration and the manner of employment of the solution as upon the dosage. For surgical purposes, from 0.5 to 2 per cent. solutions are usually employed in combination with suprarenin. Nast and Kolb have injected up to 50 c.c. of a 1 per cent. solution, Axhausen up to 170 c.c., and in one case as much as 200 c.c., *i. e.*, 2 grams of the drug. Of the 1.5 per cent. solution Borchardt has administered up to 150 c.c., Hesse up to 220 c.c., Braun from 100 to 200 c.c., in some cases even 250 c.c., *i. e.*, 1.5 grams of the drug. Excepting occasional vomiting immediately following injection, surgeons have not noted any untoward sequelæ from these doses, hence Braun's statement that "of these 0.5 to 1 per cent. solutions it is permissible to inject so large quantities as are necessary in a given case for the local anesthetization of the field of operation."

If more highly concentrated solutions are used of course the injected quantity must be considerably reduced; the dose of 20 c.c. of a 2 per cent. solution must not be exceeded. For superficial anesthesia of mucous membranes, etc., by topical application, novocain is not so efficacious as alypin, which is being used most successfully in 10 per cent. solutions with suprarenin, in otology, rhinology, and laryngology.

As has been said before, Braun originally advocated four solutions, *i. e.*, 0.25, 0.5, 1 and 2 per cent., with carefully graduated additions of suprarenin. At present, 0.5 per cent. solutions or, if extensive conductive anesthesia is desired, from 1 to 2 per cent. solutions are chiefly employed. Braun prepares all his solutions from novocain-suprarenin tablets A, which contain 0.125 grams of novocain and 0.000096 gram of synthetic suprarenin. The required number of tablets is transferred into a sterile test-tube, covered with a small quantity of normal salt solution, dissolved by vigorous boiling over an alcohol flame, and diluted in a porcelain graduate with sterile normal salt solution; 100 c.c. of a 1 per cent. solution, or 50 c.c. of a 2 per cent. solution, prepared in this manner, contain about 1 mg. of suprarenin. The method of preparing a solution from tablets Braun considers the simplest and most reliable.

The opinion that the healing process following dental operations may be disturbed by local anesthesia is regarded as erroneous by Braun, because no disturbances in the healing process are noted.

"Local anesthesia in its present form is harmless. It was not perfect in the beginning, of course, and for the tyro in the technique it is even yet not entirely without risks. The introduction of novocain-suprarenin has greatly broadened the scope of local anesthesia, because large quantities of a most efficacious anesthetic solution can be introduced into the body with impunity. Among other operations, we employ local anesthesia for all strumectomies, all hernia operations except in children, the majority of operations in the male sexual organs, and in the rectum, also for resections of the maxillæ and operations on the tongue. In all these the use of cocain would be impossible. We inject 150 c.c. and over of a 0.5 per cent. novocain solution with an infinitesimal amount of suprarenin, as contained in the A tablets. I have never observed any intoxication or other untoward secondary effects from novocain, except occasional vomiting following very large doses. He who returns to cocain makes a step backward and betrays his lack of technical skill. Such perfect and safe anesthesia as can be produced by novocain-suprarenin cannot be obtained with cocain. Nobody, of course, will dispute that cocain *per se* is a stronger anesthetic than any of its substitutes or than novocain; but novocain allows of an infinitely wider range of application without risk.

"Local anesthesia is harmless, provided no cocain is used, and the suprarenal preparation employed is pure and free from decomposition. This is the reason why I am advocating the tablet form so strongly. In dentistry such high doses as might eventually produce untoward sequelæ are not even approached. The maxilla, the mandible, and all the organs of the oral cavity can be anesthetized at one time with such small quantities of the solution that untoward sequelæ cannot be reasonably expected.

"The practice of leaving it to the patient whether general or local anesthesia should be resorted to, is most reprehensible. Patients have no idea of the requirements of their case; all they wish is that the operation be painless. It is for the operator, and for him only, to decide just what is to be done, and how it is to be done. It goes without saying that, if the patient's mental condition demands it, general anesthesia must be resorted to, even though local anesthesia would be feasible. This applies especially to many children and those adults who act like children. Even then, the decision should not be governed by the patient's wishes but by the operator's judgment."

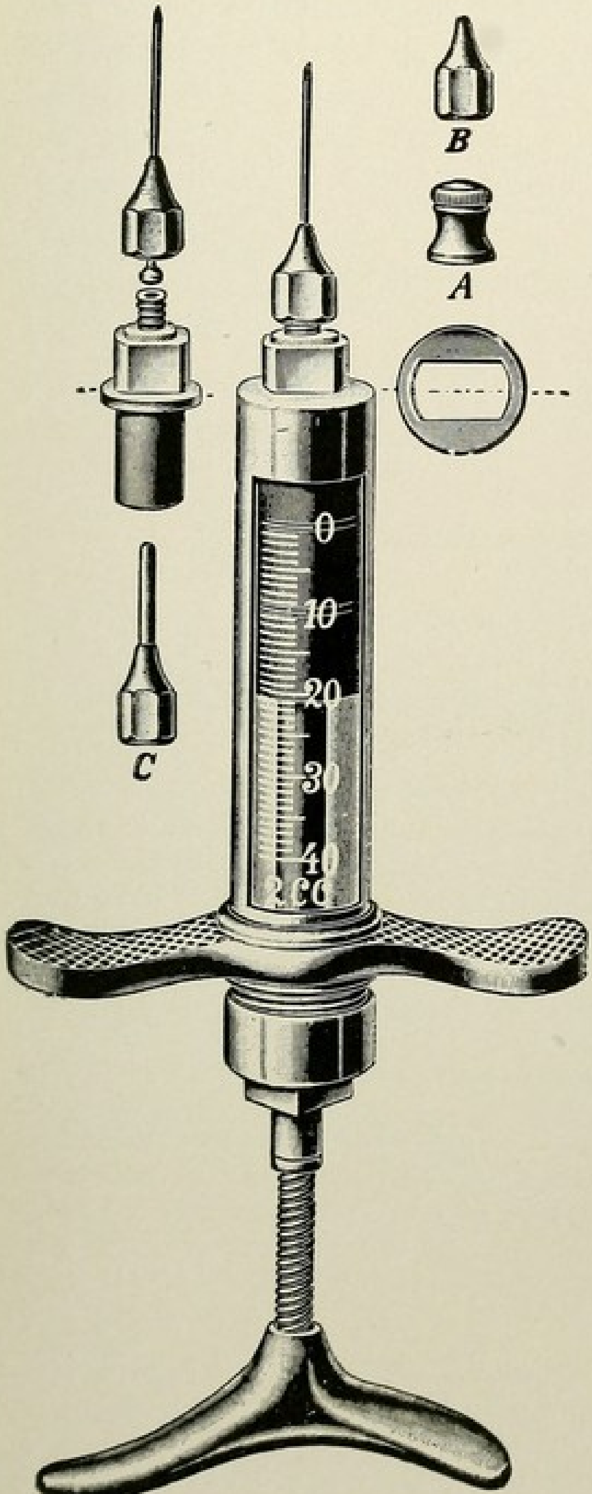
From the foregoing considerations there is no denying the fact that local anesthesia, especially by novocain-suprarenin solution, is bound to occupy a leading position in modern dental practice. The claim that, in regard to the anemia produced, novocain-suprarenin is inferior to cocain-suprarenin, must be energetically refuted, for, according to Braun, "the anesthetic action of novocain is at least fully equal in intensity, duration, and extension to that of cocain. Novocain is an ideal anesthetic, which not only is destined to supersede cocain entirely, but which has greatly enhanced the safety of local anesthesia owing to the possibility of injecting with impunity much greater quantities of efficacious anesthetic solutions."

THE INSTRUMENTARIUM.

The instrumentarium selected for injection anesthesia fully complies with all modern rules of asepsis and can be subjected to any form of sterilization, especially boiling.

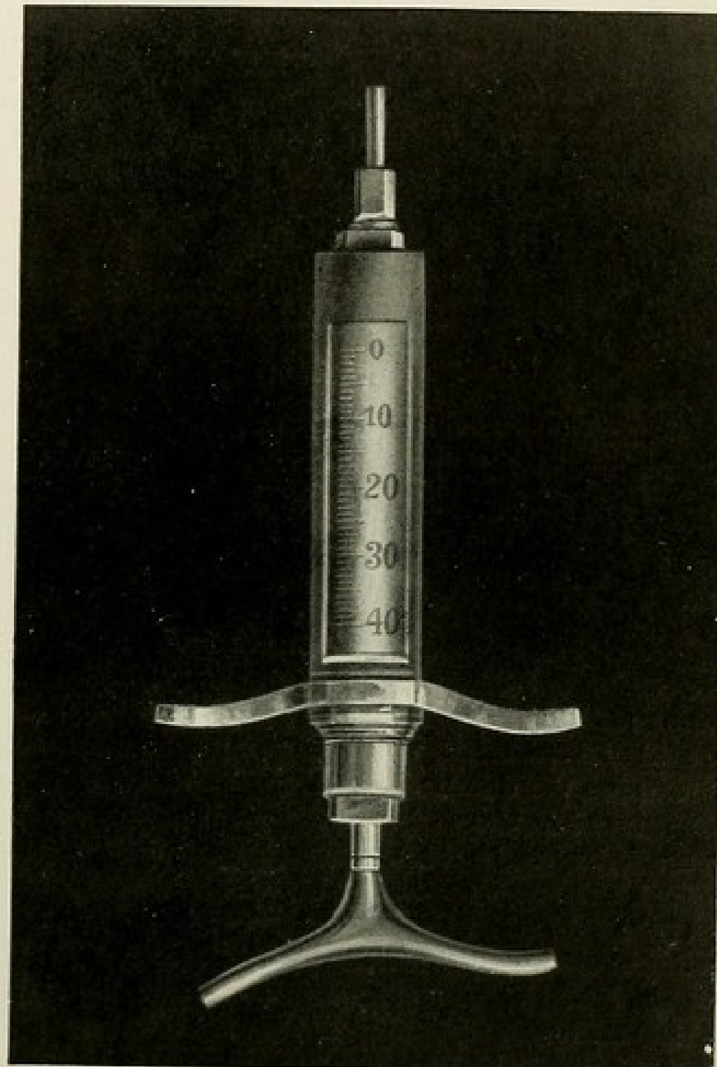
The Injection Syringe.—The selection of a suitable syringe, this most important instrument, has always involved the greatest difficulties, because syringes with leather piston, which are the tightest, cannot be exposed to steam, while most glass-and-metal, all-glass, or all-metal syringes, do not have a hermetically fitting piston. After examining a great number of models we have designed, with the assistance of Freienstein, of Berlin, a syringe which promises to fulfil all the

FIG. 3a



Injection syringe of glass and metal, designed by Dr. Guido Fischer. (For explanation of lettering see Fig. 4.)

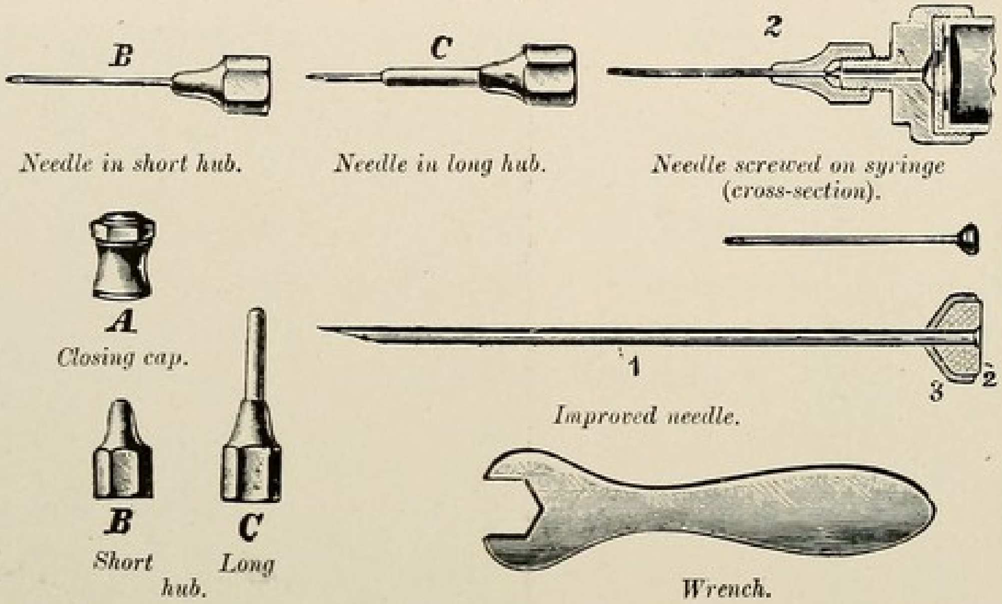
FIG. 3b



Syringe with hub for telescoping trocar needle.

necessary requirements. In view of the thorough tests of the past few years this syringe has indeed surpassed all expectations, and has proved superior to all other partly antiquated models which are advertised for dental purposes.

FIG. 4

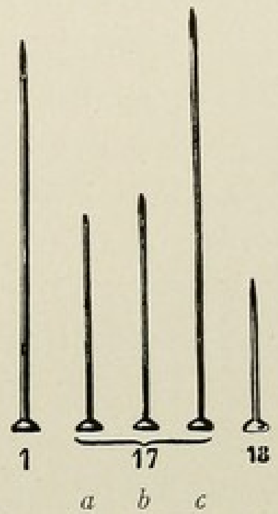


Needles, hubs, and wrench for injection syringe, designed by Dr. G. Fischer.

On the right is a considerably enlarged reproduction of the new needle showing the details of construction as follows: 1, the hollow needle, either of seamless steel, pure nickel, gold or iridio-platinum; 2, body of soft metal for firmly tightening the needle upon the orifice of the syringe; 3, conical shell of hard metal, open below, from which the soft metal core protrudes. This arrangement remedies the deficiencies of the old-style needles in which the unprotected soft metal cone could not stand much use, became flattened easily, and jammed in the hub so firmly that both hub and needle had to be replaced, which was rather expensive when gold or iridio-platinum needles were used. The new needles are attached to the syringe absolutely tightly by inserting the needle in one of the hubs (*B* or *C*) and screwing it firmly on the orifice of the syringe. In order to enable practitioners with sensitive fingers to manipulate the hubs easily, which heretofore were milled, the hubs *B* and *C* are made with hexagonal connections, so that they can be conveniently and firmly tightened by a slight turn of the wrench. No force should be used, otherwise the soft metal cone of the needle becomes unnecessarily worn.

This syringe is made of glass and metal, resembling in principle the Progress syringe, and is constructed so as to avoid all minute furrows and corners which catch dirt and are difficult to clean (see Fig. 3). The entire outer surface of the syringe is uniformly round and smooth, and the hubs *B* and *C* are tightened with a wrench (see Fig. 4). The metal piston is made accurately so as to fit tightly in the glass barrel, and terminates in a crutch-shaped handle, so that it can be conveniently laid against the ball of the thumb and firmly braced there. This handle, being threaded and fastened in a screw socket, can be shortened or lengthened at convenience. To allow for the exertion of such pressure as is necessary for injection, two wing-like, strong, and milled finger rests are fitted to the metal sheath of the syringe barrel; these finger rests are a little smaller in the 1 c.c. syringe than in the larger size.

FIG. 5



Improved injection needles for dental practice: No. 1, length, 42 mm. with long point; diameter, 0.9 mm.; No. 17, *a*, length, 23 mm.; *b*, length, 26 mm.; *c*, length, 42 mm.; diameter, 0.47 mm.; No. 18, length, 16 mm.; diameter, 0.42 mm.

For practical reasons this syringe is made in two sizes, one holding 1 c.c., the other 2 c.c. of solution. On the glass barrel a scale is etched for gauging the contents. After some time, viz., after from three to six months of continual use, the piston wears and should then be replaced, as it loses its required tightness. It is best always to keep three or four syringes of both sizes on hand—a luxury which will pay in the end.

Hubs.—The syringe is sold with various smooth hubs (see Figs. 3 and 4, *B* and *C*), which are selected according to the place of injection. The closing cap *A* is used to close up the barrel after use.

Steel Needles.—For our purposes the needles No. 17, with short points (see Fig. 5), are employed. The needles Nos. 1 and 18 (see Fig. 5) are designed for special purposes, as follows: No. 1 (diameter 0.9

mm.) which is preferred by Williger, for mandibular anesthesia; No. 18, for subperiosteal injection, if a specially short needle is desired. The trocar needles (see Figs. 6 and 7) have proved very serviceable in conductive anesthesia in the upper jaw.

The three needles No. 17 have a diameter of 0.47 mm., *a* being 23 mm., *b* 26 mm., and *c* 42 mm. long. In contradistinction to needle No. 1, the needles Nos. 17 and 18 are ground with blunt ends (Fig. 5), which are indispensable if the needle is to come into direct contact with the bone. Long and tapering needle-points are not suitable, because they easily get stuck in the periosteum and bone, break or bend, and cause complications. In mandibular anesthesia, however, where the needle is advanced along the bone, we prefer needle No. 17 to No. 1, since the orifice of the No. 1 needle may allow of a too rapid and liberal discharge of the fluid.

The needles have been so improved by Freienstein that they can be firmly locked in the hubs, and hermetical closure during the injection is guaranteed (see Fig. 4, No. 2). The cone of soft metal is protected by a hard metal case of heavily gilded copper; it is open below, so that, even under firm pressure, flattening of the soft metal cone and sticking of the needle in the hub are prevented. This arrangement also insures the exactly central position of the needle and prevents all possibility of leakage (see Fig. 4).

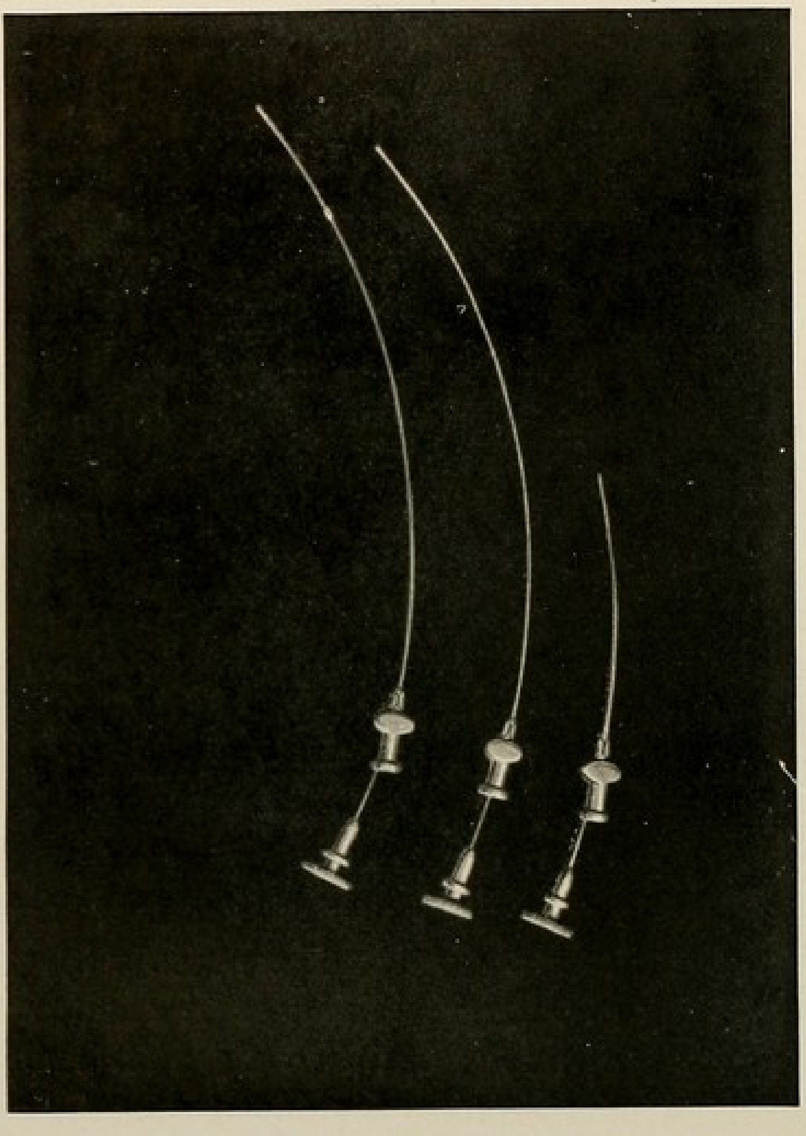
Whenever possible a new steel needle should be used, since needles which have not been perfectly dried after use rust and break. By repeated use the needle becomes dull and unfit. It is a good plan to employ one needle for one day's work, and discard it. After finishing a case, the needle is drawn several times through absolute alcohol and removed, and its lumen vigorously blown out with a hot air syringe; a small wire is then introduced, and the needle laid in a dry test-tube ready for the next injection. For the next case, it is screwed to the filled barrel and immersed in boiling water for a minute.

Iridio-platinum Needles.—The use of iridio-platinum needles cannot be too strongly advocated, because they can be sterilized in a flame before and after use, and do not break so easily. They possess sufficient elasticity to allow the operator to remain in constant contact with the bone, as, for instance, in advancing to the inferior dental foramen. If excessive pressure is exerted or unusual resistance is met with they give and bend; but this is a minor disadvantage as compared with breaking, which may happen with steel needles. Once mounted, an iridio-platinum needle, so long as it is perfect, may remain upon the syringe for months; it will not rust or wear out quickly with use, and is therefore cheaper and more reliable than steel needles, which must be new.

The Trocar Needle.—For conductive anesthesia in the upper jaw, blunt and strong trocar needles with sliding attachment seem preferable. These allow of more certain manipulation than the needles No. 17 as formerly used, lessen the risk of breaking, and, being blunt and slightly curved, prevent injuries to important vessels in the area of injection, especially in injection at the maxillary tuberosity, as Gasser has demonstrated in anatomic preparations. These trocar needles have been very successfully employed in lumbar anesthesia. For our purposes the needle should be so constructed that, when inserted, its point sharply separates the tissues, but, after passing the mucous membrane and the muscular fibers, advances as a blunt point. It can easily be pushed forward along the bone without perforating or lacerating any vessels or nerves. Excellent results have been obtained with a slightly curved trocar needle (see Figs. 6 and 7) of 7 cm. length and 1 mm. diameter, and a hub which can be slid upon a suitable middle piece screwed to the syringe (see Fig. 3*b*). The curvature of the needle corresponds to the protuberance at the maxillary tuberosity and insures continual contact with the surface of the bone in advancing the needle. The needle canal contains a trocar of fitting size which protrudes from 1 to 1.5 mm. beyond the needle-point and affords a sharp point for insertion. The sterile trocar needle is gently pushed through the mucous membrane and muscle fibers to the surface of the bone, the inner sharp trocar is withdrawn, the full syringe is slid upon the needle-hub (see Fig. 3*b*), and the needle gradually advanced along the bone while discharging the anesthetic solution. If necessary, the syringe can be removed, refilled, and reattached to the needle which remains *in situ*.

In conductive anesthesia at the maxillary tuberosity this needle has proved most satisfactory. In conductive mandibular anesthesia also the same principle can be applied and offers the following great advantages: unobstructed view in inserting the needle, continuous

Fig. 6

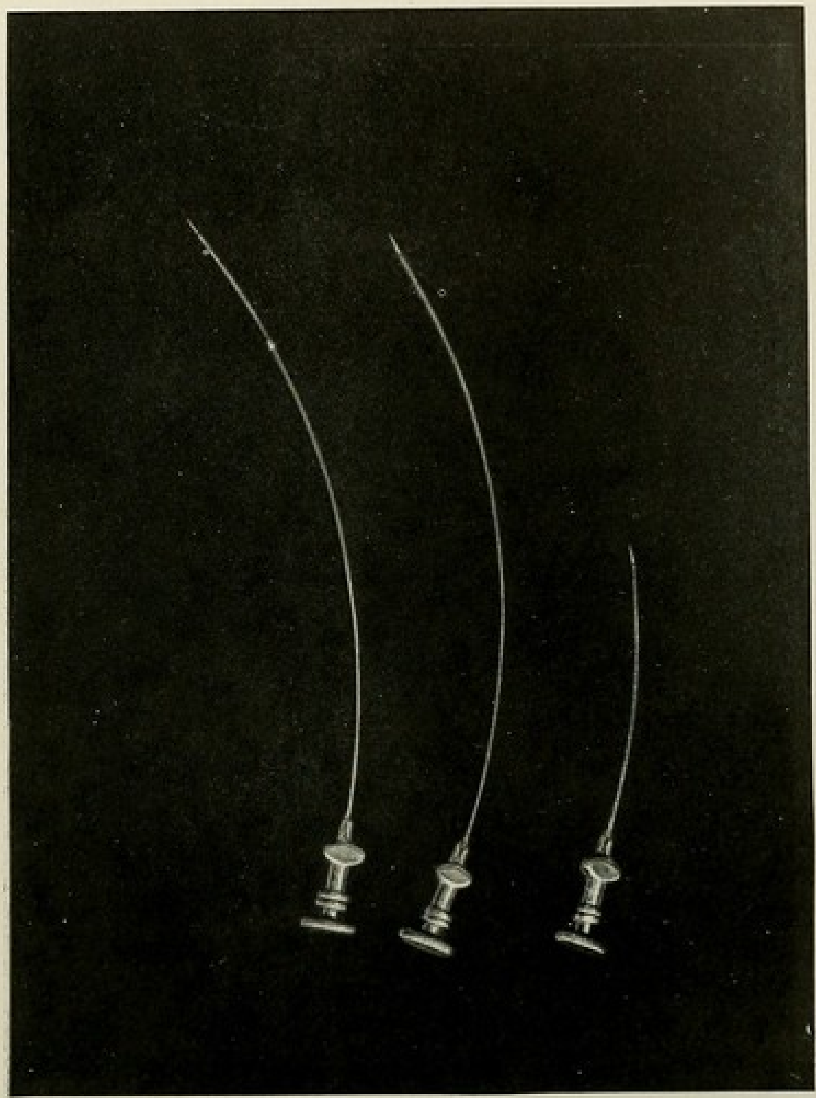


Trocar needles with telescoping attachments.

contact with the bone, no tissue lesions, and no danger of breaking the needle. In mandibular work a straight needle is superior to a curved one, preference to be given to a thicker model of 1 mm. diameter.

In the technical execution of conductive anesthesia this form of needle appears to be preferable to the sharp and thin needle. The danger of breaking a needle is practically eliminated, the certainty in guiding it is enhanced, and vascular lesions are prevented. Hemato-

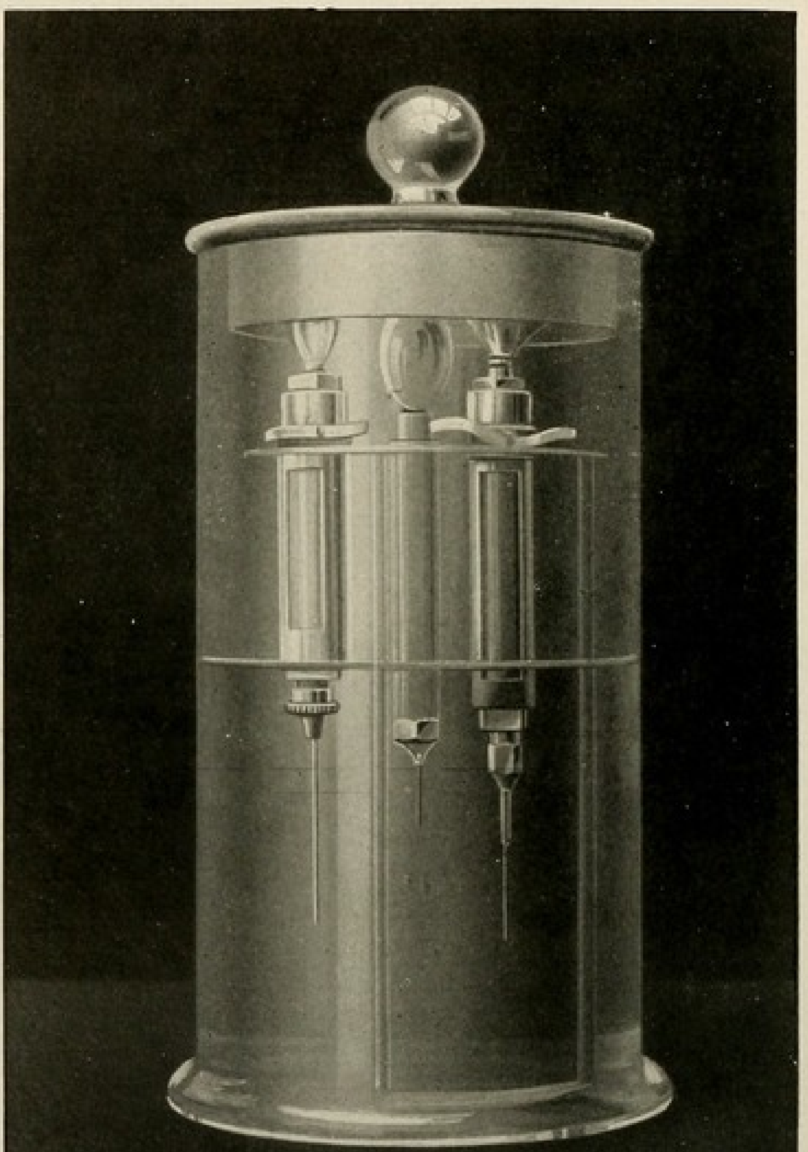
Fig. 7



Trocar needles.

mata, such as sharp needles may produce, can hardly occur, especially at the maxillary tuberosity. For the insertion itself, a sharp point is necessary because in both jaws taut mucous membrane and delicate muscle fibers must first be penetrated, after which the needle advances through very loose interstitial connective tissue where the solution is deposited. With either form of needles no untoward sequelæ such as infection, hemorrhage, etc., at the point of insertion have been noted; neither need infiltration of the muscles be feared, because the injection is always made into loose connective tissue after the muscle fibers have been penetrated.

Fig. 8



Glass jar with metal stand for preserving syringes in a sterile alcohol-glycerin solution.

Treatment of the Syringe.—The syringe is best kept in a tall vessel with stand (see Figs. 8 and 10), containing two parts absolute alcohol and one part of chemically pure glycerin. This solution remains sterile and does not attack the metal parts. Before and after use, hot distilled water is drawn into the syringe several times, the iridio-platinum needle is sterilized in a flame, and the syringe and needle are returned to the glass jar (see Figs. 8 and 10). It is best to have the syringe dip into the alcohol-glycerin mixture down to the hub. For washing off the alcohol and glycerin, distilled water alone should be used, since alkaline water precipitates novocain and renders the solution ineffectual.

In this connection Riethmüller[1] writes: "The syringes, with hub and needle attached, are best kept suspended in an upright glass jar filled with absolute alcohol and fitted with a German silver stand to prevent dulling of the needle point by resting on the bottom of the vessel. Such a stand can be shaped up and soldered quickly by any mechanic. The jar is covered with a flat glass cover with ground edge, which is vaselined, and this cover is kept tightly on the jar overnight by binding it down with strips of adhesive plaster to prevent evaporation of the alcohol. The flat cover is preferable to a ground glass stopper, which sometimes is very difficult to remove. Alcohol of 70 per cent. has been found more strongly bactericidal than absolute alcohol; still, absolute alcohol may be preferably used as it soon absorbs enough water from the atmosphere to approximate it to that alleged optimum percentage. In the Bardet syringe sterilizer, which is used by some operators, only the needle is kept sterile by immersion in lysol, while the greater portion of the barrel and piston are exposed to undesirable contamination with microörganisms from the air.

"On removing the syringe from its alcohol bath, some of the alcohol is drawn through the needle and barrel, pressed out and burnt off by passing through a flame.

"After the alcohol is burnt off, hot water is drawn into the syringe, as any trace of alcohol which is not thus removed would produce anesthesia lasting several days, as is appreciated by anyone familiar with the treatment of trifacial neuralgia by alcohol injections. The

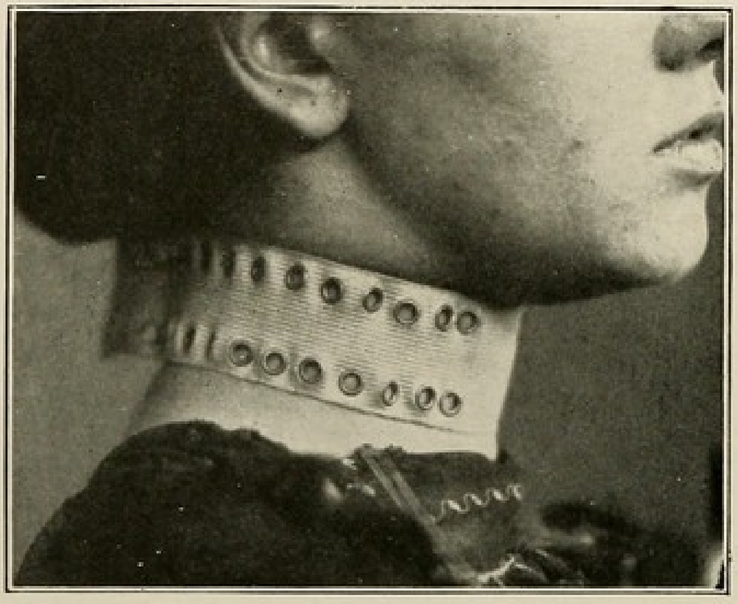
[1] Dental Cosmos, February, 1913.

hot water also heats the syringe, and prevents the anesthetic solution from cooling below blood temperature."

If glycerin is mixed with the alcohol, which will keep the instrument bright and slightly lubricated, a thorough washing in hot distilled water is the only feasible procedure.

Ampoules.—If ampoules are employed, one proceeds as follows: The ampoule is sterilized, the neck broken in a sterile linen napkin, and the contents drawn into the syringe through the mounted needle. It is advisable first to immerse the ampoule in hot water in order to raise the solution to body temperature.

Fig. 9



Stasis bandage applied to patient's neck. Diminishes danger of intoxication and anemia of the brain, and retards absorption.

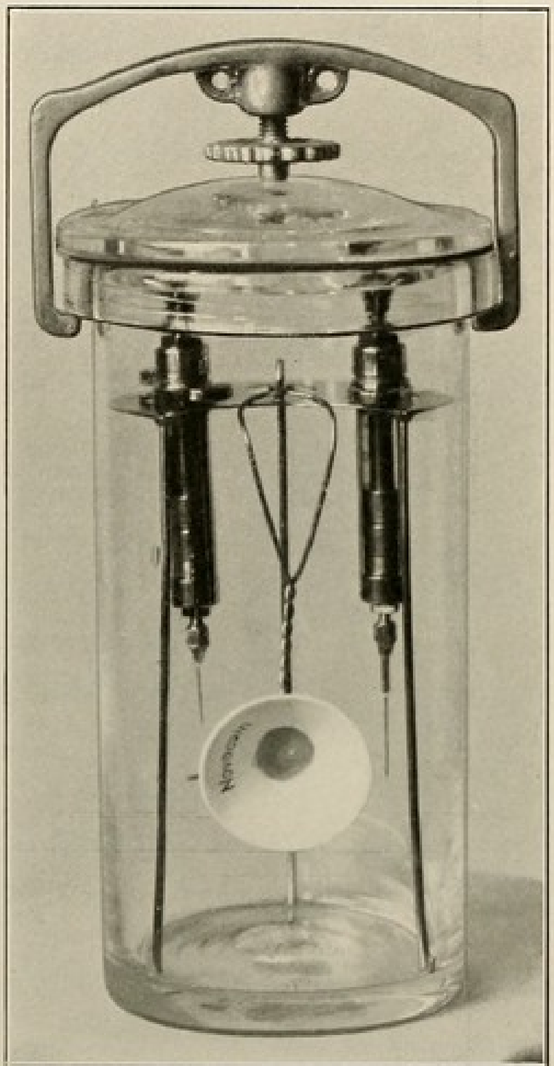
Stasis Bandage.—Finally, a very practical addition to the instrumentarium should be mentioned, *i. e.*, the stasis band, as devised by the writer for certain complicated cases. This is adjusted by means of a number of eyelets, and fitted around the patient's neck tightly enough to cause the face to become slightly reddened (see Fig. 9); deep red or blue coloration must be avoided. This bandage produces compression of the jugular veins and retards the return of the venous blood from the head, thereby rendering cerebral anemia unlikely, and retarding the absorption of the anesthetic solution. In this way still greater certainty of success is guaranteed, the danger of intoxication is minimized, and fainting spells due to cerebral anemia are prevented, or at least the likelihood of their occurrence is lessened. The hyperemia which follows this stasis seems advantageous for the healing process, and is never pronounced enough to produce hemorrhage, but ranges within moderate physiological limits. For the formation of clot in wounds, the hyperemia following removal of the bandage is of incalculable value, preventing, as it does, disturbances in the healing process, postoperative pain, necrosis, etc., which may follow excessive anemia. Normal circulation is rapidly reëstablished after removal of the stasis bandage, which in special cases has proved very successful.

Seidel, like other writers who seem to have misunderstood the purpose of this bandage and apparently have never given it a fair trial, has raised the objection that its "cumbersome, conspicuous, and disagreeable application preceding an extraction materially increases the patient's fear as well as the danger of fainting, and complicates the operator's work." In reply to these objections it must be emphasized that in delicate and anemic persons the bandage renders invaluable service, as any one will admit who has taken the pains to test it—not in two or three but in hundreds of cases. Many dental and general surgeons have reported most favorable results from the application of this bandage, which fully deserves a place in our instrumentarium.

It goes without saying that it is not to be applied in every case, nor was it ever intended for routine practice. It is indicated, however, in delicate patients of livid complexion who are subject to fainting. The operator's judgment will determine the cases in which this valuable accessory may be resorted to with advantage.

A Modified Instrumentarium.—After experimenting with various modifications of the Fischer instrumentarium, Riethmüller has devised a set of three pieces which have proved most practical by their simplicity and compactness. First, instead of a glass jar with ground cover, which easily sticks, an anatomic specimen jar is used, allowing the flat cover with rubber washer to be clamped down tightly. This handy jar contains a suitable metal stand providing for two Fischer syringes, a pair of pliers of aluminum, which metal is not corroded by the iodin used for disinfection of the mucous membrane, and for

FIG. 10*a*



Hermetically sealed glass jar for preserving syringes, dissolving cup, and pliers in alcohol-glycerin solution.

FIG. 10*b*

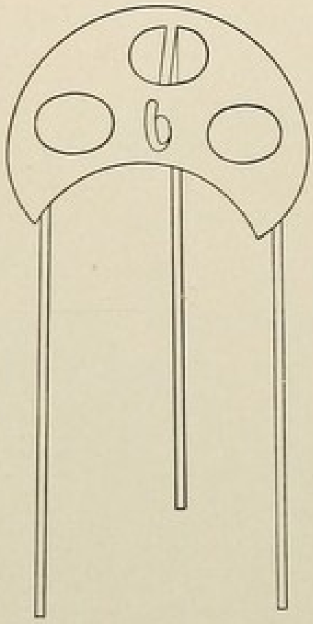
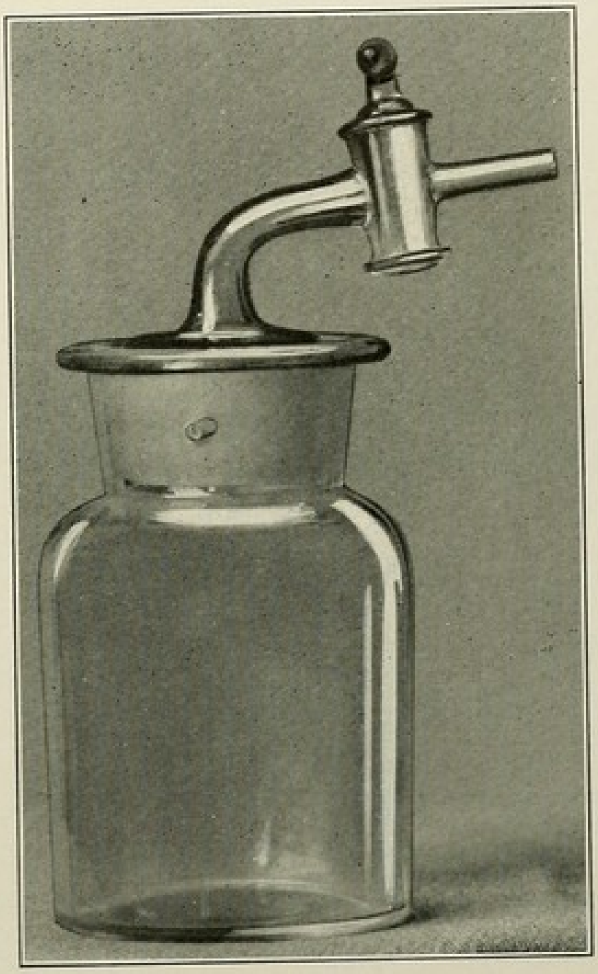


Diagram showing arrangement of metal stand in glass jar.

suspending the dissolving cup in the alcohol-glycerin solution (see Fig. 10). Second, for preserving the modified Ringer solution a stock flask is used, which is hermetically closed with a ground stop-cock, doing away with the danger of bacteria accumulating in the cotton wad as employed in the Fischer bottle (see Fig. 11). For pouring out the solution, the stop-cock is opened, the ground cover slightly turned in the neck of the bottle, so that a minimum of air is admitted through the concentric pinholes, and the bottle inclined. For filtering the admitted air, a piece of sterile gauze or cotton is fastened over the airholes with a rubber band, to be renewed daily. After the

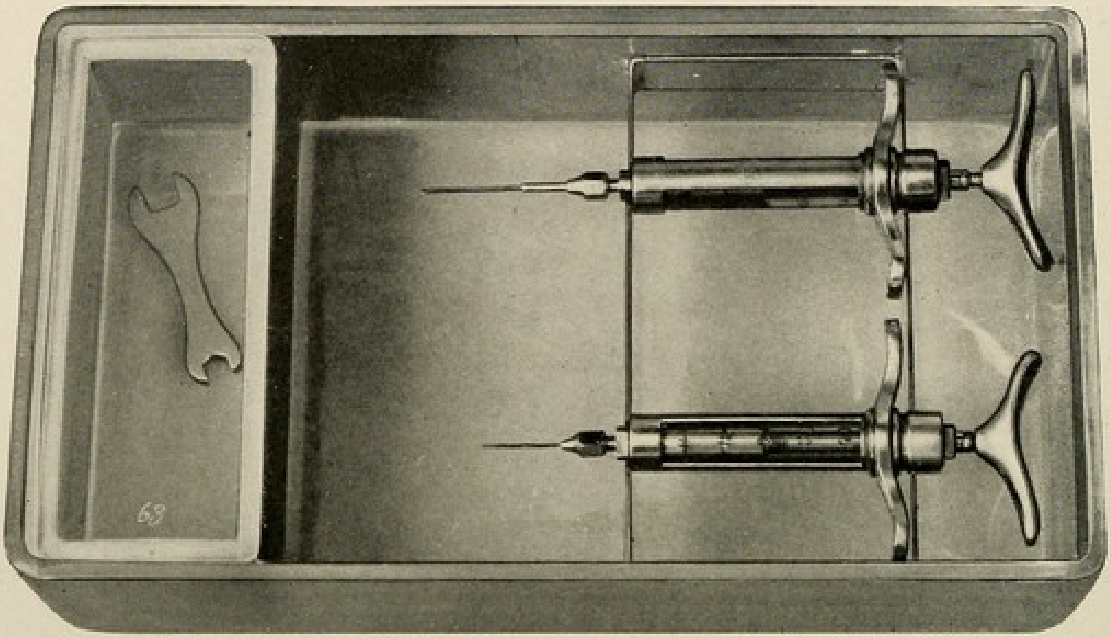
FIG. 11



Modified stock flask for Ringer solution.

desired amount of Ringer solution has been poured out, the stop-cock is closed, and the ground-glass stopper turned, so that all air is excluded until the next use. Third, for protecting the syringe from contamination or the needle-point from becoming dulled accidentally, a glass tray is fitted with a metal inset which accommodates two filled syringes mounted with short or long needles. This tray also holds a small glass tray with ground cover, in which needles and wrench may be kept in an antiseptic solution (see Fig. 12).

Fig. 12



Glass tray with metal inset, accommodating two filled syringes with long or short needles; also smaller covered tray for preserving wrench, needles, pulp broaches, etc., in antiseptic solution.

In designing this set it has been the aim to perfect the individual links in the chain of asepsis to the highest degree feasible.

DISINFECTION OF THE FIELD OF OPERATION.

Asepsis in Injecting.—As the injection generally precedes surgical intervention of some sort, it plays a part in the subsequent healing of the wound. For this reason, even if a very minute quantity is injected, full attention must be paid to asepsis, as untoward sequelæ may arise from neglect of one of the factors involved. Many cases of edema following injections are attributable to insufficient asepsis, such as neglect in sterilizing the hands, the instruments, the solution, or the field of operation.

Disinfection of the Mucosa.—It is imperative to sterilize not only the instruments and the operator's hands before making an injection but the oral mucosa, which is always infected, must also be subjected to a most thorough and careful sterilization. Among disinfectants, iodin occupies a predominant place. Disinfection with iodin (iodo-benzin) has been generally adopted in modern surgery, where hardly any incision in the epidermis is made without previous swabbing with iodin. This antiseptic not only possesses a deeply penetrating power but also produces dryness of the swabbed area, which is of special advantage in the oral cavity.

Effect of Iodin.—Tincture of iodin (tincture of iodin and tincture of aconite, equal parts), according to König, fulfils the requirements "which are considered in all modern efforts at disinfection as most essential, *i. e.*, hardening the skin, tanning it, as it were, and fixing the bacteria for some time in such a way that they cannot get into the wound. That iodin, besides these properties, retards bacterial growth is a well-known fact." Iodin clings for a long time to the tissue to which it has been applied, thus insuring deep penetration. In a dilution of 1 to 6000, iodin still impedes bacterial growth. Lewy justly emphasizes that the tanning of the mucosa is an advantage "facilitating, as it does, the introduction of the needle into spongy gums." The purely superficial brown coloration of the place of injection is also of importance, as it very clearly marks the prepared portion of the skin to be injected. The objections that have been raised against iodin as a disinfectant of the mucous membrane cannot be maintained unless an idiosyncrasy for iodin be present. The author has never noticed any lesion or sloughing in the area of injection following the application of weak iodin.

The combined action of iodin and aconite (equal parts) upon the mucous membrane also successfully counteracts the slight pain which would otherwise be caused by the insertion of the hypodermic needle, so that after the first injection, the patient's fear of the needle-prick is overcome and his confidence and coöperation are fully insured.

Application of Iodin.—The painting with iodin is accomplished by not merely applying a few touches, but by repeatedly wiping to and fro, in order to combine real mechanical cleansing with the disinfection, and to effect penetration. The filled syringe is once more dipped in boiling water, the iridio-platinum needle drawn through an alcohol flame, and the injection is then made.

The author has also successfully employed 10 per cent. thymol alcohol for disinfecting the point of insertion of the needle. The lack of the characteristic brown discoloration following the application of tincture of iodin, however, seems to be a drawback.

In order to enable him to observe the gradual advance of the anemia of the gum following the injection, which is a valuable symptom in mucous anesthesia, Riethmüller prefers one of the colorless iodin solutions, which is also appreciated by the patient. A 5 to 10 per cent. alcoholic solution of iothion (di-iodohydroxypropane) has given most satisfaction, as it causes no irritation of the mucous membranes like excessively strong iodin solution, and seems to be applicable even in iodin idiosyncrasy.

PREPARATION OF THE PATIENT FOR LOCAL ANESTHESIA.

In dental cases, no preparation of the patient for the injection is necessary, as a rule. In cases of great excitement and fear, camphorated validol, 7 drops in a little water, to be taken internally, acts as a sedative; in extreme cases, morphin with hyoscin is administered by the mouth.

"For various reasons," Braun writes, "a combination of local with general anesthesia may be necessary as an auxiliary, if, somehow or other, the local anesthetization of the field of operation is insufficient. Such cases, of course, will occur the more seldom the greater the operator's skill and experience.

"The method of preparing the patient for lumbar anesthesia by narcotics such as morphin, scopolamin, veronal, etc., as first suggested by Krönig, has proved very useful in local anesthesia. Most patients, however, do not require such preparation, which in minor interventions is not indicated."

"To insure uniformly successful results," Riethmüller[1] writes,

[1] Dental Cosmos, February, 1913.

"even in timid, nervous, and obstinate patients and in children, one or two tablets of bromural should be given internally from twenty to thirty minutes before injection. The agreeable sedative and hypnotic effect of this drug is greatly appreciated by the timid in everyday dental operations, even though these may involve nothing more than nervous strain. Bromural is more easily tolerated and absolutely harmless as compared with quinin, chloral hydrate, or morphin-hyoscin. The twilight slumber which frequently follows the internal administration of bromural greatly enhances the ease with which our injections can be made."

Williger reports most favorable results from bromural 0.3 (one tablet) for children, and 0.6 (two tablets) for adults, to be taken with water forty-five minutes before operation; also from scopolamin hydrobromid 0.006, morphin 0.15, distilled water 10, from three to six divisions of a Pravaz syringe, to be injected hypodermically one hour before operation.

Concerning scopolamin, Riethmüller writes: "Scopolamin, to be administered hypodermically by a Pravaz syringe, has a place in our medicinal equipment, and is especially serviceable in preparing alcoholics for local anesthesia. Very stubborn or neurasthenic patients, or those in whom deep general anesthesia is absolutely contra-indicated, may be induced to submit to local anesthesia by being given a few inhalations of ethyl bromid or nitrous oxid and oxygen, if available, the mask being held at a distance from the face until superficial slumber has set in."

PART II.

INDICATIONS FOR LOCAL ANESTHESIA.

DANGERS OF LOCAL ANESTHESIA.

THE dangers of local anesthesia vary according to the method employed and the care observed in introducing the anesthetic. With cocain substitutes these dangers are considerably less than with cocain itself. Whole volumes could be written about the syndrome of untoward symptoms which cocain may produce in the organism. "Cocain is contraindicated in persons with diseased or weak heart, while novocain seems harmless, and, so far as we know, can be applied with impunity even during pregnancy and lactation." (Williger.)

Ethyl Chlorid.—Least dangerous is local anesthesia with ethyl chlorid, which may be used to advantage for producing insensibility in pericemental diseases of the anterior teeth. Many practitioners apply the ether spray, especially in children, for the production of a brief analgesia. Only small quantities, however, should be employed, as this anesthetic is by no means harmless in children, and even small doses of it may produce syncope. It should never be employed near an open flame or in connection with a thermocautery, owing to the danger of fire.

In obstinate and unmanageable children, and sometimes in intractable adults, the induction of a brief analgesia is preferable to local injection. These are practically the only cases in which nitrous oxid and oxygen analgesia, at present so popular among American dental practitioners, can compete with novocain-suprarenin anesthesia, and even these exceptions prove the rule of the vast superiority of local injection, as any one familiar with both methods will attest. Ether analgesia, according to Braun, is a fairly safe form of narcosis suitable for short interventions such as simple extractions. The inhalation of a few whiffs of ethyl chlorid produces a brief condition resembling alcoholic intoxication, which has led to the erroneous belief that it is the freezing of the gingivæ which renders the extraction painless.

Analgesia alone can be considered in dental operations in competition with local anesthesia, while full anesthesia should be a thing of the past for the dentist. At any rate, it is so rarely called for in dental practice that he need not or cannot acquire sufficient practice in it, but, if demanded, should engage an expert anesthetist. Analgesia involves the disadvantage that it is not always satisfactory, inasmuch as its duration and depth are insufficient if the least complication arises in extractions, and sometimes excitement and frequently erotic or unpleasant dreams occur in patients. For these reasons the presence of a third person is imperative. Local anesthesia, on the other hand, offers a simpler and safer method of an infinitely wider range of usefulness, which does not require the services of an assistant. In complicated operations which last more than a few seconds, local anesthesia alone is indicated, as any one will admit who has witnessed a resection of a mandible under general and one under local anesthesia. Local anesthesia is not only equivalent but far superior to general anesthesia.

Drugs for Hypodermic Injection.—The possible danger from hypodermically injected drugs must always be realized, first, because the toxic effects of these solutions may be variable; second, because an injection may be followed by untoward sequelæ. Every local anesthetic has a toxic action, and one should never forget that novocain also is a poison. The employment of excessive doses, also an idiosyncrasy on the part of the patient, may produce serious toxic symptoms. If, however, the operator has correctly judged the character of the surgical intervention, the resistive power of the patient, and the maximal dose, *i. e.*, the specific toxicity of his solution, he will have no accidents ordinarily, if he has observed strict asepsis.

Local Action of Novocain.—Locally the novocain solution recommended involves no risk of tissue lesions whatever. Even when employed in large quantities, this drug has an indifferent action, and is very well tolerated by the tissues. Necrosis used to occur when cocain solutions of high percentage or proprietary preparations containing strongly escharotic drugs such as nitric acid were still in vogue.

