E. L. Babcock,
Brooklyn,
N. Y.

April 1912.

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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, SURGEONS AND STUDENTS

BY

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TRANSLATED FROM THE SECOND GERMAN EDITION

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PREFACE

WHILE efforts toward the abolition or reduction of pain are inseparably interwoven with the history of the human race, it was not until the introduction of general anesthesia with nitrous oxid by Wells in 1844, with ether by Morton in 1846, and with chloroform by Simpson in 1847, that "the beautiful dream of the elimination of pain became a reality," to use Dieffenbach's words. Local anesthesia, although prior to 1884 it had been induced by freezing, as by salt and ice, ether, and ethyl chlorid, did not attain general popularity before that year, when Köller demonstrated the anesthetic properties of cocain. Since then the advance of surgical anesthesia, both general and local, toward perfection has reached a remarkable point of development, for the attainment of which humanity owes to dentistry no less a debt of gratitude than it does to medicine.

In operative interventions in the oral cavity, which, while involving but a limited area, are so extremely painful, local anesthesia seemed from the beginning to be specially indicated; in fact, so welcome has been the elimination of pain in dentistry that the limits necessarily attaching to this beneficent aim have at times been overstepped, and progress has been jeoparded, and legitimate and conscientious effort discredited by the exploits in "painless dentistry" of unethical practitioners. The ethical dentist should, therefore, gladly avail himself of a guide which, issuing from the pen of a recognized authority, will aid him in adopting a safe and scientific method of inducing local anesthesia, in raising the standard of his operative work, in sparing pain to his patients, and conserving his own nervous energy. The demands that modern civilization is making upon our vital forces are so great that anesthesia is imperatively demanded even in minor dental operations, and the daily and urgent pleas for humane dentistry should no longer be left unheeded even by the most conservative practitioner.

The timeliness of this guide is fully evinced by the fact that the first German edition was exhausted within ten weeks, and that Ch. J. Fleischmann has based his monograph on "Local Anesthesia in Operative Dentistry," which has since appeared in French, on Fischer's investigations. The author is convinced that local anesthesia, in its present perfection, is destined to supplant general anesthesia in dentistry almost entirely. He has, therefore, laid chief stress upon an exact presentation of the technique of injection, and by painstaking studies of the anatomy, physiology, and pharmacology involved has succeeded in surmounting successfully the defects that, until recently, still inhered in methods of local injection of anesthetic agents.

The experience reported and the results obtained are presented in this volume with absolute impartiality, yet the author's individual conviction is unhesitatingly asserted in the treatment of such an essential question as the choice of the anesthetizing agent. This will be fully appreciated by busy practitioners eager to avail themselves of a valuable, trustworthy, and tried method without incurring the trouble, expense, and risk of experimenting with a host of strenuously advertised proprietary preparations before arriving at a definite choice. The author advocates novocain and its solutions, which, after innumerable experiments with all available anesthetizing agents, the majority of which are proprietary, he has found the most suitable and safe. Novocain, after having been the subject of an article by the translator of the present work, entitled "Recent Studies on Novocain," was unconditionally endorsed by no less an authority than Dr. Hermann Prinz, in his paper on "A Rational Method of Producing Local Anesthesia," in which he terms novocain as "alone fully corresponding to every one of the demands to be made upon a local anesthetic." Since the publication of these papers, novocain is daily being discussed most favorably in American medical and dental literature, in full substantiation of Fischer's claim that if the details of the improved technique of injection as laid down in this book are followed, novocain will rapidly find new advocates and insure for the dental operator success in his operations, together with his patients' hearty appreciation. A local anesthetic of known chemical composition that has been successfully employed in nearly a million cases by leading dental and general surgeons without one fatal result, or even any untoward sequelæ whatever, may be conservatively said to have passed the experimental stages.

Various other methods of inducing local anesthesia are described, though intentionally not elaborated upon, as having relatively limited value, the author being satisfied with having evolved a single accurate method conforming to the most rigorous standards of modern science, toward the perfection of which many prominent investigators, especially of the Heidelberg and Berlin universities, have coöperated. The indications and contraindications of other methods of anesthesia especially by cocain, have, however, by no means been overlooked, and a valuable gauge is thus obtained of their relative merits by way of comparison.

Special consideration has also been given to anesthesia in the therapy of inflammation and wounds, to adjuvant, systemic, and sedative treatment, to the manipulation of nervous, debilitated, or sickly patients and of children, and to local anesthesia in the extirpation of vital pulps and in obtunding hypersensitive dentin.

The publishers, Messrs. Lea & Febiger, have spared no effort or expense in the technical execution of this book, and the wealth of illustrative material incorporated should prove a most practical feature. The translator wishes to make most grateful acknowledgment of the inspiration and invaluable aid given by Professor Edward C. Kirk, D.D.S., Sc.D., Dean of the Dental Department of the University of Pennsylvania, in the preparation of this work. His thanks are also given to Mr. A. F. Tilly for his painstaking work in the preparation, and to his wife for her valuable assistance in the proof-reading of this volume.

R. H. R.

PHILADELPHIA, 1912.

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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 earnest attention in the practice of the healing art, and no other branch of medical science was better suited and more capable of striving after its abolition than surgery. Fostered by this special branch, dentistry has now matured into a fully privileged and independent department, after having received numerous tokens of maternal care from the mother science, not the least of which being the great inspiration in the endeavor to attain local anesthesia.