Breaking of the Needle.—A possible local accident to be reckoned with is the breaking of the hypodermic needle, a fragment of which sometimes disappears so rapidly in the mucosa that it cannot be found again. These accidents have increased in number since the introduction of conductive anesthesia, and have occurred mostly in mandibular injection. In our opinion, very frequently lack of technical skill and unfamiliarity with the correct method of procedure are responsible for such accidents. Only new steel needles, or those that have been used but a few times, should be employed; rusty ones break easily. Iridio-platinum needles are far preferable for this, if for no other reason. Thin needles, of course, are more apt to break than stouter ones, and, since the break usually occurs at the mouth of the hub, long needles are safer. This risk, it is hoped, will be eliminated by the use of the trocar cannula previously described.

The needle may, however, break without the operator's fault, if, for instance, the patient moves his head or gives a sudden start. If the needle fragment has been sterile and free from rust, it seems to heal in without causing any trouble, as has been noted in several cases. It is quite possible, however, that complications may be produced by the fragment later on. In all such cases, therefore, an attempt should be made to remove it, after determining its location by a Röntgenogram.

If, in subperiosteal injection, the operator has properly palpated the tip of the advancing needle, he will, with some experience in minor oral surgery, be able to fix the fragment, and, after waiting for the completion of the anesthesia, locate it by a transverse, never a vertical, incision with a sharp, sterile lancet, and pick it out with sterile pliers. If this attempt is unsuccessful, or if a needle is broken during conductive anesthesia, a surgeon must be summoned to extricate the fragment.

Idiosyncrasy.—Without any fault of the operator, intoxications are sometimes caused by idiosyncrasies, indisposition, and reduced power of resistance on the part of the patient. It is hardly possible to know or diagnosticate, in advance, the patient's disposition to abnormal reaction to certain drugs. Some persons do not tolerate cocain and exhibit grave toxic symptoms even after the minutest dose. Others, again, are indifferent to large doses, which fail to produce in them the desired anesthesia. Still others who do not tolerate alypin, for instance, react perfectly normally to other salts, such as novocain, and *vice versa*.

Very frequently, by way of anamnesis, the details of such peculiarities may be learned in the same way, as a hemophiliac cannot be recognized at first sight, and information must be previously obtained from the patient himself.

At all events, caution is required with patients who complain of palpitation almost immediately after the introduction of the needle, or show a threatening color of the face. In doubtful cases small quantities and weak doses of the anesthetic should be employed at the start. A slight acceleration of the pulse is notable after every injection, but usually it soon returns to normal.

Shock and Collapse.—Shock is of great importance in anesthesia. The psychic shock is invariably greater in local than in general anesthesia, the patients being under the impression that they are to undergo an operation while fully conscious. In hysterical and highly nervous patients difficulties may be encountered in persuading them to submit to local anesthesia, owing to their reduced resistance to psychic shock. They exhibit conditions of excitement and collapse which may assume the proportions of syncope. Serious hysteria, therefore, is a contra-indication to local anesthesia. Cases have been reported in which the patients collapsed before the injection and expired from shock before any anesthetic whatever had been applied.

In nervous patients of low vital resistance and in persons without self-restraint or courage, special persuasion is required to dissipate all fear before the operation. In such cases invariable success will be assured only to that operator who, by his skill, training, and familiarity with the method of procedure is capable of fully keeping his promise. It is a great mistake for any operator to guarantee full success before the operation, because, in case of failure, he undermines his reputation thereby. Besides being most unprofessional and unscientific, such a guaranty is apt to arouse more suspicion than confidence in an intelligent patient.

Antidotes in Collapse.—A number of effective measures may be adopted in case of disquieting symptoms. In light affections, such as palpitation, rapid pulse, pallor, perspiration, and trembling, a decoction of strong black coffee, fresh aromatic spirits of ammonia, or from 5 to 7 drops of camphorated validol in a little water are administered internally; in more serious affections amyl nitrite, from 1 to 3 drops on a napkin, is given by inhalation.

Validol is a colorless liquid of mild, agreeable odor and refreshing taste. It consists of menthylester of valerianic acid with 30 per cent. of free menthol and 10 per cent. of camphor. It is insoluble in water, but readily soluble in alcohol, and, if given internally, in doses of from 5 to 7 drops in a tablespoonful of water, constitutes an ideal restorative in serious cases of collapse.

Amyl nitrite is a clear, volatile, yellow fluid with fruit-like odor. On inhaling the vapor, flushing of the face occurs, the pulse is accelerated, and vascular dilatation in the head and thoracic region is produced. The increased blood-supply to the head and brain counteracts the anemic condition present, and prevents collapse.

Disquieting symptoms of a lighter nature following injection, fainting, or syncope may be combated by placing the head in a recumbent position. In serious cases the heart must be stimulated; the chest is wrapped in wet cloths, and cold douches, coffee or a hypodermic injection of oil of camphor are administered. A few or all of these agents should be kept ready for use, as immediate application is essential.

Injections may produce two further unpleasant sequelæ, namely, postoperative pain and hemorrhage.

Postoperative Pain.—Postoperative pain is often due to purely accidental conditions of the wound, *i. e.*, sharp splinters of bone remaining in an empty alveolus, sloughing of the margins of the wound, insufficient hemorrhage and clot formation after excessive ischemia, injection of non-isotonic solutions or those containing strongly toxic agents, insufficient disinfection of the field of operation, infection from extraction with unclean instruments, or the patient's touching the wound with septic fingers, also from food debris, all of which can be averted by suitable precautions.

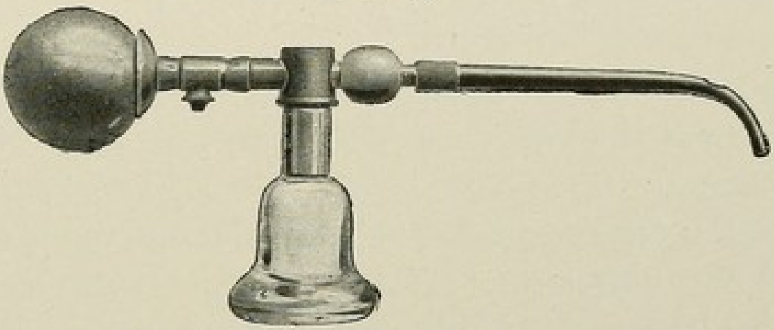
While it is irrefutable that every anesthetized wound will pass into a state of more or less pronounced hyperesthesia, from which it returns to a normal condition sooner or later, yet from personal experience, it is safe to assert that, if the anesthetic solution has been made with Ringer base, and the injection correctly performed, no postoperative pain is to be expected. If all the necessary precautionary measures have been observed, even severe inflammations of the periosteum subside in due course of time, after the effect of the anesthetic has worn off. "The claim that postoperative pain is more severe in patients operated upon under local anesthesia than in those operated upon under general anesthesia," Braun writes, "is contrary to all our experiences. There are, of course, patients who for various reasons suffer severe pain following operations, regardless of what method of anesthesia might be employed. Local anesthesia, however, does not intensify such pain, but rather reduces its duration until the return of full sensibility."

The greatest mistakes are made in regard to asepsis, for there are still many operators who make an injection without having previously disinfected the mucosa. By simply swabbing with iodin, as described above, the great danger of infection, frequently followed by edema, is materially reduced.

A. Cohn, of Berlin, reports a case which is interesting in this connection: "A patient, aged twenty-seven years, asked me to extract an upper third molar affected with pericementitis. The injection and extraction were entirely successful. About four hours afterward, postoperative hemorrhage occurred, with a sensation of heaviness in the left limb. The hemorrhage was readily arrested. The following day grave symptoms of blood-poisoning occurred, combined with paralysis of the left arm and leg, which led me to suspect intoxication by novocain-suprarenin. This diagnosis had to be abandoned, however, when on the following day the right side also became paralyzed. It was then ascertained that, despite careful injection, streptococci had caused embolism in the lumbar region, producing paralysis of the legs, which has not yet disappeared (two years after), while the other symptoms vanished. This accident, therefore, must be regarded as indirectly due to local anesthesia."

In many cases, postoperative pain after injection is of psychic origin, as Cieszynski has pointed out. His assertion, however, that after-pain most frequently follows pulp extirpation under anesthesia is untenable, since the normal solution always yields a most favorable result.

FIG. 13



Syringe for spraying novocain powder.

Therapeutic Measures in Postoperative Pain.—Postoperative pain is prevented or counteracted therapeutically by internal administration of morphin, trigemin (0.25 gram per dose), aspirin (1 to 3 tablets), pyramidon (0.3 gram per dose), or combined doses of pyramidon (0.1 gram) and aspirin (0.3 gram), or of any two of these drugs. Cold compresses also have proved most useful. In wounds, tamponing with pure novocain powder renders surprisingly good service. In all cases of inflammation of wounds novocain powder also can be advantageously applied. The cavity of the wound is carefully cleansed and sterilized with hydrogen peroxid and a 10 per cent. aqueous solution of chlorphenol, and a layer of about 2 mm. thickness of novocain powder (from 0.5 to 1 gram) is introduced, and a gauze tampon, saturated with 10 per cent. iodoform, which also has been previously charged with novocain powder, is applied with light pressure. For some time the writer has employed a convenient powder-spraying syringe, from which, by compressing a rubber bulb, pure novocain is blown through a hard rubber tube which is held close to the wound (see Fig. 13). This procedure of disinfecting and tamponing the wound is repeated every twenty-four hours, after which the healing process is left to itself without any further therapeutic aid. (See chapter on Anesthesia in the Therapy of Inflammation, page 129.)

In cases of severe inflammation with general depression due to pain from pulpitis or pericementitis, doses of morphin internally are most favorably indicated, especially if given half an hour before induction of anesthesia or extensive dental operations. The formula is as follows:

Morphin	0.2
Hyoscin	0.005
Distilled water	10.0

From 6 to 8 drops in a tablespoonful of water.

Besides its pronounced sedative effect, this dose accelerates the wound healing and prevents reaction. The extensive application of anesthesia in the therapy of inflammations is especially indicated in dentistry. With this point in view, the writer has compounded an arsenic paste which contains arsenous acid, novocain, āā 4; thymol, iodoform, āā 0.5; glycerin, chlorphenol crystals, āā enough to make a paste; to be incorporated in asbestos fiber. This paste has proved most efficacious in the practice of many operators.

Postoperative Hemorrhage.—Postoperative hemorrhage caused by injection is very rare indeed. It is arrested according to the principles recommended by Williger, the chief measure being tamponing. A normally bleeding wound, however, should never be dressed with tampons. Novocain tamponade is applied only superficially, so that the formation of granulating tissue or blood-clot in the fundus of the wound is not inhibited.

All in all, the complications that may arise during or after local anesthesia are far less numerous and not so serious as those involved in general anesthesia; consequently, the prognosis in the latter is far more uncertain and unfavorable than in local anesthesia.

Secondary effects of this nature are fewer in direct ratio as conductive anesthesia is practised. As the anesthetic solution is deposited at a distance from the diseased area, it exerts no direct action thereupon. Subperiosteal injections are more prone to cause trouble, because the process of infiltration, the subsequent anemia, and the resulting irritation of the wound, may produce complications. After conductive anesthesia, on the other hand, the hemorrhage and the behavior of the tissues involved in the operation are the same as after general anesthesia, or when no anesthetic has been used.

THE OPERATOR'S RESPONSIBILITY.

The patient's risk in local anesthesia varies according to the operator's skill, and therefore it cannot be too strongly emphasized that local anesthesia demands from the operator a specially thorough technical and scientific knowledge which can be acquired only by practice and experience.

The operator's duty is specially exacting, owing to the fact that he has to be anesthetist as well as operator. Since the extent and the depth of the anesthesia can be calculated only by the one who has induced it, it seems imperative that the operator himself should make the injection. He should always personally prepare and sterilize the solution, and never leave this important part of the work to his assistant. This, of course, complicates his duties as compared with an operation performed under general anesthesia, because he must combine great technical skill and ability, circumspection, clearness of observation, and presence of mind with wide experience and enthusiasm.

During the operation, an assistant should carefully watch the heart and lungs without, however, neglecting the special requirements and conditions of the operation itself. Besides having a thorough knowledge of the surgical conditions, the operator must fully master the anatomy of the field of operation. He must know all secondary symptoms that may arise during or after the injection, and, simultaneously with the anesthetic and operative instruments, must prepare all the accessories necessary for emergencies, such as amyl nitrite, validol, oil of camphor, and a Pravaz syringe. By a quick perception of any untoward symptoms accidents can generally be prevented or so counteracted as to avert serious danger. The chief symptoms of approaching danger are facial pallor, perspiration, shallow respiration, irregular pulse, and dilatation of the pupils.

For these reasons, while waiting for the injected anesthetic to take full effect, patients should never be left in the waiting-room without an attendant, but be kept under continuous observation.

The following alarming case has been reported, which illustrates very well the necessity for such precaution: A practitioner had injected 2 c.c. of a novocain-suprarenin solution by the subperiosteal method in the maxilla of a woman who had just recovered from influenza. The operator subsequently left the room in order to remove in the laboratory the needle which had become firmly stuck in the syringe. Upon returning after not more than one minute, he noted, to his astonishment, that the patient had collapsed, had fallen back in the chair and become wedged between seat, armrest, and back. The head was deeply reclined, respiration was difficult and slow, the pupils dilated, the facial color cyanotic; in short, all symptoms typical of approaching asphyxia were present. With great effort he lifted the unconscious patient from the chair and laid her on the floor. As respiration ceased, artificial respiration was induced, which proved successful after about two minutes' effort. The patient recovered relatively quickly after cold cloths, fresh air, and amyl nitrite had been applied, and despite the serious character of her collapse was able to return home by carriage an hour afterward.

This accident furnishes convincing proof of the necessity of having a third person present for assistance in every case of local anesthesia.

Anamnesis.—The operator, before inducing anesthesia, must question the patient concerning his heart, lungs, and nervous condition. In many cases he will thus be able to obtain an accurate history and gather the information necessary for making his dispositions in regard to individualization in the dose to be injected, calculation of the time of waiting, etc.

As we have pointed out before, it does not seem practical for the dentist to make a thorough examination by way of auscultation and percussion, nor is an absolutely certain diagnosis necessary, because the solution advocated never imperils the patient's life. Individual peculiarities must, of course, be duly considered, and no factor tending to a successful injection should be slighted.

Harmlessness of the Normal Solution.—In some cases it may be difficult to decide whether local or general anesthesia is more favorably indicated. In arteriosclerosis and nephritis great hesitancy has heretofore been entertained toward injecting anesthetic solutions; in the former disease, owing to the altered condition of the vascular walls, which often do not tolerate even a moderate change in blood-pressure such as is produced by suprarenin; in the latter disorder, owing to the danger of intoxication involved in the passage of the anesthetic through the diseased kidney.

The weak 0.5 and 1 per cent., even the 1.5 per cent. novocain solutions, with their small additions of suprarenin, must be regarded as agents which in such cases, even in diabetics, render excellent service and involve no risk to the life or health of the patient.

From these observations it appears that the anesthetist has a great responsibility, being liable for the slightest injury inflicted by his negligence upon the patient. A perfect mastery of the science and technique of local anesthesia is an essential consideration in order that the operator's conscience may be clear in regard to the proper fulfilment of his duty.

To be safe in case of any accidents, the findings of the examination, and the composition, dosage, and quantity of the solution injected should always be charted. Such a record is the best proof for the operator's conscientiousness, and is of paramount importance in case of legal complications.

ACCIDENTS FOLLOWING NOVOCAIN INJECTIONS.

Serious intoxications after injection of novocain solution have never been observed by the writer personally, unless he were to regard a case of narcotic slumber as one of dangerous intoxication. The case referred to was as follows:

Narcotic Slumber Following Novocain Injection.—Before extracting the gangrenous roots of a lower second molar in a strong and healthy woman, aged thirty-six years, local anesthesia of the mucosa was induced; 3 c.c. of a 2 per cent. novocain-thymol solution, as employed at that time, were injected, 3 drops of fresh synthetic 1 in 1000 suprarenin solution having been added immediately before injection. The injection, as in all patients of strong constitution, was completed without pain. The period of waiting for the establishment of perfect anesthesia, owing to the tardiness of diffusion in the mandible, was calculated at fifteen minutes; in the meantime two cavities in upper teeth on the same (left) side were to be excavated. Very soon (about one minute) after the injection, the patient noted considerable numbness in the entire left mandible, similar to that produced by conductive anesthesia, and five minutes afterward could no longer feel the touch of the rinsing glass on that side of the lip. The vascular system was affected at the same time by a slight acceleration in pulse, lasting for two or three minutes, whereupon the patient lapsed into a condition of semi-slumber or light sopor, and exhibited difficulty in keeping her mouth open. Pulse and respiration soon resumed their normal rate, and the patient seemed to be sleeping comfortably. As in hypnotic sleep, she answered every question, rinsed, opened, and closed her mouth as requested, in short, followed all directions, without, however, opening her eyes or being conscious of her actions. The two cavities, after painless excavation, despite close proximity to the pulp, were filled with amalgam inserted over a protective cement step. In the meantime twenty minutes had elapsed since the injection, and the two badly carious roots were extracted. Immediately afterward the patient suddenly straightened herself up with a start, opened her eyes and, according to directions, vigorously rinsed the mouth. From this moment she assumed an entirely changed attitude, acted perfectly normally, and stated that a pain as from pressure had startled her. She still felt the numbness in the left side of the mandible, and was almost ashamed when told of having been asleep. She boasted of always having enjoyed an exceptionally strong constitution, and, as if to excuse herself, mentioned that her system reacted with extraordinary readiness and intensity to any medicament. To this peculiarity she ascribed the slumber following the injection, saying that the normal dose evidently had affected her very strongly. She did not know what operations had been made in her mouth, and was glad to hear that her upper bicuspids had been filled in the meantime. She left in normal possession of her senses and feeling quite well, and experienced no further after-effects.

In the writer's opinion, this case of brief "hypnotic" slumber was due exclusively to the action of the novocain and the unusual susceptibility of the patient. No erotic symptoms were noted in this case, such as are frequently observed in general anesthesia, also sometimes in local anesthesia with ethyl chlorid or cocain. Nevertheless, such symptoms may occur in sexually highly excitable individuals after novocain injection, which again justifies the demand that not only during general but also during local anesthesia a third person should be present to avoid all risks of suspicion.

Since the patient's excellent state of health in the case cited was corroborated by her physician, the writer is inclined to consider the extraordinary effect of the novocain as a mild intoxication, or rather an irritation of the central nervous system, produced by the exceedingly small quantity of 0.06 novocain.

Toxic Action of Novocain.—It is remarkable that in the above case there appeared none of the heretofore observed phenomena of intoxication by novocain, which Liebl has endeavored to test in his own body. Upon injecting 0.75 gram of a warm 10 per cent. solution in his right thigh, this investigator noted, after four minutes, "a sudden, strange warmth in the entire body, especially in the region of the liver, slight malaise, symptoms of nausea, and general agitation, but no notable change in pulse or complexion. Two minutes later slight deafness in the left ear set in; also ocular disturbances; accommodation in both eyes, especially in the left, being possible only with great effort; and diplopia. Thirteen minutes after the injection slight pungent headache on the left side was noted; after seven additional minutes, paresthesia in the region supplied by the radial nerve on the left side." After about half an hour of general malaise normal ease returned.

The slight acceleration of pulse shortly after injection, as noted in the case reported by the writer, is perhaps to be attributed to the suprarenal extract rather than to the anesthetic, since it has not been observed in pure novocain solutions. Liebl also emphasizes that in his own case no change in pulse and complexion was noted.

It is interesting and important to note that even novocain, although it is almost devoid of irritating action on the tissues, and can be tolerated even pure without disturbances, if applied topically and externally, may occasionally produce irritation of the central nervous system, even in a dosage far below the maximal. On the other hand, it must not be overlooked that an organism which reacts even to the lightest chemical stimuli, and in which the protoplasm is extremely sensitive, as in the case reported, will tolerate a maximal dose of novocain only far below the average. To cite Braun: "Whether and in what intensity novocain intoxication occurs in the central nervous system by no means depends only upon the dose of novocain introduced into the blood, but also upon the time allowed for its introduction. If introduced into the blood suddenly, or in concentrated solution—in the reported case the injected solution exceeded in its action that of the usual maximum dose—immediate toxic action may result from a dose which, if administered gradually, *i. e.*, in dilute solution, or in portions at intervals, may not produce even the slightest suggestion of an intoxication of the central nervous system, because then the concentration of the novocain in the capillaries of this organ will at no time exceed the toxic dose."

Klein also claims to have observed pronounced symptoms of intoxication from novocain in five cases, three of which he attributes to complication with functional disorders of the heart, lack of resistance of the whole organism, and abnormal menstruation. In his other two cases, however, he regards novocain as exclusively responsible for serious symptoms of collapse. Just as the case reported by the writer seems to illustrate an instance of extraordinary action of novocain solution that must be judged by itself, so the two cases of intoxication reported by Klein, which apparently cannot be ascribed to any other causes, must be regarded as abnormal exceptions to the rule. From his own experience with the use of novocain, now extending over a period of eight years, the writer can only once more emphasize its eminent advantages over cocain, even though novocain, as we have seen, may occasionally produce untoward secondary effects. Until now these cases have been of such a mild or trivial nature, and so far above comparison with cocain cases, that novocain loses none of its great superiority in regard to the relatively almost complete absence of irritation. A local anesthetic, as Liebl has definitely established, "surely possesses extremely favorable properties, if, like novocain, it only occasionally produces relatively harmless symptoms of slight intoxication, which cannot be compared for one minute with the ghastly clinical picture of cocain intoxication, and does it only under conditions specially favorable for the appearance of symptoms of absorption, that is, at body heat, and only in the high dose of 0.75 gram of a 10 per cent. solution, which is never employed in local anesthesia." Cases of intoxication from novocain are very exceptional, and no great importance can be attached to them, since in the vast majority the experiences with this drug have been extraordinarily favorable, as Klein fully acknowledges.

Cases of gangrene and necrosis following novocain-suprarenin injections, which have now and then been reported, have in every case been traced to stale and infected solution, lack of sterility of the instrumentarium, and injudicious injection directly into a focus of infection. This last cause is also responsible for the "case of novocain peridental anesthesia followed by unpleasant symptoms," as reported by John S. Marshall,[1] in which 0.09 gram of a novocain-

[1] Items of Interest, March, 1914, p. 220.

suprarenin solution had been injected peridentally for the extraction of two molar teeth affected with pyorrhea alveolaris. Granted that every step in the operation was performed under strictly aseptic conditions, granted even that the solution which was prepared from novocain-adrenalin-sodium-chlorid tablets which have proved extremely unstable, was perfect, the symptoms of malaise, constriction in the region of the heart, labored breathing, and increase in pulse rate which were noted on the day following the operation are clearly those of mild septicemia due to the bacteria carried from the pyorrheal area into the blood by the needle and the injected fluid, but not, as Marshall suspects, manifestations of the cumulative effect of novocain.

Statements regarding accidents due to the toxicity of novocain, especially those appearing in the lay press, should invariably be accepted with a grain of salt, inasmuch as the case histories given are rarely complete and intelligible enough to enable the expert to draw his own conclusions as to the real cause or causes. Such reports usually contain statements and inferences prejudicial to novocain, which should be carefully verified before acceptance. As the *British Journal of Dental Science*[1] aptly remarks, editorially: "The dental and medical world have for a considerable time regarded novocain as an ideal local anesthetic, because, if injected with proper aseptic precautions, it involves, so far as we know at present, no risk whatever to the patient. An anonymous correspondent to our contemporary (*The Times*) complains of an immediate effect upon the heart, 'a tingling sensation of the nerves near the region of the heart,' followed after an hour by 'a bad heart attack,' accompanied by a sense of suffocation and intense pain, and during the subsequent two months several similar attacks, ending in a nervous breakdown. Before these experiences can be of any service in extending our knowledge of the effects of novocain, many things will be necessary. We shall require to know all about the general anesthetic that was administered just before the novocain was injected, what was the exact nature of the preparation employed, its strength, and whether it was freshly prepared; whether any of the ritual of asepsis was omitted, and, most

[1] March 16, 1914.

important of all, we must know from some reliable medical authority the condition of the patient's cardiovascular system. No doubt the 'Reader of *The Times*' was quite unaware of the fact that no single injection of novocain ever has or ever could produce consequences lasting two months. Septic poisoning might possibly have a lingering sequel, though recurrent heart attacks could scarcely constitute the symptoms even in such a case. Some of the writer's expressions would be explained by an attack of angina, but from a perusal of the letter and without further information we should unhesitatingly refuse to believe that an injection of novocain had anything whatever to do with the sequelæ." After citing similar reports, the *Journal* continues: "The interest of these letters is chiefly this: that while they attribute amazing consequences to an injection of novocain, and can hardly be expected to lead to any really useful result, they may cause widespread mischief to the community by raising a groundless panic with reference to the use of a very valuable and, when properly employed, a very safe local anesthetic. If such loose appreciations of the nature of cause and effect are allowed to disturb the public mind, then every sufferer from gastric trouble and consequent cardiac symptoms traceable to another cause will be able to find an explanation of months of trouble in one injection of novocain, and possibly this may prove a more convenient explanation for circulation in the family circle." To this we might add that it is extremely unfair to the patient and to the science of local anesthesia if a dental practitioner, as occurs occasionally, attempts to cover up his own omissions and commissions in an untoward case by laying the blame on the "toxicity of the drug."

Personally, in a practice comprising over 30,000 cases, the writer has not experienced a single instance of serious intoxication following injection, while he will ever remember several grave accidents which came to his notice after cocain injections. The few interesting observations of abnormal action of novocain merely corroborate the old postulate of individual discrimination in the administration of every drug. Cocain very frequently produces general disorders, and local gangrenous conditions in the injected tissue, especially if the solution was not absolutely pure. These conditions have never been noted after injections of novocain, which only in very rare cases are followed by postoperative pain, which with cocain is almost the rule.

Hysterical Spasms Following Novocain Injections.—Several cases of hysterical spasms following novocain injection have been reported, one by Kehr,[1] one by Knoche, of Gotha, and one by Jelonek, of Duisburg. In all these cases the patients were subject to hysteria, which broke out under the added stimulus of the novocain injections. In the last case reported, the patient had tolerated novocain very well on former occasions, which proves that the novocain produced no specifically toxic effect, but was merely the final contributing factor to a long-preparing new outbreak of hysteria, the predisposition to which was greatly enhanced at the time of the last injection, while during previous injections the disease had lain dormant. All the details of this last case confirm our opinion of the infinitesimal danger of intoxication from novocain, which has been found to be and for the present remains the best and least toxic anesthetic. Its relative toxicity, to quote Braun once more, "is incomparably smaller than that of all heretofore known local anesthetics; for the extraction of teeth, therefore, this drug is most favorably indicated."

These case reports corroborate what has already been demonstrated, namely, that even entirely harmless doses of novocain occasionally may act toxically by eliciting an outbreak of already established nervous diseases, especially of hysteria. These outbreaks, however, would have been induced by any other nerve irritation. The procedure of injection and operation in itself is an unusual experience which, for a highly excitable patient, it is difficult or impossible to overcome. In hysteria, therefore, as has been said before, special precaution is required on the part of the operator.

Unduly Prolonged Duration of Local Anesthesia.—Several cases of anesthesia lasting for weeks or months and extending over smaller or larger areas have been reported, and again it was possible to prove that these most disagreeable after-effects were not due to any toxicity of the novocain-suprarenin solution, but to surgical injury of a nerve

[1] Deutsche Monatsschrift für Zahnheilkunde, January, 1910.

trunk inflicted accidentally, especially during the extraction of teeth with abnormal roots. The therapeutic measures in these cases consisted in electric treatment and massage of the muscles of mastication, with the object of stimulating the regeneration of the injured nerve.

One case of brief temporary paralysis of the facial nerve also has been reported. In a review of these unusual dental cases, Braun writes: "Our surgical literature contains no reports of novocain intoxications, although we are daily using infinitely greater quantities than have been used in the cases in question; to mention only a few examples of operations which for years have been performed by many surgeons under novocain anesthesia exclusively: In hemorrhoid operations we regularly inject 100 c.c. of a 0.5 per cent. solution, in hernia operations from 100 to 150 c.c., in excisions of goitre from 100 to 150 c.c., in resections of the maxilla from 10 to 20 c.c. of a 1 per cent., and 75 c.c. of a 0.5 per cent. solution. Quantities of from 150 to 200 c.c. of a 0.5 per cent. solution, I have injected in hundreds of patients of every constitutional variety imaginable. Hesse, of Stettin, uses up to 250 c.c., Borchardt and Axhausen 150 c.c., the Heidelberg Surgical Clinic 50 c.c. of a 1 per cent. solution, each c.c. of solution containing 0.00012 gram suprarenin. Neither myself nor other surgeons have noted any after-effects except occasionally a single attack of vomiting after injection of very large doses.

"It was only recently that I observed novocain intoxications in experiments with sacral anesthesia, in which 25 c.c. of a 2 per cent. novocain solution with suprarenin admixture were injected into the sacral canal. In some of these cases secondary effects were noted very soon after the injection, consisting in collapse, vomiting, and other disturbances which passed off within an hour. Owing to these experiences, I have discontinued these experiments. These observations, however, as well as those made in spinal anesthesia are not applicable to local anesthesia, because the anesthetic is applied in an entirely different way. It is unreasonable to think that novocain when injected into the gingivæ should act differently than when introduced into soft tissue in any other part of the body. The peculiar phenomena which some dentists have observed here and there after injections of very small doses cannot be attributed to novocain.

"It is sheer nonsense to compare novocain with cocain. First of all, its low toxicity has been distinctly proved by pharmacological investigations; again, how is it that we can inject such large doses of novocain every day with impunity?

"The case of unduly prolonged anesthesia mentioned can in my opinion be explained only as being due to hysteria. Pharmacologists have proved the innocuousness of novocain to nerve tissue in contradistinction to stovain, therefore, whenever possible, we inject directly into nerve trunks."

It might also be suggested that the case of unduly prolonged anesthesia, as cited, might be due to alcohol having been left in the syringe and injected together with the anesthetic solution (cf. page 89).

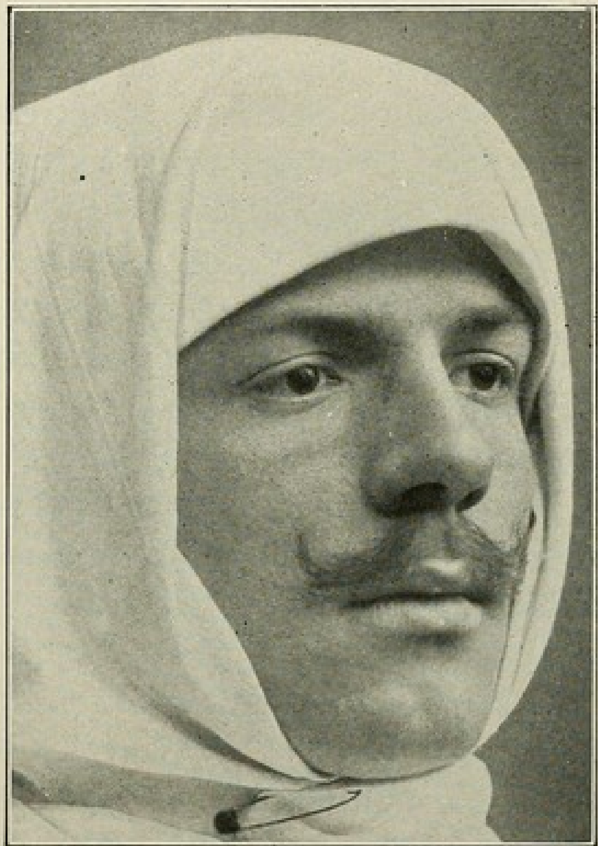
"At any rate," Braun says in his text-book, "all such observations teach us that even the smallest operative interference, no matter how carefully we proceed, may lead to dangerous complications which in all probability are due not to one single cause, but to an unfortunate combination of sometimes inexplicable conditions."

INDICATIONS FOR LOCAL ANESTHESIA.

The question as to when local anesthesia is indicated cannot be solved within the limitations of this book, as this depends more or less upon the conditions presented in each case. For the dentist local anesthesia offers a wide field of application, and in its present state of perfection furnishes an invaluable addition to his resources. As long as major surgery is rapidly adopting local anesthesia more and more generally, dentistry, as a branch of minor surgery, should surely employ this method universally. The possibility of local anesthesia should always be considered before resorting to general anesthesia, and not *vice versa,* as, unfortunately, many dentists are still in the habit of doing.

Oral Surgery.—In oral surgery, local injection can be employed in an infinite number of operations which it is needless to discuss here in detail. Besides extractions, all incisions in the mucosa, resections of roots, bone chiselling, cyst operations, partial resections, extirpation of small tumors, setting of fractures, etc., come under this heading. In all such surgical operations, before inducing anesthesia, the patient's head is protected with the head wrap indicated by J. Witzel. A sterilized napkin is laid over the hair and fixed at the neck with a safety-pin (see Fig. 14).

Fig. 14



Head wrap, designed by J. Witzel.

Anesthesia of Pulp and Dentin.—Several writers have recommended the method of injection for anesthesia of the pulp or the dentin. Its application in the conservative treatment of teeth is, indeed, most opportune. The principles governing the technique of anesthesia are the same in conservative interventions as in the surgical measures enumerated.

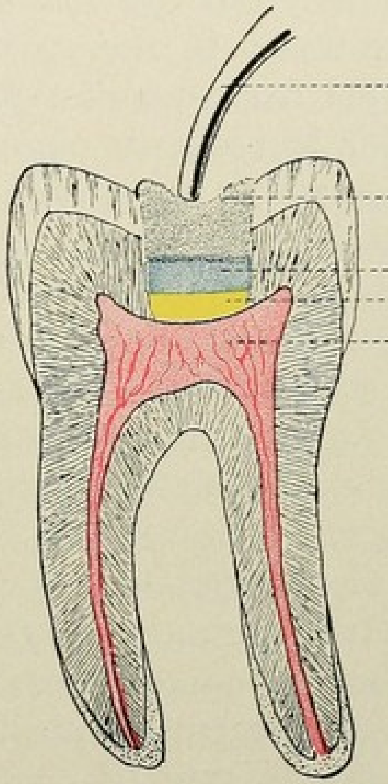
Pressure Anesthesia.—A number of measures have been suggested for the direct anesthetization of the pulp and the dentin, without injection. Among other things, novocain-suprarenin pluglets and alypin pluglets are offered in the market for this purpose, which in hypersensitive dentin often yield very satisfactory results. One of these pluglets is either rubbed with a round-headed instrument into the area of hypersensitive dentin, or introduced into the moist cavity, pressure being exerted with a suitably shaped instrument for from five to ten minutes. In cases of close proximity or exposure of the pulp, full anesthesia can sometimes be obtained by several applications. For desensitizing hypersensitive dentin in the preparation of a cavity, however, this method of direct anesthesia is extremely uncertain, and the operator is often obliged to resort to injection which in the great majority of cases affords absolute painlessness.

The anesthesia for the purpose of conservative treatment in many cases must be more profound than that for surgical purposes. It has, for instance, been observed that under mandibular anesthesia the extraction of a tooth was absolutely painless, yet the sensitivity of the pulp of an approximating tooth on the anesthetized side was not entirely abolished. In all dentinal anesthesias, therefore, either the usual amount of the anesthetic solution is increased by one-third, or the concentration of the solution is raised by using 3 instead of 2 tablets, thereby insuring an almost certain effect. For the sake of completeness, we shall briefly describe a method which seems most suitable for pressure anesthesia, and with which every dental practitioner is familiar. Griffin[1] prefers for pressure anesthesia hypodermic tablets containing cocain, morphin, and atropin. One-third or one-half tablet is introduced in the cavity on a minute cotton pellet saturated with adrenalin, and allowed to lie on the exposed pulp for a few seconds. Then a piece of unvulcanized rubber slightly smaller than the cavity is laid over this pellet, and gentle pressure is exerted (see Fig. 15). If the patient shows the least sign of pain, the pressure is relinquished, to be again gradually increased, without, however, causing any pain. In approximal cavities the rubber is first firmly pressed against the cavity margins, and then

[1] Ergebnisse der Gesammte Zahnheilkunde, 1910, vol. iii.

slightly against the pulp. Small round-headed instruments are not suitable for this purpose, as they pierce the rubber and do not permit of uniform pressure. Only flat, broad pluggers should be used, as they can easily be lifted without displacing the rubber. After from one to three minutes, when the pressure is no longer painful, rubber and cotton pellet are removed, the opening into the pulp chamber is enlarged, and the pulp can then be immediately extirpated without

FIG. 15



Pressure anesthesia in exposure of the pulp.

pain or hemorrhage. A repetition of this pressure anesthesia within the pulp chamber is rarely necessary. This method is most convenient in exposed pulps, though it is efficacious even when the pulp is still covered with a thin layer of dentin. A drop of adrenalin, a few cocain crystals, a drop of formagen, and pressure with rubber is all that is required.

"For pressure anesthesia," Riethmüller[1] writes, "small rods or pluglets containing 0.01 gm. novocain and 0.0002 gm. suprarenin are

[1] Dental Cosmos, February, 1913.

in the market. These rods are applied in the same way as the cocain rods sold for this purpose. The anemia produced by the suprarenin allows of a cleaner operation with less danger of subsequent discoloration of the tooth, and is specially appreciated in children's teeth with large apical foramina. These rods produce perfect results even in advanced stages of pulpitis and in cases of pulp-stones, in which the familiar procedure may have to be repeated once or twice. The great advantage of these novocain-suprarenin rods over cocain or arsenous oxid lies in the absence of pericementitis following pulp extirpation."

For confining the anesthetic in the cavity and distributing the pressure evenly, Riethmüller recommends the use of weighted rubber, which he finds far superior to ordinary unvulcanized rubber. In his opinion cocain involves some risk, even when used for pressure anesthesia, in patients with an idiosyncrasy, as is illustrated by the following clinical case: A student in our Dental Infirmary, while attempting pressure anesthesia in the lower left second bicuspid of a young, healthy-looking woman, accidentally dropped a very small crystal of cocain on the patient's tongue, but immediately picked it up with cotton pliers, and requested the patient to rinse to remove the bitter taste of which she was complaining. After rinsing, the patient's extremities began to tremble, her pupils were dilated, breathing became labored, and in less than two minutes the typical syndrome of symptoms of cocain intoxication was noted. Restorative measures were at once applied, as the patient threatened to collapse. Not until one full hour afterward was she able to leave the infirmary, accompanied by an assistant, owing to her weakened condition. Upon her return to the Infirmary several days afterward, she gave a history of hysteria, and stated that malaise had persisted for several hours. In this case of extreme susceptibility, the application of cocain to the pulp would in all probability have produced similar symptoms. The pulp was subsequently extirpated after devitalization by arsenous oxid.

Injection Indicated for Anesthesia of the Dentin.—Since none of the obtundents when introduced into a hypersensitive cavity or applied to hypersensitive dentin acts with sufficient certainty and without danger to the vitality of the pulp, we have conducted experiments to ascertain the applicability of anesthesia by injection for this purpose. These experiments with novocain-suprarenin solution have yielded such splendid results in regard to efficiency and innocuity that the injection method must be regarded as being the best at present for dentinal anesthesia. If, before making an injection, the condition of the pulp has been accurately tested by thermal, mechanical or electric stimulation, we can carry out our measures without harming the metabolism of the pulp, and can often fill such teeth at the same sitting. After the anesthesia has worn off, the pulp will exhibit a slightly reduced sensitivity, but will soon return to normal. According to Euler's and Scheff's experiments, the life of the pulp is not imperilled, provided all due precautions in regard to solution, technique, and instrumentarium have been observed. The elimination of the excruciating pain which usually accompanies any attempt at excavating hypersensitive dentin is indeed a blessing to highly nervous patients.

Injection of novocain-suprarenin produces also anemia, which is evinced by the pale appearance of the pulp tissue. Extreme care is therefore required in the preparation of a cavity, in order to avoid the danger of inserting a filling too close to or directly upon an exposed pulp without protecting it by an aseptic pulp capping, or of overlooking the initial stages of an already established pulpitis. Such mistakes are apt to occur because all the usual criteria regarding the proximity of the condition of a pulp are obliterated by the anesthesia. Death of the pulp is the inevitable consequence of such errors in treatment. Cocain-adrenalin mixtures such as were at one time employed for the purpose of dentinal anesthesia often caused keen disappointment, because pulps anesthetized with these agents preliminary to cavity preparation would subsequently succumb to atrophy or necrosis. These failures were justly attributed in part to the adrenalin, the dosage of which was gradually reduced. Pure cocain, which is still frequently used for obtunding hypersensitive dentin, possesses ischemic properties which are so intensified by the addition of an excessive quantity of an adrenalin preparation that the anemia of the injected tissue persists for a dangerously long period of time. Unless a pulp is exceptionally strongly constituted, it is incapable of recovery, and doomed to mortification. On the other hand, the doses of anesthetic solution advocated are so readily absorbed that they will not injure a normal pulp.

Quinin as a Sedative in Cavity Preparation.—In highly sensitive, hysterical, or neurasthenic patients, in whom anesthesia is contraindicated, it is of advantage before dental operations to give internal doses of quinin sulphate, 0.5 gram, or chloral hydrate, 1 gram, to quiet the nervous system. Le Monnier, of Nizza, who is said to have been the first to apply quinin in dentistry, reports as follows:

"In February and March of 1887, when the severe earthquake took place in Nizza, I had occasion to observe that many of my patients showed so much nervousness that it was impossible even to touch their teeth, and all the measures usually resorted to in such cases failed. Especially teeth in the advanced stages of caries were so sensitive that they could not be excavated, even after the application of caustics. One of my patients was seized with general neuralgia of the head, so that he excused himself for not keeping his appointment. Several hours later he appeared, however, and was treated. I noticed that he did not make the usual twitching motions, and learned that he had taken a large dose of quinin for his neuralgia.

"It then occurred to me to prescribe for another similarly nervous patient 0.5 gram of quinin sulphate, to be taken for two successive days. The same effect as in the former case was observed, and the patient's teeth could be filled during the next sitting. The quinin seemed to reduce the sensitivity of the teeth much more effectively than locally applied caustics.

"In the same year I had occasion to treat a woman who exhibited the same symptoms, and again I prescribed 0.5 gram of quinin for two successive days. I was agreeably surprised to see the patient return the following morning and submit to the required operation. These experiences have recently been corroborated, and I believe to have found in quinin sulphate a valuable addition to our medicinal resources in nervous cases."

Chloral Hydrate as a Sedative.—Chloral hydrate (from 0.5 to 1 gram) also is a sedative which obtunds the brain function and reduces the sensitivity of the teeth. In speaking of this drug, Seitz says: "In 1899 a young woman, aged eighteen years, who was undergoing nerve treatment in a sanatorium, presented for dental treatment. The year previous she had met with an accident while telephoning during a thunderstorm. Lightning struck the wire, and she fell senseless beside the apparatus. When she regained consciousness, several hours afterward, hyperesthesia of the entire surface of the body had set in, intolerable pain being caused upon the slightest touch. In a year's time this hyperesthesia had somewhat abated after treatments of various sorts, yet it persisted in the trigeminal region, so that the mere touching of the teeth with a finger still caused great pain, and for the time being dental treatment could not be instituted. When, however, idiopathic odontalgia set in, every possible therapeutic means had to be tried to give relief, and, since local application of chloral hydrate was unfeasible, the internal administration of this sedative was resorted to. The patient was given one powder of 1.5 grams in wine in the evening, and the same dose on the following day, half an hour before the operation. The sensitivity of the teeth was actually reduced to such a degree that even the dental engine could be used. During the operation the patient was in a seminarcotic condition and completely indifferent, and showed not the least sign of pain. Half an hour later she was able to return to the sanatorium by carriage. No secondary symptoms occurred.

"Similar cases have been reported in the July, 1900, issue of *Dental Office and Laboratory*. According to this report chloral hydrate was administered in doses of from 10 to 15 grains, which acted promptly even in cases of extreme nervousness, in which all attempts at local anesthesia of the dentin had failed. Further experiments with this sedative are therefore highly desirable."

From personal experiments with chloral hydrate (1 gram) and morphin (0.01 gram) for the reduction of sensitivity, we have come to the conclusion that internal medication of this nature in suitable cases is most advantageous. The analgesic effect is noted after from four to five minutes, characterized by a notable reduction in the sensitivity of the dentin, varying in different individuals. In highly excitable persons this effect is frequently noted to a remarkably extensive and pronounced degree. While harmless, this method involves one disadvantage, inasmuch as the certainty of its success is not invariably uniform. Before the induction of either general or local anesthesia, however, it is of great value in fortifying the psychic condition of nervous patients.

Pulp Extirpation and Root Canal Treatment.—Healthy pulps can invariably be extirpated painlessly after an injection. If, for some reason or other, some slight sensitivity in a pulp is encountered after opening into the pulp chamber, pressure anesthesia with a novocain-suprarenin pluglet, after the method described, will quickly abolish all sensation. The immediate filling of root canals is indicated only under certain rare conditions. In pulpitis due to pulp-stones or any other cause, injection is most favorably indicated for the painless exposure of the pulp, the coronal portion of which can be immediately amputated with a sharp spoon excavator of suitable size. Immediate total extirpation and root canal filling, however, is contra-indicated in such cases, where the arsenic dressing indicated on page 106 invariably should be applied, and a few days afterward the pulp stumps should be removed, the root canals cleaned and disinfected, and a root canal filling then inserted.

The immediate filling of root canals under anesthesia is bad practice for the additional reason that pulp tissue, unless it has been coagulated by an arsenic dressing, clings very tenaciously to the dentinal walls of the canal and cannot be removed in its entirety. Even the pulps in incisors and canines which are so easy to extirpate are frequently torn into shreds, the complete removal of which is most trying and uncertain, not to mention the difficulties involved in extirpation of the pulps of bicuspids and molars. Moreover, the hemorrhage in a root canal is very difficult to arrest. It produces an unsafe edematous zone of demarcation at the apical foramen which disappears only gradually after subsequent periodontitis, and, in case of infection by way of the root canal, leads to suppurative pericementitis which renders the preservation of the tooth very uncertain.

Pulp debris that has not been removed becomes the cause of protracted irritation of pulpitic and pericementitic nature, which can be combated only by means of cauterization. Even granting that there are many teeth which remain quiescent under such conditions, it is a well-known fact that pain in pulps may be of greatly varying intensity. We only need to mention the cases of patients who present putrescent pulps, though they have never suffered any pain. "Shot-gun methods" of pulp and root canal treatment under local anesthesia must be absolutely tabooed, since they will reflect discredit upon a procedure which is invaluable if judiciously applied. "Quick cure" artists, of course, will always attribute any pain following their slipshod treatments to "the injection or the toxicity of novocain."

In this respect, the writer fully agrees with Schröder, who warns against abandoning devitalizing fiber in favor of local anesthesia. Rapid pulp and root canal treatment is not desirable, and local anesthesia should be employed merely to allay any pain arising in the course of treatment. Local anesthesia is a welcome accessory, but not a substitute for arsenic.

If, in exceptional cases, the filling of root canals at one sitting becomes necessary, *aqua regia* seems the most suitable of the many drugs recommended for the destruction of pulp remnants and the cleansing of canals. A number of cases treated in this manner for the sake of experiment have all been successful, while treatments with antiformin, formalin solutions, zinc chlorid, sodium and potassium, sulphuric acid, and sodium dioxid were followed by irritations.

Crown and Bridge Work.—In crown and bridge work also, local anesthesia is rapidly gaining ground. Numerous minor operations, such as the grinding of vital teeth, the shaping of abutments, the taking of measurements, the fitting of bands, the trying-in and setting of crowns, etc., are so painful that it is most desirable to afford relief to the patient. The mode of injection of novocain-suprarenin solution for this purpose is the same as described in this book. Occasionally, the mucosa and gingival tissue can be successfully anesthetized by the topical application of a 20 or 30 per cent. novocain solution; alypin, however, owing to its more rapid and penetrating action, is preferable to novocain.

Résumé.—Novocain solutions of a concentration up to 1.5 per cent. can be employed with impunity in arteriosclerosis, diabetes, nephritis, diseases of the heart and lungs, anemia, chlorosis, pregnancy, and lactation. Cocain is absolutely contra-indicated in diseases of the heart and lungs.

Novocain injection is contra-indicated in ankylosis, severe purulent periostitis, phlegmon, obstinate and highly excitable patients, neurasthenics, and hystericals.

If general anesthesia must be resorted to, analgesia by nitrous oxid and oxygen, ethyl chlorid, ethyl bromid, or ether is preferable to deep anesthesia.

Among the local anesthetics available, the least toxic is the best. Novocain is from seven to ten times less toxic than cocain, and three times less toxic than other substitutes for cocain. It is not a habit-forming drug like cocain.

In hypersensitive patients the insertion of the hypodermic needle can be rendered painless by topical application of aconite, phenol, or a 30 per cent. novocain or alypin solution.

The concentration and quantity of the novocain-suprarenin solution advocated for dental operations is far below the toxic limit.

The strength of the solution to be injected must be gauged by the patient's age and health.

The advantages of novocain-suprarenin injection may be summed up in Braun's words: "The chief advantage of local anesthesia consists in the possibility of introducing almost unlimited quantities of solution into the body and obtaining a local insensibility of heretofore unthought-of intensity and duration. This possibility has opened the field of surgery to local anesthesia, and has determined its remarkable progress which, even with an improved technique of injection, could never have been achieved with the old drugs. The introduction of novocain and suprarenin was as important an event for local anesthesia as that of cocain.

Local anesthesia, therefore, is the method of choice whenever conditions indicate successful desensitization of the entire field of operation by moderate doses of the anesthetic readily applied;

whenever the operator is familiar with the technique and the limits of this method; and whenever the patient's psychic condition does not absolutely demand narcosis."

ANESTHESIA IN THE THERAPY OF INFLAMMATION.

For combating inflammatory conditions in the oral cavity the writer, as early as 1907, recommended the generous use of anesthesia, and first introduced into dentistry a method which had already proved most effective in other branches of medicine.

"The chief object of anesthesia in the therapy of inflammations is to bring the anesthetizing agent in such frequent and intimate contact with the wound that pain is prevented or reduced to a minimum." (Spiess.)

The patient's sensation corresponds exactly to the appearance of the wound and the intensity of the inflammation. The total absence or limited degree of pain permits of a safe conclusion as to the total absence or the limited extent of inflammation.

Practical Experiences in the Oral Cavity.—In a large number of throat operations, also in surgical interventions in the tongue, the cheeks, and the mucosa of the lips, anesthesia has been therapeutically applied by Spiess in various ways. When superficial analgesia proved insufficient, submucous injections were made for the postoperative treatment of cases in which anesthetic dressings were technically impossible. The object was to anesthetize inflamed tissue and wounds situated in such areas, and to keep both in an analgetic condition for a prolonged period of time.

Tongue.—In minor injuries of the tongue due to awkward biting or to sharp edges and corners of carious teeth, and in the intensely painful desquamations or blisters at the tongue margin, pain rapidly disappears after several applications of an anesthetic agent made at short intervals.

Coryza.—The disagreeable sensations of incipient nasal catarrh are relieved by insufflation of orthoform or novocain into the naso-pharyngeal cavity, repeated until normal sensation is reëstablished.

9

Coryza can be aborted with absolute certainty in this way. Insufflation or dressings of novocain involve no risk whatever, since novocain is not a habit-forming drug. A great many victims to the cocain habit have been started in their fatal practice by the application of cocain to their nasal mucous membrane by thoughtless physicians.

Lacerations.—Minor bruises, lacerations, also wasp- or fly-stings, should be painted with orthoform or novocain in the form of a thick, watery paste, or in strong solution, until all pain has ceased. Redness and swelling will thus be arrested, the wound edges will be smoother, paler, and without sensation, and the wound will undergo rapid healing. By all these observations, extending over a long period of years, it has been established beyond doubt that local anesthetics arrest pain; that wounds when dressed with one of these agents heal without inflammation; and that inflammation, when present, subsides in a very short time.

Modifying the Healing Process.—It has also been found that, together with pain, redness disappears. Heretofore it was impossible by means of antiphlogistics to modify an inflammation at the climax of its development in such a way as to combat redness. With the local anesthetics mentioned this can be accomplished in a very short time, often within a few minutes; moreover, pain can be absolutely abolished. This rapid abatement of redness can be explained only by assuming a direct relationship between pain and redness, in opposition to Cohnheim's theory. It simply remains to establish:

"1. That in the same way as an irritation of sensory nerves produces hyperemia by way of reflex, so inhibition of this irritation prevents or cures hyperemia.

"2. That therapeutic treatment should be directed exclusively against irritation of the sensory nerves, and that the normal function of bloodvessels should be maintained.

"3. That anesthesia is required only to such a degree as to inhibit reflex action and to prevent in the parts involved any changes induced by the sensory nerves by way of reflex."

Examples from General Pathology.—*Insanity.*—All these postulates are fulfilled in anesthesias occurring in the hysterical and the insane. Alienists have noted many cases in which injuries, burns, and wounds in such patients healed completely without any reaction whatever. Insane patients have torn open the abdominal wound after laparotomy, touched it with unclean fingers, yet made an uneventful and complete recovery.

Hysteria.—Hysterical persons can stick pins in their skin without any untoward consequences. In one case of hysteria the patient, who was suffering with general lack of sensitivity, dipped his hands repeatedly in boiling water without being scalded in the least. The explanation may be that the afferent nerves being insensible, could not be stimulated, and the reflexes upon the vasomotor nerves remained inert. Since the influence of the heat was only of short duration, no direct thermal scalding effect was produced upon the tissues, and no hyperemia or inflammation occurred.

Experiments with spinal anesthesia in animals have confirmed these observations; anesthetized tissue, upon being touched with a test-tube filled with boiling water, exhibits no blisters nor even redness.

Local Effects of Anesthesia.—The sensory sphere is paralyzed not in hysteria only but also in those pathological conditions in which, besides the afferent nerve fibers, the sympathetic nerves, often termed trophic nerves, are affected. Of special interest to us are the cases of gangrene caused by drugs, in which the above factors probably play a part. If carbolic acid is allowed to act too long and too intensely, the well-known phenomena of thrombosis appear, and not only the conductivity of the afferent fibers is inhibited but the bloodvessels also are paralyzed, and their function is destroyed. Cold of sufficient intensity also will abolish sensation, as is shown by the ether spray. If its influence is unduly prolonged, the vasomotor nerves permeating the vascular walls are directly affected and gangrene ensues.

While anesthetization of the afferent nerves promptly prevents or combats inflammation, all inflammatory phenomena appear more rapidly and severely if the sympathetic nerve branches are paralyzed, as Samuel has proved by animal experimentation.

Combating Local Irritability.—Pain, which is a specially pronounced specific sensation of discomfort, hence a condition of conscious sensation, undoubtedly intensifies not only general irritability but also local irritability and actual irritation of inflamed areas by conscious and wilful acts; furthermore, by way of unconscious reflexes, *i. e.*, by way of the centripetal (afferent) nerve supply of the irritated brain centres. This, however, is after all not the primary or most important cause of these local conditions. It is, therefore, the first aim of the therapeutist to reduce the increased local irritability—the cause of the abnormal central processes—either directly or by a general reduction of the normal or pathological sensitivity of the nervous system. In light cases this may be accomplished by very simple measures, viz., by covering and resting the inflamed parts. Since, however, despite the protection from external stimuli, owing to the continually recurrent action of internal tissue stimuli, local irritability may gradually increase and become excessive, these simple measures are frequently inadequate, and an attempt must be made to modify the local irritability of the tissues themselves by the application of cold or heat, which reduces the disposition to abnormal irritability, and indirectly regulates the blood-supply and the process of repair. For these reasons, Spiess' method is especially efficacious, as it acts in both directions, first, by the thick layer of orthoform or novocain powder protecting the part against external stimuli; second, by directly preventing the irritability of the morbid tissue. The latter effect is produced to a notable degree by morphin also, which is intended to act not as an hypnotic but merely as a sedative; for it is improbable that morphin attacks the central nervous system primarily. Such direct action upon the nervous centre is peculiar to chloroform and ether, while morphin affects above all the peripheral, the integumental nerves, and reduces the irritability of the central nervous system by acting from the periphery. Simultaneously with the altered irritability of the tissue the healing process commences its favorable course, not because pain is abolished or the pain-conducting nerves are paralyzed, but because the source of pain is blocked and the cause of increased irritability is removed, so that the nerves are no longer abnormally stimulated.

Effect of Sedatives.—The drugs which reduce irritability act best in the early stages of inflammation, or when the equilibrium of the tissues is tending to return to normal. The favorable action of carbolic acid, locally applied, must be attributed chiefly to its anesthetizing property, and it appears that other drugs, the favorable action of which was formerly attributed to their disinfectant power, possess the same sedative effect. The local application also of morphin to inflamed tissue denuded of epithelium exerts a favorable influence, as has already been mentioned, if the powder is allowed to dissolve on the mucosa, or if a few drops of a strong solution are allowed to be absorbed.

In painful lesions of the mucous membrane of the mouth and tongue doses of potassium sulphocyanate, three tablets daily after meals, have produced remarkable improvement and rapid healing, in my practice, so that it seems worth while to collect further data regarding sulphocyanate treatment.

Effects of Anesthesia.—"No inflammation will develop if the reflexes conveyed from the area of inflammation by way of the afferent sensory nerves are successfully inhibited by anesthesia. Rapid healing of inflammation is induced by anesthesia of the centre of inflammation, if only the sensory nerves are anesthetized, and the normal function of the sympathetic (vasomotor) nerves is not interfered with" (Spiess).

At all events, it is of great importance to prevent external irritation, and, if this is no longer possible, to treat the area favoring internal irritation in such a way as to reduce the hypersensitivity of the tissues to a state of normal sensitivity, which is accomplished by anesthetics.

Duration of Painlessness.—*Process of Healing.*—In all cases which the writer has had occasion to observe, painlessness lasted until the termination of treatment. In prophylactically treated cases no inflammation of extraction wounds set in, which otherwise would surely have occurred, considering the severe nature of the operation. It might be suggested that antiseptic applications alone would suffice to bring about an alleviation of pain and a reduction of inflammation. Judging from experience, however, the new method of wound therapy by novocain tamponade marks a great improvement over the old procedures, inasmuch as no postoperative pain arises, and the healing process is rapid and uneventful following extractions or other surgical operations.

It is important to emphasize that local anesthesia is as valuable in the prophylaxis as in the curative treatment of inflammation, and this relatively novel method of treating inflamed tissues will permit of further elaboration. The extensive application of local anesthesia will bring us nearer to one of our foremost aims, which is, to make our operations as well as postoperative treatment painless, thereby hastening the process of repair in tissue lesions.

PART III.

TECHNIQUE OF LOCAL ANESTHESIA.

ANATOMICAL STRUCTURE OF THE OSSEOUS FRAME OF THE MAXILLÆ.

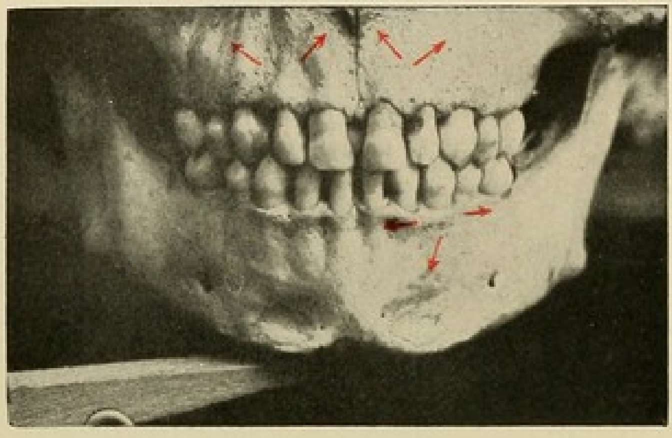
THE osseous frame of the maxillæ, which is formed by the maxilla and the mandible, possesses a number of peculiarities which are of special importance for the technique of local anesthesia and the diffusion of injected solutions. The pressure exerted in injecting serves to force the anesthetic through the *canaliculi* in the outer surface of the bone into the interior of the *alveolus*, whereby the nerves supplying the teeth can be paralyzed. It is the purpose of the following pages to demonstrate at which points of the maxillary apparatus these areas favorable for diffusion are constantly found.

The Surfaces of the Maxillæ.—If we examine the jaws of a macerated skull, we note that *spongiose*, greatly *canaliculated* or *cancellated* osseous tissue alternates with *cortical* bone which presents but few canaliculi.

MAXILLA.—In the maxilla the compact substance extends chiefly labially and buccally, but is interrupted in most skulls by definite and invariably present cancellous areas, which are of the greatest importance in local anesthesia. For only in these areas is it possible to force the solution under moderate pressure and without causing lesions through the bone into the alveolus, and to infiltrate and anesthetize the entire profusely innervated environment of the tooth root (see Fig. 46).

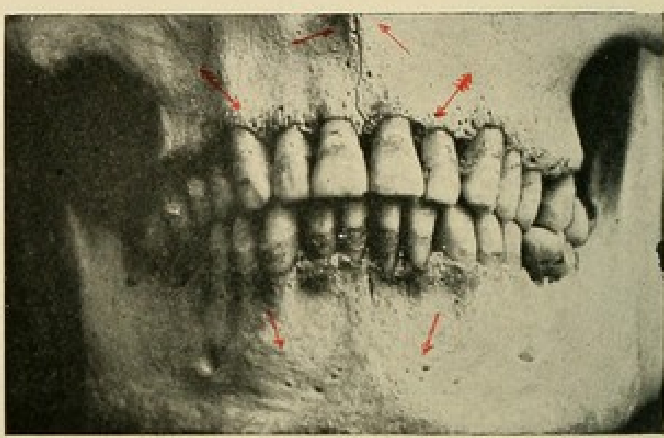
ANTERIOR SURFACES OF THE MAXILLARY BONES.—In Figs. 16 to 22 the anterior views of several skulls of persons of different sex and age are presented in order to show the various stages in the development of the sieve-like, cancellous or spongiose areas, and their varying extent. Red arrows indicate specially favorable areas which guarantee a good diffusion of the solution. Fig. 16 shows the skull of a child,

Fig. 16



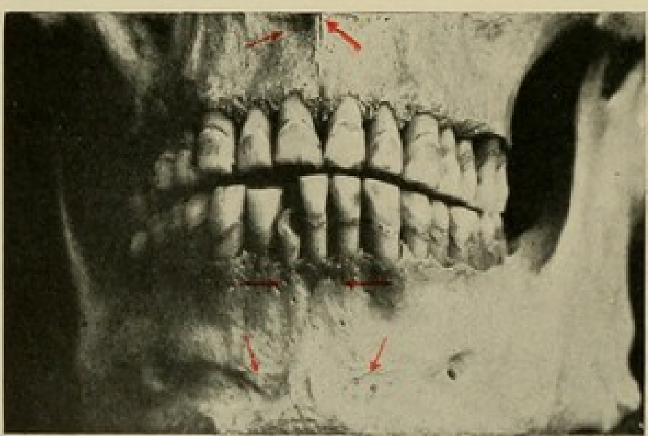
Maxillæ of child, aged seven, showing extensive cancellous areas.

Fig. 17



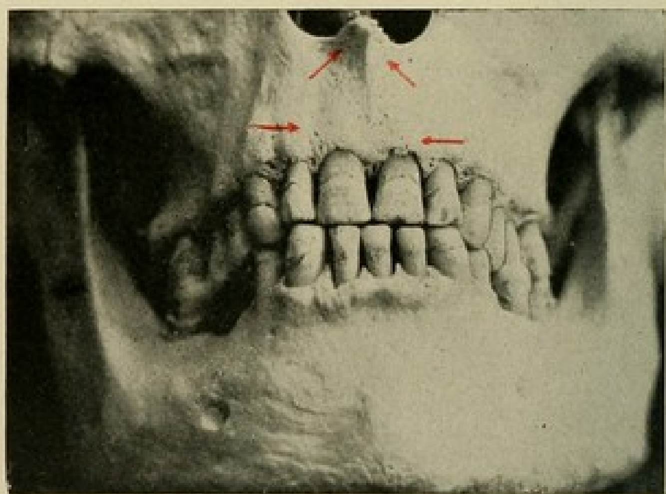
Maxillæ of young man, showing extensive cancellous areas.

Fig. 18



Maxillæ of young person, showing extensive cancellous areas.

Fig. 19

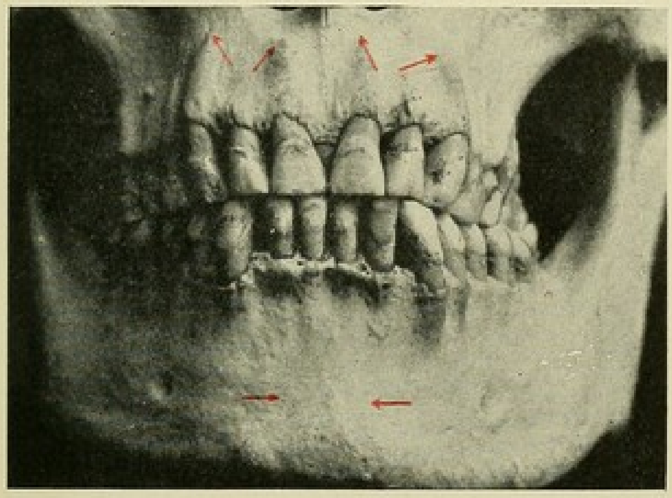


Maxillæ of old person, showing few perforations.

aged seven years, in which the conditions are extremely favorable for diffusion; Fig. 17, the skull of a man, aged twenty years, in which the characteristic cancellous areas plainly appear.

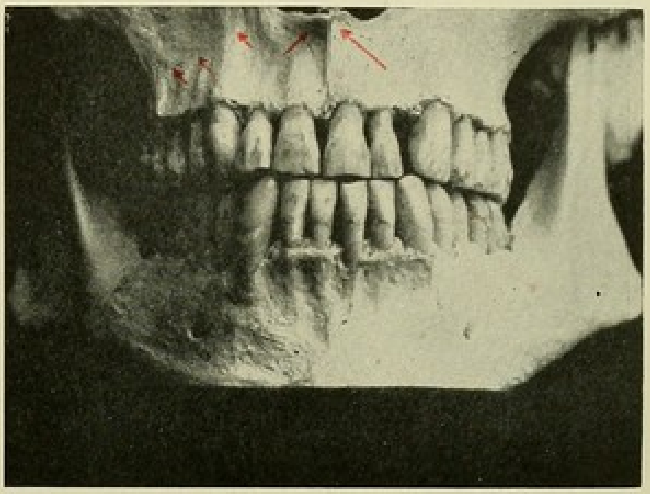
In the maxilla as well as in the mandible the *alveolar ridges* at the necks of the teeth always exhibit sieve-like perforations, as does the depression at the *anterior nasal spine*, or incisive fossa in the region of the root apices of the upper central incisors. In the mandible the cancellous areas are limited to the anterior portion in the region of

FIG. 20



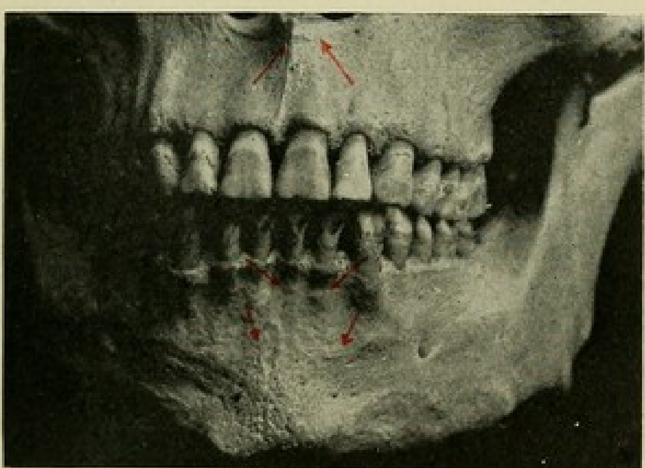
Maxillæ of old person, showing few perforations.

FIG. 21



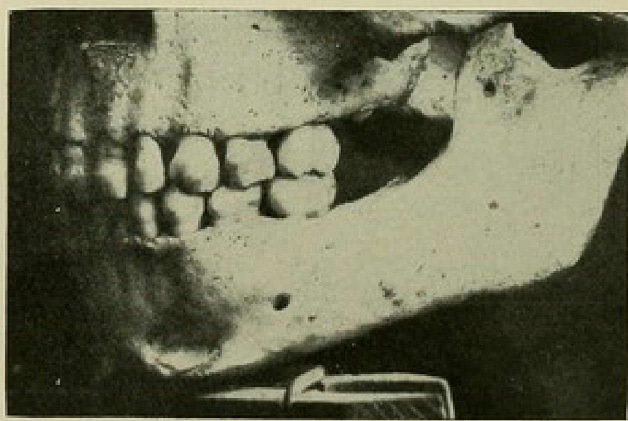
Maxillæ of adult, showing numerous perforations.

FIG. 22



Maxillæ of adult, showing numerous perforations.

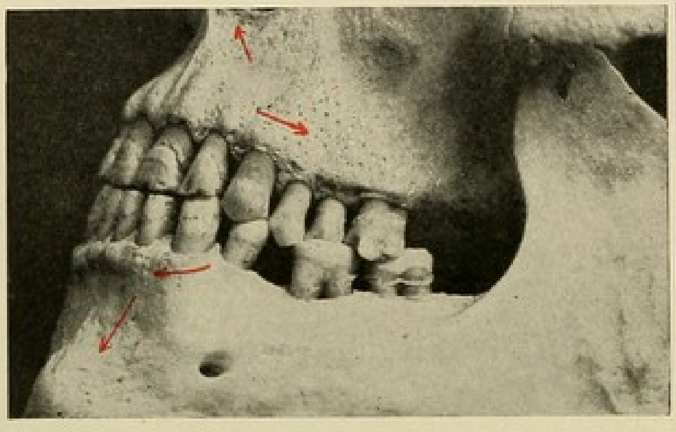
FIG. 23



Lateral view of Fig. 16.

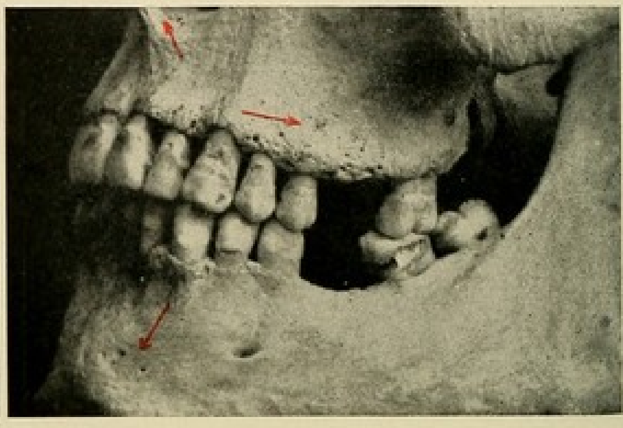
the chin, or *mental region* (see Figs. 17 and 22). Mesially to the root apex of the canine, in the *mental fossa*, on either side, groups of small *foramina* are distributed which sometimes extend up to the alveolar ridge (see Figs. 16, 18, 21, and 22). Especially Fig. 22 shows plainly how finely perforated the *mental portion* may be. The skulls of *older persons*, especially in the mandibular portions, show very few perforations (see Figs. 19 and 20).

FIG. 24



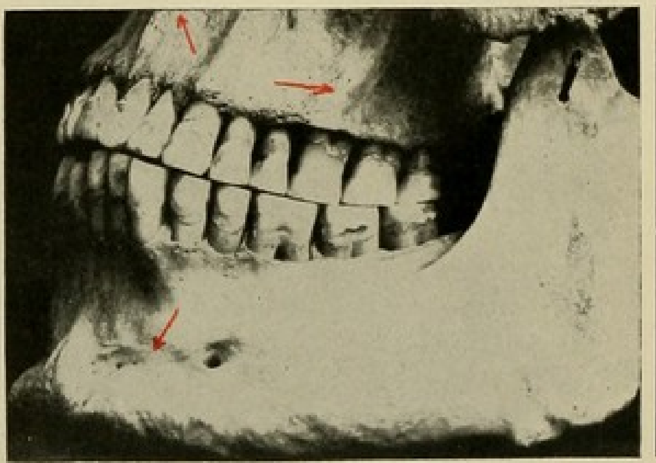
Lateral view of Fig. 17.

FIG. 25



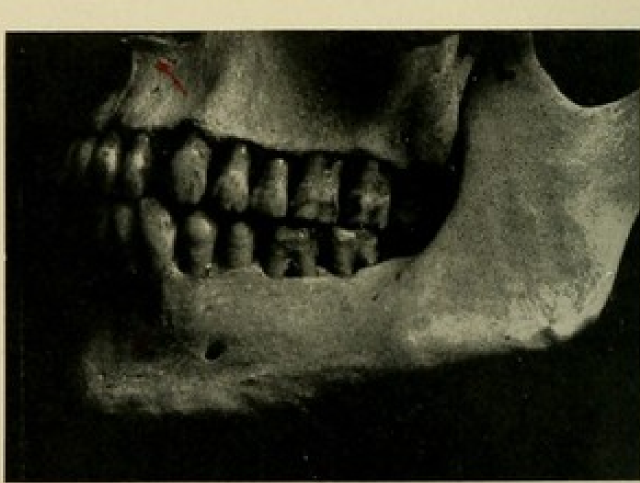
Lateral view of Fig. 18.

FIG. 26



Lateral view of Fig. 19.

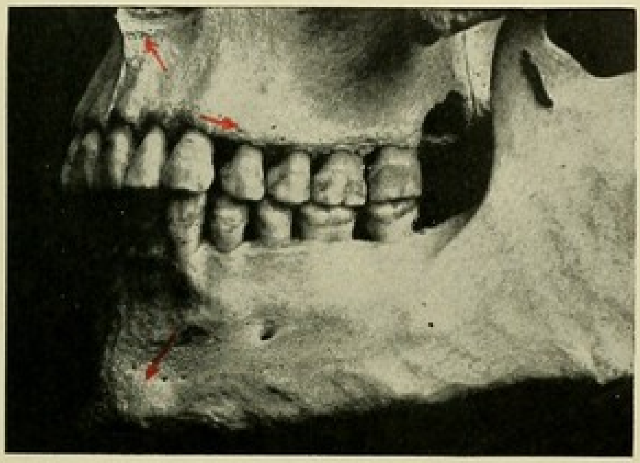
FIG. 27



Lateral view of Fig. 20.

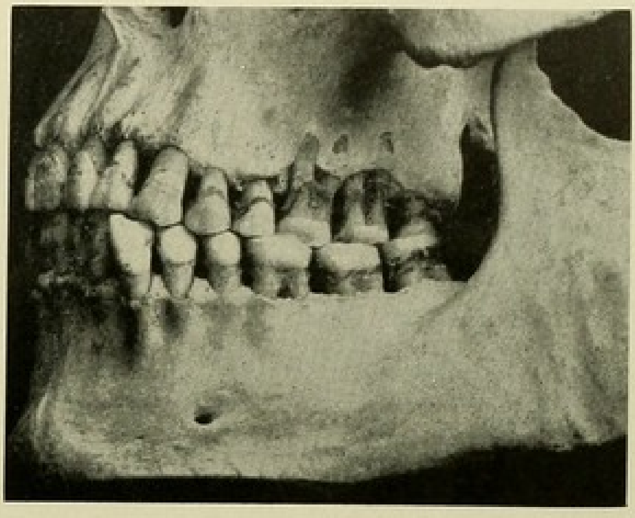
The lateral aspect of the same skulls shows that in the maxilla, in the molar region, the cancellous areas become fewer, while in the mandible they are lacking entirely (see Figs. 23 to 29). In the mandible the alveolar ridge only is perforated, while toward the base a thick cortical layer prevails. The *youthful jaw* (see Fig. 23) exhibits the widest extent of cancellous bone; even the mandible in this skull is traversed by numerous canaliculi. Fig. 24 gives a good view of the cancellous fossa at the level of the *root of the upper canine;* this *canine fossa* in all skulls is of more or less canaliculated structure. The middle root

Fig. 28



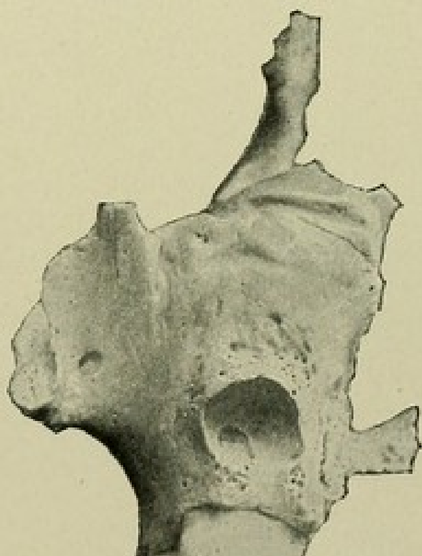
Lateral view of Fig. 21.

Fig. 29



Lateral view of Fig. 22.

Fig. 30

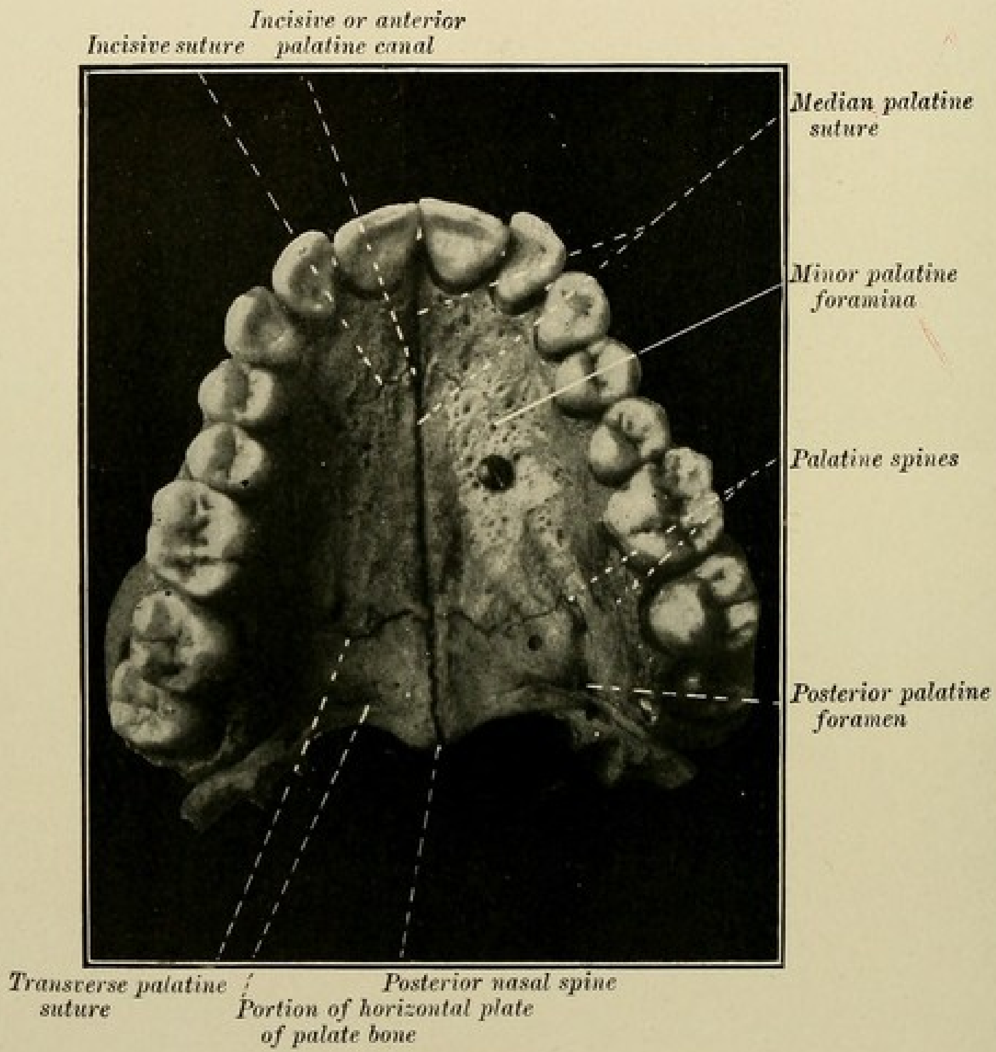


Extent of cancellous bony tissue at the maxillary tuberosity. Above the empty alveolus of the third molar large foramina are seen by which the posterior superior dental nerves enter the maxilla.

portion in these teeth, however, is often covered by a dense cortical layer (see Figs. 25 to 27).

The character of the osseous tissue above the upper *bicuspids* is of great interest. It is especially closely perforated, generally to the entire extent from the alveolar ridge to the root apex (see Figs. 24 and 25).

FIG. 31



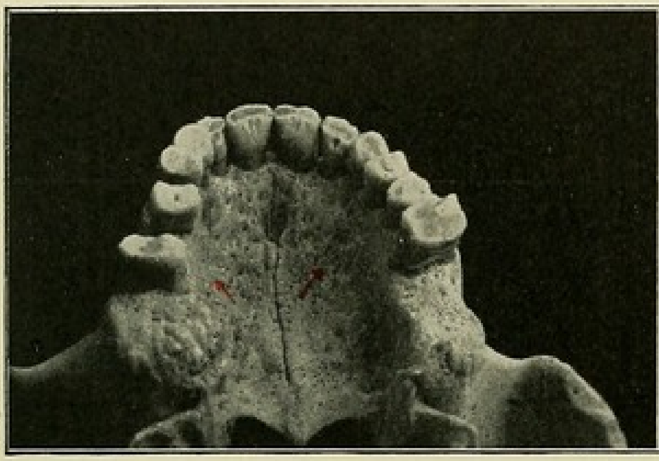
View of palatal surface of maxilla.

The upper molars are covered by an osseous plate of chiefly cortical character, which above the third molars usually is again densely perforated, as a glance at the tuberosity in Fig. 30 plainly shows.

FORAMINA IN THE ANTERIOR SURFACE.—The anterior surfaces of the maxillæ present two very important large foramina which permit the passage of important nerves and vessels, namely, in the maxilla the *infra-orbital foramen* above the root of the first bicuspid, in the mandible the *mental foramen* below and between the first and second bicuspids.

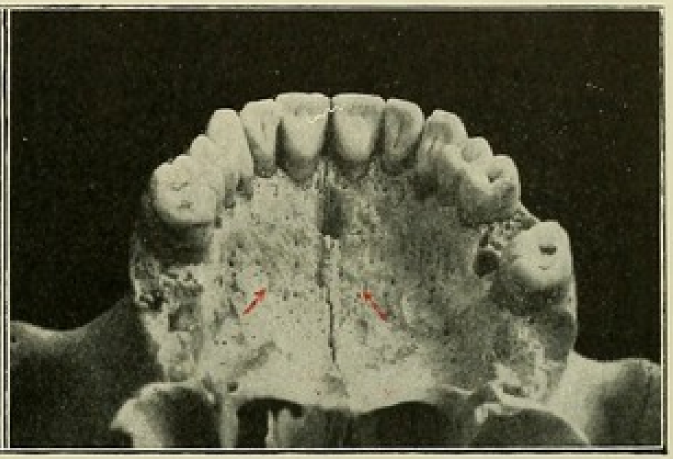
The Posterior Surfaces of the Maxillary Bones.—MAXILLA.—*Palatal Surface of the Maxilla.*—The *posterior surface* of the maxilla

FIG. 32



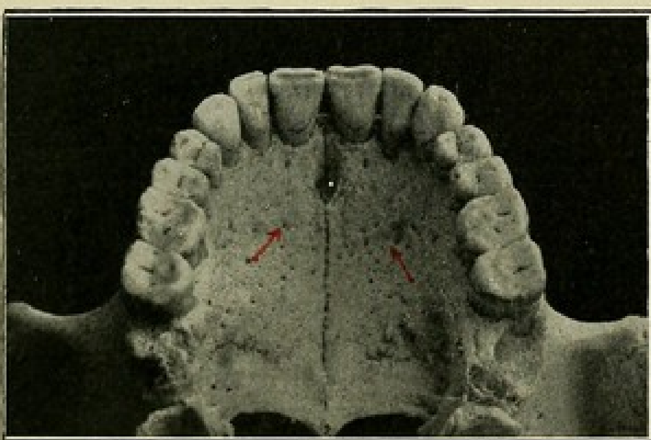
Palatal surface of maxilla of youthful person, showing extensive cancellous areas.

FIG. 33



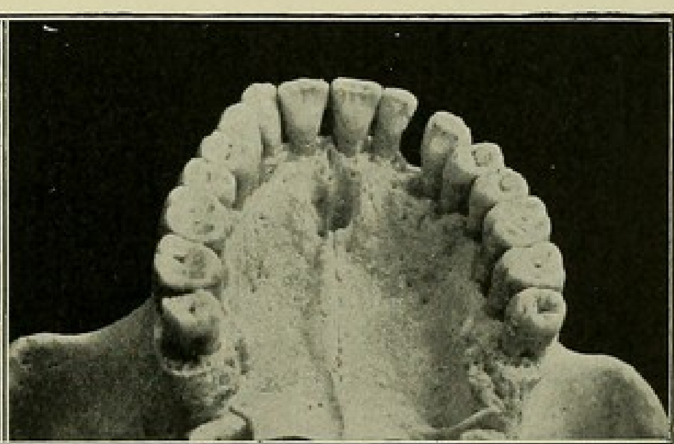
Palatal surface of maxilla of youthful person, showing extensive cancellous areas.

FIG. 34



Palatal surface of maxilla of adult, showing few perforations.

FIG. 35

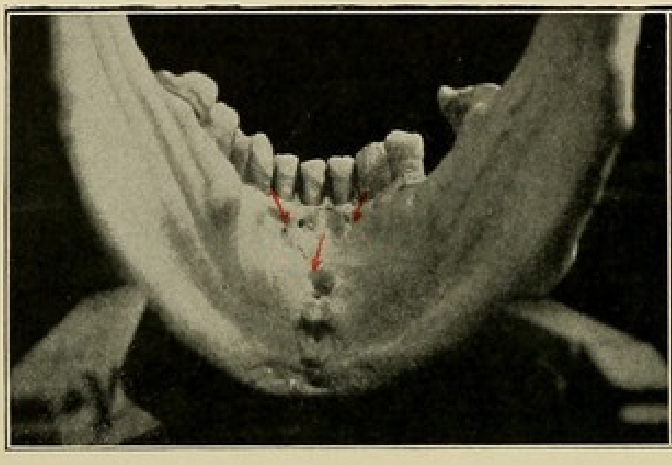


Palatal surface of maxilla of old person, showing few perforations.

is traversed by numerous canals which are distributed very regularly. Fig. 31 shows the palatal view of the maxilla. The hard palate in its anterior and median portions is seen to be closely perforated. At the bicuspids the canaliculi in the alveolar bone decrease in number at the middle portion of the roots, and gradually disappear toward the molars. In this region we find the large *posterior palatine foramen.*

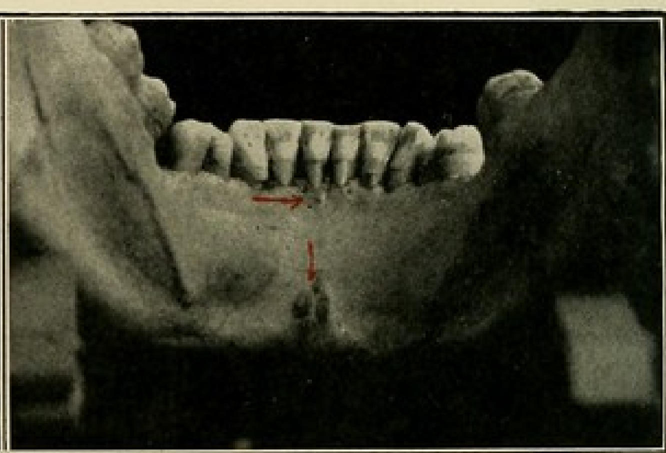
These conditions are clearly shown in Figs. 32 to 35. These illustrations furthermore disclose the fact that the cancellous areas in the palatal surface vary in different individuals. Figs. 32 and 33 represent densely perforated *youthful skulls;* Figs. 34 and 35 the considerably less cancellated maxillæ of *older subjects.*

FIG. 36



Inner surface of mandible, showing dense bone.

FIG. 37

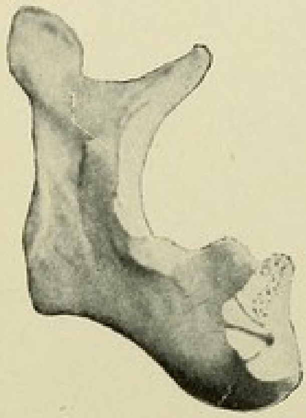


Foramina are noted at the symphysis.

Foramina in the Palatal Surface.—In the *palatal surface* of the maxilla we find two well-marked large foramina, the *incisive* or *anterior palatine foramen* behind the central incisors and the *posterior palatine foramina* at the level of the third molars, as clearly illustrated in Fig. 31. (See also Figs. 32 to 35.)

MANDIBLE.—*Inner Surface of the Mandible.*—The inner surface of the mandible, in contradistinction to the maxilla, is entirely non-canaliculated. Only at the *internal genial tubercles*, or *mental spines*, some partly fair-sized *foramina* are noted which frequently reach to the alveolar ridge, and in transverse sections are seen to communicate with the mandibular canal (see Fig. 38; also Figs. 36 and 37), while the entire posterior portion up to the third molars is almost impenetrable and non-canalicular (see Fig. 39). Above the angle of the jaw, however, in the ascending ramus we find a very large aperture, namely, the *mandibular* or *inferior dental foramen* (see Figs. 39 to 41), which is important for conductive anesthesia of the mandible.

Fig. 38



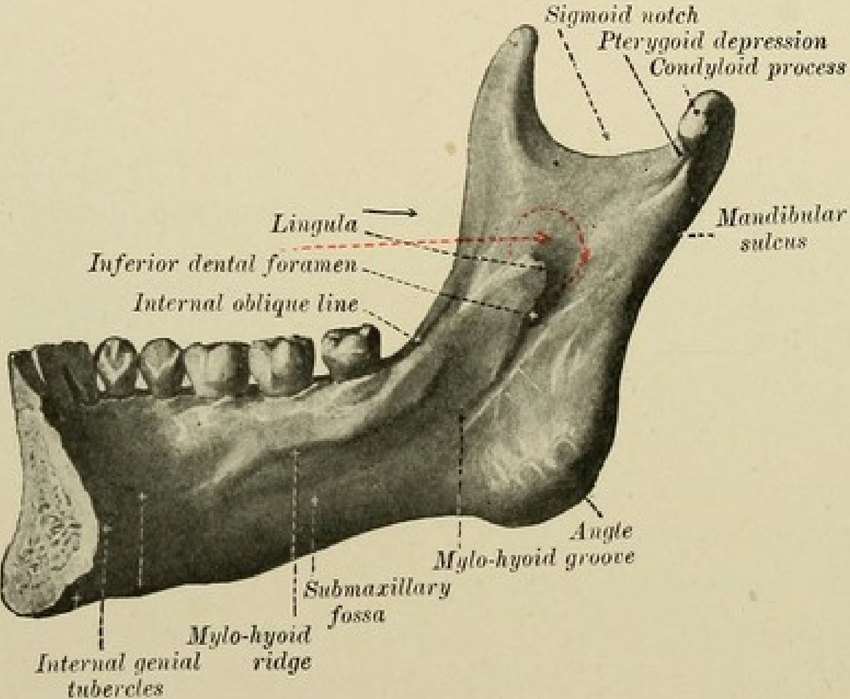
Section through symphysis of mandible. Some of the foramina on the inner surface communicate with the inferior dental canal, fibers of the lingual nerve probably joining the inferior dental nerve.

THE MANDIBULAR SULCUS AND THE MANDIBULAR OR INFERIOR DENTAL FORAMEN.

In adults the *ascending ramus* begins a little behind the third molar, sometimes in an abruptly ascending surface. At its basis, when regarded as resting upon the alveolar process, the ascending ramus, in front view, shows an outer buccal *anterior ridge*, representing the last ascending portion of the *external oblique line* (see Figs. 39 to 43). About 0.5 cm. inward and backward of this line runs a ridge bordering the lingual surface, the *internal oblique line*, which gradually loses itself in the posterior section of the coronoid process. Between these two lines in the bony surface is situated a more or less pronounced deep groove which we might call the *retromolar fossa* (see Figs. 40, 42, and 43). This fossa, which is covered by a thin layer of mucous membrane, serves as the most reliable place of orientation for the palpating finger before inducing conductive anesthesia of the mandible.

About the middle of the internal surface of the ascending ramus the large *mandibular* or *inferior dental foramen* is situated (see Figs. 39 to 41, and 43), which marks the starting-point of the *mylohyoid* *groove* which runs obliquely downward and anteriorly (see Figs. 39, 41, and 43). The orifice of the foramen itself is protected anteriorly by a spiculum of bone of varying size, the *mandibular lingula* (see Figs. 39, 41, and 43). This lingula may be developed as a pointed plate of bone or as a tongue-like cover, or only as a thickened process on the anterior margin (see Fig. 41). Sometimes the lingula is connected with the lower free margin of the orifice of the mandibular canal by a small bony spiculum or bridge.

FIG. 39

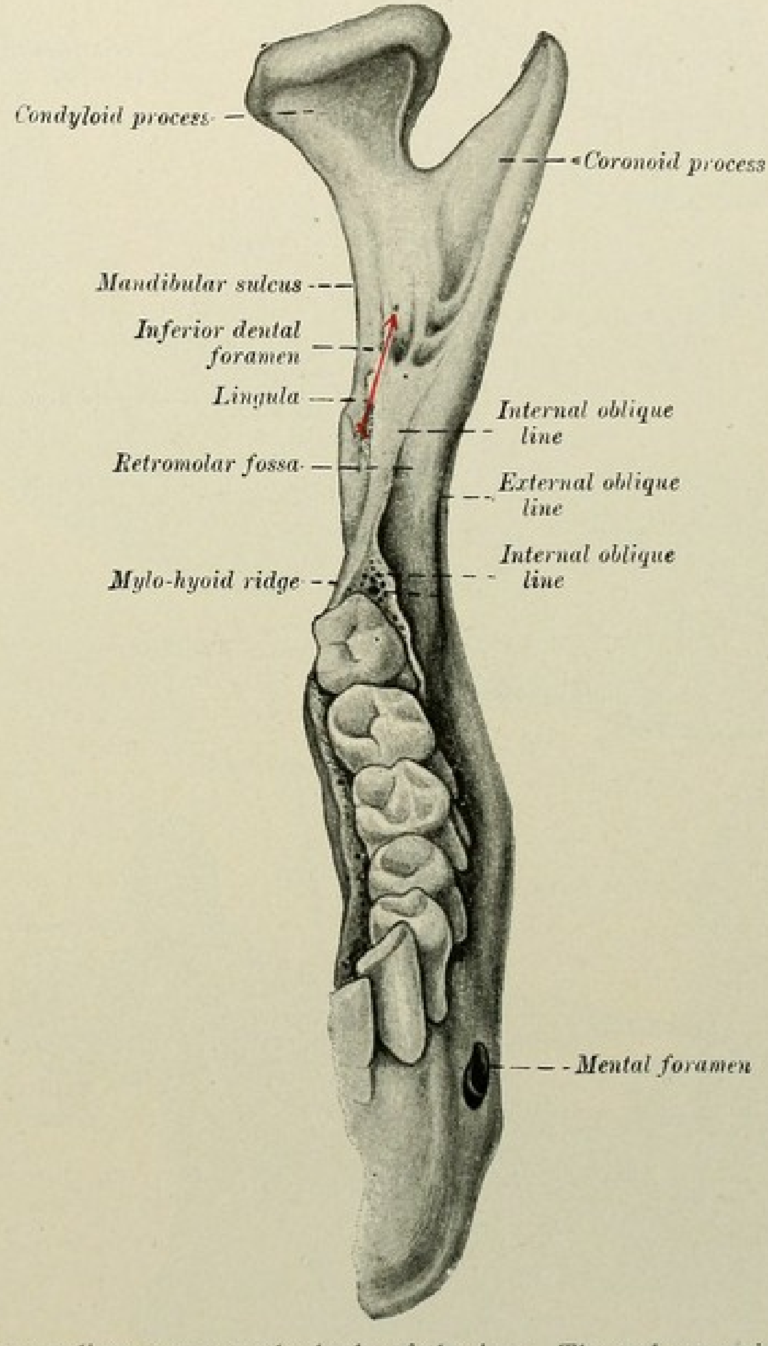


Side view of inner surface of right half of mandible. The red arrow indicates the direction in which the needles should be pushed forward over the lingula. The red circle indicates the area of injection.

In adults the *mandibular foramen* is always situated above the alveolar ridge and in a horizontal plane about 1.5 cm. from the anterior ridge of the jaw, the *external oblique line* (see Figs. 41 and 43). The two halves of the mandible, when viewed from front, gradually diverge toward the angle, so that the inner surface of the ramus with the mandibular foramen is inclined posteriorly and pharyngeally, and appears entirely covered by the *internal oblique line* (see Figs. 41 and 42).

The mandibular foramen is continued posteriorly and upward by a shallow groove of varying depth and extent, which Spee and others have named the *mandibular sulcus* (see Figs. 39 to 43). By its anatomic

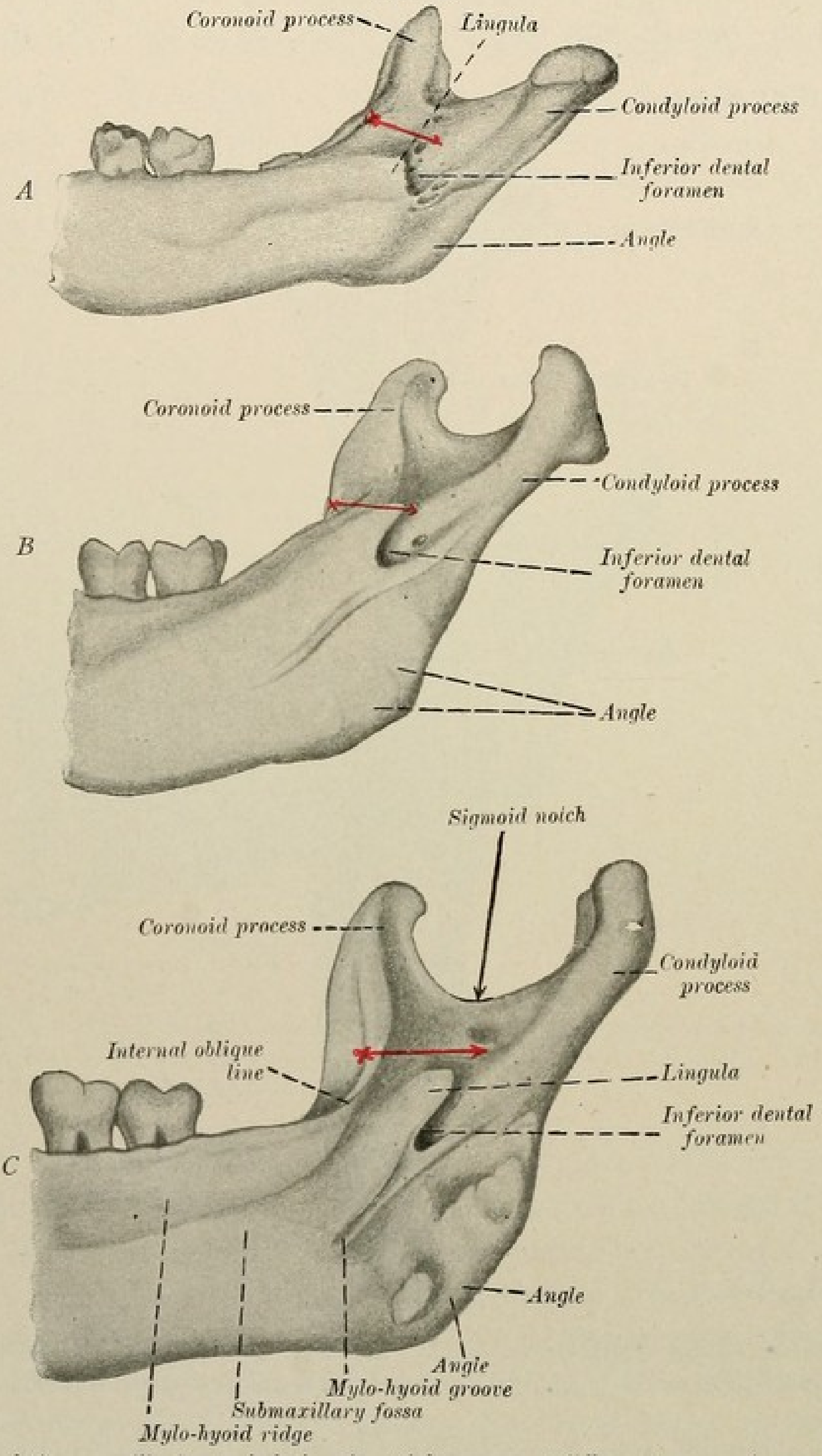
FIG. 40



Relationship of the ascending ramus to the body of the jaw. The red arrow indicates the direction in which the needle should be advanced to the inferior dental foramen.

nature this sulcus is the most favorable place for the reception of the solution injected in conductive anesthesia of the mandible. The

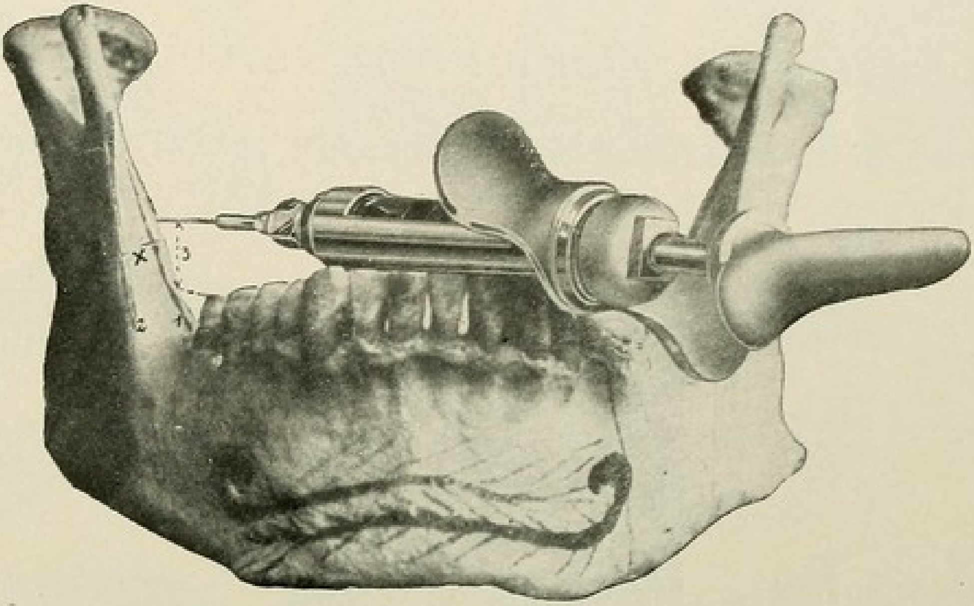
FIG. 41



Variations of the mandibular or inferior dental foramen at different ages: *A*, mandible of a child, aged seven years (the needle should be inclined slightly downward). *B*, mandible of a youth, aged eighteen years. *C*, mandible of a male adult, aged thirty years. The red arrows indicate the direction of the needle.

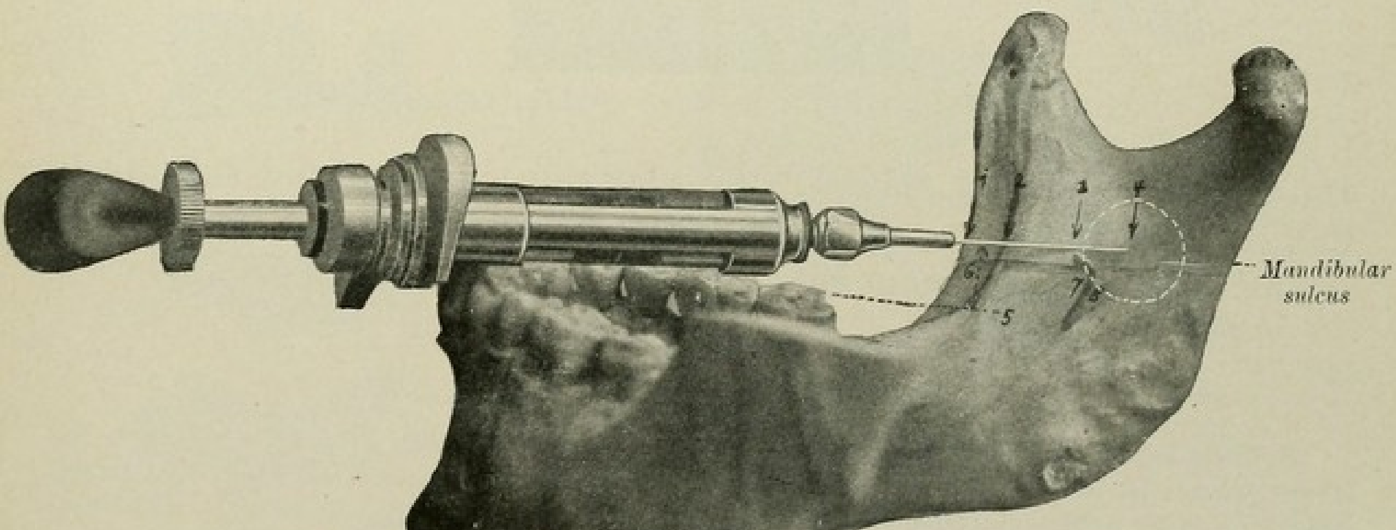
needle is therefore inserted a little above the lingula, and the solution is deposited in this sulcus (see Figs. 42 and 43).