The operations in the oral cavity, so extremely painful as compared with other operative interventions, prompted a special desire to diminish or to abolish entirely the sensibility of the teeth, a desire which was all the more justified as the general enervation accruing from modern civilization was daily increasing. Moreover, the destruction of the teeth is assuming most alarming proportions, and all possible means of inhibiting this universal disease should be studied.

Pain in itself 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 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 of 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 save 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 sensation 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; for 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 sensations which are usually termed conditions or general sensations, so-called, 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, with central radiation of the same over neighboring nerve plexuses, and by a prolonged duration of the stimulus. Besides, a sufficient sensibility of the stimulated tissue area is required. Hence the intensity and the duration of the stimulus exert a decisive influence upon the character of the irritation. In the case of a prolonged stimulus the irritations are probably stored in the sensory ganglionic cells, resulting in a consummation of individual stimulative impulses producing the affection of pain, and at the same time a hyperalgesic condition. Inflammatory pain is probably due to the hyperalgesic condition of the ganglionic cells, induced by the continuous duration of the stimulus.

The character of the pain may vary considerably. According to Erb, by the admixture of sense perceptions, burning pains may arise; by localization or expansion, pricking pains; by the change of the stimulative process, throbbing pains. "Their intensity is greatly dependent upon psychic factors, and it is the greater the more we abandon ourselves to them, 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.)

Besides, other factors, such as education, character, intelligence, nationality, age, sex, and general health, exert a considerable influence upon the origin and manifestation of painful affections. The newly born is free from all sensations of pain, which gradually asserts itself with the development of the sensory organs.

Like all other sensations, that of pain 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 proceed from cell to cell, and non-physically effective stimuli are transmitted by the cell.

Stimuli of different quality, *i. e.*, mechanical, chemical, thermal, and electric, are able to produce painful sensations in the sensory end organs, *i. e.*, 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, not clearly localized, however, but vaguely circumscribed, as frequently in the oral cavity. In diseased tissue the irritability is generally increased, rarely diminished. Acute inflammations, in which the increase in blood pressure plays an important role, tend especially 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 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 very sensitive; the 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 insensitive.

Consequently the sensibility to pain is widely distributed in the human body, and this fact sufficiently accounts for the continuous efforts of practical medicine from its beginning to influence this property of each tissue by an artificial reduction of sensibility before operative intervention. By these efforts it is intended to produce inhibition of sensibility, *i. e.*, *anesthesia*, or at least inhibition of painful sensation, *i. e.*, *analgesia*. This condition of insensibility can be produced partly by natural means, *i. e.*, reduction of the normal irritability of the sensory nerves as during profound sleep or in sickness, or by artificial means, *i. e.*, employment of narcotics, such as chloroform, ether, and others, of drugs such as cocain, novocain, etc., or of hypnosis.

BRIEF HISTORICAL REVIEW

Among all peoples and in all eras, efforts more or less successful have been made to discover means for preventing pain. It was, however, not so much local as general anesthesia which at a very early period appeared specially desirable, and was to be produced by various means, most frequently by vegetable extracts. By the application of narcotic agents, which consisted mostly of narcotizing decoctions administered before the operation, such as the mandrake root potion, attempts were made to produce a state simulating sleep, during which the operative intervention was 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 the 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 entirely, for it was not until the end of the eighteenth century that James Moore suggested that by compressing nerve trunks as well as by severing them, analgesic areas could be produced. Owing to the numerous anastomoses, the effect naturally was but a limited one, and the chief aim of the investigators of that time was to perfect the methods of general anesthesia.

Not until 1866 did local anesthesia begin to come into its own, being supported and inspired by the 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 was a pioneer also in the field of general anesthesia, is entitled to additional 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, like all the other fields of science and art, 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 readily 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, frequent fatalities occurred, owing to the toxicity of cocain, until Schleich and Reclus introduced their infiltration anesthesia by means of considerably smaller cocain doses. This method was still further perfected by the extract of the suprarenal capsule, which was recommended in connection with anesthesia by Braun (see p. 23).

Conductive anesthesia (*perineural* or *regional* anesthesia), which is used so successfully today, was first suggested in 1885 by Halstedt, who instead of injecting cocain in the vicinity of the tooth to be anesthetized, injected it at the trunk of the inferior dental nerve, from the oral cavity; this principle was applied by Kummer and Pernice in anesthesia of the toes and fingers.

Medullary anesthesia, which is also 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 scientists, such as Schleich, von Mikulicz, Braun, Kocher, and von Eiselsberg, worked indefatigably toward the further development of this field, striving especially to do away with the toxic effects of cocain on the heart and the central nervous system inherent in this drug, 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 the behavior of the vessels, proving that the simultaneous vascular contraction at the place of injection is an important aid in the intensity and duration of anesthesia. In this way Braun came to combine the suprarenal preparations with the anesthetics, which method has become absolutely indispensable.

Of the greatest importance for the further development and perfection of injection anesthesia was the discovery of the anemizing action of the *solutions of suprarenal extract*, which were offered on the market under the names of adrenalin, renoform, suprarenin, etc. Their chief property consists in intensifying the action of cocain or suitable substitutes, when injected in mixture with the anesthetic solution, by producing a vigorous contraction of the bloodvessels in the injected area; thereby not only the absorption of the anesthetic is retarded, but, for the same reason, considerably smaller quantities of the solution suffice to produce an equally efficient anesthesia as the employment of larger doses of pure cocain or novocain solutions would afford. Especially the combination of *novocain* and *suprarenin* (which latter is now being prepared synthetically), *i. e.*, the so-called novocain-suprarenin mixture, while being equally potent, is less toxic than the cocain-suprarenin solution, and is therefore preferred in surgery and dentistry, which fact is to be regarded as a further advancement in the progress of our special science.