FIG. 42



Front view of position of syringe in mandibular anesthesia: 1, internal oblique line; 2, external oblique line; 3. insertion of needle about 1 cm. above masticating surfaces of molars.

FIG. 43



Posterior view of position of needle in mandibular anesthesia: 1, external oblique line; 2, internal oblique line; 3, position of needle at superior margin of lingula; 4, most suitable length of needle behind lingula (a further advancement would result in failure); 6, position of needle, 1 cm. above level of masticating surfaces of molars; 7, lingula; 8, inferior dental foramen.

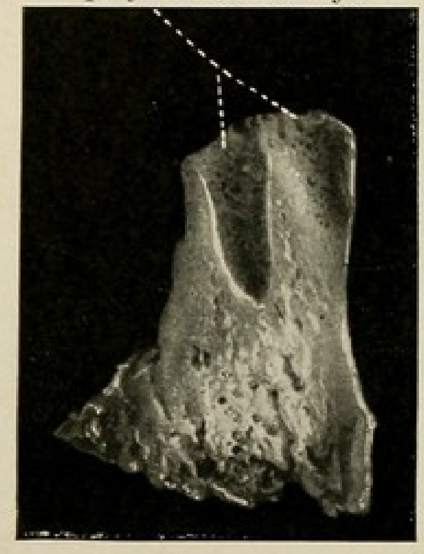
The topography of this mandibular sulcus and the anatomic conditions which are important in mandibular anesthesia will be discussed in detail in the special chapter on Conductive Anesthesia (see page 202).

THE MINUTE STRUCTURE OF THE ALVEOLAR PROCESS.

Structure of the Osseous Substance.—In ground sections of the alveolar processes of either jaw two different layers of osseous tissue

FIG. 44

Spongiose alveolar margin



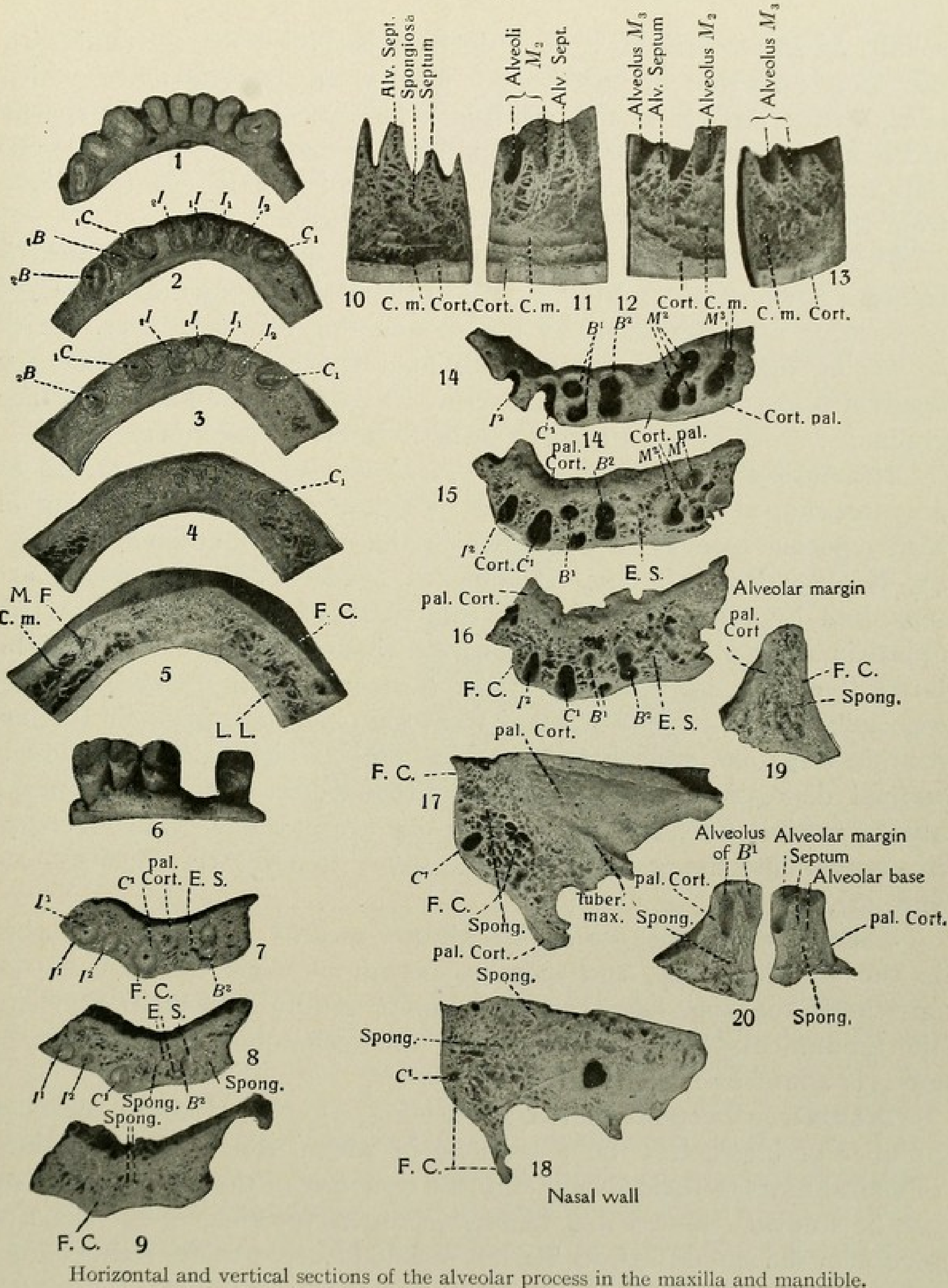
Extent of spongiose or cancellous bone within an exposed alveolus.

are continually found, namely, the sparingly canaliculated substance, the *compact substance*, and the highly cancellated and medullated tissue, the *spongiose substance*. The former in the *mandible* shows a

EXPLANATION OF ABBREVIATIONS IN FIG. 45.

${}_2B$, lower left second bicuspid; ${}_1B$, lower left first bicuspid; ${}_1C$, lower left canine; ${}_2I$, lower left lateral incisor; ${}_1I$, lower left central incisor; I_1, lower right central incisor; I_2, lower right lateral incisor; C_1, lower right canine; *M. F.*, mental foramen; *C.m.*, mandibular canal; *F. C.*, facial cortical layer; *L. L.*, lingual cortical layer; *pal. Cort.*, palatal cortical layer; *E. S.*, extraction scar; C^1, upper right canine; I^2, upper right lateral incisor; I^1, upper right central incisor; B^2, upper right second bicuspid; *Spong.*, spongiose (cancellous) bone; *Cort.*, cortical layer; M_2, lower right second molar; M_3, lower right third molar; B^1, upper right first bicuspid; M^2, upper right second molar; M^3, upper right third molar; M^1, upper right first molar; *Cort. pal.*, palatal cortical layer; *Tuber. max.*, maxillary tuberosity.

Fig. 45



Horizontal and vertical sections of the alveolar process in the maxilla and mandible.

solidly arranged periphery, its thickness varying with age and with the long diameter of the bone. The spongiose substance which occupies the interior of this solid cortical capsule resembles a sponge in the arrangement of the individual lamellæ and rods. These osseous rods are generally so arranged in regard to direction as to radiate from the cortical layer (see Fig. 45, Nos. 1 to 20).

Toldt attributes this architecture of bone partly to an intracartilaginous ossification, partly to the normal developmental processes (apposition and resorption) of the surrounding compact layer. With advancing age the spongiose medullated spaces increase, while the osseous supports of the teeth decrease, so that the compact substance gradually closes in upon a space of little internal resistance.

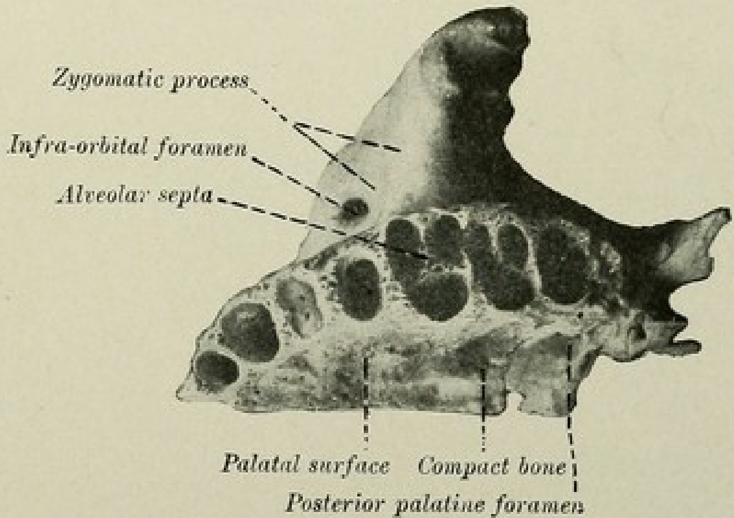
Structure of the Alveoli.—The *dental alveolus* may be regarded as a crater-shaped depression in the spongiose substance consisting of highly porous osseous tissue, in which the root is contained (see Fig. 45, No. 19; Fig. 48, Nos. 17 and 19). The individual alveoli are separated by *septa*, consisting of thin and porous lamellæ from two approximating alveoli and of spongiose tissue developed between the latter (see Figs. 45, 46, and 48). The alveoli of the upper bicuspids, especially the first, also those of the lower bicuspids in their fundus, contain ridge-like eminences, *septal processes*, which fit into the longitudinal depressions in the roots of these teeth. The *alveolar walls* always exhibit fine, cribriform, sieve-like perforations, which increase in number and diameter toward the upper margin (see Figs. 45, 46, and 48).

These perforations, which are always present in varying number in the alveolar ridge, and seem to permit of rapid diffusion of the anesthetic solution, have heretofore been unduly neglected; they are the fundamental feature upon which the technique of infiltration or mucous anesthesia is based.

Transverse Sections of the Jaws.—Fig. 45, Nos. 1 to 20, shows a number of instructive bone sections in which the various relations of dental roots to their alveoli, and the structure of the jaws themselves, can be studied. Nos. 1 to 5 illustrate lamellar portions of the anterior section of the mandible from the left second bicuspid to the right canine.

Besides the instructive transverse sections of roots, we can trace in No. 2 the gradually increasing thickness of the outer and inner cortical layers, and study the manner in which, between these, the spongiose layers are arranged around the bodies of the roots. In No. 4 only the apical portions of the long roots of the canines can be seen, while in No. 5 the widely cancellated tissue appears in the proximity of the mandibular canal, which, on the left, communicates through the exposed mental foramen with the anterior surface. While most roots are surrounded with spongiose substance, the roots of the canines are gripped by the cortical layer, which in this region bulges remarkably; this condition contributes largely to the firmness of the supporting abutments of the normal denture, namely, the canines.

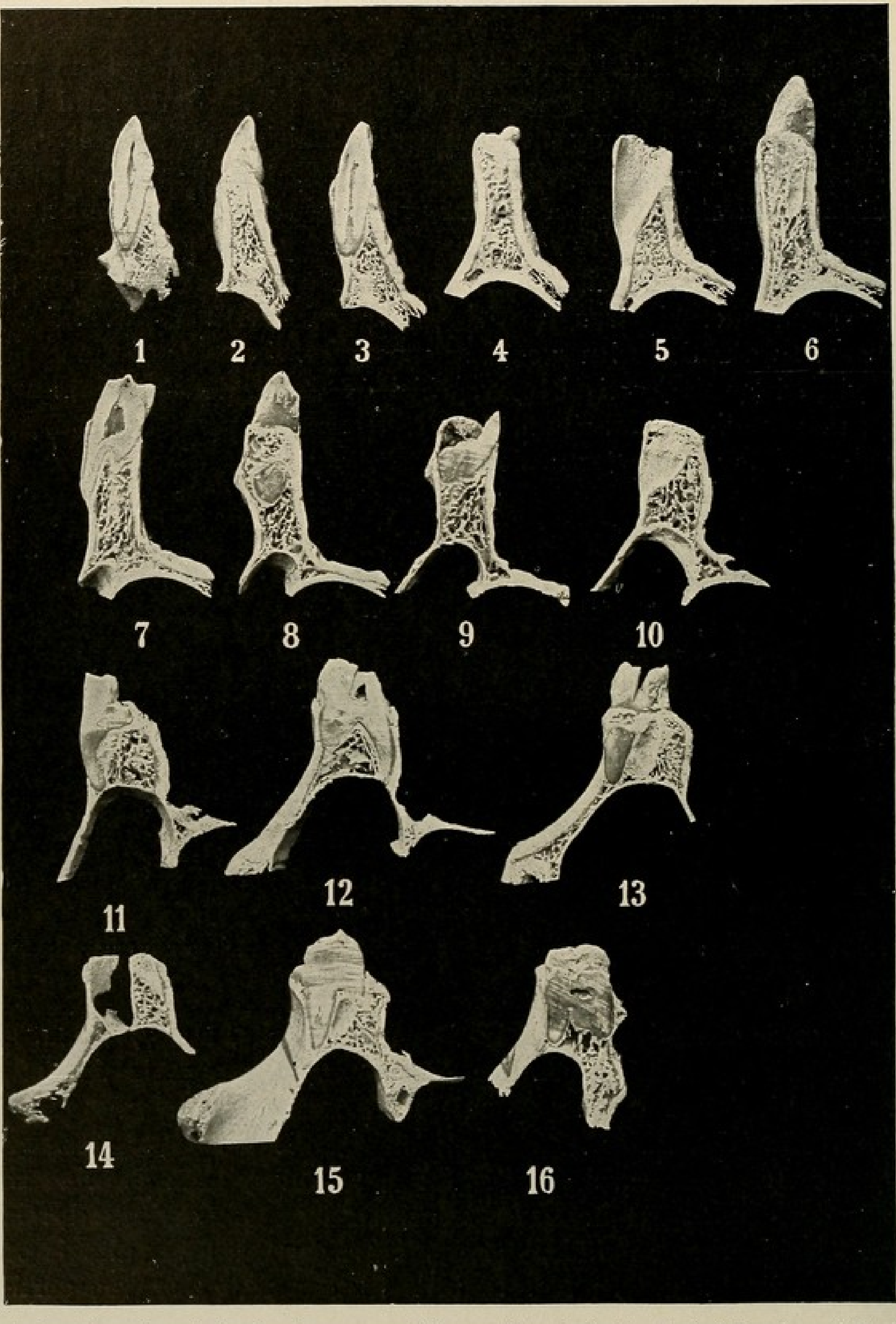
Fig. 46



View of cancellous alveolar margin of maxilla. The alveolar septa and margins are densely cancellated.

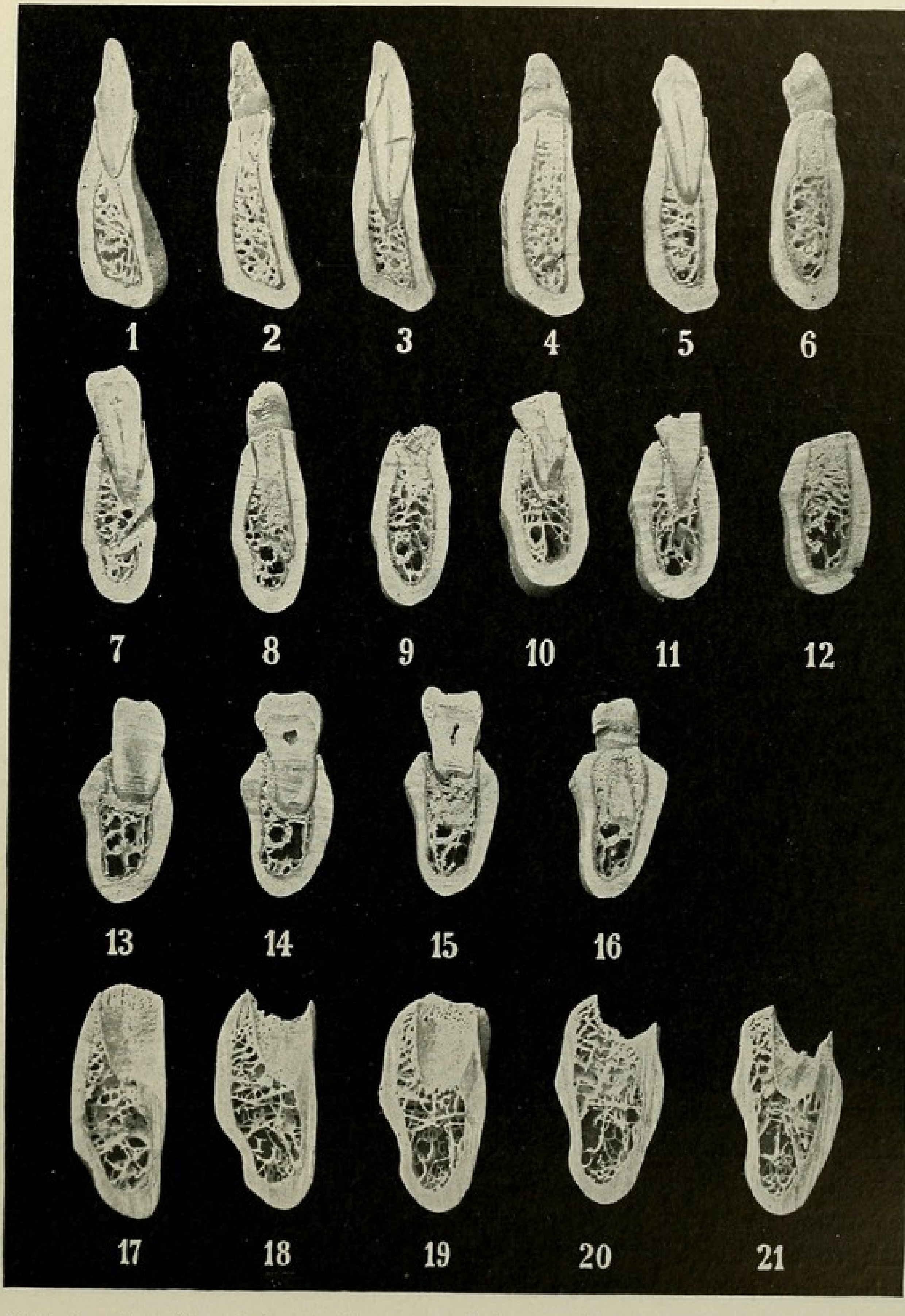
The same condition is plainly shown in Fig. 45, No. 7, which, like Nos. 8, 9, 15, and 16, illustrates additionally the organization of an old extraction wound into spongiose substance (see Nos. 8 and 9, between C^1 and B^2, Nos. 15 and 16, between B^2 and M^1). Nos. 14 to 18 present the structural details of one maxillary half, showing that the cortical layers are here of a considerably more delicate development than in the mandible. The palatine cortical layer also is seen to be canaliculated. In No. 19 it is further seen that the cortical

FIG. 47



Vertical sections through the alveolar process of the maxilla. Left side, the facial surface; right side, the lingual surface; 1 to 4, incisors; 5 and 6, canine; 7 to 10, bicuspids; 11 to 16, molars.

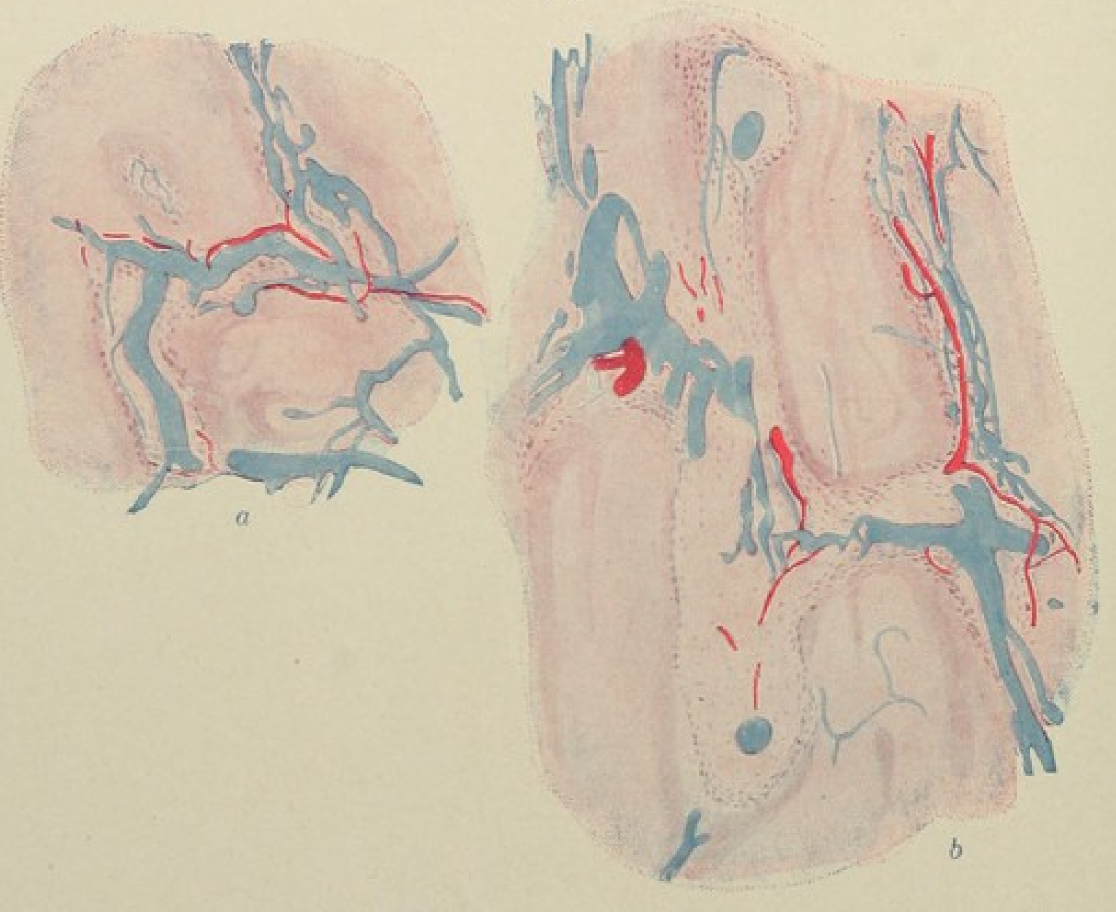
Fig. 48



Vertical sections through the alveolar process of the mandible. Left side, the lingual surface; right side, the facial surface: 1 to 4, incisors and canines; 5 to 9, bicuspids; 10 to 16, molars; 17 to 21, alveoli of molars from another skull.

layers covering the posterior buccal and palatal surfaces of the maxilla may increase or decrease in thickness. While the buccal surface starting from the alveolar margin often increases from a delicate stratum to a thick cortical layer, the palatal covering is rather thick at the alveolar margin, whence it gradually tapers. Fig. 44 shows the open alveoli of an upper first molar; this illustration again emphasizes the fact that the most favorable conditions for diffusion exist at the alveolar margin.

Fig. 49



Bloodvessels (blue) and lymph vessels (red) in spongiose substance of maxillæ.

Sections of the Maxilla and Mandible.—In order still further to elucidate the conditions for diffusion in the maxillary bones, we have made special vertical sections of the maxilla and the mandible, as shown in Figs. 47 and 48.

Maxilla.—In Fig. 47, Nos. 1 to 16, the relations of the upper teeth to the alveolar process are illustrated. The left side of each of these sections represents the facial; the right, the palatal surface.

Nos. 1 to 6 show the anterior teeth including the canine; Nos. 7 to 10, the bicuspids; Nos. 11 to 16, the molars. All these illustrations present on the palatal surface a broad osseous layer, which, on the facial surface, is delicate and lamellar for the greater part, and, up to the

Fig. 50

Diffusion of injected staining solution (red) within the bony alveolar process. (Animal experiment.)

bicuspids is specially thin in the proximity of the root apices, which area is generally richly cancellated. It is here, therefore, that the best possible diffusion can be obtained. The roots of the molars frequently are covered with but a thin lamella, which is, however, almost non-canaliculated, and increases in thickness in the third molar region. This tooth, by way of compensation, is surrounded at its root apices by richly cancellated bone, so that it can be perfectly well anesthetized by inserting the needle high up on the gum.

FIG. 51

Appearance of red stain particles within the pulp capillaries (vessels blue).

Mandible.—Sections through the mandible plainly show the massive nature of the cortical layer on either side (see Fig. 48). While in the anterior teeth the facial surface of the bone (on the right in the illustrations) is of relatively thin structure, its thickness increases considerably from the bicuspids on, and at the molars (Nos. 10 to 16) attains the same proportions as the lingual surface. Though in the mandible local anesthesia by infiltration is of little value, it can be effected by injection at the cervical margin of the gum, because the alveolar ridges in all lower teeth are of spongiose character. This fine, spongiose, cancellous area in the alveoli, even in the molars, is limited, however, to the upper marginal portion, as illustrated in Fig. 48, Nos. 17 to 21, also in Fig. 45.

The foregoing renders it sufficiently apparent that the technique of injection depends not only upon the nerve supply of the masticatory apparatus but also to a great extent upon the character of the bony substance. We shall have occasion to prove that the technique of local anesthesia as demonstrated subsequently is based on these anatomical principles, and for that very reason guarantees such a high degree of perfection and safety.

Details of Diffusion.—In order to establish the velocity and manner of diffusion of solutions injected in the jaws, the writer has injected the periosteum of the maxilla and the mandible in various animals, such as cats, with isotonic coloring solutions, using the same technique as for local anesthesia. In all cases the cancellated bone was permeated, and, where cortical substance was present, the red carmine solution penetrated by way of the foramina (see Fig. 49). Spongiose cancellous bone tissue absorbs the stain with uniform avidity, permitting it to penetrate into the medullary spaces (see Fig. 50). In most cases the interior of the jaw was entirely permeated with the colored solution in five minutes, the pulp within from six to eight minutes. The capillaries of the pulp at the odontoblastic layer are seen to be filled with particles of stain (see Fig. 51), while within the osseous canaliculi red-stained lymph vessels are found chiefly in perivascular arrangement (see Fig. 49). This seems conclusive proof that an isotonic solution, such as the novocain-suprarenin solution advocated, reaches the interior of the alveolar process in a short time. Its diffusion is most rapid and extensive in spongiose substance, while in cortical areas it proceeds only by way of the few and generally large foramina.

THE NERVE SUPPLY OF THE MASTICATORY APPARATUS.

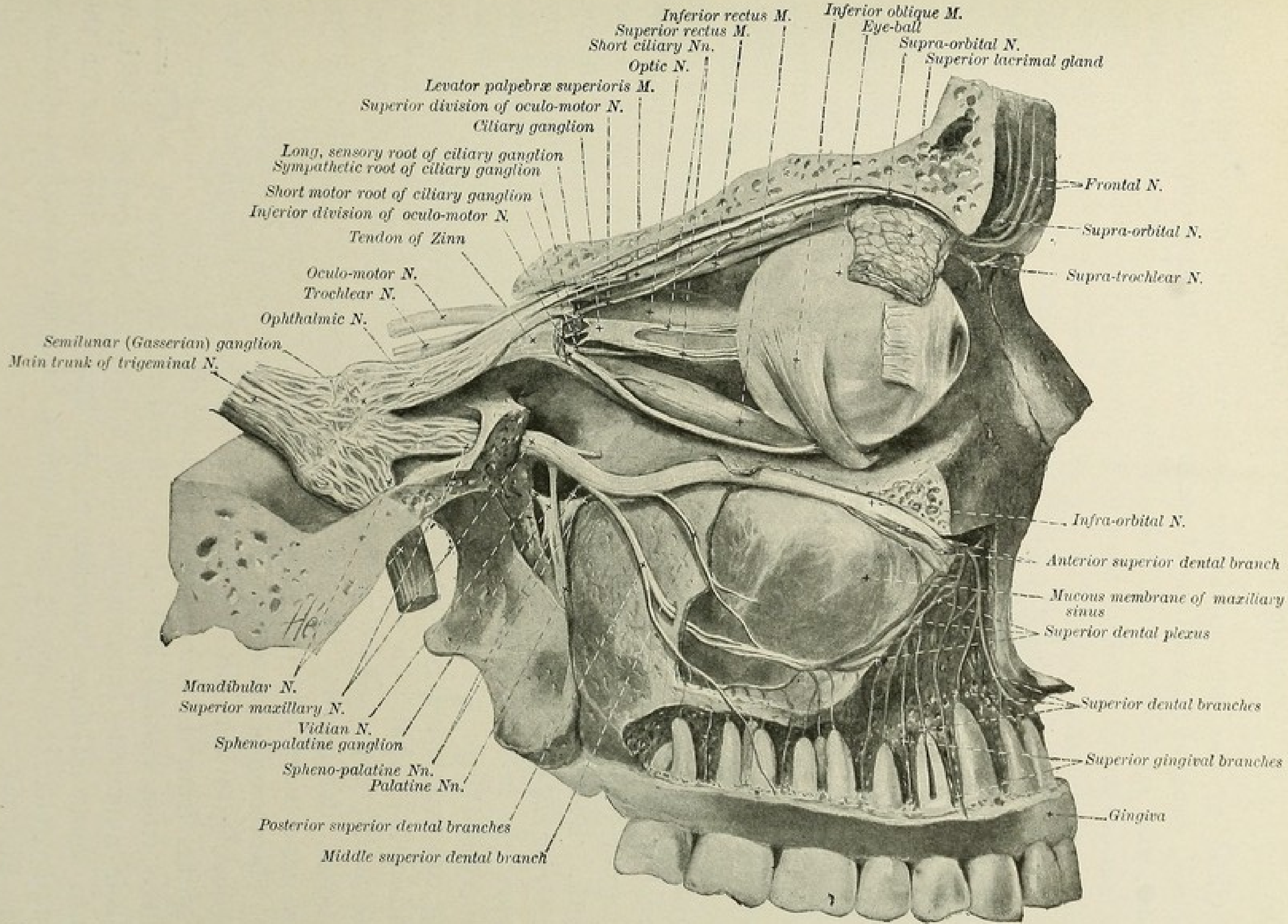
The sensibility of the masticatory apparatus is controlled by the fifth cranial nerve, the *trigeminal*.

Roots of the Trigeminal Nerve.—The trigeminal nerve arises by a ventral, smaller, motor root, and a dorsal, larger, sensory root at the pons Varolii, and extends anteriorly to the apex of the petrous portion of the temporal bone (see Fig. 52). Here the *sensory root* forms the large *semilunar* or *Gasserian ganglion*, from which proceed the three main branches, the *ophthalmic*, the *maxillary*, and the *mandibular* (see Fig. 53). The *motor root* passes independently beneath the ganglion to the *third division*, which, being a *mixed* nerve consisting of *sensory* and *motor* fibers, is distinguished from the exclusively sensory *first* and *second divisions*.

Branches of Distribution of the Trigeminal Nerve.—THE OPHTHALMIC NERVE.—The *first* or *ophthalmic division* of the trigeminus passes from the *Gasserian ganglion* through the superior orbital or sphenoidal fissure to the *orbit*. It is divided into three branches, lacrimal, frontal, and nasal. The *lacrimal nerve* passes forward along the lateral wall of the orbit at the upper border of the external rectus muscle, and supplies the lacrimal gland, the distal corner of the eye, and the conjunctiva. The frontal *nerve* runs forward under the roof of the orbit, and gives off two branches, the *supra-orbital nerve*, and the *supratrochlear nerve*. The *nasal nerve* gives off a long branch to the ciliary ganglion, also the *long ciliary nerves* to the posterior portion of the sclera. It then continues to the median wall of the orbit, giving off the *posterior ethmoidal nerve* to the posterior ethmoidal cells, and the *infratrochlear nerve* to the mesial angle of the eye, supplying the integument of the eyelids, and the lacrimal sac. The *ciliary ganglion*, which also belongs to the first division of the trigeminus, is situated in the posterior third of the orbit laterally of the optic nerve (second cranial nerve), and has three roots, one short *motor root*, one long *sensory root*, and one *sympathetic root* (see Fig. 52).

The Maxillary Nerve.—The *second* or *maxillary division* of the trigeminus passes from the Gasserian ganglion through the foramen rotundum to the sphenomaxillary fossa, and thence becomes the *infra-orbital* nerve. Its branches are *orbital* or *temporomalar branch*, *infra-orbital*, with the *posterior*, *middle*, and *anterior superior dental branches*, and the *sphenopalatine branch* (see Figs. 52, 53, 55, and 56).

Fig. 52



Nerves of the right orbit and maxilla. The greater wing of the sphenoid bone and the lateral wall of the orbit have been removed completely, the roof of the orbit and the maxillary plate partly, the external rectus muscle entirely. (Spalteholz.)

Close to the sphenopalatine foramen lies the *sphenopalatine* or *Meckel's ganglion*, consisting of *sensory* (the sphenopalatine branches), *motor*, and *sympathetic roots* (the Vidian nerve). From the ganglion the *sensory nasal branches* pass to the nasal cavity, one branch, the *nasopalatine nerve*, running to the anterior palatine canal. The *palatine nerves* pass through the pterygopalatine canal to the oral cavity, where they break up into the *anterior*, *middle*, and *posterior palatine nerves*. They supply the mucous membrane of the palate with sensory, and the muscles of the soft palate, excepting the tensor palati muscle, with motor filaments (see Figs. 52, 54, and 56).

Branches of Distribution of the Maxillary Nerve.—The *maxillary nerve* passes through the *infra-orbital sulcus* and *canal* to the *infra-orbital region* of the facial surface of the maxilla, giving off numerous branches in its course (see Figs. 52, 55, and 56). In passing through the infra-orbital canal it gives off the *superior dental branches* at various intervals through the minute canals in the body of the maxilla (see Figs. 52, 53, and 56). These *middle* and *anterior superior dental branches* supply the alveolar process, sending off small twigs to the teeth. Before entering the canal, the maxillary nerve gives off the *posterior superior dental nerves* to the *maxillary tuberosity*, which partly follow the arteries, partly pass through their own foramina into the tuberosity (Figs. 52, 55, and 56) and the body of the maxilla. Following the arteries, they pass forward above the molars, branching out within the facial wall of the maxilla, and finally communicate with the *middle* and *anterior superior dental nerves*. They supply the oral mucosa, the molars, the mucous membrane of the maxillary sinus, the periosteum, and the pericementum (see Figs. 55 and 56).

The terminal portion of the maxillary nerve, or *infra-orbital branch*, frequently divides into from two to four branches which arise closely together from the infra-orbital foramen (see Fig. 55). They run in a curve from behind and above downward to forward and inward. Their numerous subdivisions form a thick nerve plexus, which in turn sends off finer branches to the oral mucosa, the floor of the nasal cavity, the incisors and canines, and the spongiose substance (see Fig. 55).

FIG. 53

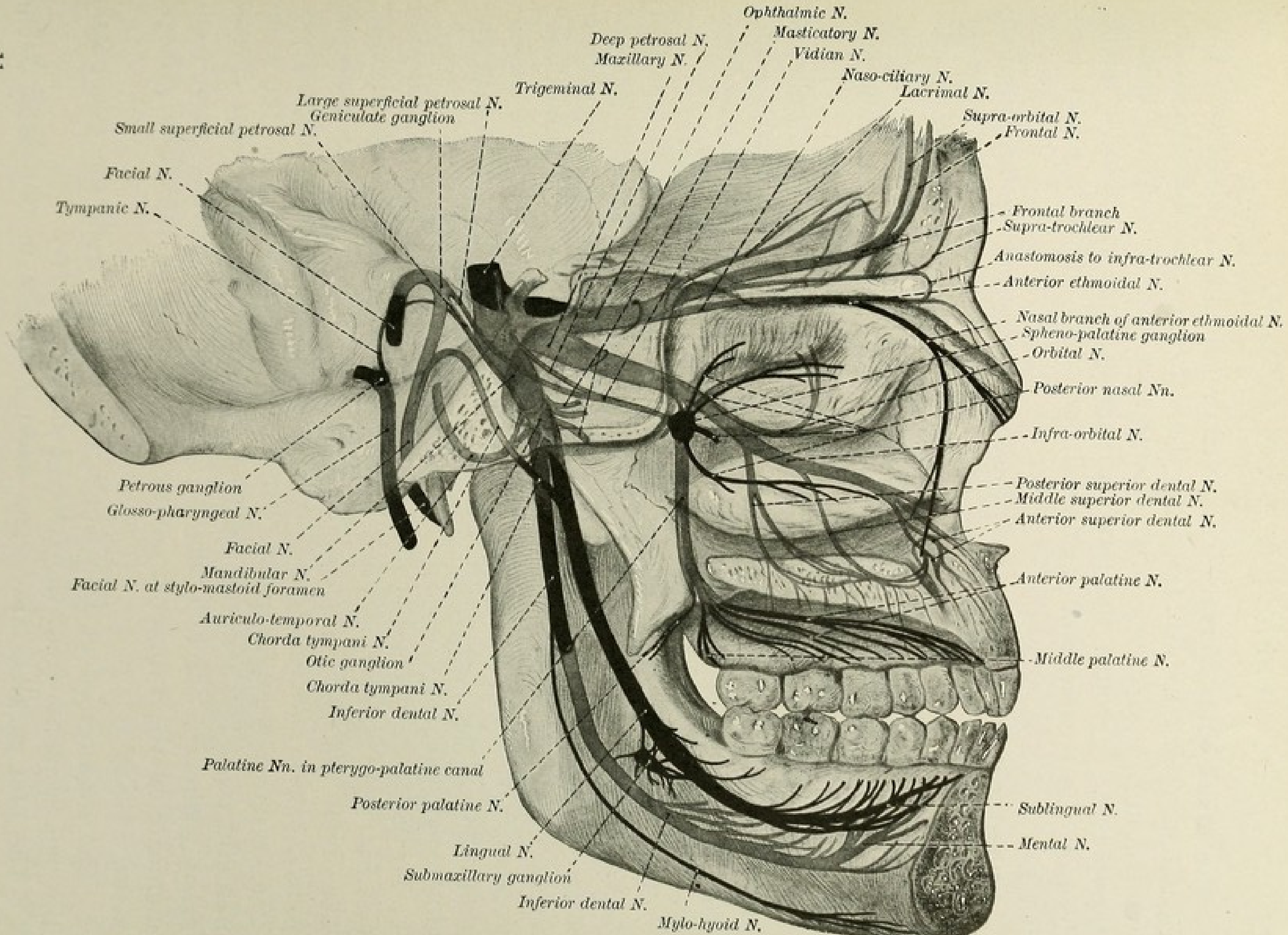


Diagram showing distribution of the fifth or trigeminal nerve. The black lines indicate the branches embedded in soft tissues, the gray lines those embedded in bony tissue. (After Sobotta.)

The Mandibular Nerve.—The third or mandibular division of the trigeminus makes its exit from the skull through the foramen ovale, dividing into a *superior*, chiefly *motor root*, and an *inferior*, chiefly *sensory root*. Through the foramen spinosum the mandibular nerve gives off the recurrent or meningeal branch to the dura mater (see Fig. 53).

From the superior motor root the masticatory muscles are supplied by the following branches: The *masseteric*, the *internal* and *external pterygoid*, and the *deep temporal branches*. The *buccinator nerve* is the only sensory branch, and supplies the mucous membrane of the cheek.

From the inferior root, the *inferior dental*, the *lingual*, and the *auriculotemporal branches* are given off (see Figs. 53 and 54).

The *inferior dental nerve*, before passing into the mandibular or inferior dental canal, gives off a motor branch, the *mylohyoid nerve*, and through the mental foramen a sensory branch, the *mental nerve* (see Figs. 53, 54, and 57).

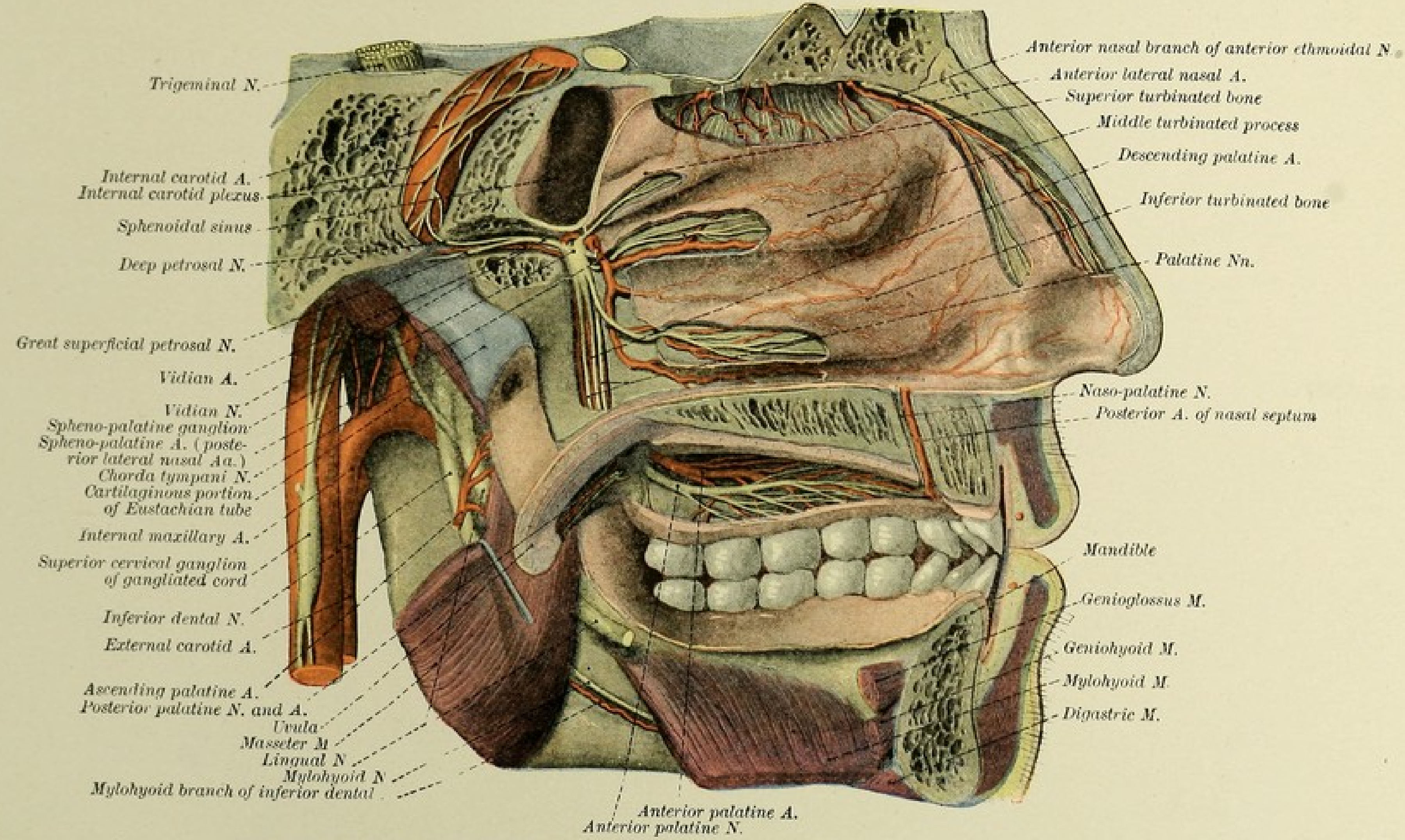
The *lingual nerve* supplies the tongue and the floor of the oral cavity with sensory filaments (see Fig. 58). From the *chorda tympani nerve*, which is a branch of the *facial nerve* (the seventh cranial), it receives secretory filaments which it conveys to the large mandibular glands. The chorda tympani nerve receives fibers from the glossopharyngeal nerve (the ninth), by anastomosis of the facial with the glossopharyngeal nerve.

To the third division of the trigeminus belongs also the *otic ganglion* (see Fig. 53), which is situated immediately below the foramen ovale. The *small superficial petrosal nerve*, a continuation of the *tympanic plexus*, conveys secretory and sympathetic filaments to the ganglion. The secretory filaments come from the glossopharyngeal, the sympathetic ones from the sympathetic plexus of the *internal carotid* artery, whence, through the *caroticotympanic branches*, they communicate in the tympanic cavity with the *small superficial petrosal nerve*.

The motor root of the ganglion is derived from the trigeminus through filaments from the *internal pterygoid nerve*.

The otic ganglion also sends *motor* filaments to the *tensor palati*

FIG. 54

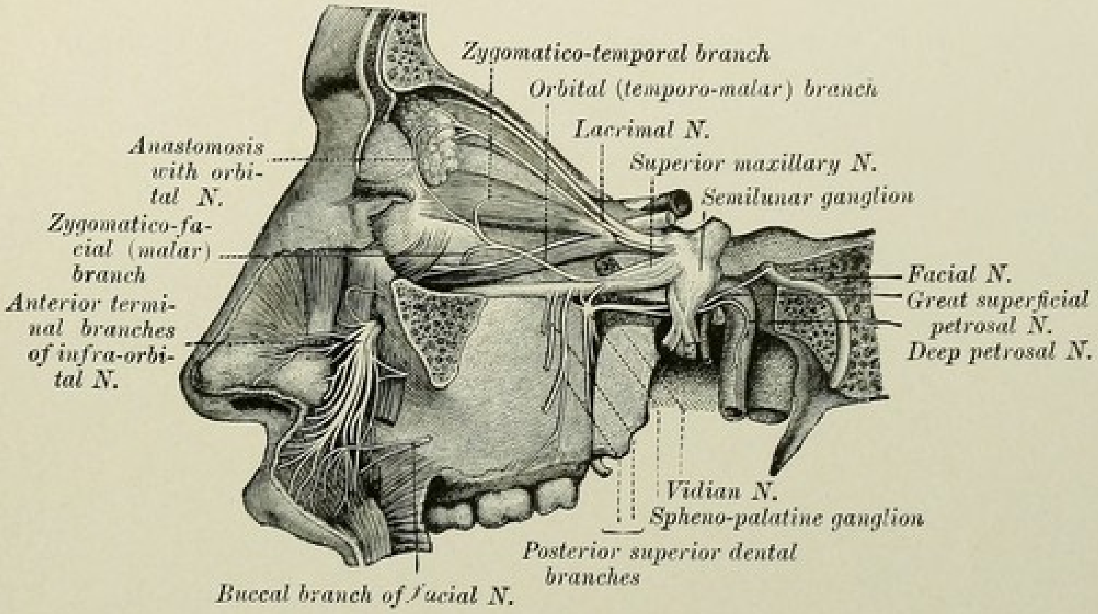


The palatal and lingual nerves and vessels of the maxillary apparatus. (After Sobotta.)

and the *tensor tympani muscles*, *secretory* filaments to the *parotid gland*.

The main trunk of the *third division* of the trigeminal is the *mandibular* or *inferior dental nerve*. After giving off the mylohyoid branch it enters the long mandibular or inferior dental canal (see Figs. 54 and 57), passing along with the artery and the venous plexus below the roots of the molars (see Figs. 53 and 54). Before its entrance into the canal it gives off a few delicate twigs to the oral mucosa and the periosteum;

Fig. 55

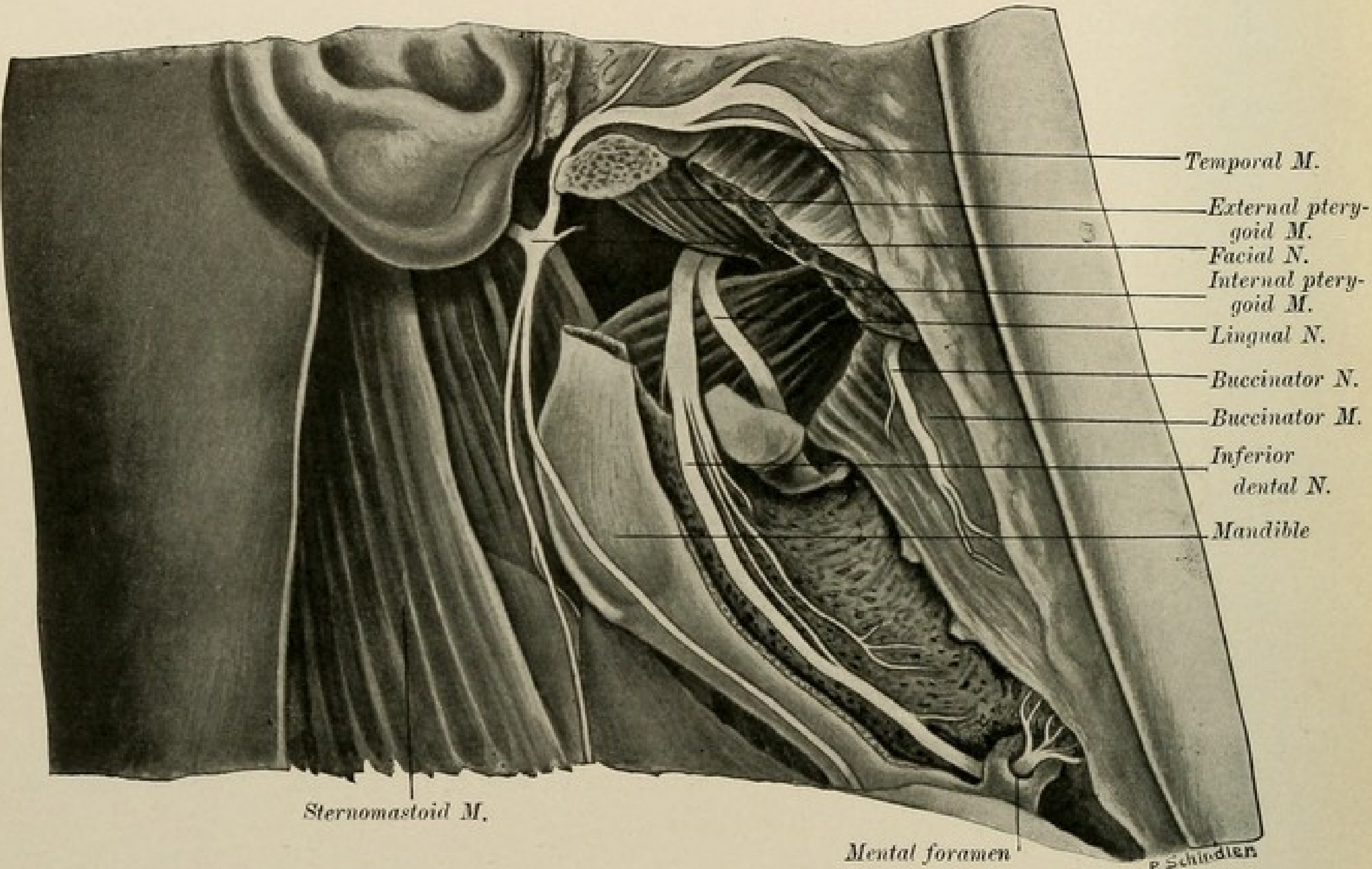


Distribution of superior maxillary nerve. (Hirschfeld and Leveillé.) The outer wall of the left orbit is removed, also most of the soft tissues in the vicinity of the maxilla. (From Rauber and Kopsch.)

within the canal it is frequently subdivided into several parallel branches. One of these extends as far as the central incisors, where it anastomoses with the nerves of the other side. At the mental foramen it gives off the *mental branch* which supplies the anterior labial surface of the mandible, the mucosa, and the lower lip (see Fig. 53). In its course the inferior dental nerve, in close relationship to the corresponding vessels, gives off two large separate branches, a *posterior branch* to the molars, and a *middle branch* between the mandibular and the mental foramina to the bicuspids.

In front of the inferior dental nerve (see Figs. 53 and 54), the *lingual nerve* passes to the tongue, sending off on its way a side branch which is minutely broken up in the anterior portion of the mandible (see Fig. 57). In the bicuspid region it ascends, finely distributing itself in the periosteum as far as the genial tubercles.