Local anesthesia by injection is sure to become soon the common property of dental science, owing to the efforts expended by many dentists toward its general adoption. The works of 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 furnished the material for the future development of anesthesia within 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, especially since we dentists, in practising on a very important but circumscribed part of the body, are vitally interested in treating and curing the organs intrusted to our care in such a manner that no damage to the entire organism will result. Therefore the question of the relative toxicity of local anesthetics as compared with that of general anesthetics is of great interest.

It was shown in our brief historical review that the earliest results in anesthesia originated in the domain of central desensitization, *i. e.*, *general anesthesia*. The development of surgical methods of operation was closely connected with the problem of the prevention of pain, and these two movements have advanced simultaneously.

In order to perform a difficult and tedious operation with safety, the surgeon has always endeavored to paralyze the nervous centres and thus to abolish completely the sensation and will power of his patient; in other words, to produce 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 endings in a circumscribed area of innervation can be paralyzed, thereby enabling the surgeon to operate while the patient is 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 main area are influenced, *i. e.*, *mucous anesthesia*, or those by which a larger nerve trunk is intercepted directly at its basis, *i. e.*, *conductive anesthesia*. In mucous anesthesia the nerve endings are for a certain length of time incapacitated from receiving impressions, while in conductive anesthesia a particular nerve trunk is prevented from conducting an impression.

The progress of local anesthesia has been enhanced above all by general anesthesia, especially by the want of perfect safety for the patient's life which still inheres in the latter method. Even with the exact method of mixed anesthesia, so-called, correctly manipulated, one fatality in 7558 cases is still to be expected. At the last Surgeons' Congress of 1910, Neuber estimated that one fatality still occurred in 2953 cases of chloroform anesthesia. The very many errors made in general anesthesia, and the frequent injudicious employment of general anesthesia when so many methods of local anesthesia are available, are additional and important factors in furnishing a special record of fatalities in addition to the above regular statistics. Unfortunately, general anesthesia has very frequently been induced for minor interventions, such as tooth extractions, thus causing fatalities in an indirect way. General anesthesia, moreover, requires preparations which are considered by most patients as decidedly disagreeable, and, moreover, it is often followed by serious after-effects.

Even though the operative measures in inducing local anesthesia may inspire him with a certain fear and anxiety, the patient, being fully conscious of all the steps during the entire operation, enjoys the great advantage of not being exposed to any vital danger whatever, owing to the high status of perfection of local anesthesia as compared with that of general anesthesia. Fatalities due to local anesthesia have been reported alone after the application of cocain. The methods of local anesthesia as practised for interventions in the eye, mouth, nose, ear, and the extremities, undoubtedly involve but little probability of vital danger for the patient, especially if these methods are practised by skilled hands.

The great danger in operations on the thyroid gland, for instance, which involve serious interference with the cardiac nerves, and which, in combination with general anesthesia, are liable to produce syncope of the heart, is sufficiently well known, and has induced surgeons to perform thyroid extirpation under local anesthesia. The application of local anesthesia in dentistry 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 of importance in the application of local anesthesia. The skin and the mucosa, as well as the periosteum, the pericementum, the pulp, and the dentin are sensible to pain in a degree to which the muscles will react far less readily. A conscientious and experienced operator, when considering all these factors, will be able to operate painlessly provided that 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 then the operator's duty to justify fully this reluctantly granted confidence of the patient by doing all within his power and skill to perform a perfectly painless operation. If he fails, the patient will lose forever his self-control gained by the operator's mental suggestion, and will thenceforth firmly advocate general anesthesia. In local anesthesia especially remarkable results can be obtained by mental suggestion, and in our hospital and private practice we have had many a patient who was induced 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 or a woman attendant, is recommendable for social reasons. Several cases of sexual hallucinations following the injection of cocain solutions locally in extractions have been reported, in which the operator had difficulty in clearing himself owing to the absence of a third person, who could easily have testified to his innocence.

"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 a medical 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, the operator becoming consequently involved in a most disagreeable situation. Especially in treating patients below the age of twenty-one great care is necessary, since every operative step which is undertaken without the permission of his guardians 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 anesthesia is involved, and injections even 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 physician's or on the patient's part. This is extremely valuable, especially for ambulatory dental practice, in a big city as well as in the country, in the dentist's surgery 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 stands in no proportion to that which, in dental operations under local anesthesia, can be obtained 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 fully master the technical methods of preventing pain, especially our modern injection anesthesia; he must know exactly the pharmacological and physiological effects of his solution, and, above all, he must be able to diagnosticate the general condition of each patient in order to treat him according to individual requirements; for there is no doubt that the resistance of the organism in absorbing injected solutions largely determines the method of procedure. Thus the dentist can use 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 his success thereby. In such patients often only very superficial general anesthesia is applicable, the patient even then being in constant danger, and pain being only partially abolished. The application of local anesthesia is consequently far more advisable, guaranteeing, as it does, perfect success and the patient's full appreciation; 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 the common usage with all dentists. To what extent general surgery has succeeded in its tendency to replace general by local anesthesia may be seen from Braun's report, which will be given later (see p. 58), and which we would specially emphasize.