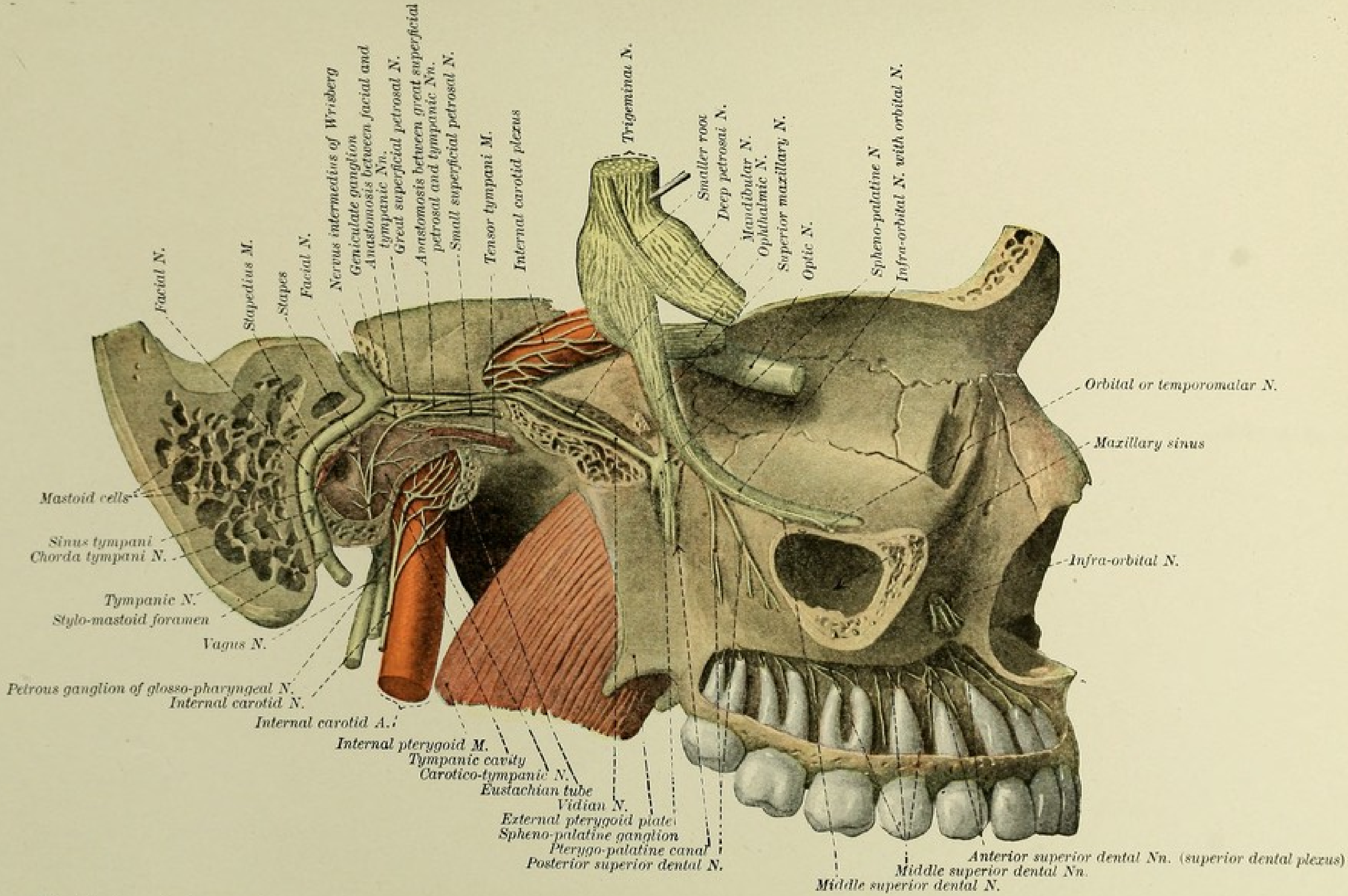
FIG. 57



Inferior dental or mandibular nerve. The strata of bone covering the nerve have been removed. (Original specimen by Gasser, of Marburg Anatomical Institute.)

Anastomoses.—Bünte and Moral have emphasized, more strongly than this has been done before, the anastomoses within the trigeminal area, which are of greatest importance in dentistry. These investigators use the fitting term "nerve loops" for the intercommunication of some of the branches of the trigeminal nerve, the most important of which are the following: *anterior palatine nerve* (second division)

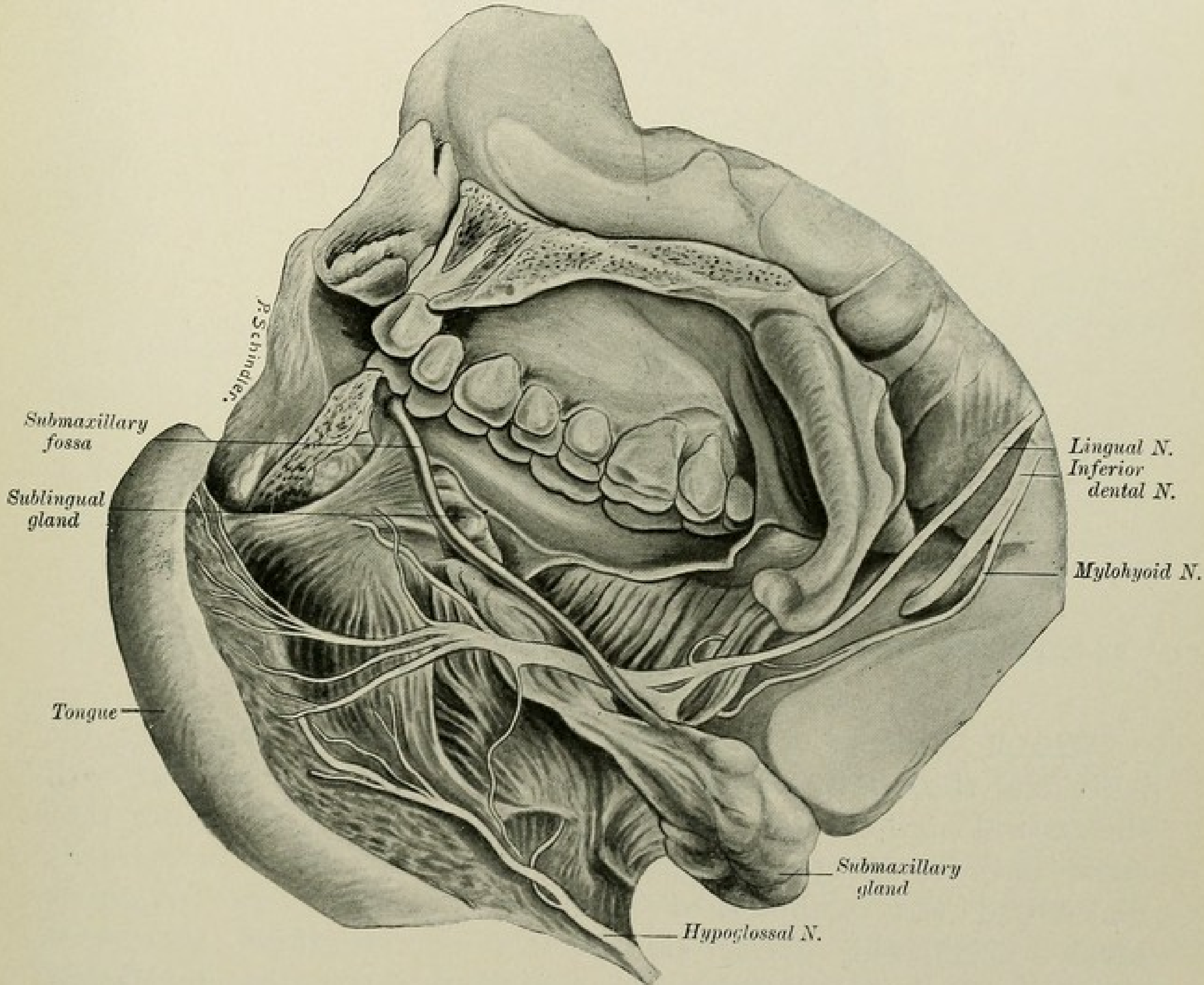
Fig. 56



Distribution of the superior maxillary nerve (second division of trigeminal nerve), and course of the anterior, posterior, and middle superior dental nerves. (After Sobotta.)

communicates in the anterior palatine canal with the *nasopalatine nerve* (second division) (see Figs. 53 and 54). On the anterior surface of the mandible the *posterior*, *middle*, and *anterior superior dental nerves* anastomose with one another and with the infra-orbital nerve

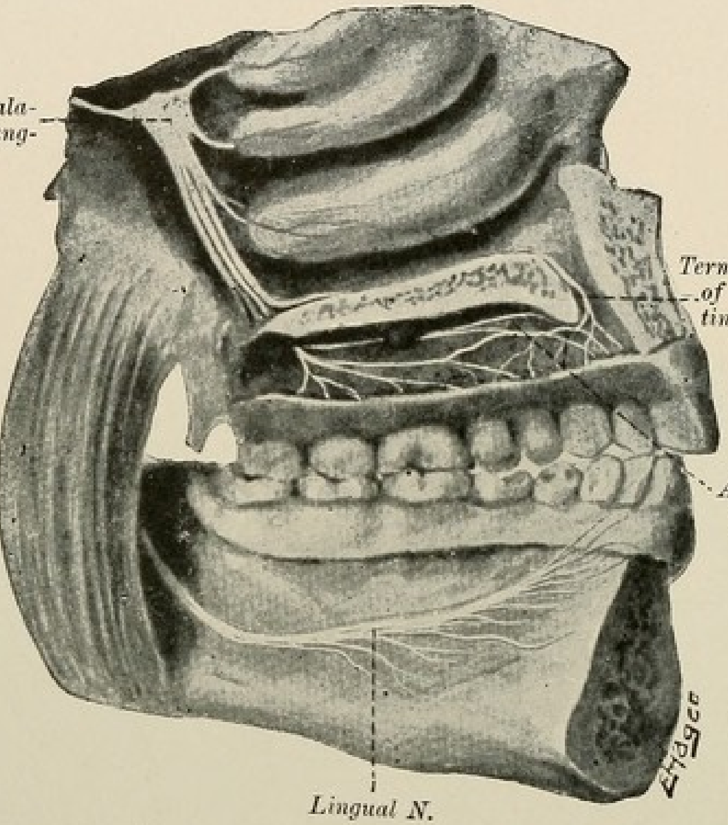
Fig. 58



Lingual nerve. (Original specimen by Gasser, of the Marburg Anatomical Institute.)

(see Figs. 52 and 56), as do the *infra-orbital nerves* in the median line at the nasal spine. In the mandible, the *inferior dental nerves* of each side communicate with one another at the symphysis. Numerous terminal loops of the second and third divisions, which supply the alveolar processes, are distributed in the oral mucosa as the gingival *posterior* and *anterior superior nerves*, and the *large* and *small palatine nerves*.

FIG. 59



Anastomosis of nasopalatine and anterior palatine nerves. Distribution of lingual nerve in the mandible. (After Bünte and Moral.)

Stimuli Referred by Anastomoses.—The nerves supplying the individual teeth are really nerve terminals which communicate with the central nervous system by larger tracts of supply. Since they stand also in direct relationship to neighboring areas, it is easily understood why pathological conditions in teeth very frequently involve neighboring normal pulps. It is not surprising, then, that especially in dental disorders the pain is so extraordinarily intense, frequently affecting large neighboring areas. By anastomoses with the *opposite side*, sensations are often referred thereto. Owing to the relations of the trigeminal nerve to the *facial nerve*, pain in diseases of the *lower teeth* is often referred to the *ear* by way of the tympanic branch, as the mandibular nerve communicates through the *auriculo-*

temporal nerve with the nerves of the external auditory meatus, whence the tympanic branch passes to the tympanic membrane. In the *maxilla* we frequently observe radiation of pain from the alveolar process to the temporal region, the eyes, the forehead, the neck, or even the upper arm. The same relationships are noted in anesthesia.

Strong electric currents applied to the teeth or the oral mucosa disclose certain very interesting relationships between the different areas of nerve supply in the facial portion of the skull. *Oscillations in the eye* and an *increase in the lacrimal secretion*, for instance, can be produced by applying strong electric currents to *all the teeth*, both upper and lower; that is, by stimulation of the second and third divisions of the trigeminal nerve. Stimulation of the soft palate is usually followed by an increase in lacrimal secretion only. These relationships are of the greatest importance in regard to pathology, as serious disorders of the teeth may involve the organs supplied by the *second trigeminal branch*.

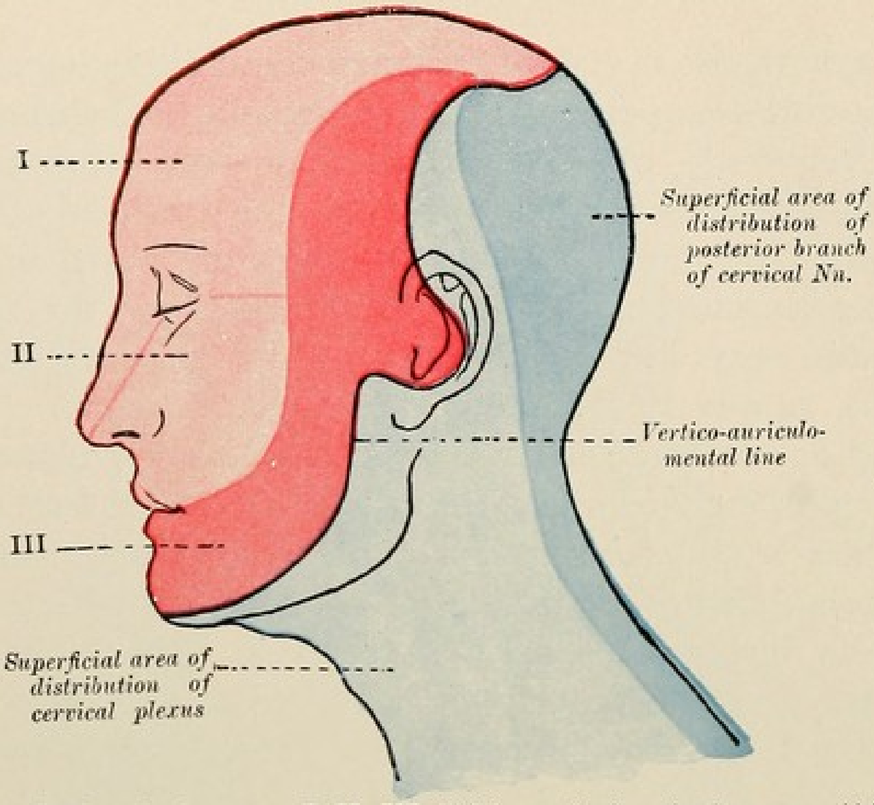
The diagram in Fig. 53 clearly illustrates the intimate relations existing between the trigeminal nerve and the branches of other cranial nerves within its area of distribution.

AREAS OF NERVE SUPPLY OF THE MASTICATORY APPARATUS.

In order to offer a clear picture of the distribution of the individual nerve trunks in the masticatory apparatus, a thorough knowledge of which is of paramount importance in local anesthesia, the different areas of nerve supply are represented in colored diagrams (see Figs. 60 to 64). In the head we distinguish generally three definite areas, supplied by the three divisions of the trigeminal nerve, as illustrated in Fig. 60.

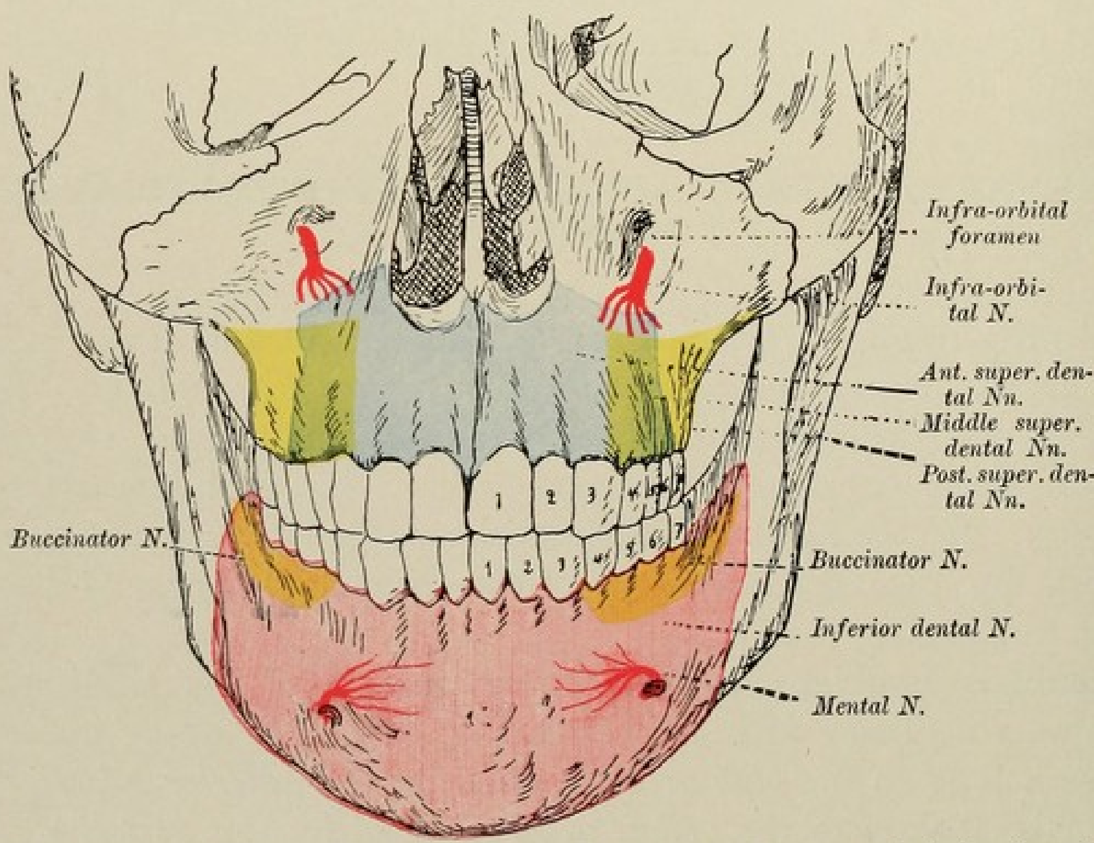
Maxilla.—Looking at the anterior surface of the skull, we note in the *maxilla* three such areas (see Fig. 61). The upper incisors and canines belong to the *blue* area supplied by the *anterior superior dental nerves;* the molars to the *yellow* area supplied by the *posterior superior*

FIG. 60



Distribution of trigeminal nerve. I, II, III divisions of trigeminal nerve. (After Toldt.)

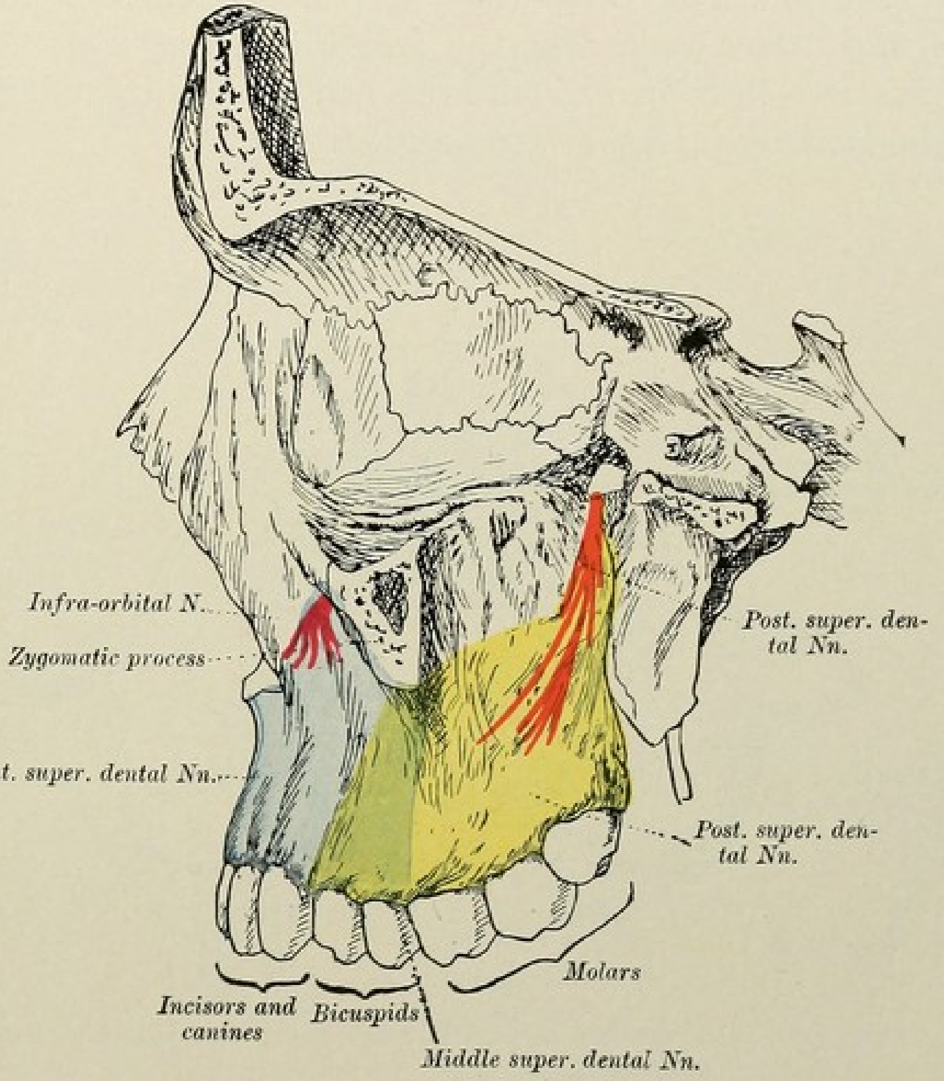
FIG. 61



Areas of nerve supply of maxillary apparatus. Front view. Red area: inferior dental nerve. Yellow area: posterior superior dental nerves. Green area: Middle superior dental nerves. Blue area: anterior superior dental nerves.

dental nerves, while the bicuspids, in the *green* area, stand in relationship to both sides, being supplied by the *anterior* and *middle superior dental nerves*. The blue and yellow areas, therefore, represent portions that are supplied by one single nerve branch each, while the green

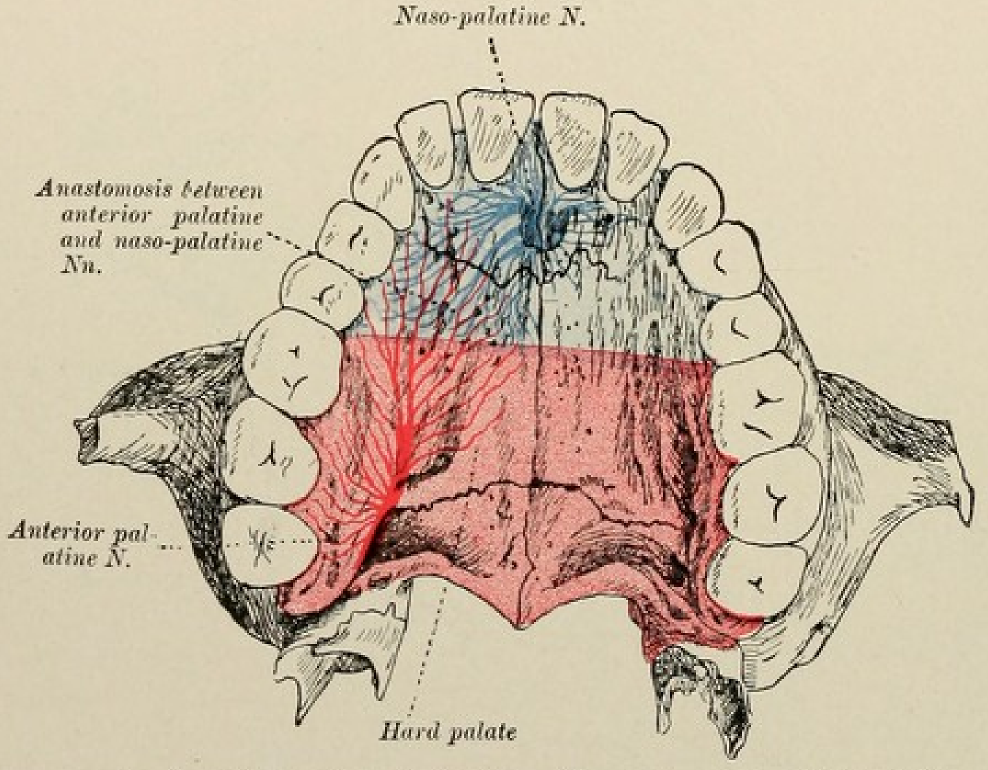
FIG. 62



Areas of nerve supply of maxilla. Blue area: anterior superior dental nerves (incisor and canine region). Green area: middle superior dental nerves (bicuspid region). Yellow area: posterior superior dental nerves (molar region).

areas are of mixed character. The nerve supply of the latter areas is furnished by three branches, viz.: the middle superior dental nerve proper which supplies the bicuspids, and the anterior and posterior superior dental nerves on either side which anastomose with the middle branch (see Fig. 52). In the green and blue areas, the nerves run partly behind the facial plate of the alveolar process, partly below the mucous membrane of the maxillary sinus (see Figs. 52 and 56). In some portions, this plate, as we have seen, is of spongiose character, and renders it most favorable for the diffusion of anesthetic solutions. At the *maxillary tuberosity* several branches of the *posterior superior dental nerves* penetrate the facial wall (see Figs. 52, 55, and 56). These nerve branches can be reached by the hypodermic needle and anesthetized by injection at the tuberosity.

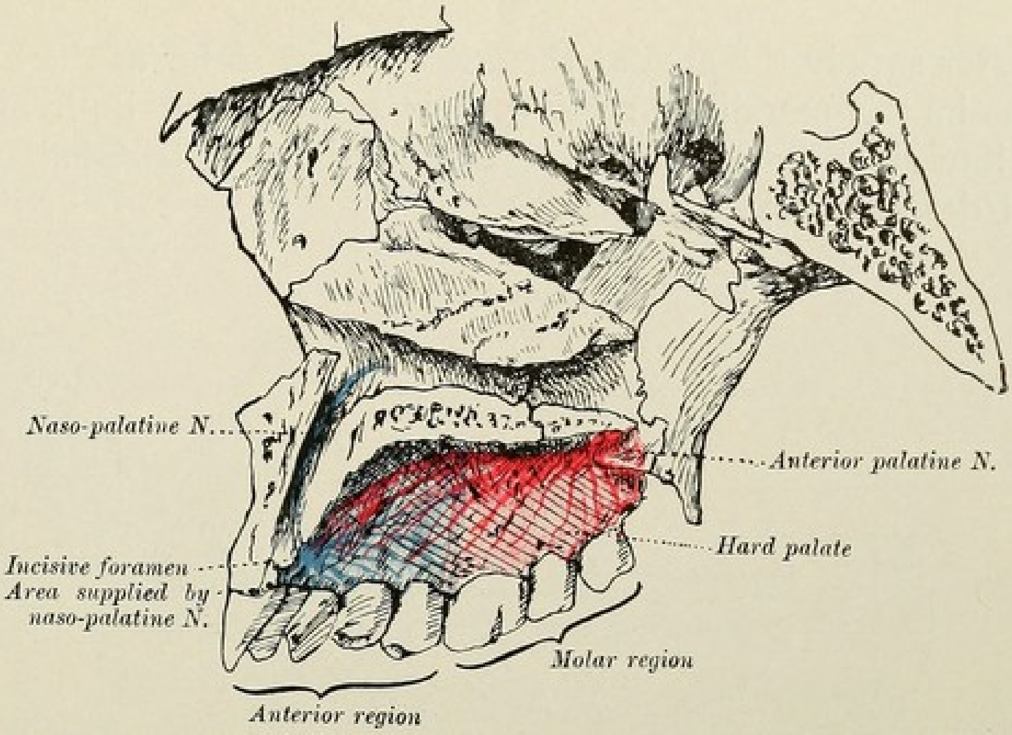
FIG 63



Areas of nerve supply of palatal surface of maxilla. Blue area: naso-palatine nerve. Red area: anterior palatine nerve (molar region).

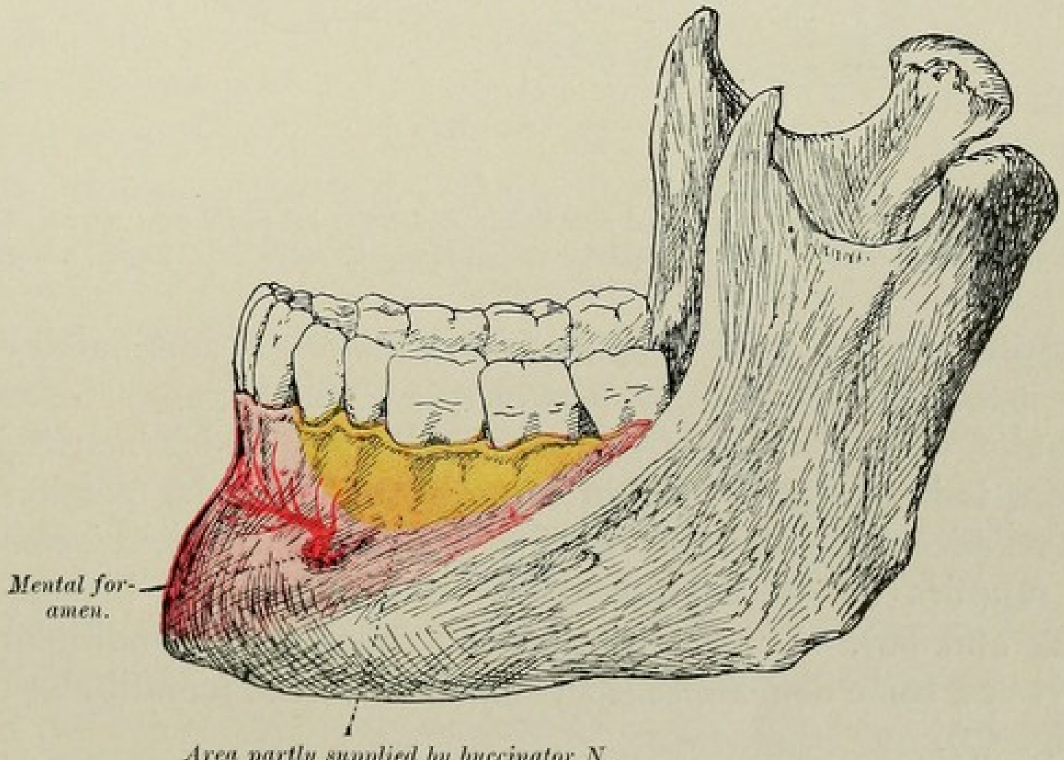
The *palatal surface of the maxilla* may be divided into an *anterior blue* and a *posterior red* section. The latter is supplied by the *anterior palatine nerve* (see Fig. 63) which emerges upon the hard palate by the posterior palatine foramen above the third molar (see Figs. 54 and 55), and, passing forward and toward the median line, communicates in front with the *nasopalatine nerve* (see Fig. 54). The filaments

FIG. 64



Areas of nerve supply of palatal surface of maxilla. Red area: anterior palatine nerve (molar region). Blue area: naso-palatine nerve (incisor and canine region). The bicuspid region is supplied by both branches.

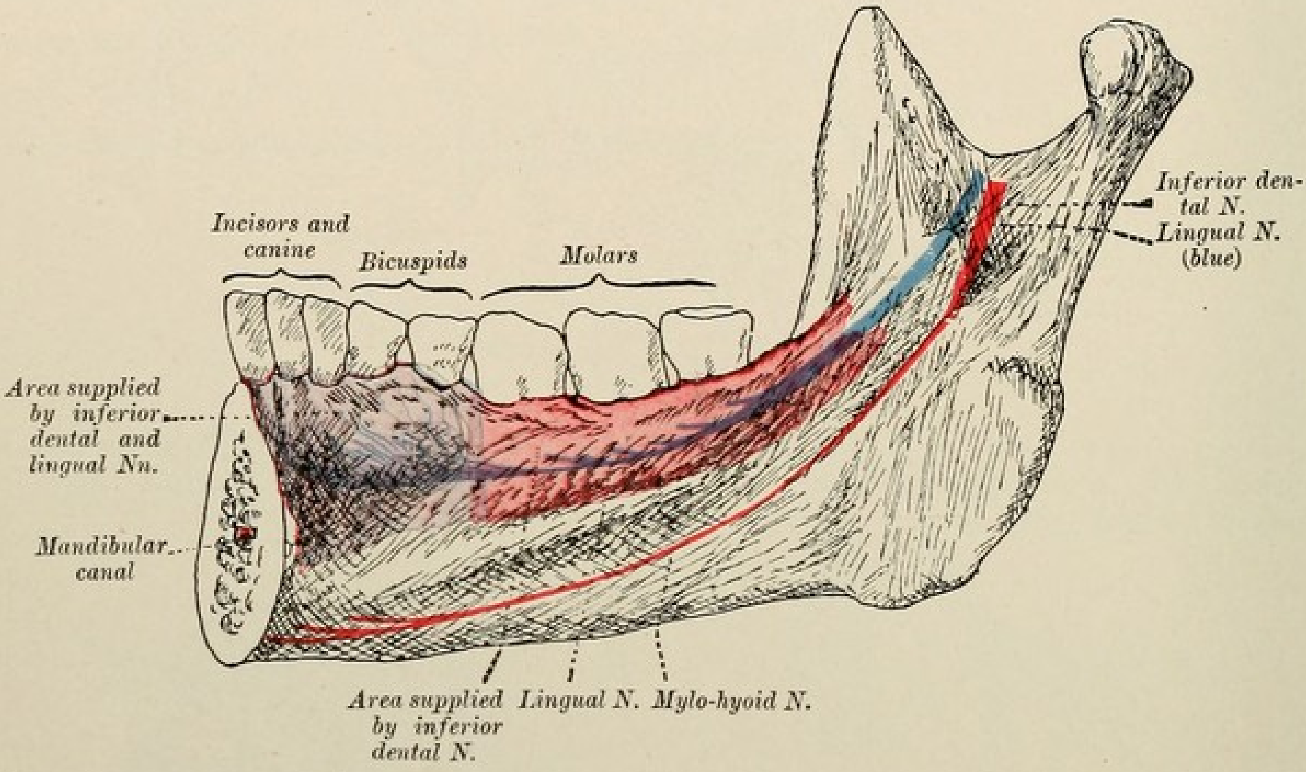
FIG. 65



Areas of nerve supply of anterior portion of mandible. Red area: inferior dental nerve. From the mental foramen emerges the mental nerve. The mucous membrane in the molar and bicuspid region (yellow) is partly supplied by sensory fibers of the buccinator nerve.

of the latter supply the area at the *anterior teeth* as far as the bicuspids which, as in the mandible, receive their supply from both branches. Viewed laterally, these two nerve branches are distributed over the area just described (see Fig. 54).

FIG. 66



Areas of nerve supply of lingual portion of mandible. Red area: inferior dental nerve. The mylohyoid nerve branches off at the inferior dental foramen. Blue area: lingual nerve.

Mandible.—The nerve supply of the *mandible* is dominated entirely by the *mandibular*, or *inferior dental nerve*, which passes through the mandibular canal (see Fig. 53). The *red* area, which marks its distribution, is interrupted only in its posterior or molar portion by an *orange-yellow* area indicating sensory fibers of the *buccinator nerve*, which supplies the buccal mucosa of the molars and bicuspids (see Figs. 65 and 66). Before entering the canal, the mandibular nerve also gives off some delicate sensory filaments to the mandibular mucosa (see Fig. 57).

The lingual surface of the mandible is supplied jointly by the inferior dental nerve and one of its coördinate branches, the *lingual* *nerve*. The latter is a large branch placed in front and mesially of the inferior dental nerve, and ascends in the region of the first bicuspid to the alveolar process as far as the incisors, where it is minutely distributed in the periosteum (see Fig. 58). Some of its terminal filaments in the vicinity of the genial tubercles probably extend through foramina to the anterior portion of the mandibular canal (see Fig. 38). Shortly before entering the inferior dental foramen, the inferior dental nerve gives off a motor branch, the *mylohyoid nerve* (see Figs. 53, 54, and 66).

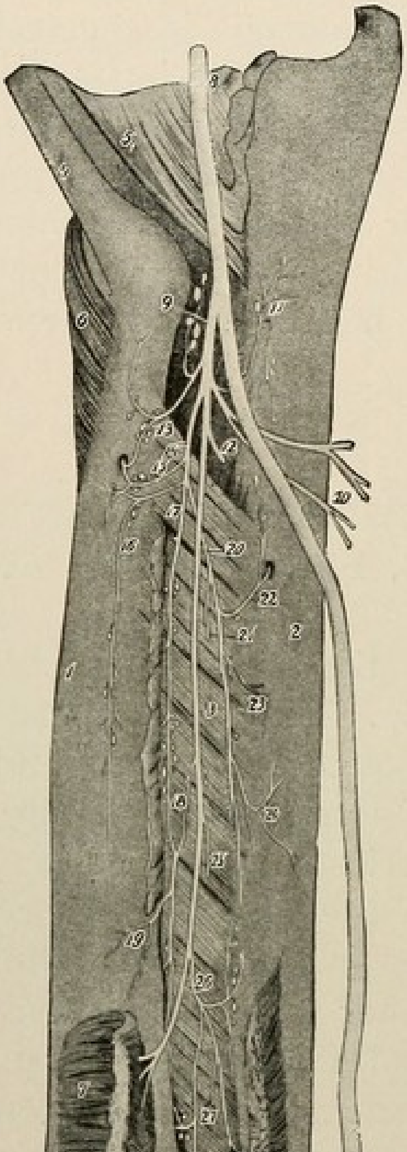
THE MINUTE DISTRIBUTION OF NERVES IN THE ALVEOLAR PROCESS, PERIOSTEUM, AND PULP.

Periosteum.—Within the alveolar processes the nerve trunks are distributed most minutely. The *periosteum* as well as the *pericementum* are especially richly endowed with sensory filaments. Fig. 67 represents *Vater's* or *Pacini's corpuscles*, sensory end organs which are always present in the periosteum.

Pulp.—The nerves of the pulp are sensory fibers of the trigeminal nerve and enter the pulp in one or more stout bundles or trunks by the apical foramen together with the bloodvessels. About the middle portion of the pulp canal these trunks branch out considerably, so that in incisors, for instance, from thirty to forty bundles can be counted. These bundles consist of cylindrical strands composed of medullated nerve fibrils of from 6 to 10 microns in diameter (see Fig. 70). Each bundle is surrounded by a sheath of connective tissue resembling the perineurium. The fibrils in these bundles run in the direction of the long axis of the tooth, and can clearly be traced to the internal terminal lamina of the dentin (see Fig. 69).

Sensitivity of the Dentin.—From the above it follows that the *odontoblastic layer* represents the most important tissue area of the pulp, as well as of the entire tooth. In this area the most delicate tendrils of the nerve filaments are distributed, arborizing with a graceful network of lymphatic capillaries, around the odontoblasts,

FIG. 67



Nerves in the periosteum and interosseous ligament in the forearm with Pacinian corpuscles. 1, radius; 2, ulna; 3, interosseous membrane; 4, tendon of biceps brachii M.; 5, tendon of brachialis M.; 6, supinator M.; 7, pronator quadratus M.; 8, median N.; 9, interosseous antibrachii volaris N., 10, branches of flexor profundus digitorum M.; 11, periosteal branch to ulna; 12, nerve to flexor pollicis longus M.; 13, radial N.; 14, trunk of interosseous Nn.; 15, second branch of radial N.; 16, periosteal branch to radial N.; 17, branch of interosseous Nn.; 18, communicating branch from interosseous antibrachii volaris N.; 19, 20, 21, branches of interosseous Nn.; 22, ulnar N.; 23, 24, branches of interosseous Nn.; 25, 26, 27, branches of interosseous volaris N.; 28, interosseous antibrachii posterior N. (From Rauber and Kopsch.)

FIG. 68

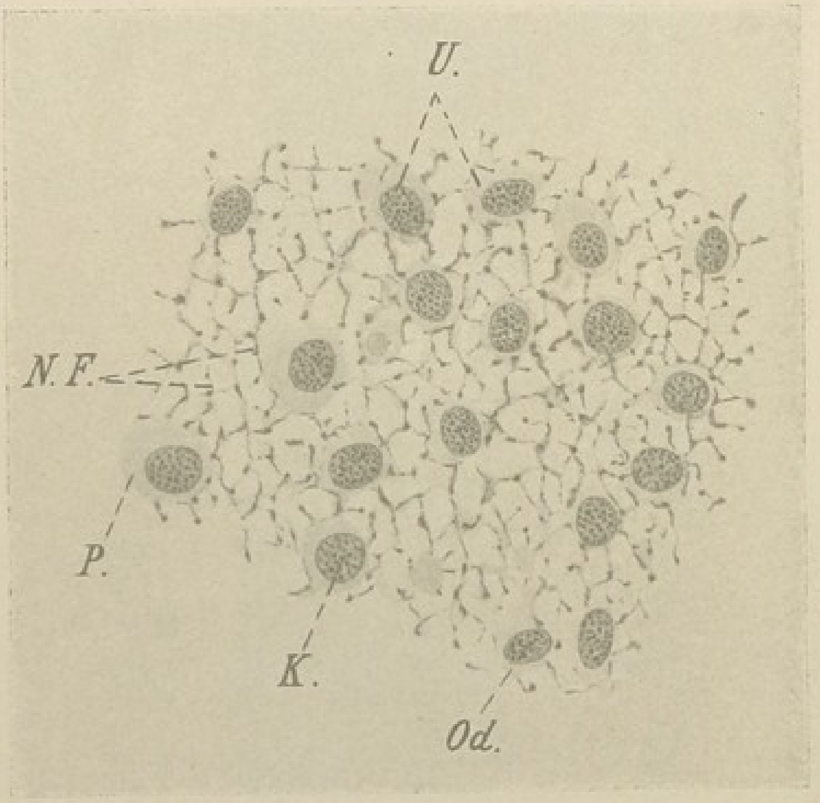
Nerves and bloodvessels in the pulp. × 56. *D*, dentin; *Od*, odontoblasts; *G*, bloodvessels; *N*, nerves; *A*, ramusculi of nerve fibers.

FIG. 69

Nerve fibers running between the odontoblasts to the dentin. (Fritsch.)

in the same manner as the bloodvessels of the pulp break up into innumerable capillary loops. As the odontoblasts with their cell processes control the nutrition and the sensitivity of the dentin which forms the bulk of the tooth, their relationship to the nervous and lymphatic systems is easily understood. Since, on the other hand, Tomes' fibrils are undoubtedly of a protoplasmic character, and nerve tendrils can be traced only to the internal terminal lamina of the

FIG. 70



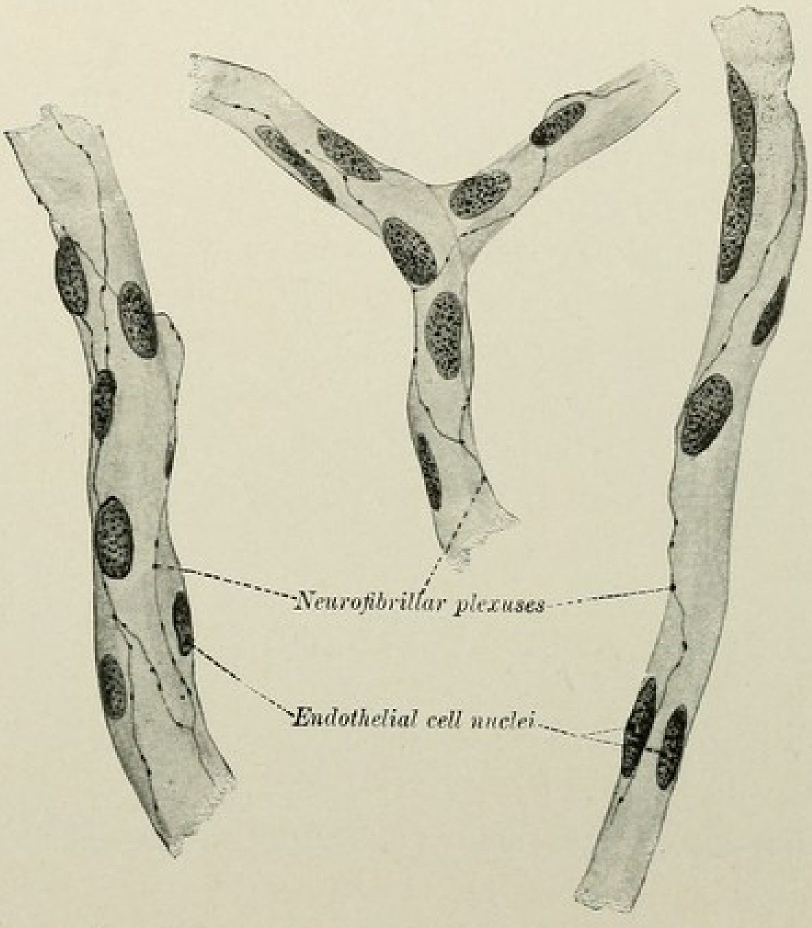
Horizontal section of odontoblasts and nerve fibrils arborizing around them. ×1560. *U*, odontoblasts surrounded by nerve fibrils; *NF*, nerve fibrils; *P*, protoplasm; *K*, nucleus; *Od*, odontoblasts.

dentin, all stimuli in the dentin are, perhaps, transmitted by way of the protoplasm, whence they are conveyed to the sensory end organs in the odontoblastic cell-layer.

According to the recent investigations of Dependorf, Fritsch, and others, the presence of nerve fibrils in the dentinal tubuli is highly probable; this, of course, would mean a direct conduction of sensations in the dentin.

Nerve Supply of the Walls of the Bloodvessels in the Pulp.—A few words should be said regarding the nerve supply of the *bloodvessels* and *capillaries*. The bloodvessels are supplied by motor as well as *sensory* plexuses, most of the latter belonging to the great *sympathetic system*. Their fibers are *non-medullated* and terminate generally within the adventitious coat (tunica adventitia) and the tunica media

FIG. 71



Nerves of capillaries. (After Joris.) (From Rauber and Kopsch.)

in a sensory end plate. The capillaries are enmeshed in a reticulum of delicate neurofibrillæ, as illustrated in Fig. 71. These fibrillæ, when acted upon by suprarenin, bring about the contraction of the vascular walls and for some time maintain the vascular constriction which is so desirable during local anesthesia.

12

THE TECHNIQUE OF INJECTION.

After the foregoing considerations, the technique of injection is merely a question of logical utilization of the factors described. The peculiarities of the bony structures, as well as the nerve supply, furnish us with definite guiding lines for a well-defined procedure of injection. Although some modifications have been suggested, the methods described in this book furnish, so far, the most reliable basis for successful and safe operations.

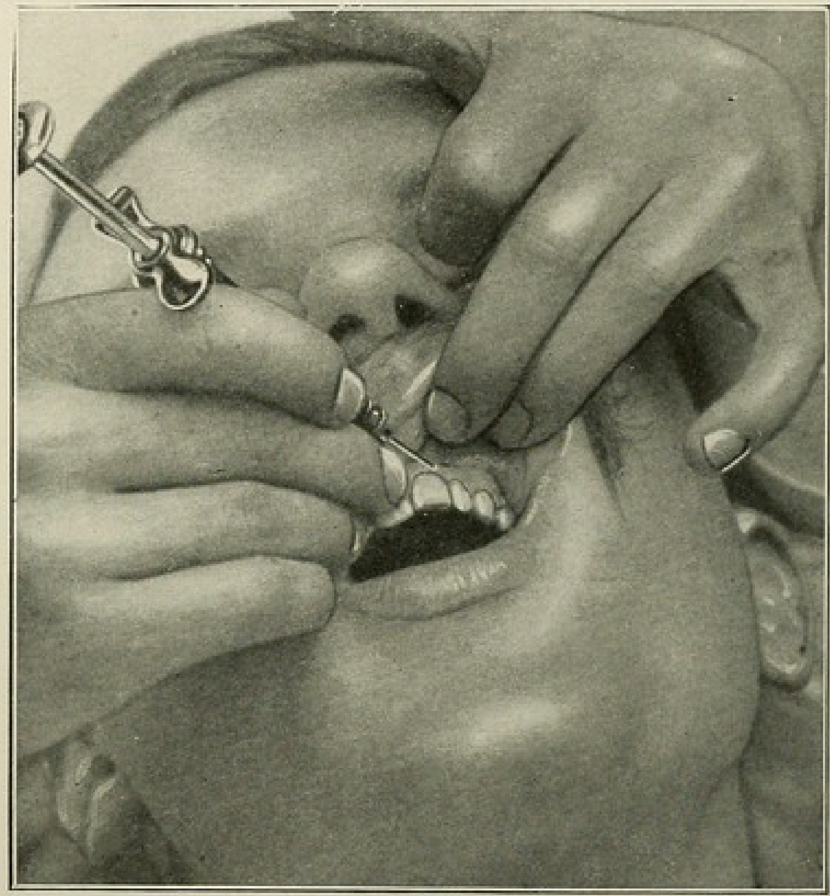
Anesthesia by local injection, as formerly employed in dental practice, was limited to *anesthesia of the mucous membrane*. In recent years *conductive anesthesia* was introduced, and with the adoption of this method in dentistry our results have become truly phenomenal. Conductive anesthesia in the mandible, for example, is really the first and only method to guarantee complete and safe anesthesia of that region. For it is undeniable that anesthesia of lower molars by the old method of injection into the mucosa is successful only in certain favorable cases; generally it spells more or less complete failure.

MUCOUS ANESTHESIA BY INFILTRATION.

By *mucous anesthesia* we mean anesthesia of a circumscribed portion of the jaw induced by way of the oral mucosa. The course of this anesthesia varies according to the condition of the mucous membrane, the manner of insertion of the needle, and the pressure under which the solution is injected into the tissues. By infiltrating a tissue area with an anesthetic solution, the functions of the nerves supplying that area are paralyzed. In every case the anesthetic effect is due to the contact of the injected solution with the sensory nerve fibers, which are gradually paralyzed within from five to ten minutes, depending upon the anesthetic employed. If injected correctly, our novocain-suprarenin solution produces complete anesthesia of the injected area within from eight to ten minutes. The anesthesia maintains its full intensity for about half an hour, after which time it wears off very gradually.

Since mucous anesthesia in the jaws depends primarily upon injection into the periosteum and the tissue elements connected with it, while the mucous membrane proper is of but secondary importance,

FIG. 72

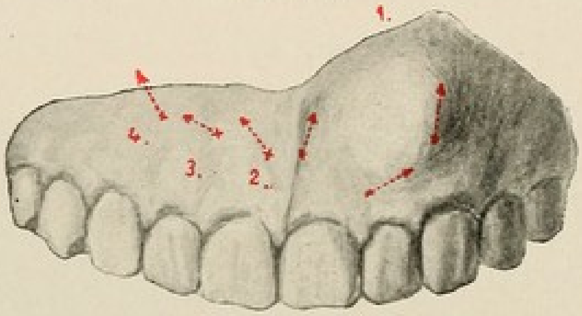


Mucous anesthesia in the maxilla in case of abscess of the root of the upper left canine. The needle is inserted in the gingival papilla of the central incisor and advanced horizontally in distal direction. Injection is made into the periosteum. The syringe is held like a penholder.

it would be more correct to speak of *periosteal anesthesia*. Success depends not so much upon injection into the submucous tissue as into the periosteum. The periosteum of the maxillæ forms an extremely taut and firm layer, and injection below this layer requires considerable pressure.

Injection in the Mucosa.—The syringe is held like a penholder (see Fig. 72), and the needle is placed at an almost right angle upon the mucosa, which has previously been disinfected with tincture of iodin. The needle is then slowly pushed through the gingiva and the

FIG. 73



Points of injection for anterior upper teeth. 1, injection for abscessed upper left lateral incisor; 2, injection for upper right central and lateral incisors; 3, injection for upper right canine; 4, injection for upper right bicuspid. The red crosses indicate the points of injection, the red arrows the direction of the needle.

FIG. 74

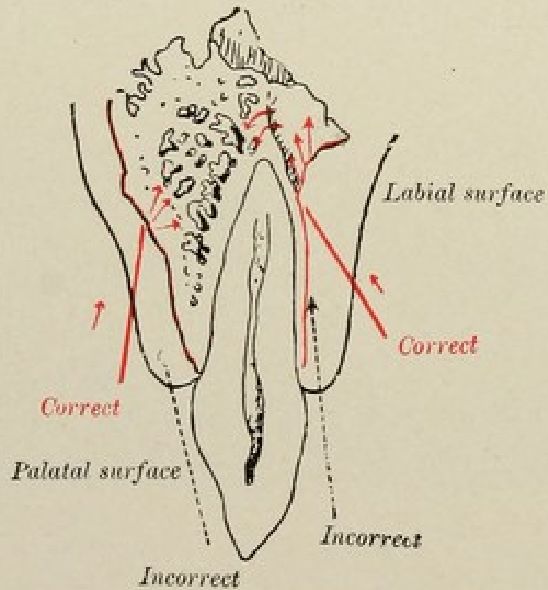
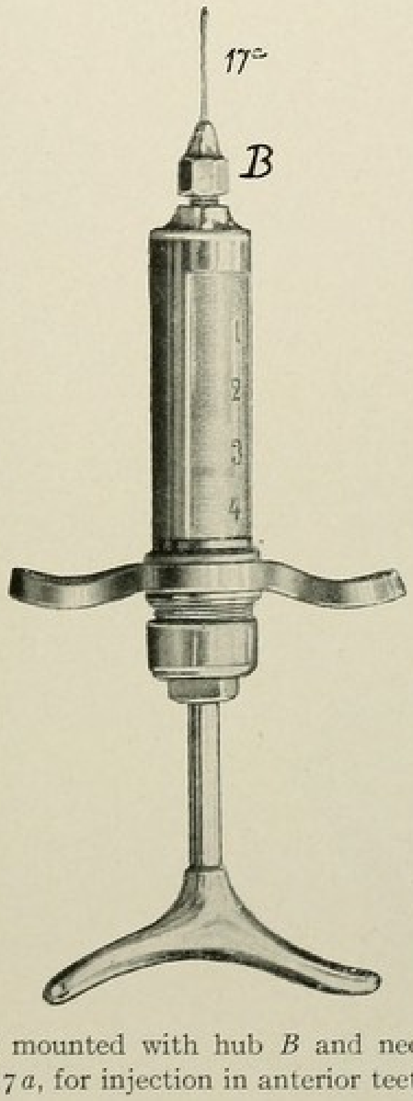


Diagram showing method of injection in maxilla (upper right canine). The red arrows indicate the correct, the black arrows the incorrect position of the needle.

periosteum, and the syringe is inclined so that the needle forms an acute angle with the bone (see Figs. 73 and 74). The syringe is then held in this position with the left hand, while the right hand moves back along the barrel until it engages the piston handle and cross bar between the thumb and the index and middle fingers.