PRELIMINARY MEASURES IN LOCAL ANESTHESIA. THE OPERATOR'S DUTIES

After having shown that the method of local anesthesia is not only indicated, but imperatively demanded of the dentist, the details of this procedure will be considered. While general anesthesia, to be correctly induced, always requires elaborate preparations, the induction of local anesthesia necessitates only certain measures, which will be discussed in the following paragraphs:

Anamnesia.—After obtaining as accurate an anamnesia as possible, which can be best and most tactfully secured in unforced conversation, 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 disease, such as influenza, also to physically depressed or nervously irritated individuals, and hystericals—all of whom require special care in painful operations. In such patients the normal quantity of an anesthetic which may be safely applied in strong and healthy persons produces more or less toxic effects, which, as a rule, can be avoided by lessening the dose to be injected. By his calm self-possession in asking questions, and his winning manners by which he can dissipate the patient's fear, the operator can suggest to the patient sufficient composure and confidence as to enable the operation to be begun. The patient's psychic composure is of great necessity in the first insertion of the needle, which is sometimes technically complicated, and can be accomplished only under the proper psychic influence on the part of the operator. The operator's success is assured as soon as he has introduced the needle in the desired position. If the patient feels little or nothing of the puncture of the needle, he will quickly gain full confidence in local anesthesia, and remain calm during the remainder of the operation, provided that the operator by his technical skill succeeds in fully attaining the expected effects from his measures.

Even if inevitable pain arises, the patient will be willing to bear it, provided the operator has beforehand hinted sensibly at such a possibility. It may happen, for instance, during operations that deeply lying areas of the alveoli have not been reached by an injection in the mucosa after severe fracture of the root, and have remained sensitive. Or the operator may introduce a hook or scalpel in an insufficiently anesthetized portion of the mucosa, thus causing sudden pain. It is part of the art of the modern anesthetist to know and consider all imaginable conditions, to reckon with all the factors involved, and thus to produce the desired painlessness. Every operator must be his own severe critic, and must know how highly he can estimate his own ability and experience, and how far he can trust his own skill. He must be certain whether he is technically able to produce such anesthesia as the conditions may demand, or whether he should make certain concessions by notifying the patient of the possibility of pain. This does not necessarily discourage the patient, rather it contributes to inspire confidence. Such a candid admission, scientifically justified as it is, is the more appreciated the greater the operator's skill and ease, and it exemplifies modesty, which unfortunately is rarely met with. The habit of some practitioners to guarantee the patient absolute painlessness—a feature which unfortunately is still being adhered to in the advertisements of a certain class of dental practitioners—cannot be condemned sharply enough, and must be rebuked as being unprofessional and unscientific.

A correct reserve on the part of the operator is all the more in place, as besides 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, the operator 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 and pulp still remains unsolved, and it requires most subtle and clever manipulation to perform this operation successfully in so minute an organ as the pulp.

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

Besides realizing the importance of general health, the operator has to 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 in putrescent processes, local anesthesia of the mucosa frequently produces severe pain upon insertion of the needle and during injection, the final effect being very unsatisfactory. In such conditions conductive anesthesia is properly indicated, also in all cases specially suitable for this method for anatomic or local reasons. The question of efficient asepsis must also be considered, being of the utmost importance in local injection anesthesia.

Thus the operator, who incidentally must be a capable anesthetist, assumes great responsibilities, since by faulty manipulation he may endanger the patient's health, even life, and is held responsible for any damage caused by negligence. The danger increases with the difficulty of the method, and the demands for a perfect mastery of the technique increase correspondingly. Although the law does not require the presence of a skilled assistant in local anesthesia cases, the operator is by no means held less responsible. Only if it is proved beyond doubt that he has fulfilled his duty in every respect will he be completely exonerated in case of unfortunate 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 and the quantity of solution injected must be noted, also any phenomena occurring during the operation. Such a conscientiously kept record will in case of unlooked-for accident go far toward substantiating the operator's realization of responsibility and favorably influencing the verdict in case of accident. The presence of a third person who may serve as witness is a valuable safeguard, especially in cases where patients, even under local anesthesia, claim to have experienced sexual affections and accuse the operator of immoral attempts.

Eroticism.—Sexual affections that may arise are always due to the strong general action of the anesthetizing agent upon the central nervous system, producing 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 in connection with local anesthesia the writer has personally noted in one case of novocain injection. In this connection the case published by Körner should be cited: A lady 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 the 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 having experienced all kinds of disagreeable accidents, above all syncopes and severe hemorrhages from extraction wounds due to failure of the bloodvessels 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 toxic secondary 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 myself can verify these observations, which are very important for the case under consideration.

"Another case reported by Dorn is very important: 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.)

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 is 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 narcotics, almost all anesthetics are poisonous to the living human organism, and their toxic effects upon the general system must therefore be checked by specially suitable dosage and solution.

Anesthesia by Freezing.—There are chemical agents, such as cocain, which produce analgesia, while the physical methods of anesthesia by freezing and pressure are chiefly localized in their effect. The latter methods have been practised the longest. Anesthesia by freezing is based on depriving the tissues of as much heat as possible by the application of congealing agents, of which the ether spray is generally known, thereby producing 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 is permeable to gaseous bodies, the mucosa even more so. The ethyl chlorid gas which is developed upon application to the warm surface of the mucous membrane penetrates the epithelial retiform interstices, the tissue pores and glands, aided by the high pressure caused by the deprivation of heat. A rapid anesthesia of the nerve elements affected is thus produced, which, however, usually wears off just as rapidly.