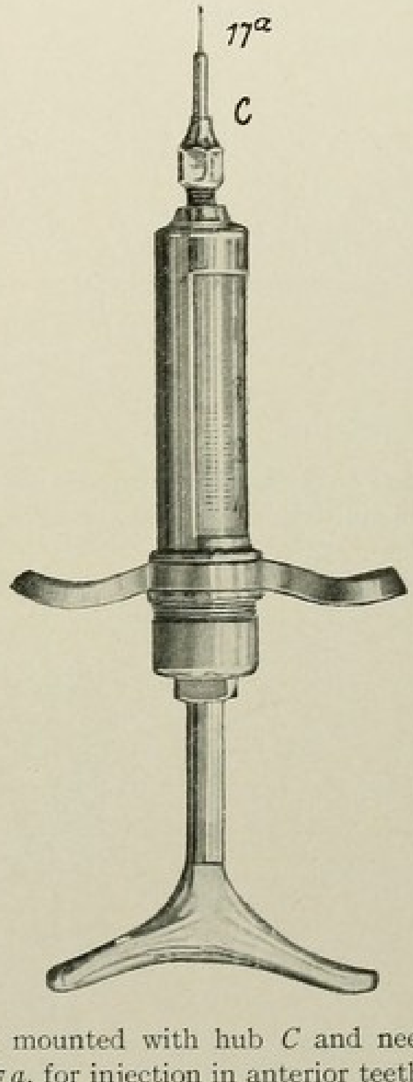
The syringe is mounted with hub *B* or *C* and needle No. 17 *a* (see Figs. 75 and 76). The orifice of the needle should always point toward the bone in the manner illustrated in Fig. 77. With the fingers of the left hand, the lip is lifted up as high as possible to gain an unobstructed

Fig. 75



Syringe mounted with hub *B* and needle No. 17 *a*, for injection in anterior teeth.

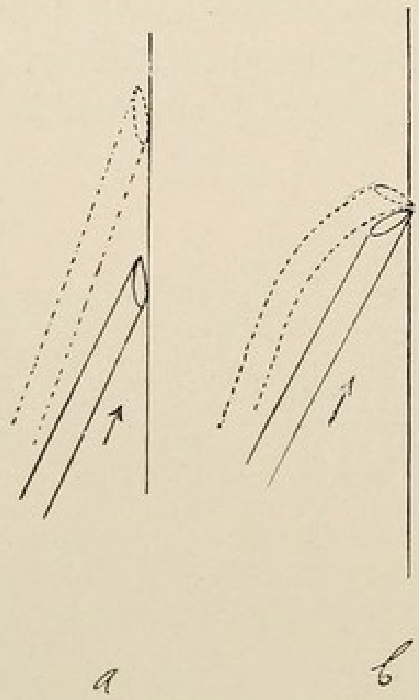
Fig. 76



Syringe mounted with hub *C* and needle No. 17 *a*, for injection in anterior teeth.

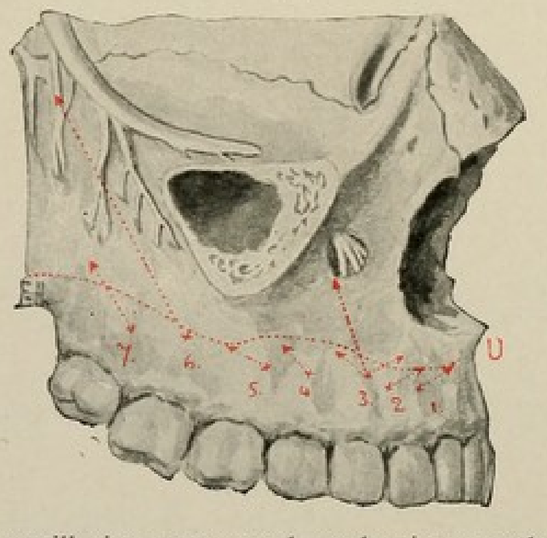
field of vision (see Fig. 72), and the correct quantity of solution, as indicated in the tables on page 233, is injected without advancing the needle farther along the bone. The syringe is then cautiously and slowly withdrawn, and the point of injection is compressed with the index finger of the free hand for about fifteen seconds.

FIG. 77



Position of the needle in mucous anesthesia, the aperture of the needle pointing toward the bone. *a*, correct position; *b*, incorrect position. The point of the needle is forced into the periosteum and to the bone. (After Seidel.)

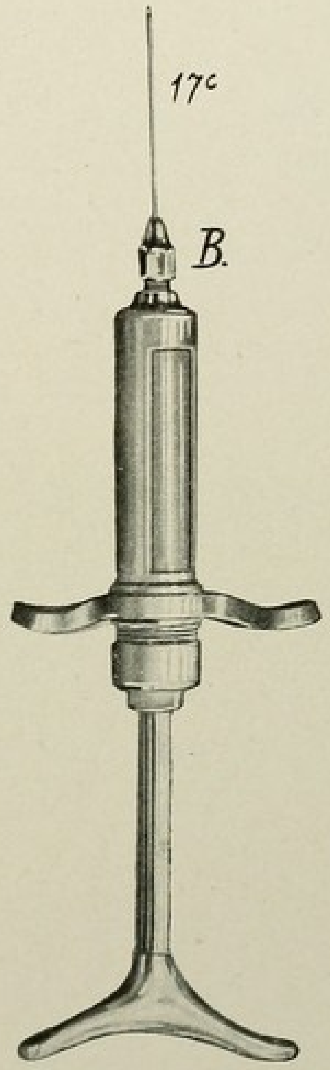
FIG. 78



Points of injection in the maxilla in mucous and conductive anesthesia. *U*, line of reflection of mucous membrane; 1, injection for upper right central incisor; 2, for upper right lateral incisor; 3, for conductive anesthesia of upper right lateral, canine, and first bicuspid, the needle to be advanced to the infra-orbital foramen; 4, for upper right second bicuspid; 5, for upper right first molar; 6, conductive anesthesia at maxillary tuberosity for upper right first, second, and third molars; 7, conductive anesthesia for upper right third molar.

In the posterior portions of the gums, owing to the interference of the cheek, the needle cannot be inserted at a right angle, and must therefore be advanced obliquely (see Figs. 78 and 80). In this case the syringe is mounted with hub *A* and needle No. 17 *c*.

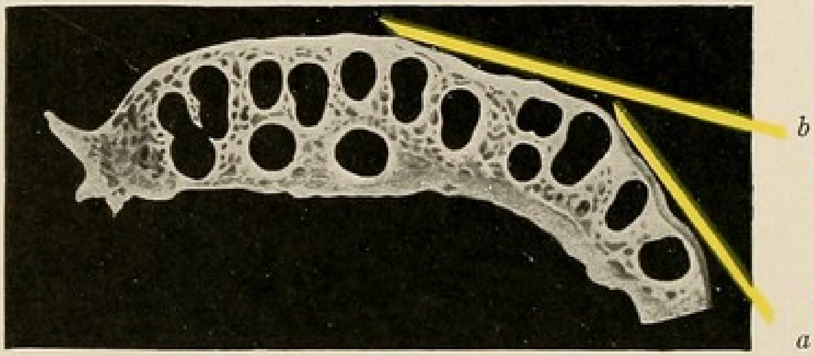
FIG. 79



Syringe mounted with hub *B* and needle No. 17 *c*, for injection in posterior teeth.

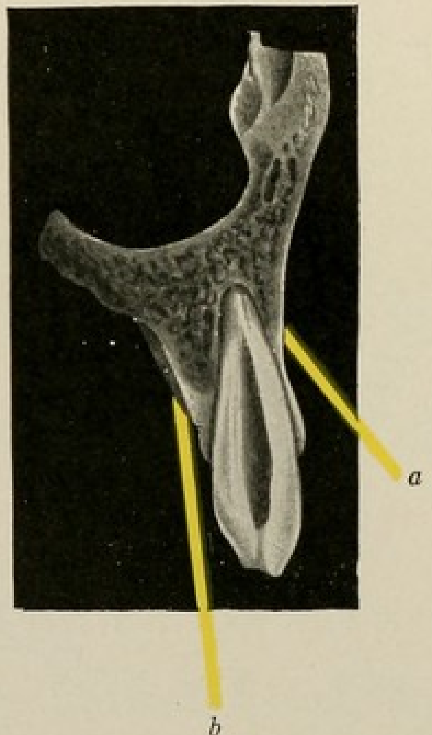
Maxilla.—*Buccal and Labial Injection.*—Injections in the buccal mucosa also are generally made in the manner just described. Repeated insertions of the needle should be avoided as much as possible, and an effort be made to infiltrate the desired area at one insertion, which is always possible in single teeth. The anesthetization even of several teeth can be accomplished at one buccal insertion, especially in bicuspids and molars, which allow nearly straight advancement of the long needle (see Fig. 80). In these teeth the needle is inserted at the

Fig. 80



Position of the needle for horizontal injection in several upper teeth. Needle yellow; *a*, labial injection; *b*, buccal injection.

Fig. 81

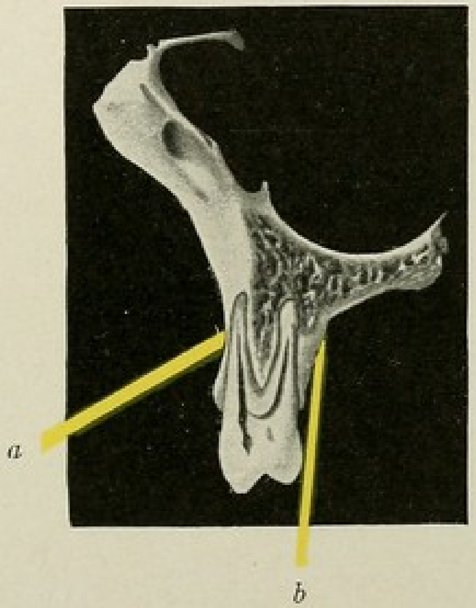


Position of the needle for injection in upper canine. Needle yellow: *a*, labial injection; *b*, palatal injection.

level of the middle root portion at a right angle to the long axis of the teeth.

At the sharp curve in the canine region, however (see Fig. 80), the needle is inserted at the level of the root apex of the canine and advanced into the depth of the gingiva, where the injection is slowly made under pressure (see Fig. 81). If the incisors and bicuspids on the same side are also to be anesthetized, the needle is pushed forward from the canine root, slowly discharging the contents of the barrel, in the direction of the anterior nasal spine to the region of the root apex of the central incisor, where the remainder of the solution is injected (see Fig. 78). After the syringe has been refilled, the needle

FIG. 82

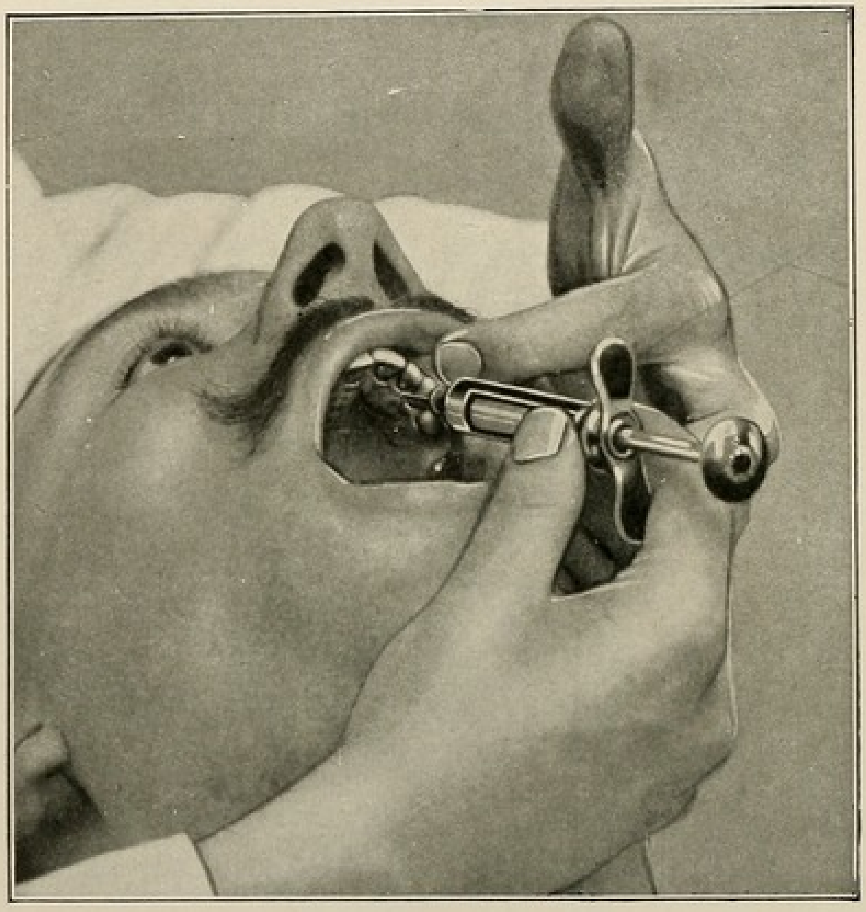


Position of the needle for mucous anesthesia in upper first bicuspid. Needle yellow. Above is seen the infra-orbital foramen: *a*, buccal injection; *b*, palatal injection.

is again inserted at the former point at the canine root, but advanced in the direction of the root apices of the bicuspids, where the barrel is again slowly discharged. If the second bicuspid also is to be anesthetized, the needle must be advanced to the root apex of that tooth (see Fig. 82).

If the gingival tissue is normal, no wheal is usually raised, and the formerly pink mucous membrane becomes pale. In spongy gingival tissue, however, the formation of a wheal cannot be prevented. The gradual expansion of the anemic area should always be carefully noted. This observation is greatly facilitated if one of the colorless iodin preparations, as advocated on page 96, is used for disinfecting the mucosa prior to injection, instead of ordinary tincture of iodin. After a successful injection the anemia frequently extends to the palate, owing to the diffusion of the solution within the interdental papilla.

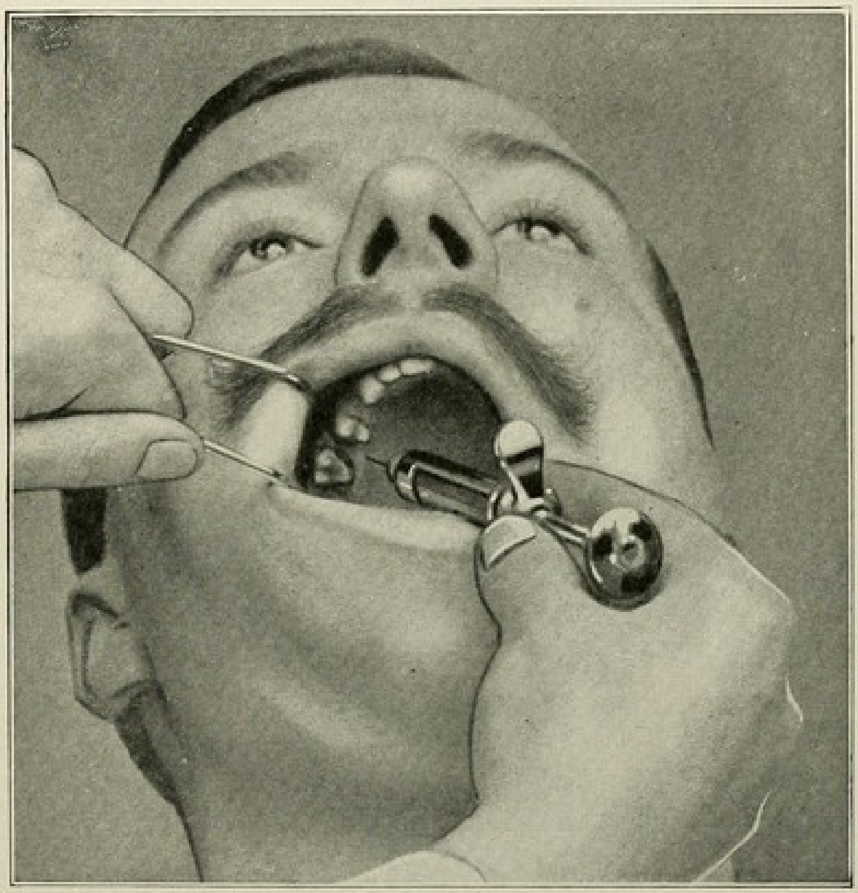
FIG. 83



Injection in the palatal mucous membrane at the lateral incisor. The syringe is held like a penholder.

Palatal Injection.—The induction of mucous anesthesia from the palatal surface of the maxilla requires special description. For palatal injection the needle is always inserted in the mucosa behind the tooth to be anesthetized (see Figs. 74, 80 to 83) and is at once cautiously and slowly advanced parallel with the alveolar process to the vicinity of the root apex (see Figs. 74 and 84), where a small quantity of the solution, *i. e.*, from $\frac{1}{8}$ to $\frac{1}{4}$ c.c., is deposited (see Fig. 73). In the deep stratum of the anterior palatine area the conditions for diffusion are most favorable, and the injection can be made much more easily, and with less pressure and pain, than near the cervical margin of the gingival tissue, where the taut circular ligament offers considerable resistance (see Figs. 85 and 86).

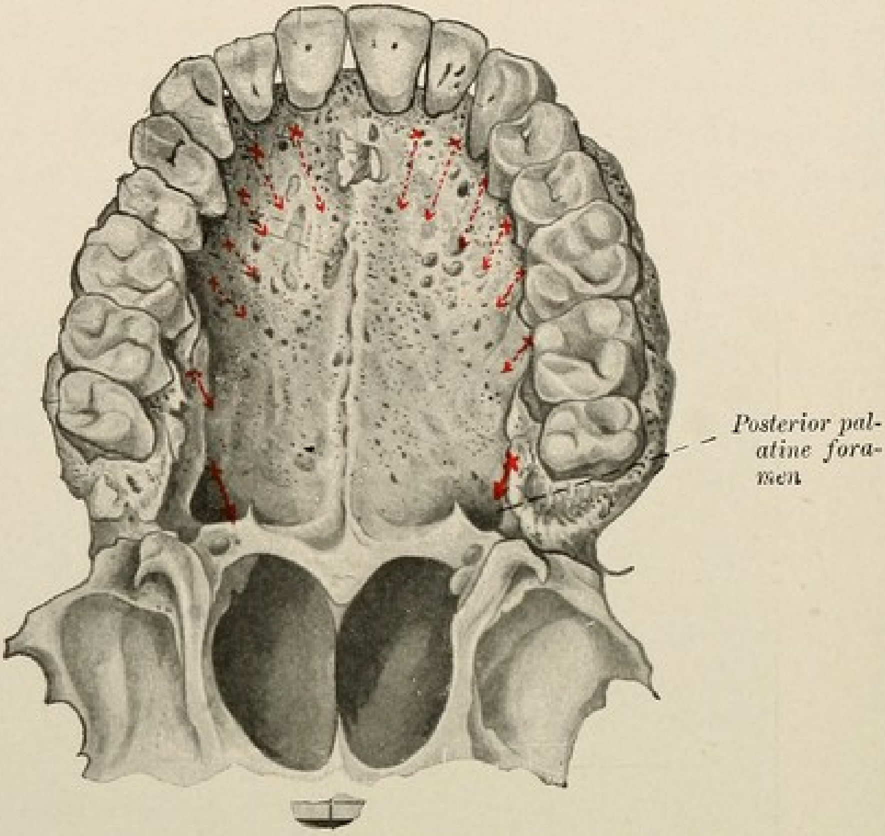
Fig. 84



Injection in the palatal mucous membrane in the bicuspid region. The syringe is held like a penholder.

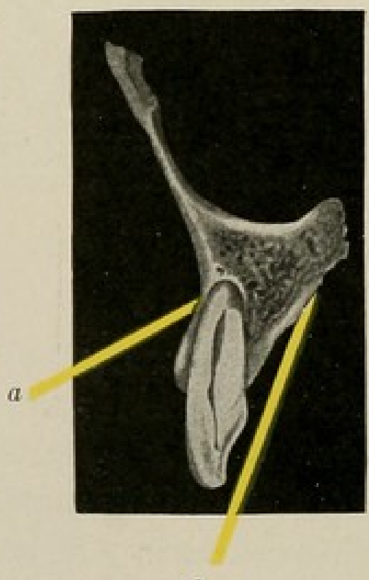
Injection at the Posterior Palatine Foramen.—The above procedure is repeated for all upper incisors, canines, and bicuspids, but is not followed in the upper molars. In these, one single injection at the *posterior palatine foramen* suffices, this foramen being situated under a slight depression in the mucosa near the palatal root apex of the third molar (see Fig. 87). The posterior palatine foramen is usually located $\frac{1}{2}$ cm. from the posterior border of the alveolar process and

FIG. 85



Bony surface of palate. The red crosses indicate the points of injection for mucous anesthesia; the solid red arrows the points of injection at the posterior palatine foramina.

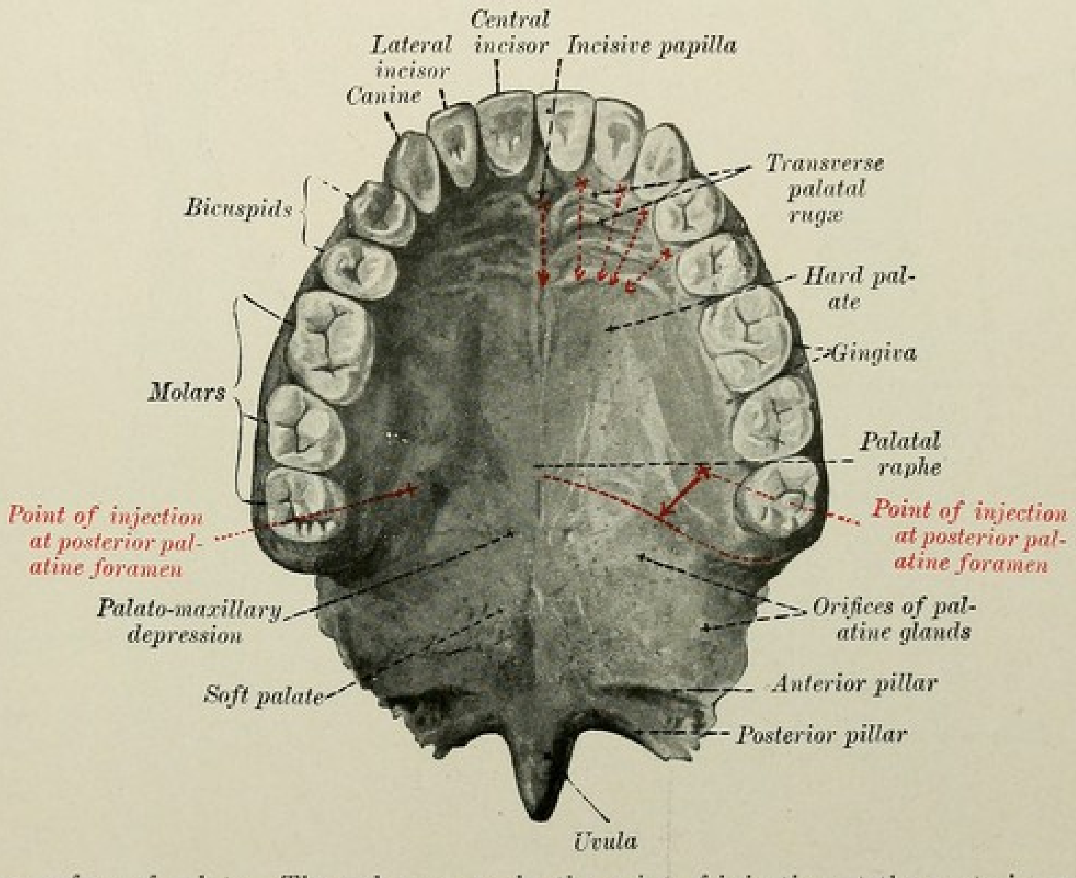
FIG. 86



Position of the needle for injection in upper central incisor. Needle yellow: *a*, labial injection, *b*, palatal injection.

above the last erupted molar (see Figs. 54, 85, and 87), viz.: up to the tenth or eleventh year above the first molar, after the eruption of the second molar above this tooth, and finally, above the third molar (see Figs. 32 to 35, 54 and 78). If the posterior portion of the alveolar process has been absorbed, it is best to inject near the apex of the palatal root of the first or second molar to be anesthetized.

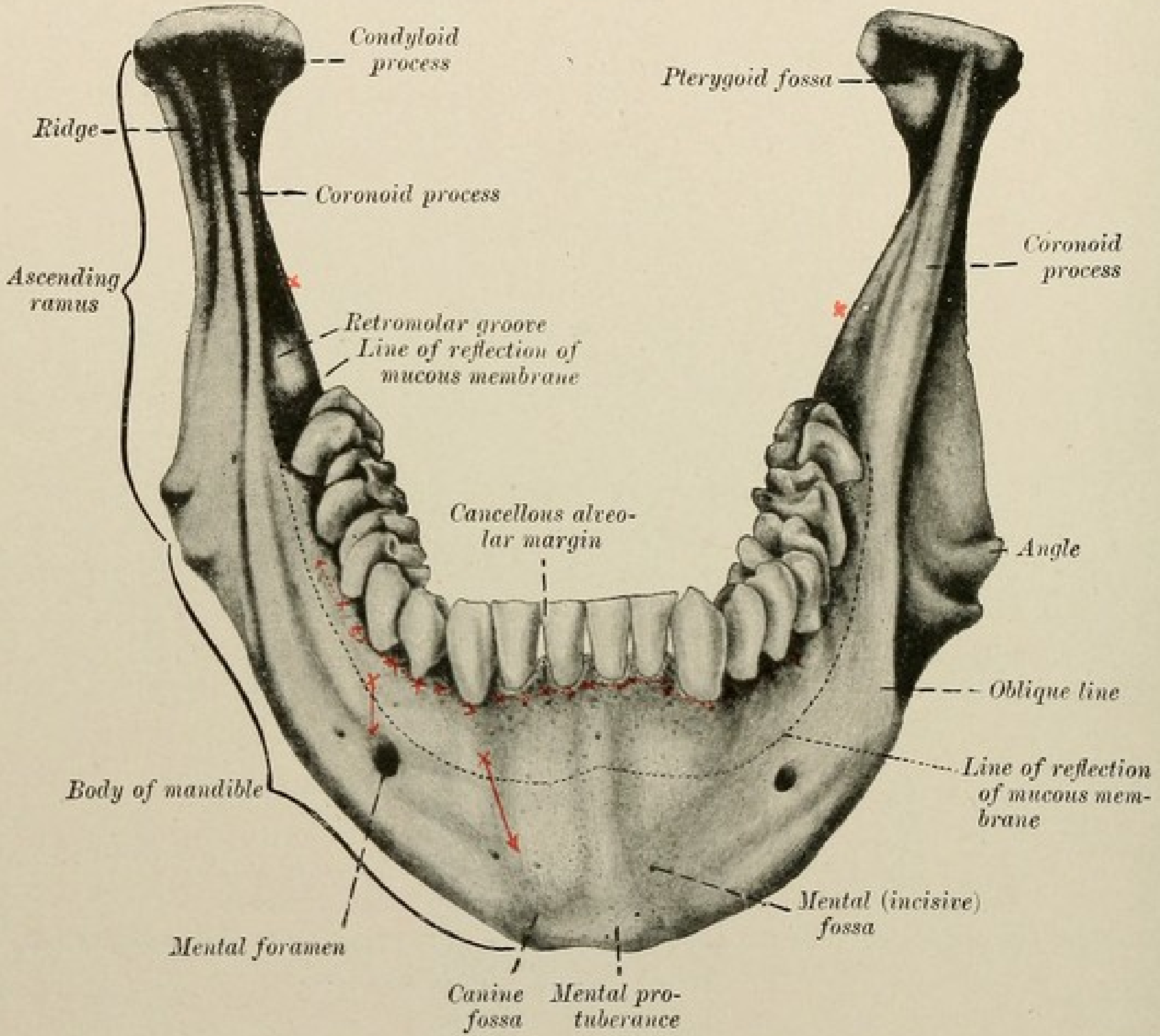
FIG. 87



Mucous surface of palate. The red cross marks the point of injection at the posterior palatine foramen on either side. (After Spalteholz.)

The needle is inserted into the depression in the mucosa at about the level of the palatal root apex of the second molar, the syringe being directed almost parallel to the alveolus and the molar root and inclined slightly backward toward the tuberosity; the needle is then advanced into the foramen and from 6 to 10 drops of the solution are evacuated. The discharge of a larger quantity involves danger of the solution diffusing into the loose tissue of the soft palate and causing disagreeable difficulties in deglutition. Strictly speaking, a conductive anesthesia is induced by this method, as the anterior palatine nerve trunk is blocked at its descent from the posterior palatine foramen. The palatal portion of the alveolus in the molar region is completely anesthetized by this injection.

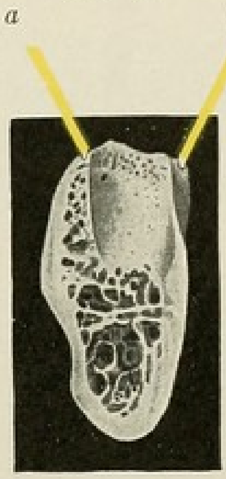
FIG. 88



Points of injection for mucous anesthesia in external surface of mandible. Red crosses indicate points of injection; small red arrows, direction of needle; two large arrows, direction of needle for injection in mental foramen and fossa. On the internal surface of ramus are marked the points for injection at mandibular foramen.

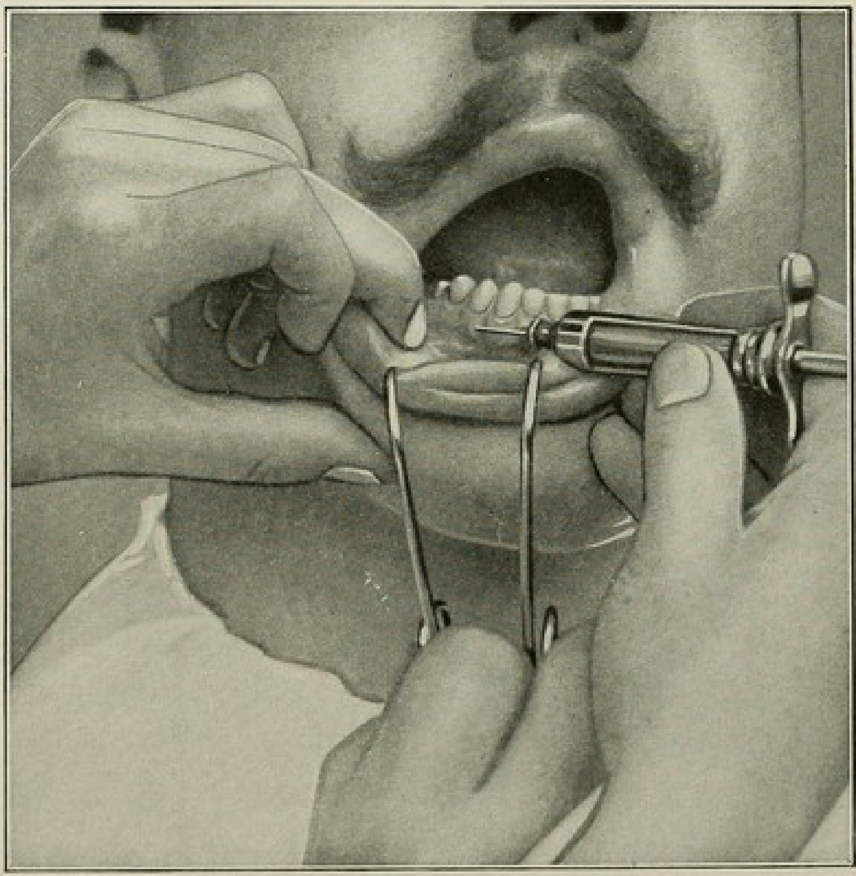
Injection in the Anterior Palatine Fossa Contra-indicated.—Experience has shown that the *anterior palatine fossa* with its four foramina, situated in the anterior portion of the palatal roof, is not a suitable

Fig. 89



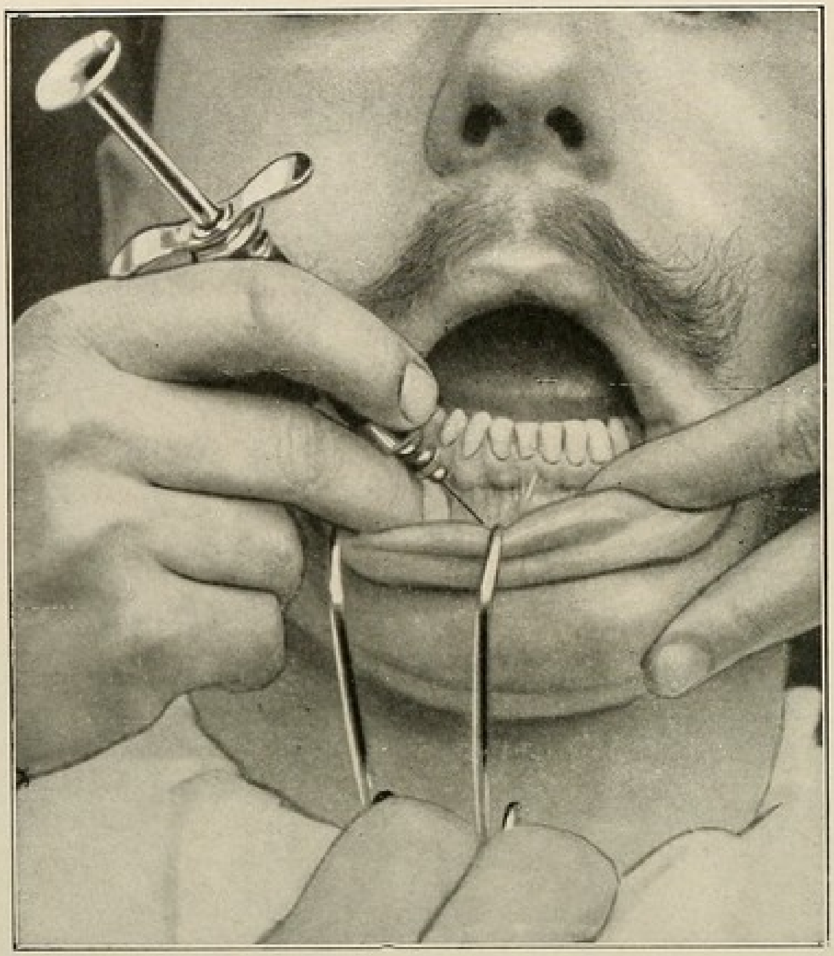
Position of the needle for injection in lower molars. Needle yellow; *a*, buccal injection; *b*, lingual injection.

Fig. 90



Injection in the mandibular mucous membrane for anesthesia of lower second bicuspid. The needle is inserted in the eminence at the first bicuspid directly below the gingival papilla. The syringe is held like a penholder.

FIG. 91



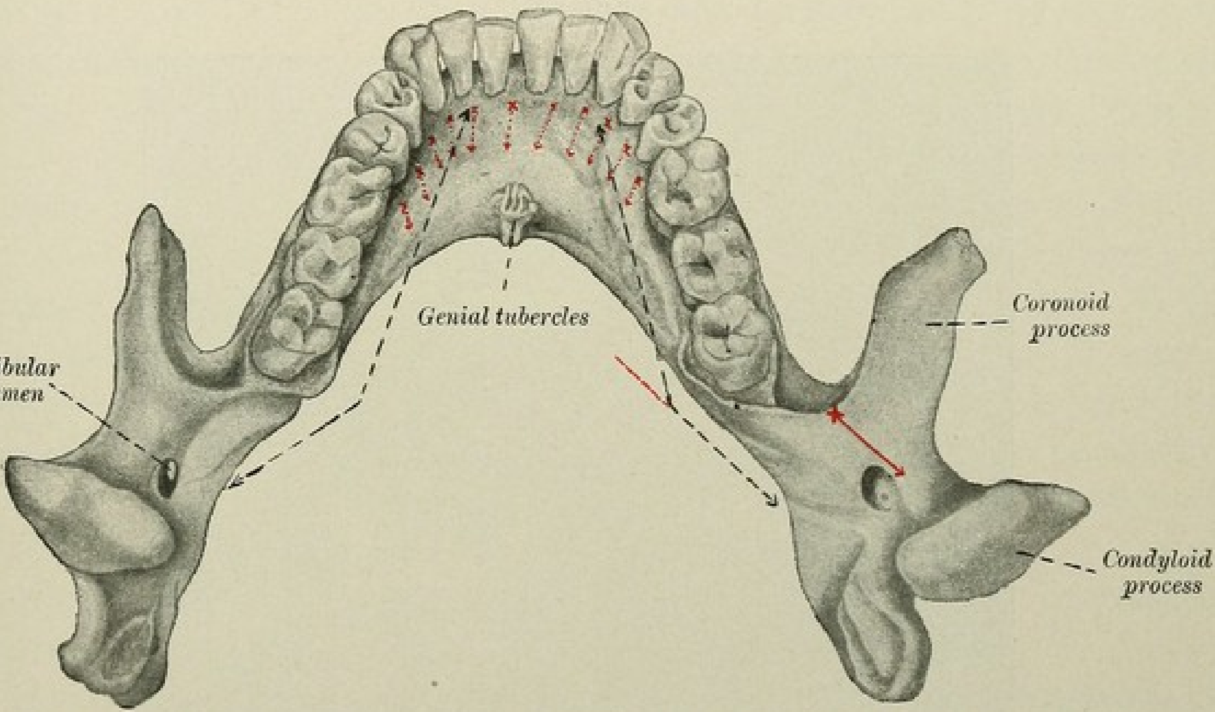
Injection for anesthesia of lower anterior teeth. The long needle is inserted in the reflection of the mucous membrane and advanced to the mental fossa. The syringe is held like a penholder.

FIG. 92

Position of the needle for injection in lower canine. Injection in mental fossa. Needle yellow: *a*, labial injection; *b*, lingual injection.

site, as an injection at this point for the purpose of anesthetizing the *nasopalatine nerve* usually produces severe pain, due possibly to the presence of a specially large number of sensory fibers in the incisive papilla. Moreover, no advantages in regard to effect are to be derived from such an injection, and palatal injection behind each tooth, as advocated (see Figs. 74, 83, and 84), is more expedient, successful, and easily tolerated, causing a minimum of pain.

FIG. 93



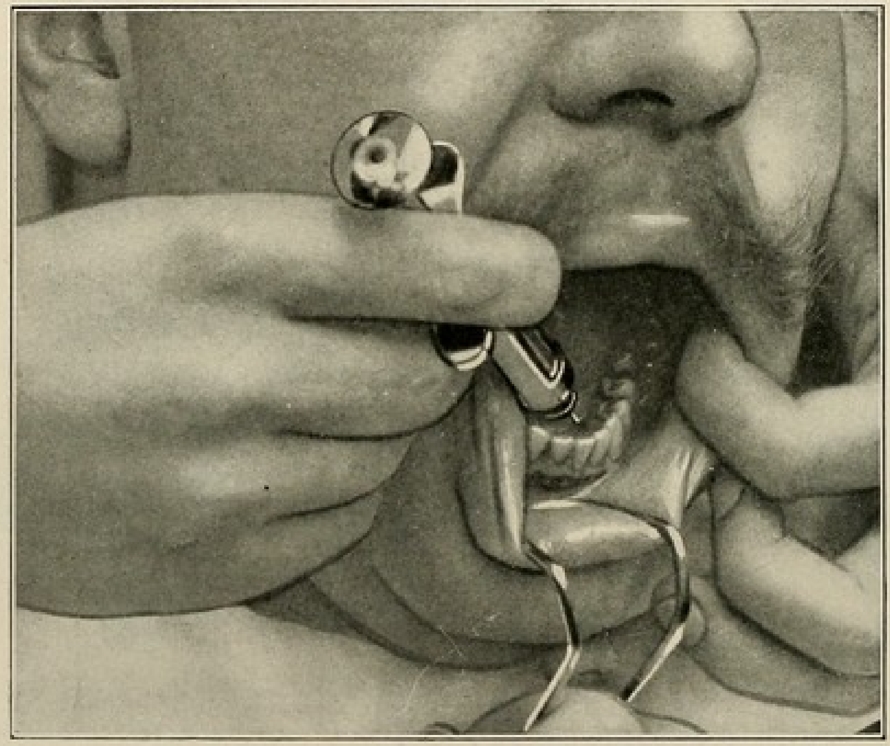
Lingual points of injection for mucous anesthesia of the mandible. Red crosses indicate the points of injection; red arrows, the direction of the needle; black-dotted lines, the angle of the ramus to the body of jaw.

Mandible.—In the mandible mucous anesthesia is limited to anesthetization of loose roots and teeth, and may sometimes render good service in the anterior teeth (see Fig. 88).

Injection in the Gingival Papillæ in the Mandible.—Mucous anesthesia of the lower anterior teeth must be clearly distinguished from anesthesia of the posterior teeth, including the first bicuspid. While in the latter teeth injection is always made in the region of the gingival papillæ, advancing the needle horizontally along the alveolar margin (see Figs. 88 and 89), which is the only place favorable for diffusion into the fundus of the alveoli (see Figs. 45, 48, and 88), anesthesia of the anterior teeth, including the canines, is obtained in the following manner:

Injection in the Mental Fossa.—The lip is depressed and the needle inserted in the reflection of the mucous membrane, which has been previously sterilized with tincture of iodin, at about the level of the root apex of the canine (see Figs. 91 and 92), and pushed forward

FIG. 94



Lingual injection between lower canine and bicuspid for anesthesia of lingual nerve fibers. Mucous anesthesia.

and downward with a slight inclination mesially, until the *mental fossa* is reached (see Figs. 16 to 22, 24 to 28, 91 and 92). This fossa is situated below the root apices of the canine and the lateral incisor, and usually has numerous foramina through which the injected solution penetrates into the interior of the jaw (see Figs. 16 to 29). While advancing the needle, a few drops of the solution are discharged; the bulk of solution (about 1 c.c.), however, is injected in the fossa itself, and invariably produces complete anesthesia of the canine and the two incisors on the injected side.

Lingual Injection.—Lingually a small quantity of solution is injected behind the central incisors and in the line of their long axis (see Fig. 93), also between the canine and the first bicuspid (see Fig. 94), in order to anesthetize the filaments of the lingual nerve (see Fig. 58) as well as to force the solution into the interior of the jaw through the foramina situated lingually at the internal genial tubercles (see Figs. 36 and 37). The needle is inserted below the tense gingival papilla of the central incisor, and is at once slowly advanced parallel to the alveolar process, while discharging some solution, to the vicinity of the root apex. An injection is also made between the canine and bicuspid (see Figs. 92 and 94), the needle being advanced directly to about the middle of the canine root, while slowly discharging some solution; in both cases about ¼ c.c. of solution is injected. While in the anterior lower teeth it is possible to inject locally, yet, if several teeth are to be anesthetized simultaneously, it is preferable to resort to conductive anesthesia, which insures full success even in periostitis, and is attained more rapidly and simply by blocking the entire mandibular nerve trunk, if necessary, on either side.

Anesthesia of Lower Molars.—In the lower molars conductive anesthesia alone is indicated.

Anesthesia in Inflammatory Conditions.—*Mucous Anesthesia in Inflammatory Swelling.*—In cases of gingival or alveolar abscess, conductive anesthesia should always be first attempted. If this, however, is unsuccessful or contra-indicated, anesthesia of the mucosa by means of the ether spray is the last and only resort.

Anesthesia by Ethyl Chlorid.—In the anterior teeth, both upper and lower, the old ether spray method can often be employed with great success. The diseased mucosa is carefully dried and disinfected with tincture of iodin; right and left of the field of operation the gingivæ are padded with cotton rolls in order to keep away the saliva as much as possible, the tongue is covered with a small mouth napkin, and the ethyl chlorid spray from an automatically closing flask is directed against the mucous membrane, from a distance of from 20 to 30 cm.

If perfectly dry, the mucosa is rapidly covered by a crust of ice and congealed. After about one minute the tooth can be extracted, and in most cases such operations are painless, or at least very tolerable.

In extracting putrescent deciduous teeth this method is particularly practical, since the ether inhaled by the child produces a light narcosis sufficient to render the operation painless. Ethyl chlorid is indispensable also in severe putrescent conditions, in incisions for gumboils, or in extraction of loose putrescent anterior teeth or roots. In such cases anesthesia by local injection would be detrimental rather than useful. The risk of infiltrating an abscessed or inflamed area is too great, as general sepsis might be induced with possibly fatal results.

FIG. 95

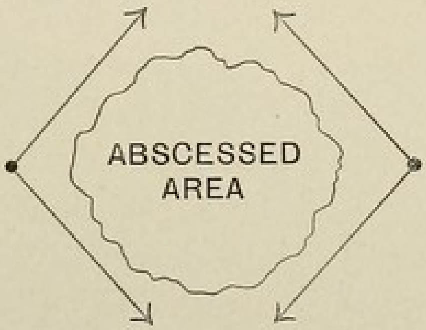


Diagram showing method of peripheral injections in abscessed areas.

If, nevertheless, mucous injection is preferred to the far more efficacious and safe conductive method, the injection must always be made in healthy mucous membrane in the vicinity of the focus of infection (see Figs. 72, 73 and 95). In such cases, however, several peripheral injections on each side of the abscess must be made, and the solution discharged immediately upon inserting the needle and without advancing it.

Injection in Swollen Areas.—Figure 73 illustrates the method of anesthetizing a putrescent upper lateral incisor when swelling is present. One injection is made above the central incisor in the direction of the root apex of this tooth, a second injection slightly above the gingival margin of the lateral incisor in distal direction, provided no abscessed tissue is met with. The third and final injection is made above the canine, the needle to be advanced in the direction of the canine fossa. In all these cases the needle is advanced directly to the periosteum, and the solution is injected slowly and under moderate pressure. As soon as the patient perceives a painful sensation of tension, the injection at that point must be immediately discontinued. Digital compression of the place of insertion of the needle is again of the greatest value.

Period of Waiting.—In all cases of mucous anesthesia, a waiting period of from eight to ten minutes must be allowed. The anesthesia lasts from twenty to sixty minutes.

Principles of Mucous Anesthesia.—Besides the cautionary measures enumerated before, such as asepsis, isotonia of the solution, etc., the following technically important factors must be observed to insure a successful mucous anesthesia:

1. Application of the stasis bandage in delicate and anemic patients, or those with heart disease.

2. Thorough sterilization of the mucosa with tincture of iodin (decolorized iodin or thymol-alcohol).

3. Infiltration of the gingiva.

4. One injection on each side of the jaw; the fewer needle-pricks the better the effect.

5. The orifice of the sterile needle (preferably of iridioplatinum) must always point toward the bone.

6. Slow, moderately strong pressure during the injection.

7. Compression of the point of injection with the finger tip after withdrawal of the needle.

8. A waiting period of from eight to ten minutes.

9. The patient should be kept under observation after the injection.

PERIDENTAL AND INTRA-OSSEOUS INJECTIONS.

Peridental Injection.—The methods of peridental and intra-osseous anesthesia are here mentioned merely for the sake of completeness;

for practice they are to be discountenanced, since they offer no advantage whatever, and are complicated and dangerous. Peridental anesthesia, which has been recommended by various writers, is best described by H. Prinz:[1]

"Teeth or roots standing singly, or teeth affected by pyorrhea or similar chronic peridental disturbances, are frequently quickly and satisfactorily anesthetized by injecting the fluid directly into the peridental membrane. This method is known as peridental anesthesia, and its technique is very simple. In single-rooted teeth a fine and short hypodermic needle is inserted under the free margin of the gum, or through the interdental papilla, into the peridental membrane between the tooth and the alveolar wall. Sometimes the needle may be forced through the thin alveolar bone so as to reach the peridental membrane directly. To gain access to this membrane, in teeth set closely together, separation is essential. It may be accomplished with an orange-wood stick or by any of the various mechanical separators. By so doing the body of the tooth is shifted to one side, thereby creating a slight space between it and the alveolar process. The injection is now made directly into the exposed peridental membrane. By reversing the separator, the tooth is shifted to the opposite side, and the injected liquid is forced toward the apex of the tooth. A second injection is now made in this freshly exposed portion of the peridental membrane. Two, sometimes three, injections are necessary. To force the liquid into the membrane usually requires a higher pressure than that which is necessary for injecting into the periosteum covering the alveolar process, but the quantity of the anesthetic liquid is less than that which is required for the former injection. Acute inflammatory conditions of the peridental membrane and its sequelæ prohibit the use of this method. Peridental anesthesia is the purest form of local anesthesia, since the seat of the nerve supply of the tooth is very quickly reached, and as a consequence the results obtained are in the majority of cases extremely satisfactory, provided that general conditions justify its application. The method is specially serviceable for the removal of pulps in all such cases where

[1] Dental Summary, March, 1912, p. 167.

contact anesthesia is not indicated, or for temporarily desensitizing a tooth for operative procedures."

This description of peridental injection contains, step by step, a condemnation of that method. It is evidently harmful and dangerous to inject any solution directly into an infected field, such as may surround teeth or single roots affected by pyorrhea or similar chronic peridental disturbances; for infectious material is invariably carried to deeper strata, especially under the great pressure required in this form of injection. This procedure cannot but produce severe after-pain, sloughing, necrosis, or constitutional septic symptoms (as described in Dr. Marshall's case on page 113), all of which misfortunes are then usually laid at the door of "the toxicity of the anesthetic." The procedure of separating the teeth in order to gain access for the insertion of the needle between the tooth and the alveolar process is dreaded by every patient, and the preliminary measures for preparing the field for injection involved in this method are almost as painful as the operation would be without the local anesthetic, while submucous and conductive injections as advocated in this book, if executed correctly, produce no pain whatever. The fact that a slightly smaller quantity of anesthetic solution is required is a negligible factor, considering the very small doses required in the methods advocated herein, which are so very far below the toxic limit. In healthy single teeth peridental injection is painful owing to the extremely tense nature of the membrane, which, moreover, it is an accepted rule not unnecessarily to injure, as such injury may prove fatal to the life of the tooth.

Intra-osseous Injection.—Intra-osseous injection, for the purpose of hastening the diffusion of the anesthetic solution, was suggested by Otté in 1896, and again, independently of him, by A. H. Parrott.[1] Various modifications of this method have been proposed, as, for instance, by B. H. Masselink.[2] The technique of this method is as follows, excluding minor details: "After the gum tissue is thoroughly cleansed with an antiseptic solution, it is anesthetized about the neck of the tooth in the usual manner. After waiting two or three minutes, an opening is made into the gum tissue and the bone on the buccal

[1] British Dental Journal, August 16, 1909. [2] Dental Cosmos, August, 1910, p. 868.

side with a round bur, a fine spear drill or a Gates-Glidden drill. The opening should be made more or less at a right angle, with the long axis of the tooth a little below the apical foramen in single-rooted teeth, or between the bifurcation in molars. The right-angle hand-piece is preferably employed for this purpose. The drill should be of the same diameter as the hypodermic needle. The gum fold is tightly stretched to avoid laceration for the rapidly revolving drill. As soon as the alveolar process is penetrated, a peculiar sensation conveyed to the guiding hand indicates that the alveolus proper is reached, and the sensation felt by the hand is about the same as that experienced when a bur enters into the pulp chamber. In this artificial canal the closely fitting short hypodermic needle with a blunt point is then inserted, and the injection is made in the ordinary way."[1]

From this description it is self-evident that the method of intra-osseous injection is complicated and risky. Inasmuch as a preliminary injection is required for the painless employment of the bur, this injection might as well be executed in such a manner as to render any adjuvant injection unnecessary. The uncertainty of the effect of the bur upon the tissues within the alveolus; the danger of lacerating the gingiva, or injuring nerves or bloodvessels; the probability of infection by way of the handpiece, that bugbear of sterilization; the not inconsiderable lesion produced by the bur, which is not justified by the result to be attained; the obscurity in regard to the actual topography of the root, if no radiograph is available, and the likelihood of a disturbed healing process—all these considerations characterize the intra-osseous method as one *in nuce*.

CONDUCTIVE ANESTHESIA.

When injected in the vicinity of a fair-sized nerve trunk, an anesthetic solution penetrates by way of the perineurium into the central nerve substance, inhibiting its function, and anesthetizing the entire peripheral area supplied by that nerve. Owing to this elimination of

[1] Prinz, Dental Summary, March, 1912, p. 169.

the conductivity of the nerve trunk, sensory irritations of its terminal filaments are no longer perceived in the central organ. "The sensory nerve tracts are extremely susceptible to anesthesia by perineurial injection, if their minute terminal branches are inundated with an anesthetic solution; conductive anesthesia, on the other hand, is more difficult, ensues more slowly, and requires a larger quantity and a higher concentration of anesthetic solution, the farther away from the terminal distribution of the nerves, *i. e.*, the nearer to the spinal column an injection is made." (Braun.)

This contention is fully borne out by practical experience with anesthesia of the jaws. The nerve terminals of the periosteum and the pericementum are anesthetized in the most direct and expedient way, often within five minutes, by mucous anesthesia. Anesthesia by injection at the maxillary tuberosity, which represents a modified form of conductive anesthesia, ensues with almost equal rapidity, *i. e.*, in ten minutes. Mandibular conductive anesthesia requires the longest period, viz., twenty minutes, because the large inferior dental nerve must be reached and permeated by the anesthetic.

For our purposes, the following methods of conductive anesthesia are the most practical: (1) In the maxilla, (*a*) injection at the maxillary tuberosity; (*b*) in some cases, infra-orbital injection. (2) In the mandible, injection at the mandibular or inferior dental foramen.

Topography of the Maxilla.—The anatomic details described below have been compiled with the coöperation of the Marburg Anatomic Institute. The illustrations are reproductions of original specimens made by Professor Gasser, who has made specially careful investigations of our field of operation. According to this expert in anatomic technique, the topography of the portions concerned in local anesthesia can be determined, in addition to visual examination and palpation in the living, in the following manner:

1. By sections through the region to be studied; if practical, by frozen sections;

2. By dissected specimens.

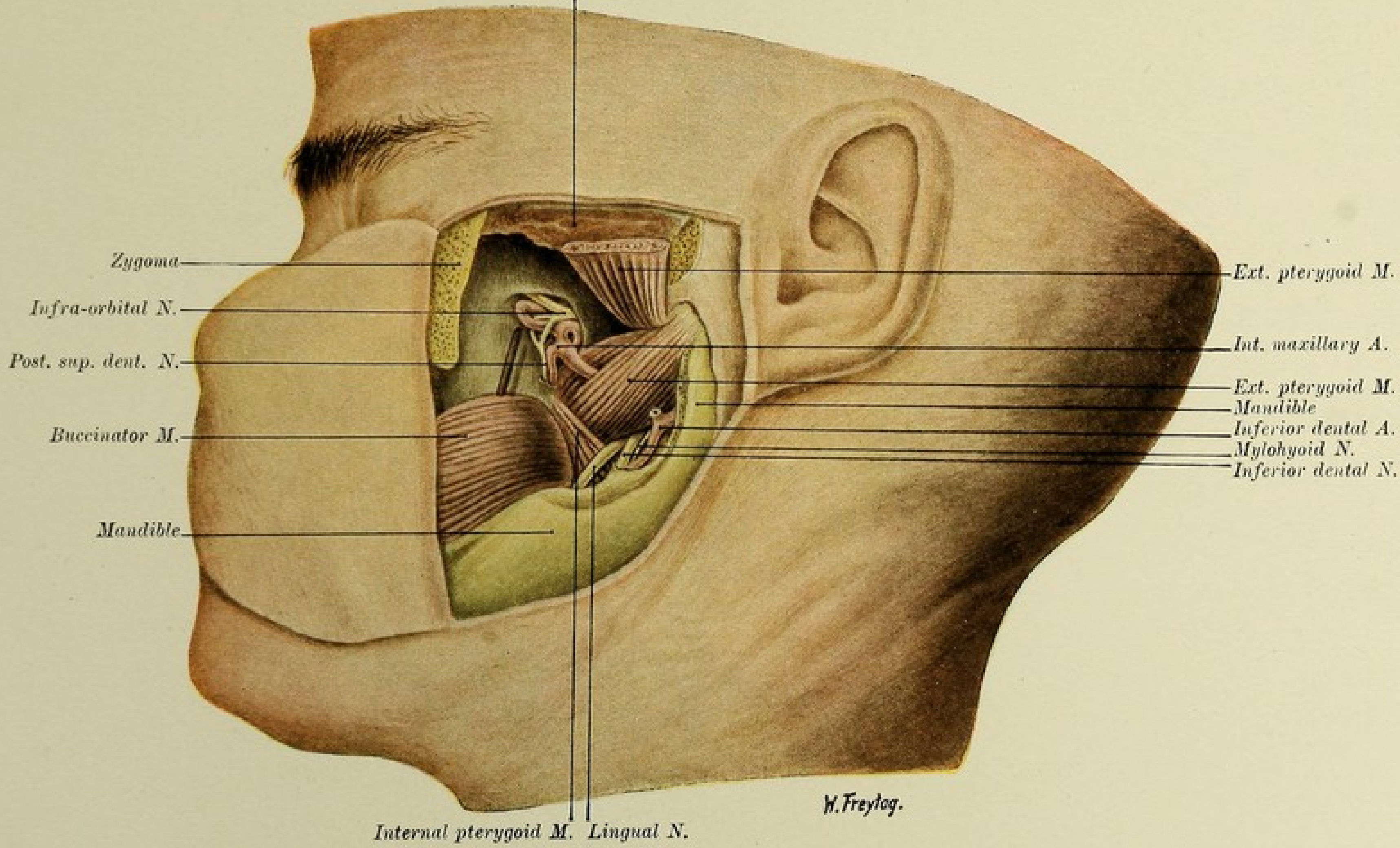
The former method affords a most accurate insight into the anatomic arrangement of the part, since nothing is dissected away; each section, however, shows only one level. The latter method offers the advantage of a comprehensive survey of the entire part. Both methods have been used.

Infra-orbital Nerve.—The topography of the *superior maxillary* or *infra-orbital nerve*, as it passes through the infra-orbital canal in the floor of the orbit, is shown in Fig. 96. In the specimen illustrated, the zygomatic arch together with the masseter muscle is removed, first exposing the mandible and the temporal muscle. The anterior portion of the ascending ramus and the head of the temporal muscle are removed next. In this way the pterygoid fissure with the *lingual* and *mandibular nerves* and the *inferior dental artery* are exposed. The upper portion of the external pterygoid muscle is reflected. The posterior portion of the buccinator muscle is shown with its characteristic curvature before it continues downward and backward. This curvature, which is in direct contact with the mucosa of the cheek, indicates the lateral and posterior border of the oral cavity. Above the buccinator muscle appears the *maxillary tuberosity*, above which the entrance to the *infra-orbital canal* is situated. Behind lies the pterygoid process and the pterygopalatine fossa, covered by the maxillary bone.

The arch of the *internal maxillary artery* disappears in the pterygoid-palatine fossa. The *infra-orbital* and the *posterior superior dental nerves* are visible. It should be remembered that the superior dental nerves are branches of the infra-orbital: the *posterior superior dental nerves* arise from the trunk of the nerve just as it is about to enter the infra-orbital canal, and pass downward on the maxillary tuberosity; the *middle* and *anterior superior dental nerves* are given off in the infra-orbital canal in the floor of the orbit and enter special canals in the anterior wall of the antrum.

Hence, at the spot illustrated in Fig. 96, we meet all superior dental nerves united in the trunk of the infra-orbital nerve. The road to this spot is extremely simple. In the posterior upper corner of the vestibule of the mouth, laterally of the upper molars, we palpate the inferior border of the maxillary tuberosity, above which, at a distance of from 2 to 2.5 cm., the desired point is reached, as illustrated by the needle shown in Fig. 96.

FIG. 96



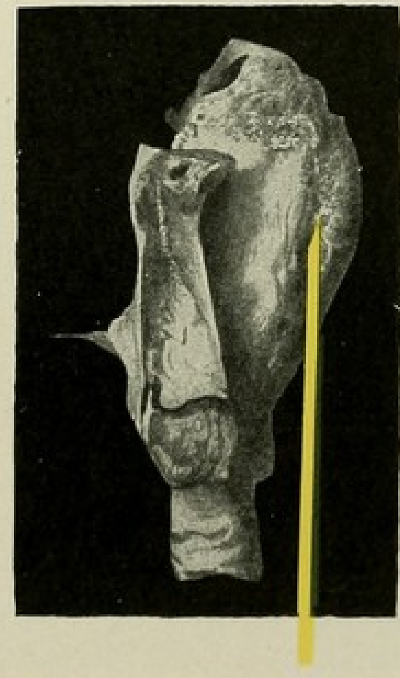
Topography of the maxillary tuberosity, with special consideration of the nerves and bloodvessels at the ascending ramus. (Gasser.)

The question now arises, What tissues are to be punctured, and what precautions are necessary?

After the needle has passed through the *mucosa* and the thin fibers of the *buccinator muscle*, it encounters only *loose connective tissue.* Fibers of the *external pterygoid muscle* at the margin of the infra-orbital fissure are avoided by keeping the needle in close touch with the bone. Some hesitancy may be entertained in regard to the *internal maxillary artery*. To avoid possible trouble, the rule is never to advance the needle more than from 2 to 2.5 cm. upward and backward from the mucosa.

In conductive anesthesia in the mandible and the superior dental nerves there is a possibility of injuring a bloodvessel and producing a hematoma. This danger is minimized, however, if an unnecessarily deep advancement of the needle is avoided; it is entirely eliminated if needles and hubs of suitable length are used.

FIG. 97

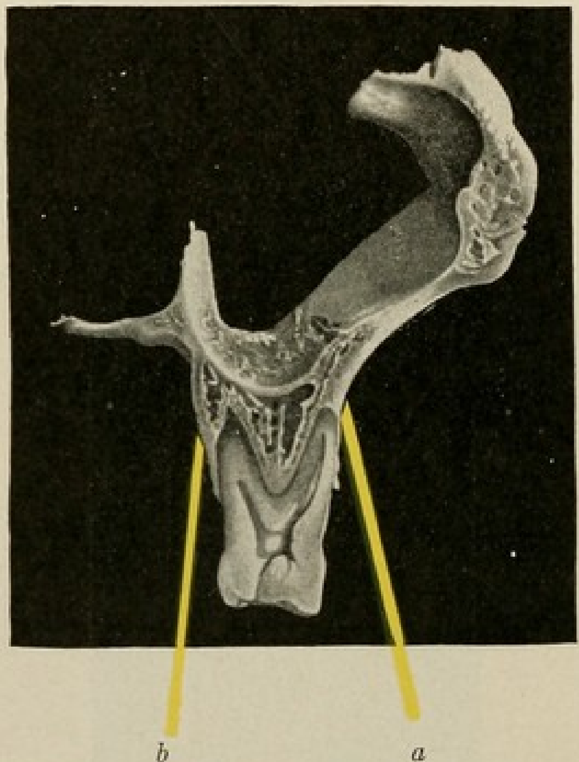


Position of the needle for injection at the maxillary tuberosity. Needle yellow.

Injection at the Maxillary Tuberosity.—*The Maxillary Tuberosity.*—Behind the zygomatic process and above the root apices of the upper molars, numerous foramina are found, through which stout nerve branches, the *posterior superior dental nerves*, enter the maxilla, after having run for a short distance with the main trunk, the *superior maxillary* or *infra-orbital nerve*, on the bony surface of the tuberosity (see Figs. 52, 55, and 56). These nerves supply the three molars with sensory filaments, and must therefore be blocked in order to obtain anesthesia of these teeth (see Fig. 62).

Technique of Injection.—The injection is made at the inferior portion of the maxillary tuberosity by infiltrating the thin anterior wall of the antrum and the nerve filaments passing through it to the molars in the following manner:

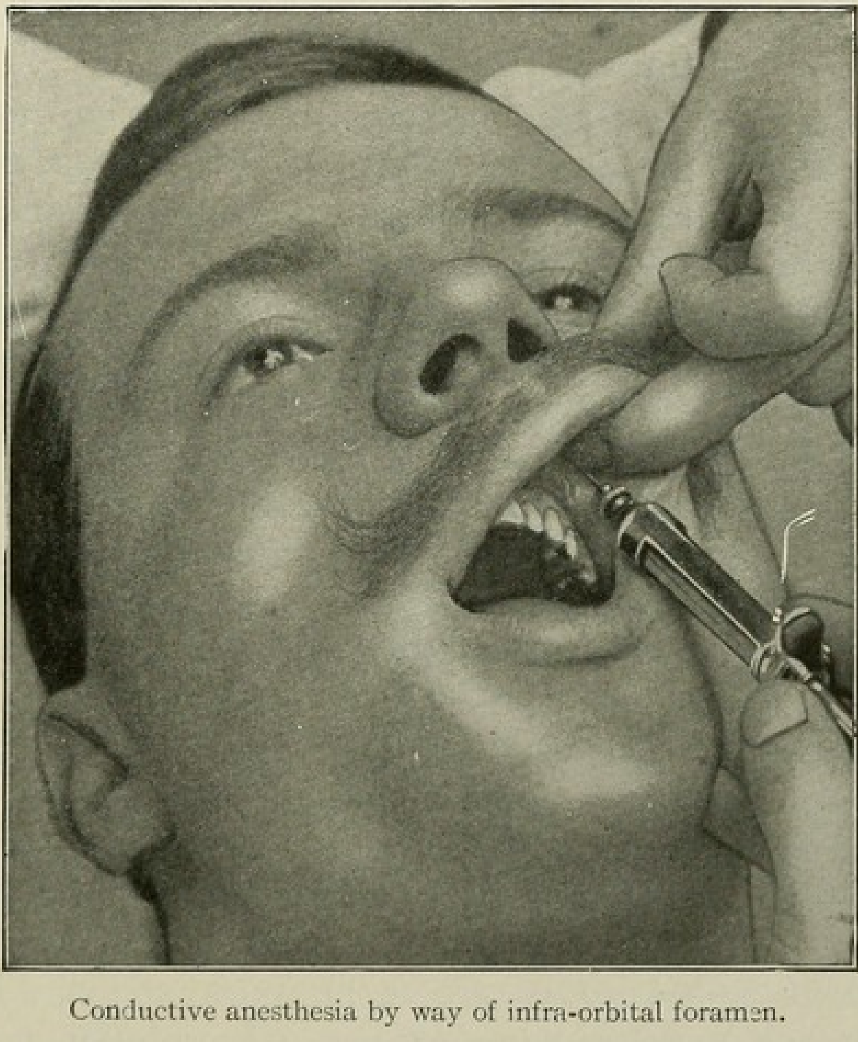
Fig. 98



Position of needle for injection in mucous anesthesia of upper first molar. Needle yellow. *a*, buccal injection, *b*, palatal injection.

In the half-open mouth the zygomatic process is palpated, its prominent border fixed with the index finger, the lip drawn upward, and the long needle No. 17 *c*, mounted upon the syringe with hub *B*, is introduced high up in the reflection of the mucous membrane at an acute angle to the bony surface and somewhat away from the bone (see Fig. 97). The needle is then advanced with a slight backward and upward inclination (see Fig. 78, red arrow No. 6), holding the syringe away from the maxilla, but keeping the needle as close as possible to the slightly convex tuberosity (see Fig. 97). As soon as the needle, which has a length of 42 mm., has been inserted in the mucosa, about 1 c.c. of the solution is gradually discharged while advancing the needle into the tissues to its full length. Mucous anesthesia buccally is unnecessary.

FIG. 99



Conductive anesthesia by way of infra-orbital foramen.

Palatally, an injection into the mucosa, as described on page 187, is made at the *posterior palatine foramen* (see Figs. 85 and 87). Within ten minutes, as a rule, complete anesthesia of the three upper molars ensues.

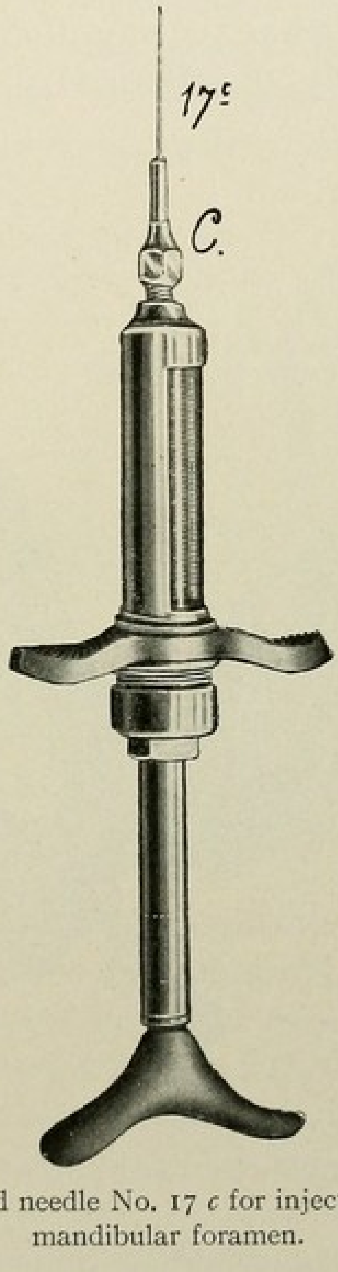
Infra-orbital Injection.—*The Infra-orbital Foramen.*—The anterior region of the maxilla is dominated by an easily reached nerve plexus, the *anterior superior dental nerves* (see Figs. 52, 56, 61, and 62). These are given off from the superior maxillary or infra-orbital nerve just before its exit from the infra-orbital foramen, and, entering a special canal in the anterior wall of the antrum, divide into a series of branches which supply the canine and incisor teeth (see Figs. 52 and 56). In acute periostitis or abscess, injection at the root apices of these teeth is contra-indicated, as it involves a risk of sepsis. In many cases injection in the canine fossa produces a satisfactory anesthesia; usually it is desirable to infiltrate both sides.

Technique of Infra-orbital Injection.—The inferior border of the orbit, below which the anterior orifice of the infra-orbital foramen is situated, is palpated, and the tissue overlying the foramen is compressed with the thumb of the left hand, at the same time drawing the lip upward and away from the gum with the third finger (see Fig. 99). The infra-orbital foramen is found 0.5 cm. below the lower border of the orbit, and almost exactly above the first bicuspid (see Figs. 52, 56, and 78). The needle is inserted in the reflection of the mucous membrane slightly posteriorly to the root apex of the canine, and close to the lip muscles, somewhat away from the maxilla, and advanced obliquely upward and slightly backward. As soon as the long needle No. 17 *c*, which is mounted with the hub *C* (see Fig. 100), is felt below the compressing finger tip, from 0.5 to 1 c.c. of the solution is injected. After the injection, massage is applied to good advantage.

This form of injection requires a certain amount of pressure to force the solution through the foramen, since not the nerve trunks which emerge therefrom but those situated more deeply, viz., the *anterior superior dental nerves*, are to be anesthetized. This method is not conductive anesthesia proper, since the solution is intended to exert its effect in the fundus of the canal.

This method is indicated only in cases of acute abscess and in major operations, such as resection, when injection in the infra-orbital foramina on either side is frequently called for. In simple cases, injection above the root apex of the canine (see Fig. 81) insures complete

FIG. 100

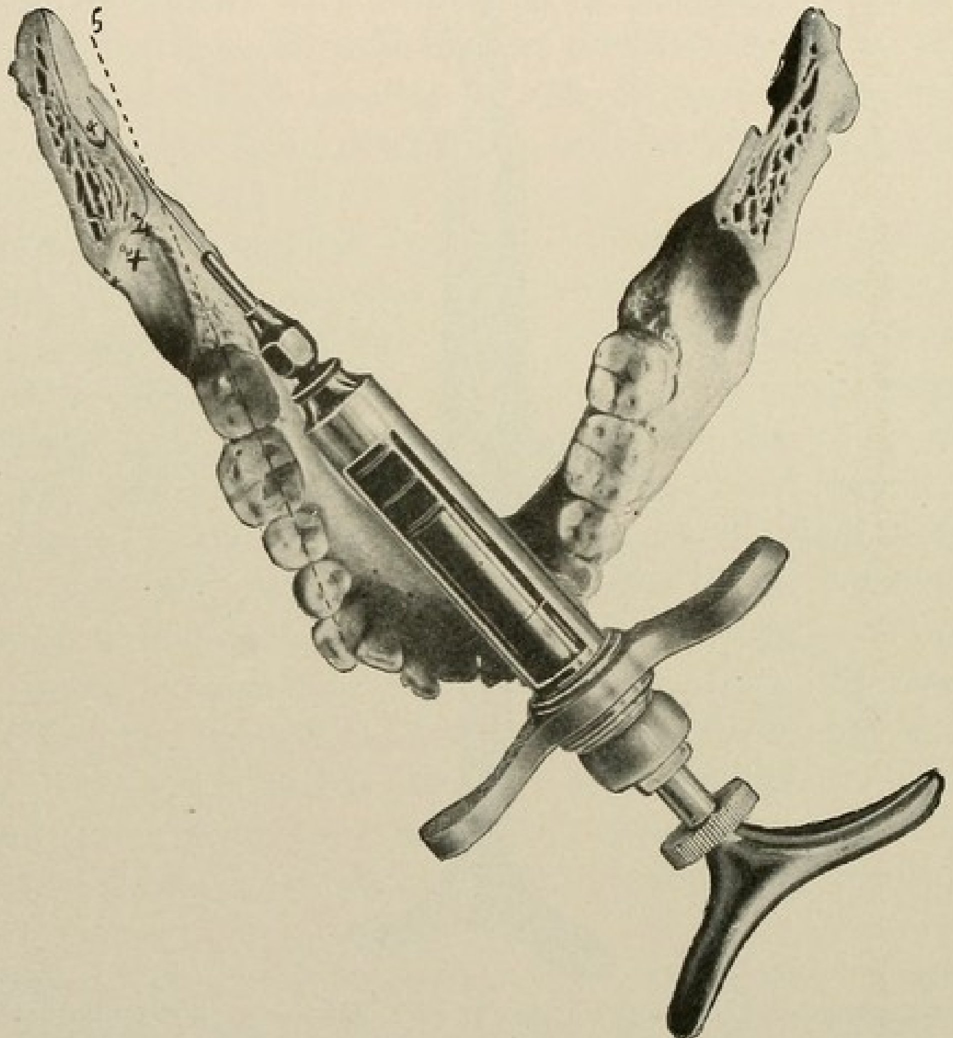


Syringe mounted with hub *C* and needle No. 17 *c* for injection at infra-orbital foramen and mandibular foramen.

success; this injection, moreover, is easier to execute, and invariably and promptly effective. The needle is inserted at the root apex of the canine, and then advanced high up into the canine fossa, where from 0.5 to 1 c.c. of solution is deposited.

Palatally again the injection is not made in the *incisive papilla*, where the insertion of the needle is extremely painful, but the short needle No. 17 *a* or *b* is introduced parallel to the long axis of the roots of the teeth to be anesthetized, and from 8 to 10 drops are discharged, as described in detail in the paragraph on mucous anesthesia (see Figs. 74, 83, and 85). Within ten minutes the anterior teeth on the injected side are completely anesthetized.

FIG. 101

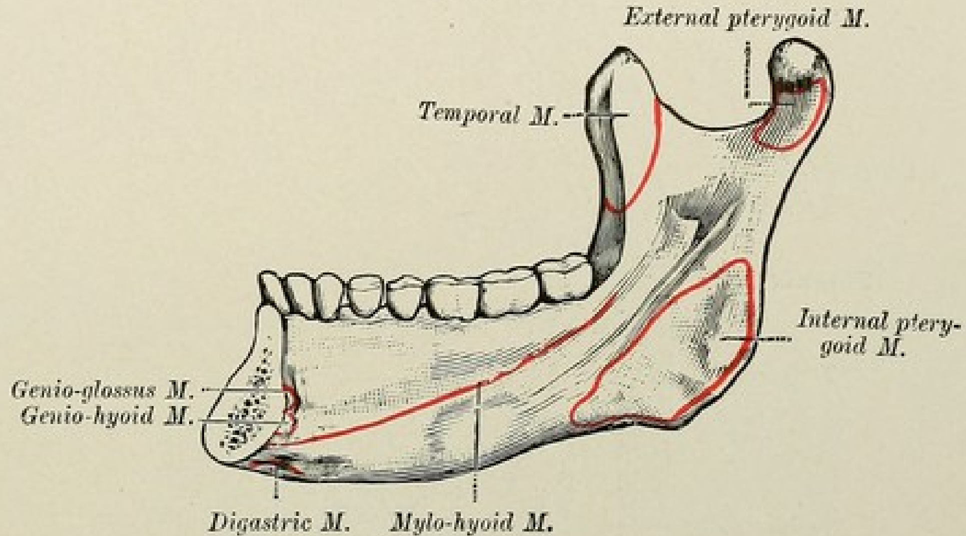


Position of the syringe for injection at mandibular foramen: 1*x*, external oblique line; 2*x*, retromolar fossa; 3*x*, internal oblique line; 4, mandibular foramen behind lingula; 5, incorrect position of the syringe, parallel to the teeth.

Injection at the Inferior Dental or Mandibular Foramen (Mandibular Injection).—*The Inferior Dental or Mandibular Foramen.*—

The inferior dental or mandibular foramen, situated in the internal surface of the ascending ramus, permits the passage of the inferior dental nerve, which, with the inferior dental artery, passes forward within the dental canal in the mandible as far as the mental foramen, where it divides into two terminal branches, incisor and mental. In the technique of injection at the mandibular foramen, certain important anatomic features must be duly considered, and for this reason a few topographic details will be briefly described.

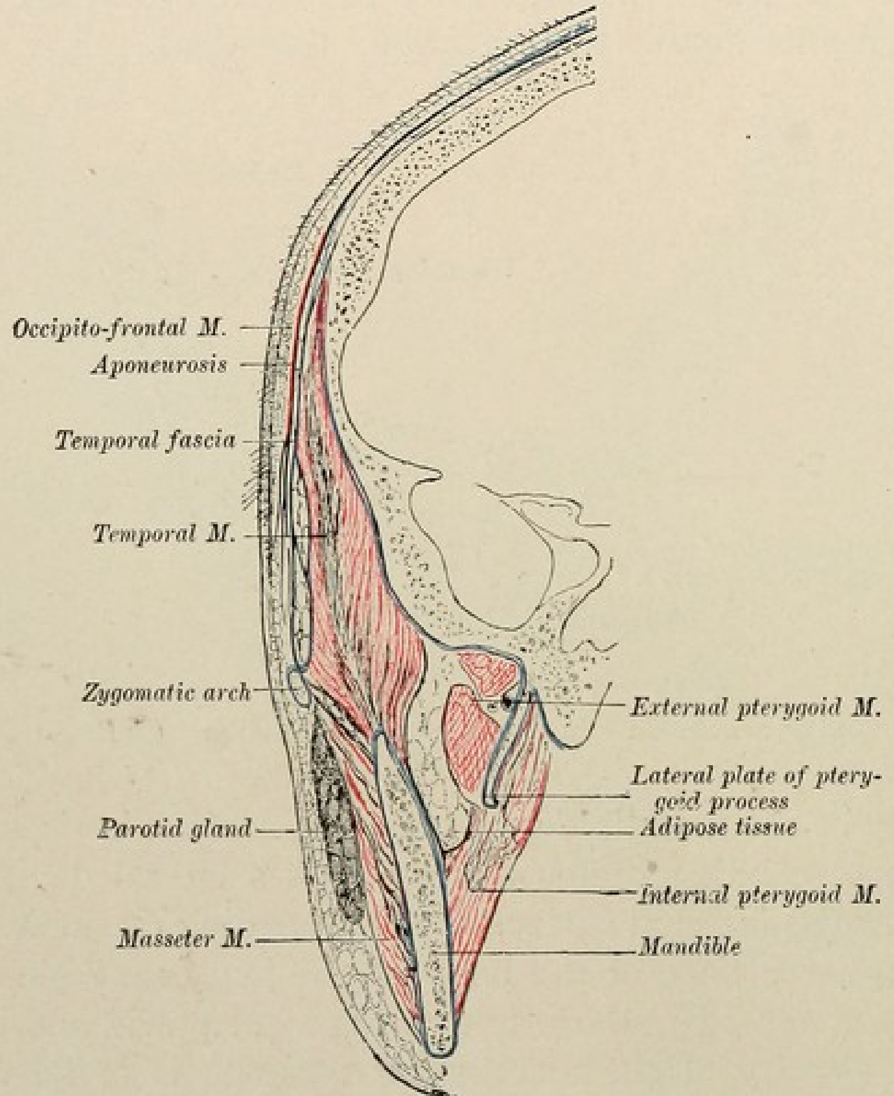
FIG. 102



Origins and insertions of muscles upon inner surface of the mandible. (From Rauber and Kopsch.)

The body of the mandible is not continuous in a horizontal straight line with the ascending ramus but presents a lateral deviation at the angle, so that the internal surface of the ascending ramus is not parallel with the lingual surface of the body of the jaw (see Figs. 40, 88, and 93). The rami spread posteriorly (see Figs. 42, 43, 88, and 101); therefore, if the vicinity of the mandibular foramen is to be reached, we must never advance posteriorly parallel with the dental arch (see Figs. 101 and 102), but parallel with the internal surface of the ramus, and at an acute angle to the dental arch (see Figs. 42 and 101). If the direction of the ascending ramus is projected anteriorly, the line of projection will intersect the opposite side of the mandible between the canine and bicuspid (see Figs. 42, 43, and 101). Hence, in order to reach the vicinity of the inferior dental foramen, the syringe must come to lie over the contact of the canine and bicuspid of the opposite side (see Figs. 42 and 101). This valuable landmark enables one to reach with accuracy the mandibular sulcus occupied by loose connective tissue, which has a great avidity for the anesthetic solution (see Fig. 103).

Fig. 103



Frontal section through temporal region. The black line indicates the aponeurosis, the blue line the periosteum and temporal fascia. (From Merkel.) At the mandibular foramen a mass of adipose tissue is observed which offers no resistance to the advance of the needle. (*Mandibular sulcus.*)

Topography of the Inferior Dental or Mandibular Nerve.—Starting with the conditions as they present themselves in the living, we shall first study the diagram in Fig. 104. The posterior limit of the dental arch is marked by the upper and lower right third molars. The lateral boundary of the isthmus of the fauces is indicated at *a* (anterior pillar of the fauces). Laterally we note, ascending from the lower third

FIG. 104

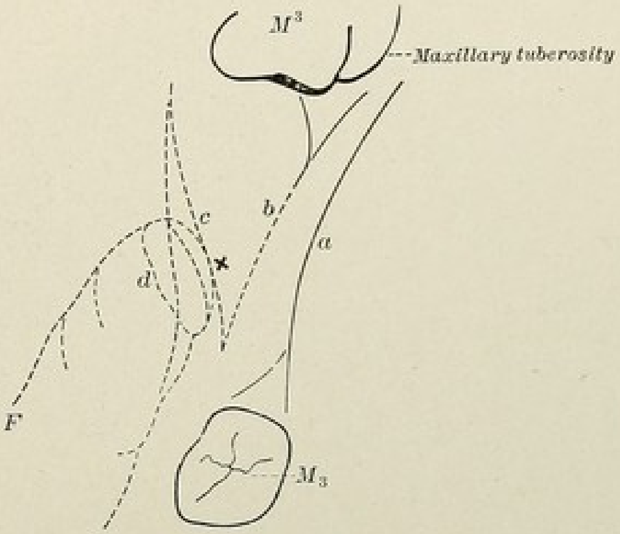
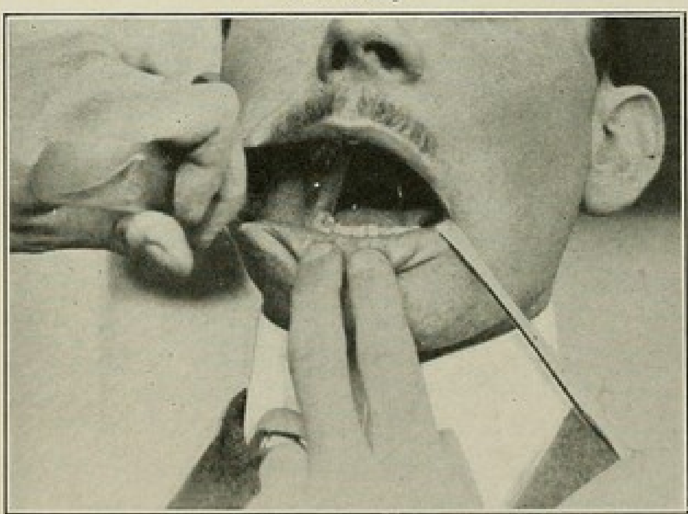


Diagram showing the mucous folds in the region of the retromolar triangle.

FIG. 105

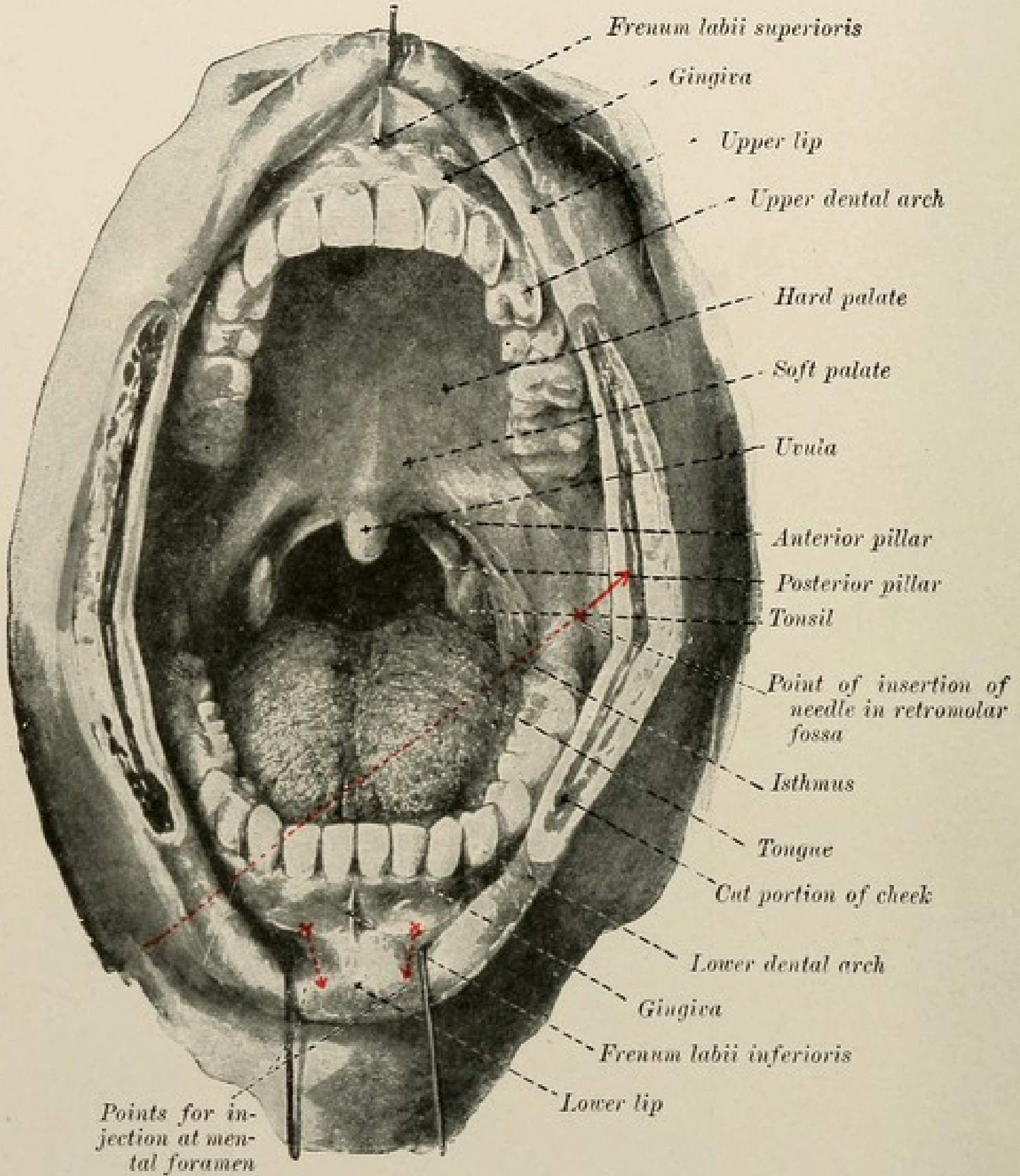


View into the oral cavity, with point of insertion of the needle for mandibular anesthesia (white spot). The point of insertion lies about 1 cm. above, and laterally of, the last molar.

molar, a well-defined mucous fold *b*, which may be fittingly called the *molar fold*. At *c x* the spot is marked where the needle is to be inserted for mandibular injection. *F* indicates the palpating finger, which is in contact with the needle-point and the ascending ramus.

Fig. 105 is a photograph of this region in the living. Across the dorsum of the tongue we look into the isthmus of the fauces, the

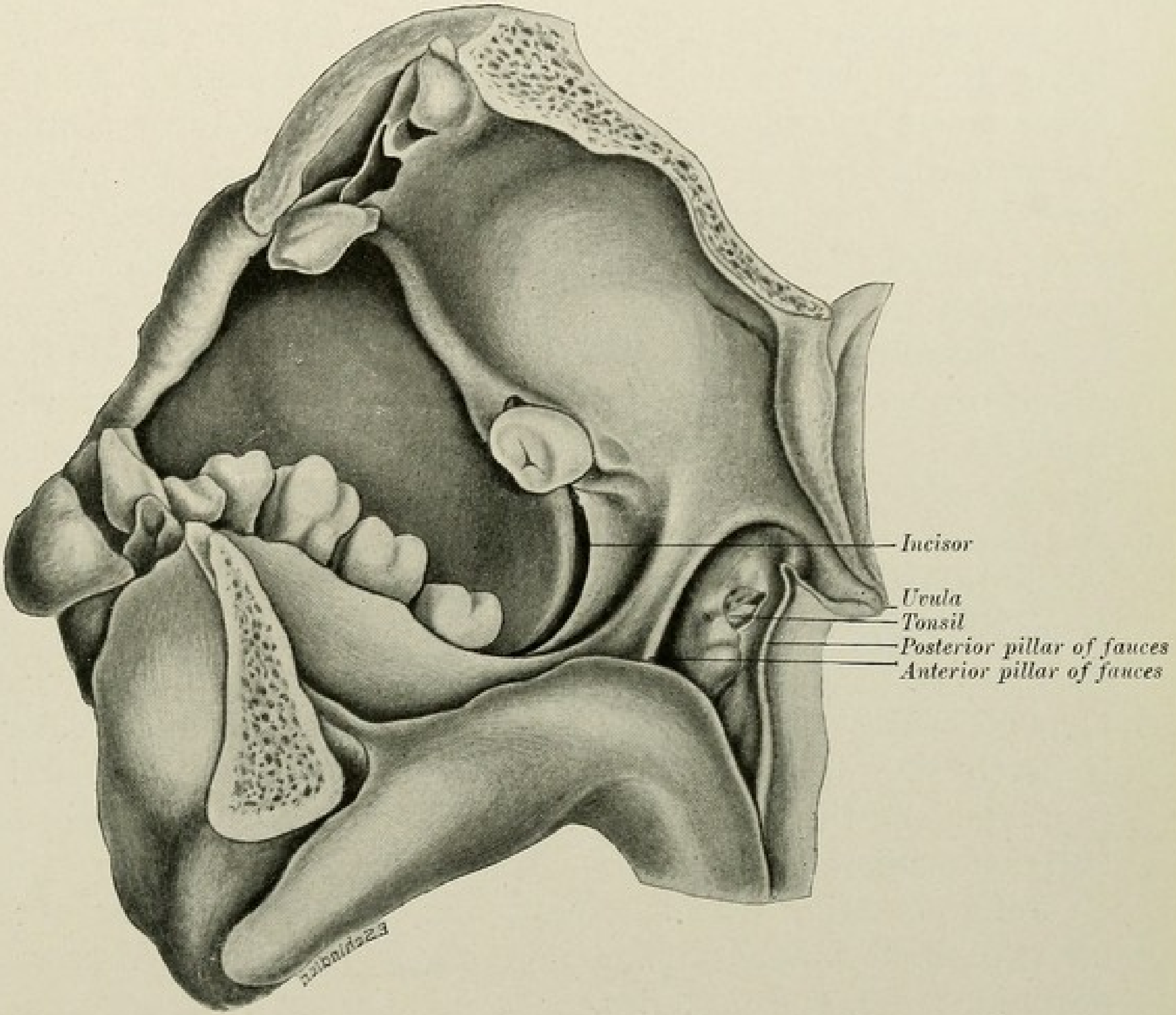
Fig. 106



Oral cavity cut widely open. The dotted red line indicates the correct position of the syringe for mandibular anesthesia. The red arrows at the anterior portion of the mandible indicate the points of insertion of the needle in the reflection of mucous membrane for injection at the mental foramen. (After Spalteholz.)

anterior and lateral boundary of which, viz., the anterior pillar of the fauces, appears as a small fold. Immediately laterally and slightly anteriorly, the broader and bulkier *molar fold* is plainly seen. At its anterior border a white point marks the place of insertion of the needle for mandibular anesthesia (see also Fig. 106).

Fig. 107



Section made close to the ascending ramus along which the needle is to be advanced. (Gasser.)

These landmarks are all that is to be recognized with the eye by way of orientation. The folds vary a great deal in appearance, least of them the anterior pillar of the fauces, so that, in obscure cases, this furnishes a valuable guide. A very important indication for finding the place of injection is furnished by the plainly palpable external ridge of the ascending ramus, which lies directly anteriorly of the place of injection. After this spot has been located correctly, the needle is simply advanced upon the posterior surface of the ascending ramus.

Fig. 107 shows an anatomic preparation.

The right side of the oral cavity is exposed by median section. The slightly distorted tongue is deflected downward. The picture is best studied by beginning from the tonsil which is situated between the anterior and posterior pillars of the fauces. In front of the latter the molar fold is very clearly seen extending from the last lower molar palatally toward the corresponding upper tooth. Anteriorly to this fold, a long incision is made through the place for the insertion of the needle as indicated in Fig. 105, exposing the structures illustrated in Fig. 108, which represents the same side in the same specimen. The parts surrounding the prepared area are indicated diagrammatically. The incision into the mucosa has been widely drawn apart, so that the way to the very spot where the injection is made is plainly seen. Together with the mucosa, the anterior fibers of the buccinator muscle, which in this locality is thin and therefore not noticeable, is cut through, affording a view into the anterior part of the space termed *pterygoid fissure* or *pterygomandibular space*.

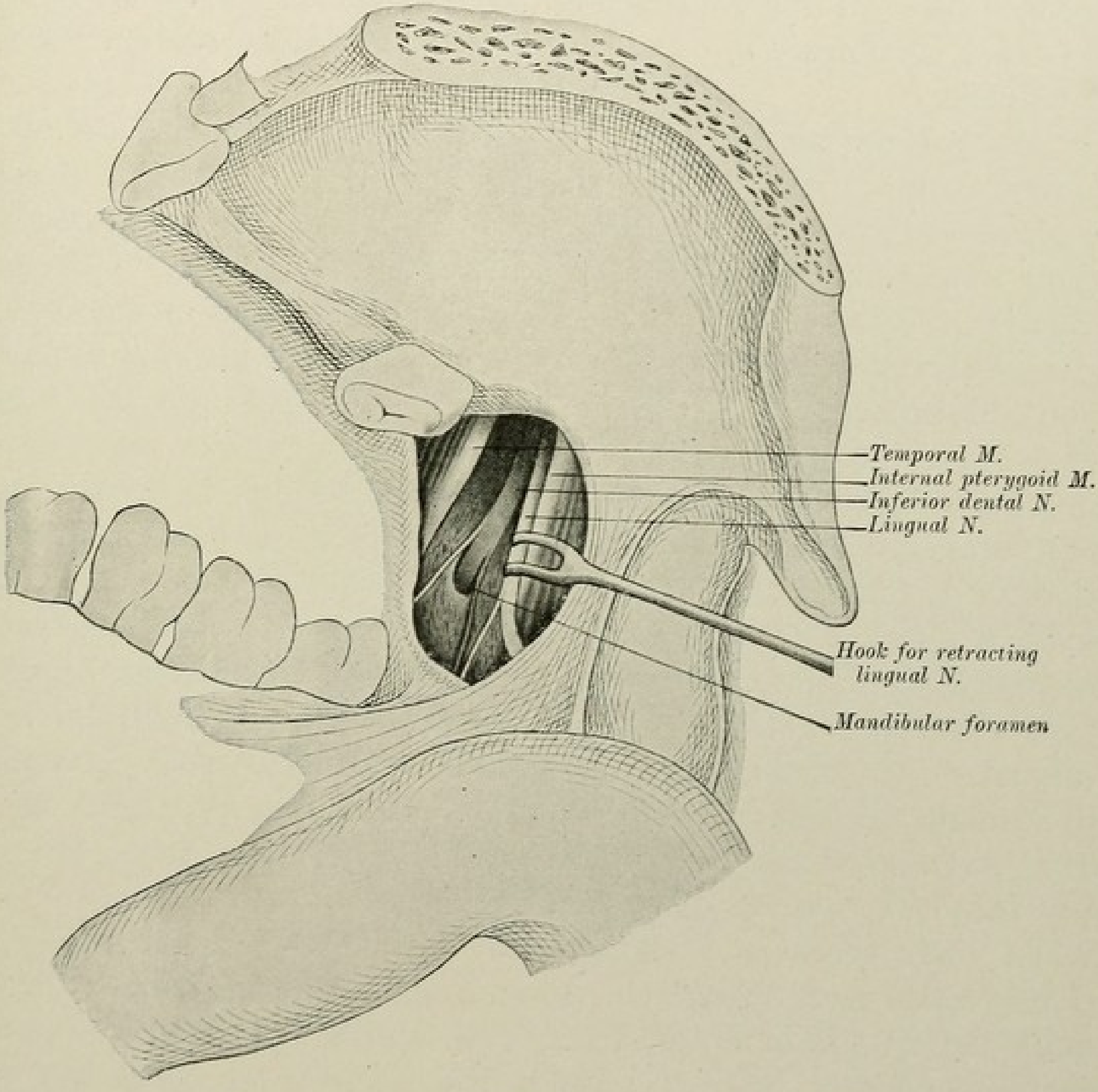
The inner surface of the mandible with the mandibular foramen, through which the mandibular nerve enters the mandibular canal, is clearly shown. In front we note the tendon of the temporal muscle running along the anterior border of the ascending ramus; in back the anterior portion of the internal pterygoid muscle.

Before entering the mandibular canal the mandibular nerve gives off two small branches: one anterior, supplying the mucosa at the posterior teeth, one posterior, or *mylohyoid nerve*.

The *lingual nerve* is seen slightly retracted; still, its situation in close proximity to the mandibular nerve is apparent. The details of the relative positions of these two nerves are seen in the subsequent illustrations. A small quantity of loose connective tissue, which posteriorly assumes a more adipose character, has been removed from the area under discussion.

Figs. 57 and 58, which appear on pages 164 and 165, give a general view of the course of the *mandibular* and *lingual nerves*. In the anterior view in Fig. 57 a portion of the ascending ramus is removed and the mandibular canal is laid open. Between the two pterygoid muscles which form the pterygoid fissure the lingual nerve runs forward to the floor of the mouth, the mandibular nerve downward into the body of the mandible; anteriorly the mandibular nerve is seen emerging from the mental foramen.

Fig. 108



View into the mandibular sulcus. (Gasser.)

Fig. 58 represents a postero-internal view; the tongue is deflected inward. By removing the internal pterygoid muscle the course of the mandibular nerve to the mandibular foramen is exposed. At the same time we note the *mylohyoid nerve;* the distribution in the tongue and floor of the mouth of the *lingual nerve* with its submaxillary ganglion; the hypoglossal nerve ascending from below; the submaxillary gland with its duct, and the sublingual gland.

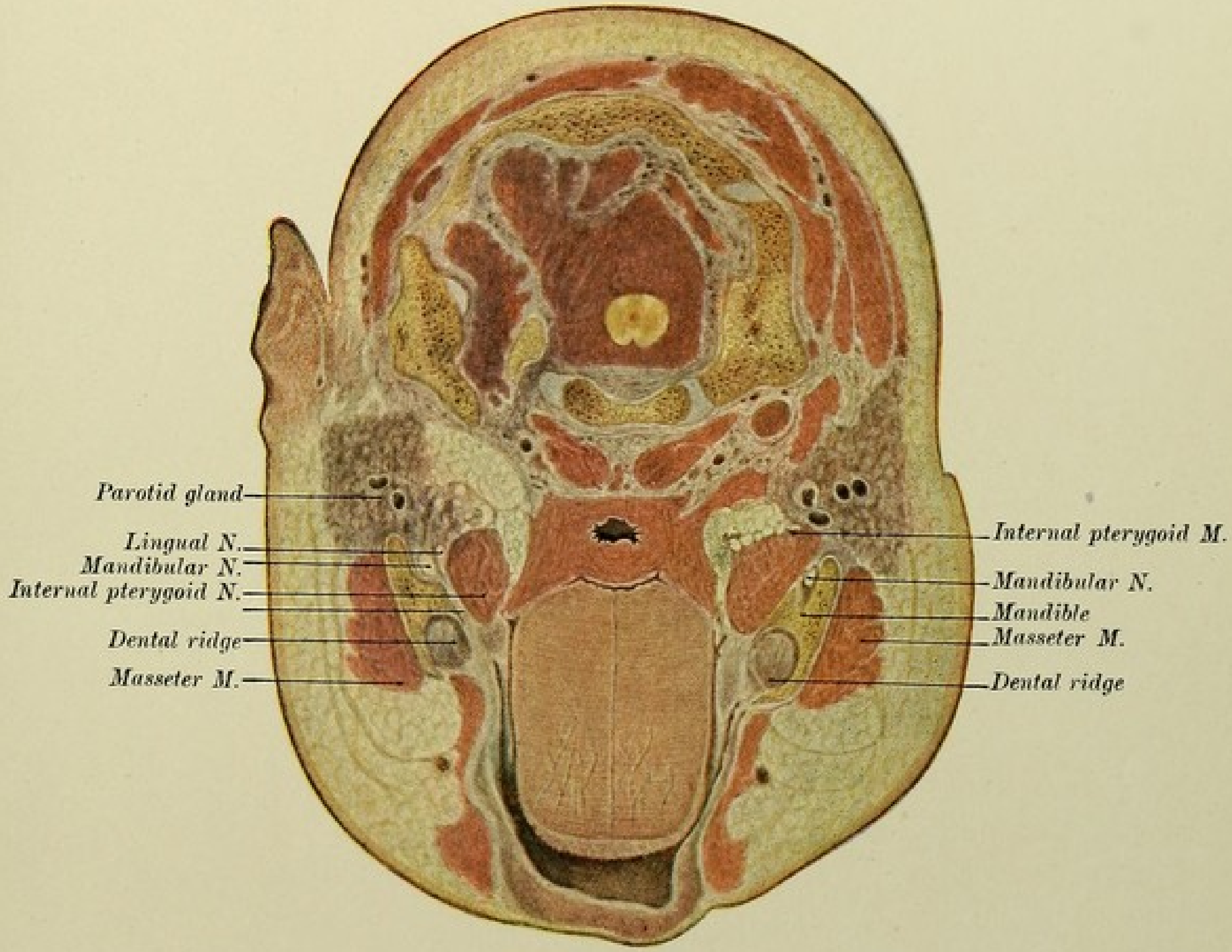
To insure an accurate topographic orientation, three sections through the mandibular region at the ascending ramus are reproduced (see Plates I and II, and Fig. 109). Plates I and II are vertical microscopic sections, Fig. 109 is a horizontal frozen section through infant heads.

In Plate I the section goes through the posterior portion of the ascending ramus, past the anterior border of the condyloid process. The bloodvessels have been injected to facilitate the comprehension of their arrangement; the nerves are marked in yellow. Of special interest is the space between the two pterygoid muscles on the internal surface of the mandible. In this space are seen the internal maxillary artery and branches thereof, the mandibular nerve and the lingual nerve. It is important to note that in the posterior part of the pterygomandibular space these parts are embedded in loose, partly adipose connective tissue, and that this space, which is so important in conductive anesthesia, broadens here considerably. This extension of interstitial tissue, as may be seen in Fig. 110, is situated between the two pterygoid muscles, and is the greater the more closely we approach the posterior border of the ascending ramus. The mandibular nerve (n. alveolar inf. in Plate I), presents a slight curvature anteriorly as it is about to enter the mandibular canal. The proximity of the *internal maxillary artery* cautions us not to advance the needle too deeply into this space.