Anesthesia by Pressure.—Besides freezing, the compression of nerve tracts has long been employed for the production of a sort of analgesia. 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 sensitive dentin or exposed pulps. How far this procedure is satisfactory will be considered in the special discussion of dentinal anesthesia.

Schleich adopted the principle of physical pressure for the production of anesthesia by completely filling the tissues to be obtunded with injected fluid, and producing an infiltration, an artificial edema. The pressure and tension produced in this way incapacitates the affected nerve filaments to convey stimuli. Schleich employed for this purpose very weak cocain solutions, at the same time aiming to produce a chemical effect, thus utilizing a combination of physically and chemically active agents. Although to but a limited degree, anesthesia of the mucosa in the alveolar region is also based upon a combination of pressure and chemical action of the solution, the latter being of decisive importance. In their action the injection anesthetics have reached such a high degree of perfection that today they dominate the entire technique of dental local anesthesia.

Chemically Active Agents.—All the prevalent anesthetics of 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 high per cent. cocain solutions or concentrated novocain solutions are employed, while for injection into the connective tissue dilute solutions are always indicated. In the external application upon the oral mucosa a superficial anesthetizing effect is produced by the lymphatic fluid, which is distributed through the tissue, readily seizing the salts introduced, dissolving them and carrying them off to deeper strata. The superficial situation of the sensory nerve endings distributed closely under the epithelium greatly favors this action.

Solubility in Water.—As the tissue juices are themselves of an aqueous nature, only aqueous solutions of anesthetics are effective, especially since their anesthetizing power is directly proportional to their solubility in water. For this reason salts that are very readily soluble in water, such as cocain, eucain, tropacocain, novocain, and others, yield the best results, especially when these salts are formed with acids, in order to increase their solubility in water, in the form of hydrochlorids.

Toxicity.—The toxicity of the anesthetizing 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 sufficient strength by the mouth, a much too rapid and extensive absorption takes place, 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 circulatory system. While partly paralyzing the brain and its special centres, they exert an irritating and destructive influence which is the greater the larger the quantities introduced into the blood. Besides, secondary effects may occur, which are specific for each individual drug, so that the conscientious operator has every reason to familiarize himself to the smallest detail with the effect of the anesthetic employed.

Cocain and its Substitutes.—Of the innumerable anesthetics 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 despite the alarming sequelæ which have frequently been observed. It possesses, however, such a great many disadvantages, especially 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 chat with trembling voice, or exhibit symptoms simulating intoxication. Others talk confusedly and show other symptoms of mental confusion and incoherence. They also experience hallucinations affecting the senses. The excitement sometimes is aggravated to the highest possible 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. A lady, for instance, jumped up in a delirious fit, drank water, retired to her bedroom, and there had another spasm; afterward she had no recollection of the incident. During the stage of excitement in another woman strongly erotic symptoms were observed. The excitement sometimes alternates with depression, the latter in the form of pronounced melancholia with delirium of persecution, or of the type of profound apathy which 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 cocain intoxication appear within ten or fifteen minutes after the injection, sometimes, however, not before 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 slight 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 pricking sensation sometimes being noticed. Cases of cramps, of 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 due to cocain intoxication have occurred suddenly, in some cases two minutes after the employment of this alkaloid, in others after 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.)

In 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 latter. Equal doses of cocain with or without adrenalin had the same effect, the lethal dose also being the same. The effect of cocain is by no means intensified by the addition of adrenalin, and the same quantity of cocain is required 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 important 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 perchance may enter a vessel

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

directly and get into the circulation, so that a large quantity of the poison is conveyed to the brain in a relatively short time. 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 is a specific toxin for the nerves, kidney, and heart; diseases of these organs, therefore, constitute a contra-indication to this drug. Cocain 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.

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 minimal doses, as Biberfeld, Lewin, Dorn, and Ritter have confirmed, can have toxic secondary effects, 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 that the patient's physical and psychic condition plays also an important role. This latter factor may be so preëminent that even novocain, in harmless solution, although being seven times less toxic, may produce toxic symptoms, as has been proved by several reported cases.

That novocain, on the other hand, is a complete substitute for cocain has already 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. We do not hesitate to claim that the cocain preparations must be banished from injection anesthesia, and novocain must be adopted, being at present the most suitable anesthetic. Port, for instance, in over 300 injections of a 1 per cent. novocain solution, has observed not one single case of intoxication, while he observed notable intoxications in an equal number of control injections of cocain, among these being one serious case.

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 manufacturers' tutelage, and to go our own way, the way clearly shown us through the unselfishness of our investigators. When coupled with a perfect knowledge of the technique of injection, the novocain solution will never be found wanting. Most cases of failure are undoubtedly due to a lack of technical skill, according to the free confessions of 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 technique, taking it all in all, is indeed much more difficult than it may appear at first glance.

Novocain, as has been stated, is the prince of substitutes. Owing to its advantages, it is being more and more generally introduced in dentistry after having already found its place in surgery, and it seems to be destined to supplant cocain entirely. Basing our remarks upon an extensive experience with anesthesia by novocain solution, we shall therefore chiefly speak of that preparation, referring to cocain and its application by way of comparison only.