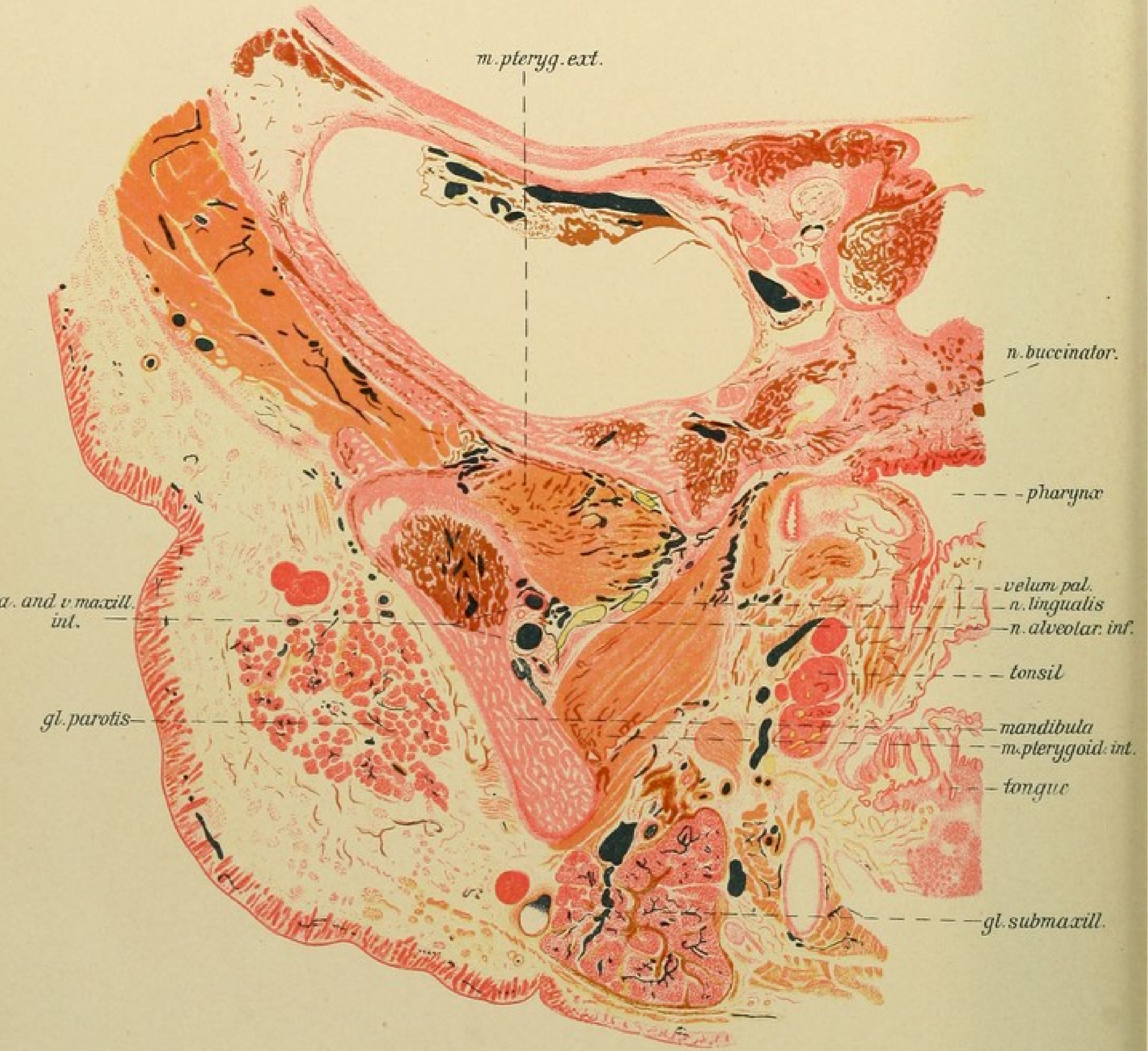
Most instructive is a comparison with Plate II, in which the section is made more anteriorly through the ascending ramus directly through the mandibular foramen. The lingula appears as a marked projection covering the entrance to the mandibular canal and protecting the mandibular nerve.

The pterygomandibular space here is considerably narrower, owing to the internal pterygoid muscle being in closer contact with the mandible. From the foregoing it appears that, in order to reach

FIG. 109

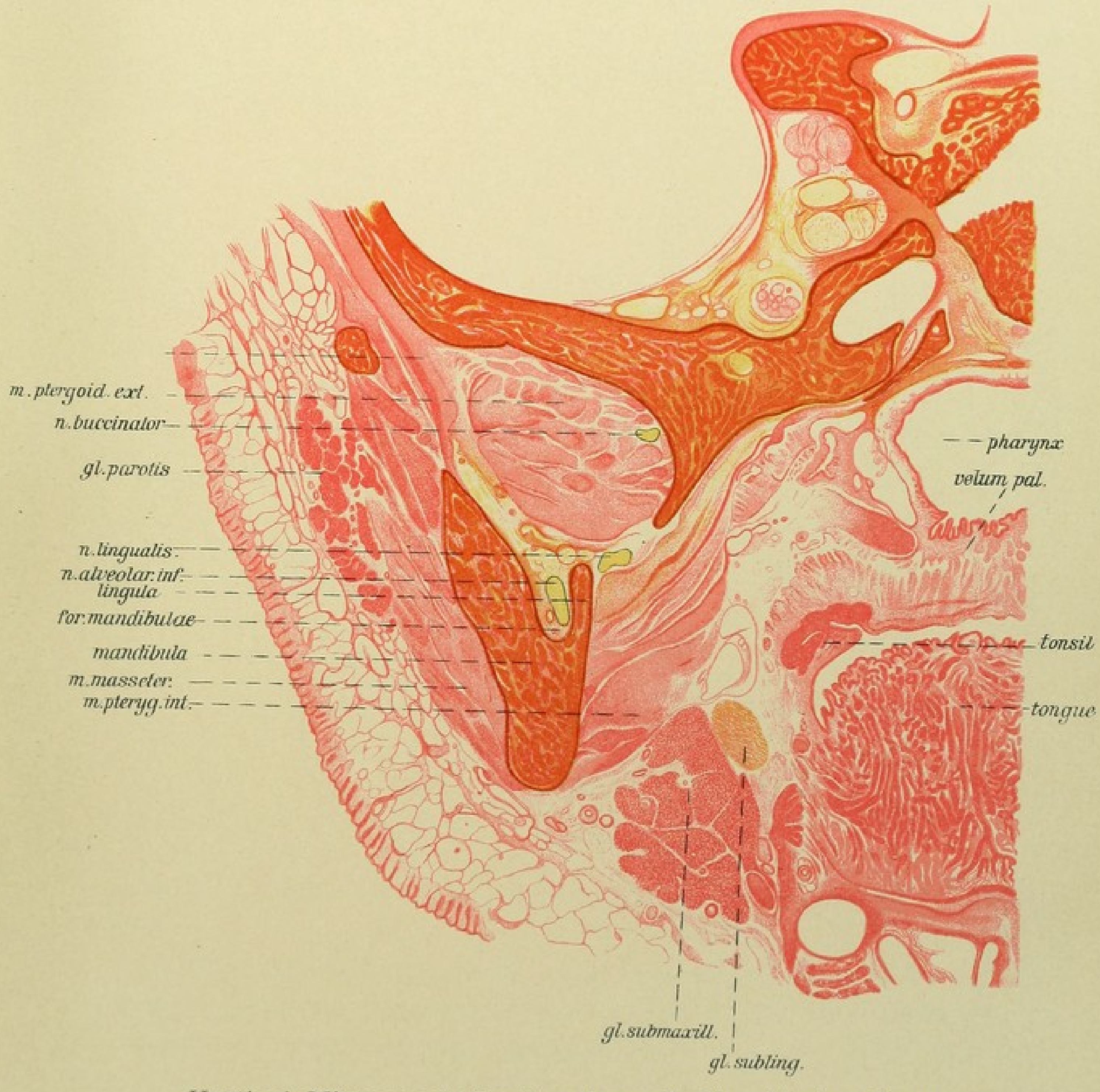


Horizontal frozen section through mandibular foramen in infant head. (Gasser.)



Vertical Microscopic Section through Posterior Portion of Ascending Ramus in Infant Head.

Paul Schindler Leipzig. gez. u. lith.

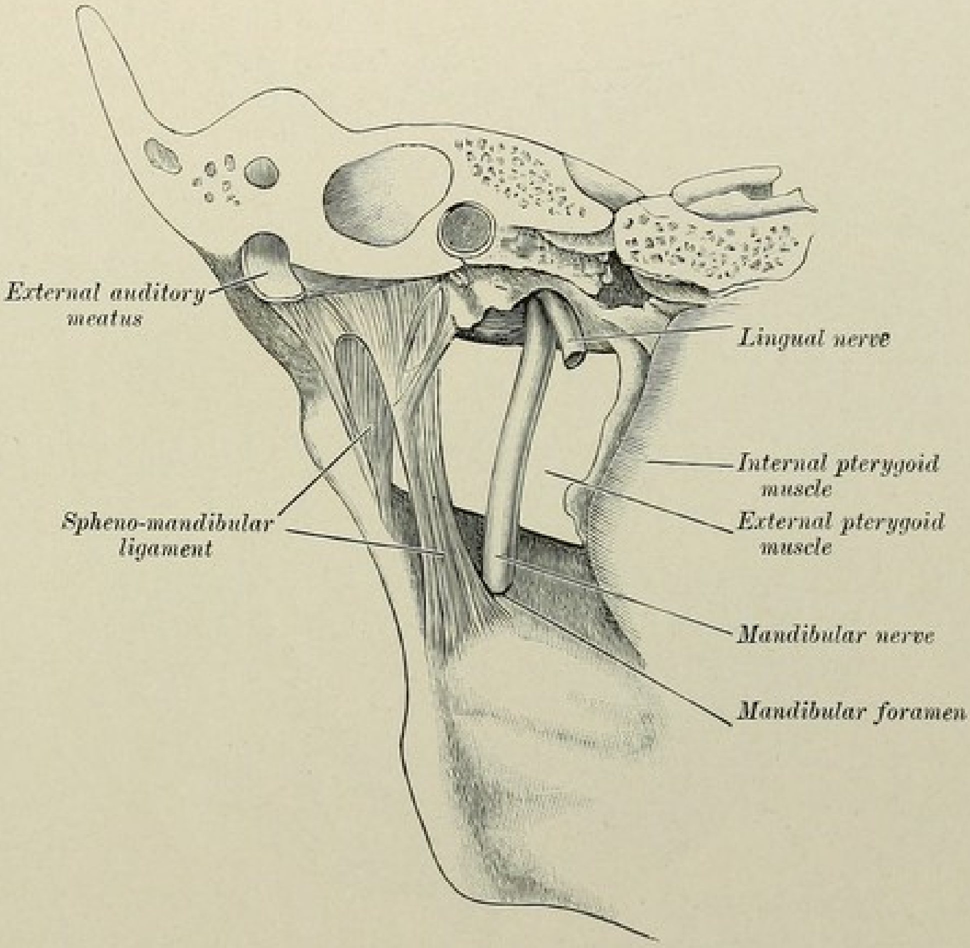


Vertical Microscopic Section through Mandibular Foramen in Infant Head.

KUNSTANSTALT H.F. JÜTTE, LEIPZIG.

the mandibular nerve, the needle must be kept in close contact with the bone, and that the conditions are more favorable about the middle of the ascending ramus than farther below (see Fig. 104). Furthermore, it is evident that the mandibular nerve cannot be reached in the mandibular foramen, because it is safely covered by the lingula, but before it reaches the foramen, viz., in the pterygomandibular space where infiltration is greatly favored by the loose connective tissue investing the nerve.

FIG. 110

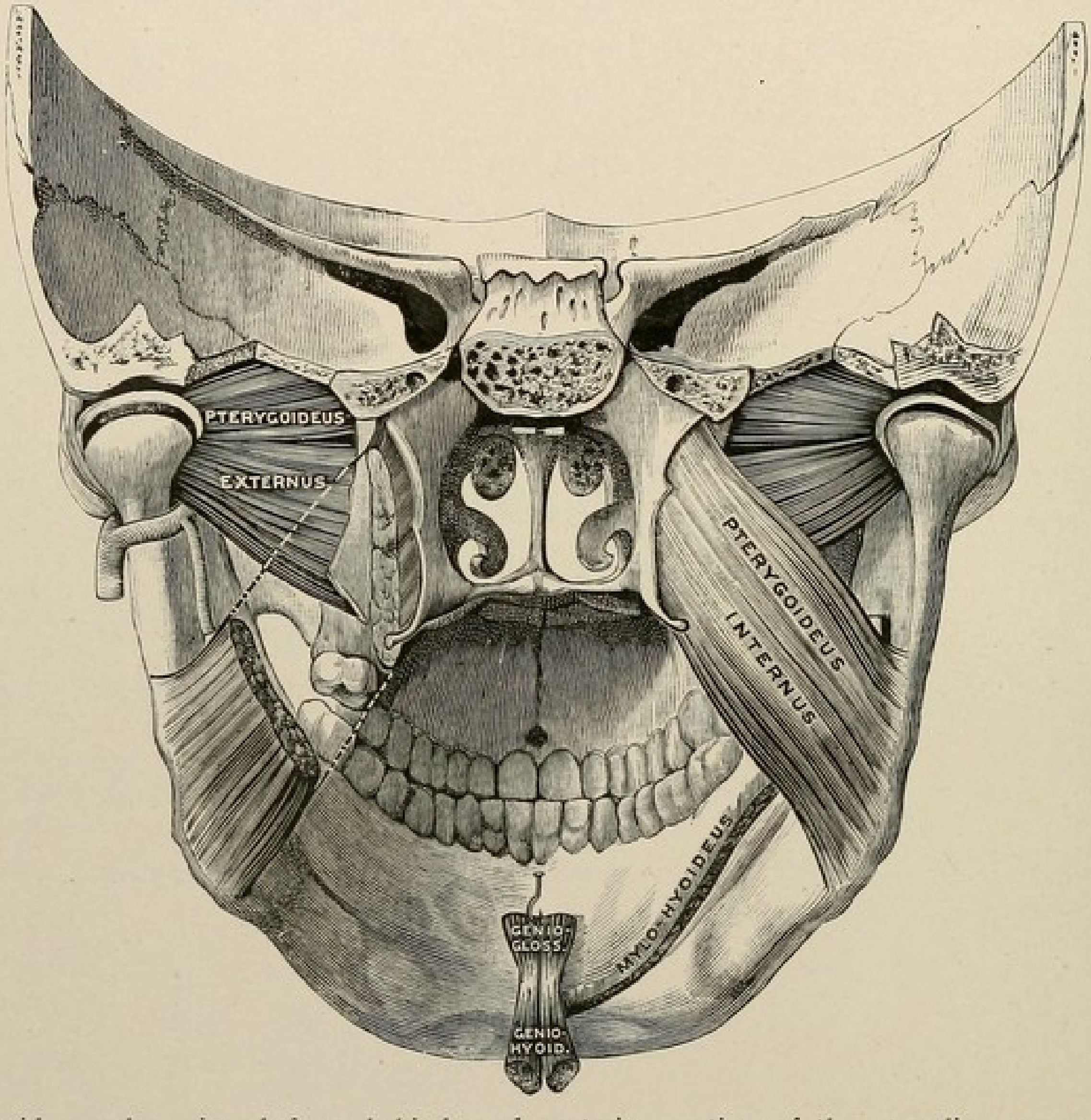


The sphenomandibular ligament is inserted at the lingula, which it covers completely. (Henle.)

In Fig. 110 the manner in which the lingula is covered by the pterygomandibular ligament is beautifully shown. This ligament is of great advantage for the management of the needle in injecting, because it effectually protects the muscles.

In order to determine the local relationships of the parts, it is most desirable to compare two sections made perpendicularly to one another, as one section merely shows the arrangement of the parts in one plane. For this reason, Fig. 109 has been inserted, which

FIG. 111



Pterygoid muscles, viewed from behind, and posterior portion of the ascending ramus. The mandibular sulcus is open posteriorly and filled with loose connective tissue. (After Testut.)

is a horizontal section through the same region. The section is made through the commissures of the lips anteroposteriorly in a slightly ascending plane, so as to go through about the middle of the ascending ramus. By a fortunate chance, the section passed through the mandible at slightly different levels, on the left side somewhat deeper and directly through the orifice of the mandibular foramen, on the right side a little above that orifice.

The parts are recognized by the position of the tongue, with the intersected soft palate and the lumen of the pharynx. On each side we note the mandible with the two projections at the anterior border of the ascending ramus, the point of insertion of the temporal muscle and the buccinator crest; on the outer side the masseter muscle; on the inner the internal pterygoid muscle; back of the mandible the parotid gland.

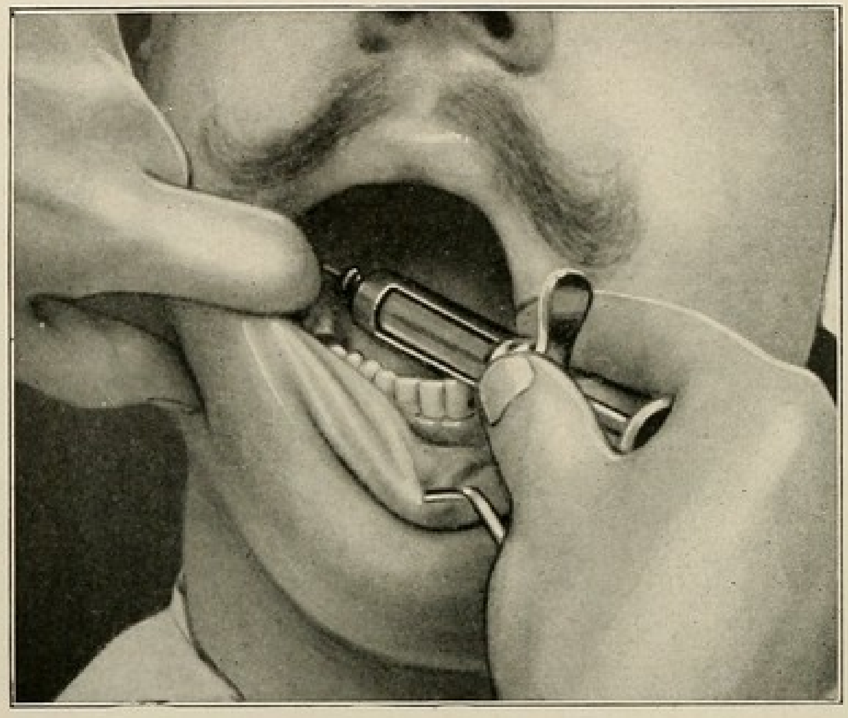
By comparing the two sides it is again seen that in the anterior portion of the mandible (left side of Fig. 109), the passage of the needle is narrowed by the closeness of the internal pterygoid muscle to the bone, while a little farther posteriorly and above (right side of Fig. 109) the road is free, because the muscle lies farther away from the bone, leaving a broad space occupied by adipose connective tissue in which the mandibular nerve is embedded before its entrance into the mandibular foramen; this space is the correct place for infiltration.

In addition, Plates I and II and Fig. 109 give a clear idea of the local relationship of the lingual nerve to the mandibular nerve in the pterygomandibular space. The lingual nerve runs a little more mesially, viz., at a greater distance from the bone, still closely enough to render it highly probable that both nerves are reached by infiltration, though the mandibular nerve will be affected more directly.

Technique of Injection for Mandibular Anesthesia.—In the technique of mandibular anesthesia the following preliminary observations are important:

In the widely opened mouth the mucous folds which, as we have seen, are of such vital importance for a successful injection, are not recognized at first glance. In front of the tonsil we note a well-defined fold, the anterior pillar of the fauces descending from the soft palate. Mesially and anteriorly another fold is seen running in the direction of the dental arch. Starting on the inner lingual side the *internal oblique line*, then the *external oblique line*, are palpated and the tip of the finger is firmly fixed in the bony groove between these two lines, whereupon a groove or depression in the mucous membrane becomes visible. This corresponds to the underlying trigonum retromolare or *retromolar triangle*, so termed by Braun. Converging with the fold *c*, the fold *b* runs downward; it is between *b* and *c*, yet more closely to *c*, that the needle must be inserted for mandibular anesthesia (see Fig. 104).

FIG. 112



Position of syringe for injection in mandibular foramen and palpation of retromolar triangle. The syringe is held like a penholder.

The patient is requested to hold the head straight and to open the mouth wide, and with the index finger of the left or free hand the anterior border of the base of the ascending ramus is palpated. Two very marked bony ridges are felt here, one anterior external, the *external oblique line*, and one posterior internal, the *internal oblique line* (see Figs. 39, 40, 101 and 104). Between these two lines, at the base of the ascending ramus, a shallow bony groove is situated, which Braun has fittingly called the *retromolar fossa*, into which the palpating finger tip sinks slightly (see Figs. 40 and 104). Over this bony fossa the mucous membrane is depressed so as to form a sort of triangle, the *retromolar triangle*, so called. The internal oblique line is fixed with the finger nail, and the needle inserted close to the nail into the mucosa near to, yet not immediately at, the border of the bone (see Figs. 42 and 101). The needle is then advanced horizontally and posteriorly along the inner surface of the ascending ramus on the side to be anesthetized, while the syringe barrel rests on the contact between the canine and first bicuspid of the opposite side (see Figs. 42, 43, 101, 112), until the needle has disappeared (see Fig. 43). The needle should be introduced into the tissue to a depth of not more than from 1.5 to 2 cm. (see Figs. 43 and 101), lest it advance too far beyond the foramen, and miss the correct point for the deposition of the solution. It is best to mount the syringe with the hub *C* and the needle No. 17 *c* (see Fig. 100), so that from 3 to 5 mm. of the needle remain visible outside of the mucosa (see Figs. 43 and 101); failure to reach the correct point for injection is then hardly to be feared.

The internal oblique line, which is important in this connection, varies greatly in different individuals, and is sometimes so strongly developed that it causes difficulties in the introduction of the needle. In such cases the needle is inserted a little more lingually, the syringe barrel being rested on the contact between the first and second bicuspids or even farther back, until one succeeds in passing this bony ridge and reaching the inner surface of the ascending ramus. As the needle advances, some solution is slowly discharged, and when the depth is reached, the syringe is gently moved back and forth so as to distribute the solution evenly.

Insertion of the Needle.—The point of insertion of the needle is selected so that the needle enters the mucous triangle about 1 cm. above the level of the masticating surfaces of the molars (see Figs. 101, 104, and 105); in children and young persons the needle is inserted a little farther posteriorly and slightly lower; in old persons higher up (see Fig. 41). If the injection has been executed correctly, mucous anesthesia at the buccal gingival margin is superfluous.

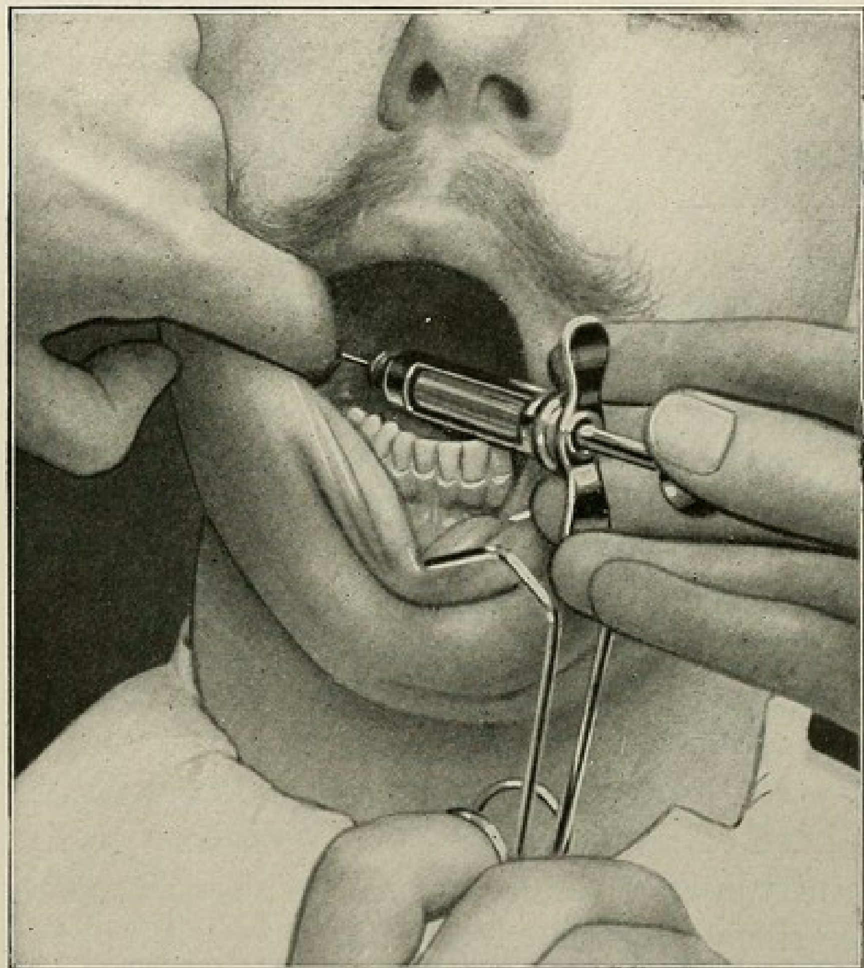
Difficulties.—The technique of this form of injection offers some difficulties which, however, with some practice are easily overcome. If the correct level for the insertion of the needle, viz., about 1 cm.

above the masticating surface of the last molars, has been found, then the mandibular sulcus is reached just above the lingula (see Figs. 43 and 101). The distance from the anterior margin of the internal oblique line to the posterior border of the lingula is about 15 mm., the length of that portion of the needle which protrudes from the hub *C* is 25 mm. (see Figs. 43 and 101); the needle, therefore, has the correct length for passing through the mucous layer (which is not seen in the illustrations of skulls) and for reaching about from 5 to 8 mm. beyond the lingula (see Figs. 43 and 101). Williger has correctly emphasized that during the injection it is best to rest the syringe barrel on the first bicuspid or between the canine and first bicuspid of the opposite side, thus securing a certain support for the syringe and a guide for the correct level for the insertion of the needle (see Figs. 42, 43, 101, 110, 112).

Management of the Needle.—The needle is first inserted to the bone without puncturing the periosteum. A certain touch is soon acquired as to whether the needle is being advanced in the correct direction, not pharyngeally, but closely enough to the bone. If, in case of a very sharp angle of the bone, the periosteum is felt to offer resistance, no matter how slight, the needle should not be advanced any farther, and under no condition by force, else the needle bores into the periosteum or the bone and, if of steel, will surely break; if of iridioplatinum, will bend. It is best to withdraw the needle carefully for a short distance, and, after slightly altering its direction pharyngeally, to make a new attempt at advancing.

Injection of the Solution.—The solution should be discharged slowly and carefully, beginning immediately after insertion of the needle, in order to anesthetize simultaneously the *lingual nerve,* which descends in front of the mandibular nerve (see Figs. 57 and 58). The bulk of the solution, however, is deposited in the pterygomandibular space. The adipose and loose connective tissues occupying this space readily absorb the solution without any pain to the patient. Infiltration of the muscles in this region is out of the question, as has been shown before; nor is there any danger of puncturing the artery, which possesses thick walls, is protected by the lingula, and has sufficient space to evade the loose surrounding tissues or the fundus of the inferior dental canal (see Fig. 114). The corresponding vein is arranged around the artery in the form of an intricate plexus, and is equally well protected. Moreover, it is extremely difficult to puncture an arterial wall, even to cut it with a sharp knife, as, owing to its elasticity, it always has the tendency to escape.

Fig. 113

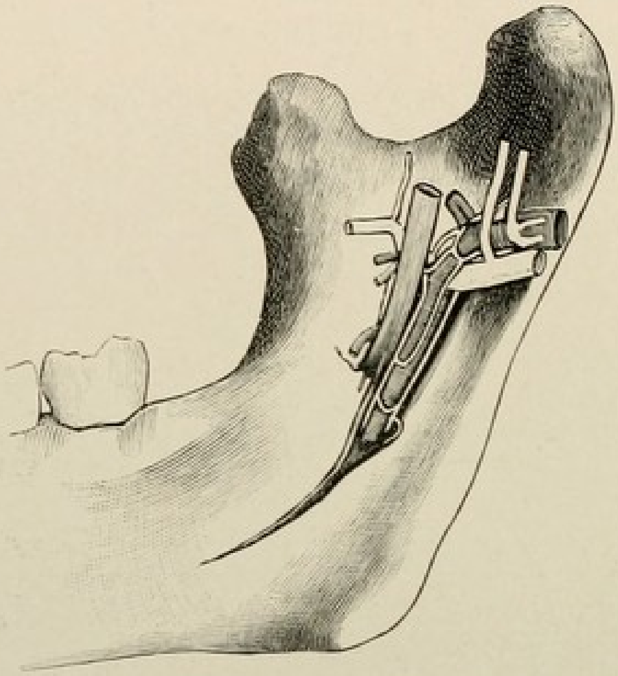


Position of the syringe during injection at the mandibular foramen. The finger of the left hand rests in the retromolar triangle.

Usually 2 c.c. of a 1.5 per cent. novocain-suprarenin solution are injected; twice that quantity, however, may be used with impunity.

The injection in the left ramus offers somewhat greater difficulties. While on the right side the retromolar triangle is palpated with the left hand, and the injection is made with the right, it is advisable to use the left hand for injection on the left side, according to Peckert's suggestion, and to palpate and fix the retromolar triangle with the right. Practice will soon determine for every operator the technically best method of executing the injection.

FIG. 114



Nerves and bloodvessels at the mandibular foramen. (After Zuckerkandl and Scheff.)

Effect of the Injection.—About three minutes after the injection the patient perceives a slight tingling in the lip and tongue on the injected side. This tingling or pricking is the best indication that the injection has been correctly made. This sensation gradually increases, and a certain numbness of the entire half of the jaw ensues, so that the contact of the rinsing glass with the anesthetized lip is no longer felt. The patients have a feeling as if the rim of the glass had been cut away in semilunar shape. The lip on the anesthetized side droops slightly, and exhibits symptoms of partial paralysis; the patient usually feels as if it were greatly swollen. A sensation of warmth is also perceived over the entire anesthetized area. Difficulty in deglutition or ankylosis is absent if the technique has been correct; its presence indicates that the injection has been made too far pharyngeally and posteriorly. The concomitant symptoms persist for about one hour and then subside gradually, the former normal condition being reëstablished after about three hours.

Anesthesia of the Buccal Nerve.—From our experience it seems unnecessary to anesthetize the buccal nerve.

Injection at the Mental Foramen.—With the present perfection of mandibular anesthesia the injection at the mental foramen, as described in the first edition, has lost its significance. Liberal use should be made of the blocking of nerve trunks, which does away with any additional injection on the same side. The fact that one correct injection at the nerve trunk produces such perfect results constitutes, in our opinion, the enormous advantage of conductive anesthesia.

External Injection in Case of Ankylosis or Infection.—Gadd, of Helsingfors, has suggested a method of external mandibular anesthesia which he has practised for some time in the surgical clinic at Helsingfors. Insertion of the needle is made, not as Peckert suggested, from the dorsal side, but at the lower margin of the mandible between the anterior border of the masseter muscle and the angle of the ramus. This method is recommended specially for cases of ankylosis and serious infections of the oral cavity and throat, when insertion of the hypodermic needle in the mucous membrane in the mouth would involve the risk of carrying infectious material into deeper strata. This, Riethmüller writes,[1] is the only indication for external mandibular anesthesia. Generally a most satisfactory anesthesia is obtained by the conductive method inside the mouth, if the operator has once learned to master the technique. The external method is more complicated, uncertain, painful, and formidable to the patient, and its advocacy in any other cases than those cited will only tend to complicate our technique and discourage practitioners from adopting conductive anesthesia.

[1] Dental Cosmos, March, 1914, p. 385.

RÉSUMÉ OF THE CLINICAL VALUE OF CONDUCTIVE ANESTHESIA.

The topography presented in the foregoing furnishes convincing proof that, in the mandible as well as in the maxilla, nerve trunks can be intercepted by injection at certain points of their course, and that conductive anesthesia should be the method finally selected in most dental operations. The practical simplification of the instrumentarium insures a simple technical execution of the methods advocated, viz., conductive anesthesia of the *maxilla* by way of the *posterior palatine canal*, and of the *mandible* by way of the *mandibular foramen*. As the injections are made at a considerable distance from the field of operation a number of disadvantages are eliminated which in infiltration or mucous anesthesia are present more or less manifestly, such as anemia, metabolic disturbances in the tissues, hence impaired tendency to heal, risk of infection, postoperative pain, etc. The course of all operations performed under conductive anesthesia is at least as favorable as that of interventions made under general anesthesia.

By the use of the special instrumentarium advocated all complications or failures that might arise in conductive anesthesia are practically wholly eliminated. The blunt needle can never produce a serious injury of important organs or bloodvessels, but cautiously advances in their vicinity, pushing aside any bloodvessels encountered in its progress. In the maxilla as well as in the mandible the needle must pass only through a thin fascial layer, and almost immediately after insertion encounters thick strata of interstitial connective and adipose tissue. After insertion, the sharp trocar is immediately withdrawn, and the advancing blunt needle is guided by a well-defined osseous surface, viz., in the maxilla by the tuberosity, in the mandible by the anterior border of the ascending ramus (retromolar triangle).

The finding of the proper places for insertion of the needle is greatly facilitated in both jaws by characteristic bony surfaces; in the maxilla by palpation of the malar bone posteriorly to which the maxillary tuberosity is immediately reached; in the mandible by palpation of the anterior border of the ascending ramus. The mucous folds over the retromolar triangle are as unreliable a guide as is the development of the bony groove situated between the two oblique lines, since both these landmarks vary greatly in different individuals, and cannot be used as never-failing indicators. In every case the palpating finger must fix the anterior border of the ascending ramus, sink in the bony groove, if it is present, and remain stationary for the guidance of the needle as it is inserted at the inner border of the bone. This palpating is done with the index finger, not with the thumb, as Seidel proposes. No other finger is as suitable for palpation as the index finger, which is endowed with an extremely delicate sense of touch. Despite Seidel's proposed modifications, which in our opinion merely complicate matters, our technique has not been changed; nor can it be changed, because, as Braun writes,[1] "It is self-evident."

The primary condition for a successful and safe conductive anesthesia is a suitable instrumentarium. After a number of experiments in green skulls and in patients it has been ascertained that the telescoping thick and blunt trocar needle is the most suitable. It is slightly curved, and in advancing insures continuous contact with the bone. Being blunt, it slides forward past the delicate tissue areas without injuring any bloodvessels. If the injection is started immediately upon insertion of the needle, then the solution will be safely and evenly distributed.

The perforation of muscle fibers is not a complicating factor, because the clean-cut lesion of the muscle invariably heals by first intention. There is no risk of infiltrating the muscles, since the injection is not started until after the muscular layer has been passed. Puncturing and advancing in the internal pterygoid muscle is impossible with this method if the technical conditions are fulfilled. It is most desirable, of course, that the correct technique be acquired by demonstrations *in situ*, because, as Braun remarks, "Its greatest difficulty consists in its description."

Injection at the Maxillary Tuberosity.—Injection at the maxillary tuberosity, the technique of which has been described in detail on

[1] Text-book of Local Anesthesia, third edition, p. 251.

pages 203 to 205, renders any additional buccal or lingual injections superfluous, and produces complete anesthesia of the molars and bicuspids. If anterior teeth are to be operated upon it is best to make an injection at the tuberosity on either side; or mucous anesthesia by way of the canine fossa toward the anterior nasal spine may be resorted to.

Injection at the maxillary tuberosity, as a rule, produces complete anesthesia within from six to fifteen minutes; it is tolerated perfectly well, and its execution is generally painless. It does away entirely with injection at the infra-orbital foramen, and greatly simplifies the anesthesia of the maxilla.

Mandibular Injection.—Injection at the mandibular foramen, the technique of which has been described in detail on pages 208 to 225, renders any additional injection in the vicinity of a tooth superfluous. Mucous anesthesia, in fact, is contra-indicated, as it detracts from the advantages of conductive anesthesia, viz., rapid wound healing, liberal hemorrhage, easy absorption, etc. Our controls have shown that anesthesia of the mandibular and lingual nerves includes the entire mucous covering of the injected side of the mandible, in the same way as injection at the maxillary tuberosity produces anesthesia of the entire maxillary half including the mucous membrane.

These two methods of anesthesia are extremely valuable in relation to therapeutics, and owing to their great simplicity, combined with innocuousness, safety, and absence of untoward sequelæ, are superior to the method of infiltration of the gingivæ.

Principles of Conductive Anesthesia.—1. Thorough sterilization of the mucosa with tincture of iodin, thymol-alcohol, or one of the decolorized preparations of iodin.

2. Infiltration of the perineurial tissue.

3. Only one insertion of the needle.

4. The orifice of the needle must always point toward the bone and advance along the bone.

5. The solution is discharged under moderate pressure, gently moving the syringe back and forth.

6. For injection at the maxillary tuberosity the malar process is

palpated. The needle is inserted in the mucous membrane behind the process, and advanced to the convexity of the tuberosity, thence upward and slightly backward in the direction of the temple.

7. In mandibular anesthesia the retromolar triangle is palpated, allowing the finger tip to rest therein. The needle is inserted 1 cm. above the level of the masticating surfaces of the molars, and at the inner border of the ascending ramus; the syringe is guided by the canine and first bicuspid of the opposite side. The needle is advanced backward and outward, in adults straight, in children slightly downward. While injecting, the syringe is gently moved back and forth.

8. A waiting period of ten minutes in the maxilla; of twenty minutes in the mandible.

9. The patient should be kept under observation after the injection.

EXTENT OF LOCAL ANESTHESIA IN THE MAXILLÆ.

The action of local anesthetics in the healthy organism can be traced step by step, especially with the aid of the electric current.

Completion of Anesthesia in the Maxilla.—In mucous anesthesia of the upper central incisors the sensibility of the pulp is notably diminished after two minutes; it gradually decreases, until after five minutes complete anesthesia is established. This condition of complete anesthesia usually lasts from twenty to twenty-five minutes. It is noteworthy that, even during this state of complete anesthesia, strong electric currents still exert an influence upon the eye, producing a slight oscillation as well as lacrimal secretion, owing to the relationship between the first and second divisions of the trigeminal nerve. After about seventy minutes, counting from the beginning of the injection, normal conditions were reëstablished in the cases examined.

Anesthesia in the Region of the Maxillary Tuberosity.—After injection at the maxillary tuberosity and in the posterior palatine foramen, sensibility is reduced in all molars and bicuspids after two minutes; after five minutes the canine also exhibits reduced sensibility. After three additional minutes, the buccal mucous membrane is entirely insensible, while the lip seems still to react normally. Within ten minutes, complete anesthesia is established in all molars, lasting for over ten minutes, then gradually subsiding. The sensibility of the bicuspids and canines is notably reduced. Within from thirty to forty minutes normal sensibility is reëstablished in every tooth, while the mucosa, especially in the vicinity of the maxillary tuberosity, is still completely anesthetized.

The prompt effect of injection at the maxillary tuberosity was demonstrated in a highly sensitive and seriously neurotic woman. Anesthesia of the second upper bicuspid with an inflamed pulp was accompanied by the following symptoms: After two minutes light anesthesia set in in all molars and bicuspids of the injected side. After three minutes the teeth, which had been extremely sensitive to a light current, tolerated a current of double; after five minutes, one of triple strength. After fourteen minutes complete anesthesia was established. The pulp of the second bicuspid was amputated to the root canals without any pain whatever. For the sake of experiment, the strong current was applied to the amputated pulp stumps. It was surprising to note a very faint reflex. Nevertheless the root portions of the pulp were immediately extirpated without any pain whatever, contrary to expectation. The mechanical irritation incidental to extirpation of the pulp evidently produced no pain, while the electric irritation was still perceived, presumably because, in contradistinction to the irritation from localized pressure, it was conveyed by the cells to remote areas of sensation. After twenty-six minutes the anesthesia began to wear off.

Anesthesia in the Region of the Infra-orbital Foramen.—At the infra-orbital foramen the injection produced a pronounced anesthetization of the superficial mucous and muscular layers, characterized by a reduction in sensibility within one minute. The anterior teeth were completely anesthetized after eleven minutes, sensibility gradually returning after twenty-five minutes.

Mucous Anesthesia in the Mandible.—The effect of mucous anesthesia in the mandible appears to be rather uncertain. This form of anesthesia was applied to a lower first bicuspid affected with pulpitis;

the sensibility of the pulp was not reduced notably, even after eight minutes. When anesthesia by way of the mandibular foramen was subsequently induced, within three minutes the sensibility of the

FIG. 115

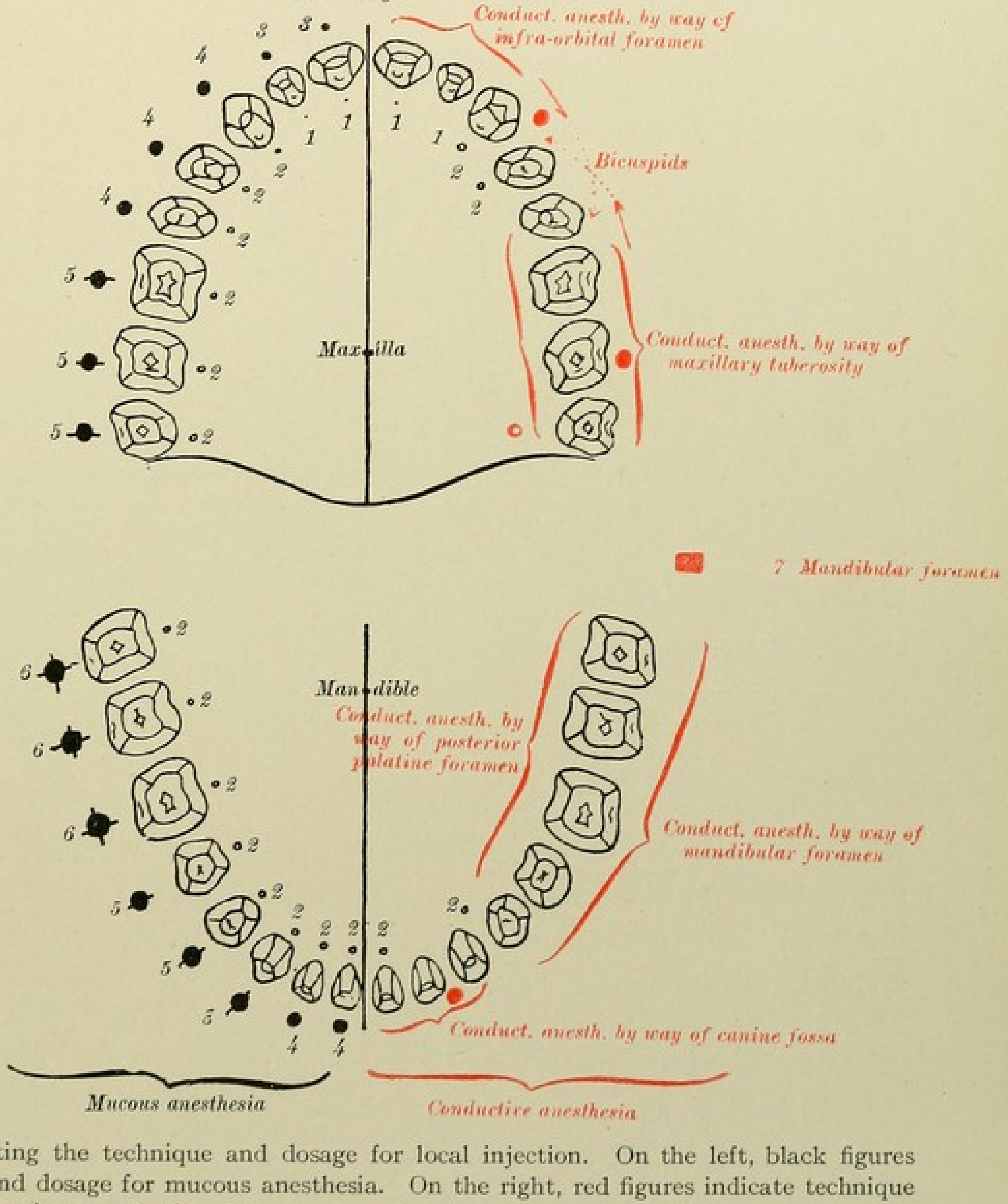


Diagram illustrating the technique and dosage for local injection. On the left, black figures indicate technique and dosage for mucous anesthesia. On the right, red figures indicate technique and dosage for conductive anesthesia. Dosage: 1 = about 10 drops; 2 = 0.25 c.c.; 3 = 0.5 c.c.; 4 = 1 c.c.; 5 = 1.25 c.c.; 6 = 1.5 c.c.; 7 = 2 c.c.

inflamed pulp was considerably reduced, and complete anesthesia ensued within fourteen minutes from the beginning of the experiment.

Anesthesia by Way of the Mandibular Foramen.—In another case it was observed that within three minutes after injection at the mandibular foramen anesthesia of the corner of the mouth and the mucosa of the lip was established. After four minutes tingling in the lip and in the corresponding half of the tongue was perceived. The tongue grew heavier every minute, and the numbness of the lip spread to the other side. After ten minutes the teeth on one side of the mandible with the exception of the second molar and the canine were insensible, and within twenty-three minutes altogether the entire half of the jaw was anesthetized. Complete anesthesia with all its symptoms persisted for twenty-five minutes, after which time it gradually subsided. The central incisors were the first to regain sensitivity, and were followed in rapid succession by the other teeth. The tongue had become normal after ninety-seven minutes, while the mucosa remained insensible even after one hundred and twenty-five minutes. Normal sensibility was not reëstablished until three hours after injection.

TABLES FOR INJECTION ANESTHESIA.

In order to avoid repetitions such as histories of practical cases would entail, yet in order to offer a practical working scheme for the application of the methods described, tables are here presented which indicate the method of injection best suited for each tooth. The special requirements of a case may, of course, call for modifications of these tables, which are intended as a general guide to those who wish to become experts in this somewhat difficult technique.

Periods of Waiting.—The period of waiting in the cases Nos. 1 to 4 and 9 to 10 is about ten minutes; in Nos. 5 to 8, fifteen minutes; in Nos. 11 to 16, twenty minutes. In Nos. 9 to 16 no injection lingually is required. Modifications or combinations for the anesthetization of several teeth on one side can easily be deduced from these tables.

Teeth. I. UPPER.	Technique of injection employed. (a) In simple cases.	Technique of injection employed. (b) In cases complicated by periostitis, parulis, abscess, etc.	Mountings of syringe.	Quantity of solution. In labial or buccal injections.	Quantity of solution. In palatal or lingual injections.
1. Central incisors.	Needle inserted at middle of root of lateral, and directed to root apex of central. Palatally, injection at central.	Needle inserted at middle of roots of canine of same, and central of opposite side, whose root apices are infiltrated with solution; palatally, injections at lateral of same, and central of opposite side. Or conductive anesthesia at infra-orbital foramen, and mucous anesthesia at central of opposite side, palatally.	Hub B, needle, No. 17*a*. For conductive anesthesia, needle No. 17*c*.	In cases of class. (*a*) 0.5 c.c. (*b*) 1.0 c.c.	(*a*) 0.1 c.c. (*b*) 0.3 c.c.
2. Lateral incisors.	Needle inserted at middle of root of canine, and directed to root apex of lateral. Palatally, injection at lateral.	Needle inserted back of root apex of canine, where solution is deposited; same procedure at root apex of central. Palatally, injection at lateral, or at central and canine.	As in 1.	(*a*) 0.5 c.c. (*b*) 1.0 c.c.	(*a*) 0.1 c.c. (*b*) 0.3 c.c.
3. Canines.	Needle inserted at root apex of canine, where solution is deposited. Palatally, injection at canine.	Conductive anesthesia at infra-orbital foramen. Palatally, injection at canine, or first bicuspid and lateral.	(*a*) As in 1. (*b*) Long needle No. 17*c*.	(*a*) 1.0 c.c. (*b*) 1.5 c.c.	(*a*) 0.5 c.c. (*b*) 0.5 c.c.
4. First bicuspids.	Needle inserted at middle of root of canine, and directed to root apex of first bicuspid. Palatally, injection at first bicuspid. Or injection at maxillary tuberosity.	Injection at maxillary tuberosity.	Hub C and long needle No. 17*c*, or trocar needle.	2 to 4 c.c.	No injection palatally required.
5. Second bicuspids.	Needle inserted at middle of root of first bicuspid and directed to root of second bicuspid. Palatally, injection at second bicuspid. Or injection at maxillary tuberosity.	Injection at maxillary tuberosity.	As in 4.	2 to 4 c.c.	
6. First molars.	Injection at maxillary tuberosity.	Injection at maxillary tuberosity.	As in 4.	1.5 to 2.0 c.c.	
7. Second molars.	Injection at maxillary tuberosity.	Injection at maxillary tuberosity.	As in 4.	1.5 to 2.0 c.c.	
8. Third molars.	Injection at maxillary tuberosity.	Injection at maxillary tuberosity.	As in 4.	1.5 to 2.0 c.c.	

Teeth. II. LOWER.	Technique of injection employed. (a) In simple cases.	(b) In cases complicated by periostitis, parulis, abscess, etc.	Mountings of syringe.	Quantity of solution. In labial or buccal injections.	In palatal or lingual injections.
9. Central incisors.	Needle inserted at middle of root of lateral and directed to root apex of central. Lingually, injection at central.	Needle inserted in reflection of mucous membrane below canine and directed to mental fossa, where solution is deposited.	(a) Hub B and needle No. 17*a*. (b) needle No. 17*c*.	(a) 0.6 c.c. (b) 1.0 c.c.	(a) 0.25 c.c. (b) 0.25 c.c.
10. Lateral incisors.	Needle inserted at middle of root of canine, and directed to lateral. Lingually, injection at lateral.	Needle inserted in reflection of mucous membrane below canine, and directed to mental fossa, where solution is deposited.	(a) Hub B and needle No. 17*a*. (b) needle No. 17*c*.	(a) 0.6 c.c. (b) 1.0 c.c.	(a) 0.25 c.c. (b) 0.25 c.c.
11. Canines.	Needle inserted in reflection of mucous membrane below canine, and directed to mental fossa, where solution is deposited. Lingually, injection at canine or first bicuspid, or mandibular anesthesia.	Needle inserted in reflection of mucous membrane below canine, and directed to mental fossa, where solution is deposited. Mandibular anesthesia.	Hub C and needle No. 17*c*.	(a) 1.0 c.c. (b) 2.0 c.c.	(a) 0.25 c.c. (b) 0.25 c.c. (see Fig. 94).
12. First bicuspids.	Mandibular anesthesia.	Mandibular anesthesia.	Hub C and needle No. 17*c*, or trocar needle.	2.0 c.c.	
13. Second bicuspids.	Mandibular anesthesia.	Mandibular anesthesia.	Hub C and needle No. 17*c*.	2.0 c.c.	
14. First molars.	Mandibular anesthesia.	Mandibular anesthesia.	Hub C and needle No. 17*c*.	2.0 c.c.	
15. Second molars.	Mandibular anesthesia.	Mandibular anesthesia.	Hub C and needle No. 17*c*.	2.0 c.c.	
16. Third molars.	Mandibular anesthesia.	Mandibular anesthesia.	Hub C and needle No. 17*c*.	2.0 c.c.	

When indicated, no hesitancy need be felt about injecting at the mandibular foramen on each side at one sitting. The results of this double injection are surprisingly favorable, and no untoward sequelæ, alarming symptoms of paralysis or tongue-biting have so far been observed. In the same way the entire upper jaw can be anesthetized by injection at the maxillary tuberosity on each side. It is specially in major operations that conductive anesthesia is most distinctly indicated and has proved to be of incalculable value as a substitute for general anesthesia.

CONCLUSION.

It only remains to remind the reader that the foregoing pages have as their *motive* the stimulation of careful practical employment of local anesthesia; consequently we have left untouched or have merely grazed the surface of many important matters of scientific interest less immediately relevant to the main design of these pages—strict adherence to which has, happily, been rendered easier by the fact that Braun, in his great *Text-book on Local Anesthesia*, has dealt with many of the theoretical problems in an almost exhaustive manner, so far as our present knowledge extends.

It is hoped that our labor may contribute to a general adoption of local anesthesia in dentistry, so that its beneficent aid may become the routine recourse of all dentists. Notwithstanding some recent efforts in advocacy of general anesthesia in dentistry, that method would seem foredoomed to ultimate abandonment by our profession, owing to the far greater advantages afforded by local anesthesia when applied by skilled hands. The method by injection is demonstrated to be equally as suitable for oral surgery as for the less severe requirements of conservative dentistry, and, as employed today, is indicated very decidedly for dentinal anesthesia, contrary to some contentions adverse to its use.

Success, however, in the field of this valuable accessory to our specialty must not be expected from mere superficial study; for truly satisfactory results, especially facility in the technique of actual injection, can be acquired only by conscientious practice. As an encouragement in patient efforts toward the acquisition of wider powers, let us reflect that attainment will not only mean the enhanced confidence of our patients in us, but we shall be materially contributing to establish dentistry as a science upon a plane which its character and importance demand, and to raise its professional status in the eyes of the civilized world.

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