NOVOCAIN AND ITS SOLUTIONS

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

1. The locally anesthetizing effect of the drug must be less toxic than that of cocain.

2. The drug 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 (1 to 1). The salt crystallizes in alcohol in 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 not be boiled at all, or for a very short time only, as the active principle of suprarenin loses its effect by continued boiling.

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 such as the great sciatic nerve.

General Effects after Absorption.—The general 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, produce 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. The low toxicity of novocain can easily be demonstrated by comparing the lethal dose of novocain with those of cocain and 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, from 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 they are introduced into fresh wounds in 20 per cent. solutions, or in concentrated powder form, not only no symptoms whatever are observed in the areas of application, but the inflammatory process is even favorably influenced, as we have been able to demonstrate. The solutions can be boiled any number of times without being affected. 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 0.75 gram. Novocain is seven times less toxic than cocain, and three times less toxic than the other substitutes thereof.

Novocain possesses a short vasodilator effect, but otherwise it fully equals cocain in its anesthetizing power. The unfavorable vasodilator action is eminently counteracted by combination with some suprarenal extract; in fact, the anesthetizing power of novocain is considerably enhanced thereby.

Consequently, as Braun has openly declared, novocain is "an ideal anesthetic which can not only supplant 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 Läwen. The results of 255 observations have proved that novocain is a non-irritant, quickly and intensely active local anesthetic, which has produced no toxic secondary effects, no irritation or necrotic symptoms. Novocain does not impair the effect 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 supplant cocain in surgery, and we can warmly recommend it for use in medical practice, judging from our clinical experiences." (Danielsen.)

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

Novocain-Suprarenin.—"The effect of suprarenin, far from being impaired, seems to be enhanced by novocain, as I have noticed from my very first and numerous investigations. The anemia is much more pronounced than if pure suprarenin solution or cocain-suprarenin solution with the same admixture of suprarenin is employed. Independently of my observation, Dr. Biberfeld had noted the same curious fact. In the combination of novocain and suprarenin, consequently, correlations of the two agents play a part very favorable for local anesthesia, inasmuch as very small quantities of suprarenin are needed to intensify the local anesthetizing action of novocain to such an extent as is peculiar to cocain-suprarenin solutions. The same small quantities of suprarenin suffice to retard the absorption of the two drugs, thereby rendering their action purely local and limited to the place of injection. The anesthetizing power of these novocain solutions in regard to intensity, duration, and extension is at least as great as that of cocain solutions. All the operations described in my book can equally well be performed with these as with cocain solutions." (Braun.)

Suprarenin.—Suprarenin is a product of the suprarenal gland possessing the specific property of contracting the walls of the capillaries and small vessels within the region of injection, thus reducing the toxic effect of the anesthetic injected in the solution by retarding absorption, and at the same time producing an anemia in the area of injection which affords an unobstructed field for operation without parenchymatous hemorrhage. The suprarenal preparations in former years were secured from the suprarenal glands of sheep and oxen. Recently, suprarenin is being prepared synthetically, being much purer, less toxic, and more stable than the organic preparation.

Suprarenin is a grayish-white powder, slightly soluble in water, 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 to 100,000. Its toxicity is consequently relatively high. More than 0.5 mg. should never be injected in one dose. The toxic symptoms 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 vessels and capillaries. A concentration of 1 to 1000 seems to be most favorably indicated for injection.

Adrenalin, a suprarenal preparation of English origin, is mixed with a small quantity of chloretone in order to render the solution more stable, which, however, has been disputed by B. Müller, who found that chloretone impairs its action.

Stability of Suprarenin Solution.—Synthetic suprarenin is stable only to a limited degree after the bottle has once been opened. If preserved in a cool place in sealed dark bottles, however, it seems to keep very long. In a test, up to six months the solution remained absolutely clear.

For injections, a slightly acidulated sodium chlorid solution is used as a base, the suprarenin being added in the concentration of 1 to 1000. Even fractions of 1 mg. of suprarenin suffice to render the largest field of operation anemic, if the solution is introduced in liberal quantity and evenly distributed in the tissue, *i. e.*, all along the periphery of the area.

In small cork-stoppered bottles suprarenin solution does not keep as well as in glass-stoppered ones. Dr. Schönbeck, of Leipzig, has found that the disintegration of the solution is due to the sulphur compounds contained in rubber, and has suggested that in the future glass-stoppered bottles shall be employed in marketing suprarenin. The color of the glass is to be dark red, to avoid any untoward decomposition which is caused by red and yellow light specially.

If synthetic suprarenin is exposed to light for some time, the clear solution undergoes a reddish, later on a yellow, discoloration. As long as the solution is red, it can still be used. It is generally employed in combination with hydrochloric or boracic acid.

Biberfeld ascertained that synthetic suprarenin equals the natural product also clinically.

Action of Suprarenin.—Suprarenin is sold and used in physiological salt solution with a small addition of thymol. If applied externally upon the mucous tissue, the solution produces anemia within from one-half to five minutes; if applied hypodermically, in from fifteen to thirty seconds. The anemia is complete as soon as the formerly red mucous tissue has assumed a pale whitish shade. The action of the solution extends only in a radius of from 1 to 2 cm. After the anemia has disappeared, at first in every case dilatation of the vessels ensues, until gradually the vascular wall returns to its normal condition.

Toxicity of Suprarenin.—Suprarenin is a drug which may exhibit intensely toxic action, if introduced in excessive quantity and concentration into the circulation. The toxicity is greatest if the drug is injected intravenously, viz., directly into the blood. According to Batelli, the toxicity is forty times greater when injected intravenously than when injected subcutaneously. Even the doses employed for dental purposes sometimes produce disagreeable toxic symptoms, such as palpitation of the heart, acceleration of pulse, dizziness, fainting, and collapse, especially if stale solutions are employed. For this reason the smallest possible violet bottles of solution should be employed which must be used up within two weeks at the longest. Ready-mixed solutions combined with novocain are the best, and should be dispensed in small, violet ampoules of 1 and 2 c.c.

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

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

The Standard Pipette.—Dr. Schönbeck has endeavored to design a so-called standard pipette most suitable for practice. He made the interesting observation that all the standard pipettes, as bought in various drug stores, furnished drops of different sizes, consequently no uniform standard pipette exists. 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."

No Tissue Lesions from Suprarenin.—A fortunately rarely occurring danger consists in postoperative hemorrhage, which has been observed in reaction to the resulting abnormal vascular contraction with subsequent hyperemia, especially after tooth extractions. Suprarenin by its extremely local action retards the process of local circulation most pronouncedly, 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 experimentally. The latter found that novocain-suprarenin solutions disturb neither the vitality of the teeth anesthetized nor that of the approximating teeth in any way whatever, "provided the perfect vitality of the pulp before application of the drug has been established beyond all doubt." (Scheff.)

Dosage of Suprarenin.—It is important to discriminate in the application of suprarenin, especially to reduce the dose in children and in the aged. If arteriosclerosis is present or suspected, a lesion of the rigid vascular wall may occur. In weakly, anemic, and pregnant patients the minimal dose should always be employed.

If all these conditions are observed, no disturbance in the patient's health is to be expected from a correct application of suprarenal extract, as our experience in several thousand clinical and private cases has shown, especially if, instead of the highly toxic cocain, the most efficient substitute, *i. e.*, novocain, is injected.

The Injecting Solution.—The injecting solutions of novocain-suprarenin must always be as pure as possible, and must contain no admixtures which may enter into the composition of these drugs during the process of manufacture. Toxic secondary effects may occur, unless the solution has been sufficiently protected from light and heat and subsequent premature decomposition.

The good quality of the solution is generally evinced by its behavior in the living organism. It must penetrate the tissue cells without producing any lesions by way of turgescence or contraction. This property of a solution is called isotonia.

Isotonia.—Every body cell is protected against the tissue juices by a semipermeable membrane which regulates the interchange of the juices between the cell contents and the cell environment, *i. e.*, maintains metabolism. If the same conditions of solution are present within and without the cell, if the amount of salt in the fluid is uniform, then isotonia, equal tension is present. If, however, the amount of salt is greater in the environment of the cell, then there is a tendency to establishing compensation. Since, however, only the water, not the salts, diffuses through the plasmatic membrane, the salts, on the other hand, have the tendency to attract the water from the cells, and the water by leaving the cells produces a contraction. Again, if the environment of the cell is poor in salts, the cell is distended. The power that regulates this compensation is called osmotic pressure. Disturbances are due to difference in concentration, *i. e.*, differences in the osmotic pressure on either side of the 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, often assuming the form of edema. Hypertonic (rich in salts) and hypotonic (poor in salts) solutions, in unfavorable cases, may produce necrosis of the tissue, especially when containing highly toxic drugs such as cocain.

Non-isotonic Preparations.—Numerous solutions in the market, besides containing an admixture of highly toxic drugs, lack sufficient neutrality; in other words, they are not isotonic, 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 analgeticum, and dolantin.

Novocain, on the other hand, 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 full anesthetizing power remains unchecked throughout.

The injected fluid enters the circulation most rapidly. 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 injected toxic agents upon the organism.

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

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

1. The solution must produce no lesions in the blood or the tissue cells.

2. It must not alter the hemoglobin.

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

4. It must contain the anesthetic in the exactly suitable mean concentration.

5. It must not react acid.

6. It must be free from non-essential or harmful admixtures.

7. For the sake of preservation it must contain an antiseptic that is easily tolerated by the tissues.

Admixture of Thymol.—To fulfil the seventh requirement we have for years added thymol to the solution, this antiseptic having proved itself specially suitable for this purpose. If we consider that thymol, next to corrosive sublimate, possesses the greatest bactericidal power, that it inhibits, for instance, the anthrax bacillus in a dilution of 1 to

33,000; if we further consider that even solutions of 1 to 1000 are tolerated by the organism without irritation, its application is specially favorably indicated in this field. Since thymol, moreover, in the dilution recommended favorably influences the anesthetizing power of the novocain solution, it must be regarded as a most felicitous agent.

Of the several favorable properties of thymol, two deserve special emphasis—(1) its energetic antiseptic and antizymotic power; (2) its anesthetizing power.

Antiseptic Property of Thymol.—Referring to the first property, relatively small quantities of thymol greatly retard the putrefaction of organic substances and inhibit the progress of an already active process of putrefaction. Husemann observed that pieces of muscle, preserved in concentrated aqueous solution of thymol in the open air and in a hot place, remained free from putrefaction for about six weeks. In a dilution of 1 to 2000, thymol prevents the development of bacteria, and in a concentration of 1 to 200 impairs their propagating power, consequently it exhibits an antibacterial power second only to that of corrosive sublimate.

Other Effects of Thymol.—If applied in sufficient quantity, a 0.1 per cent. thymol solution completely inhibits sugar fermentation, or, if applied in small quantity, permits it to go on to a minimal degree only. As employed in man, toxic phenomena cannot appear, since the effects sought in certain cases are obtained by solutions of a strength which is far below the toxic maximal dose.

Anesthesia by Thymol.—Referring to the second requirement, Lewin has proved by animal experimentation that a 1 to 1000 aqueous solution of thymol, if applied to the epidermis of a frog, is able to produce a paralysis of the peripheral endings of the sensory nerves of the skin. Thymol, if applied in suitable strength, more or less cauterizes the mucous membrane or the tissues lying close to the mucous membrane. This cauterization, which does not involve any serious tissue lesion, produces insensibility in the frog's skin and, after more profound penetration, also in the superficial muscular layer.

To dentists thymol has long been known as an anodyne in pulpitic pain, and has been generally and successfully applied in dressings not only for disinfection, but also for palliation of pain. "The anodyne effect of thymol," Miller says, "in pain due to the pulp has long been known." Thymol probably reduces the temperature, counteracts the hyperemia in pulpitis, and acts as an anesthetic.

Thymol as an Admixture to Novocain Solution.—From these facts we have considered it expedient to add thymol to the novocain solution, which per se is not antiseptic. To be sure, novocain solutions, even in large quantities, after having been sterilized once, can be preserved for a considerable length of time, perhaps even permanently, if they remain well stoppered—this being of prime importance—just as many other solutions do not undergo chemical decomposition so long as they remain sterile. One of the great disadvantages of cocain is the generally acknowledged fact that solutions thereof, despite conscientious sterilization, remain stable for only a short time, *i. e.*, that they are quickly decomposed and lose their power, even if kept hermetically sealed from the open atmosphere. If novocain solutions that have once been sterilized are drawn off a large quantity, from case to case, we run the risk, every time we open the bottle, of infecting the solution with bacilli from the surrounding air. According to the nature of the invading specific microörganisms, processes of fermentation and putrefaction may be set up in the solution, impairing or destroying the stability and power of the solution. In order to prevent such decomposition, the solution itself should possess antiseptic properties. Antiseptic thymol solutions are known to retain their aseptic or sterile character, because they successfully combat and destroy any accidentally invading microörganisms. The suprarenin solution also contains an admixture of thymol.

Reduction of Body Temperature.—Another advantageous property of thymol should be mentioned, *i. e.*, its power of reducing the body temperature. From 2 to 3 grams of thymol, if applied internally, are able to produce in healthy persons, as well as in fever patients, a reduction in temperature of 2° C. This effect is hardly pronounced in the generally applied solution (1 to 2000), but it enters into consideration in the generally favorable action of the thymolized solution in regard to absorption, especially in hyperemic tissue.

Thus it appears that the addition of thymol imparts to the novocain solution several important properties, which are of advantage in a local anesthetic, *i. e.*, inherent antiseptic power guaranteeing the permanent asepsis of the solution, increase in anesthetizing power, and finally, easy and convenient manipulation. By this composition it becomes unnecessary to resterilize solutions which have been standing for some time. Consequently the advantages accruing from the addition of thymol render its admixture to the novocain solution indispensable, especially if large quantities of solution are kept in stock, to be used from time to time. But even in small quantities, which are dispensed in ampoules, the admixture of thymol has proved to be invaluable.

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 more it is likely that irritations will be produced. 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 the admixtures, especially the suprarenin, have undergone alteration or decomposition.

Ampoules.—For the convenience of practice we have made tests in order to ascertain how long novocain-thymol solutions with suprarenin added will keep in small dark ampoules. After fifteen months the solution was still as clear and effective as on the day when it was prepared. For this reason we can warmly recommend the 0.5 to 1.5 per cent. normal solution, which is dispensed with suprarenin added, ready for use, in ampoules of 1 and 2 c.c., and which we have frequently tested. This normal solution represents the purest stock solution of this preparation known.

Nature and Manipulation of the Ampoules.—Efforts are being made to manufacture a more suitable glass for these ampoules, the customary brown glass not meeting all requirements. The color of the glass is to be dark red, for the exclusion of all deleterious light rays, which is not obtained with brown glass. The glass, moreover, must be entirely free from alkalies, this requirement being also lacking in the glass usually employed in the manufacture of ampoules.

The ampoule itself must be kept as sterile as every other instrument used in injection. The full ampoule contains a sterile solution, yet its outer surface is by no means sterile. It passes through many hands, is packed in cotton simply, 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 make it break 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. The ampoules are best sterilized by carefully washing from about 6 to 10 of them in a weak solution of carbolic acid or lysoform, and then preserving them in a glass jar of dark violet color containing absolute alcohol. When needed, an ampoule is taken from the alcohol with sterile pincers and laid between sterile gauze or cotton, the neck of the ampoule is broken in the gauze—an easy procedure—the mouth of the ampoule is carefully exposed, and the contents are drawn out with a syringe that has previously been sterilized by boiling. Dr. Schönbeck has made interesting experiments 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 the sterile solution was not previously sterilized. In all cases the solution was found to be infected. It remained sterile only when carefully manipulated after the above-indicated method.

Grades of Concentration of the Solution.—The ampoules are furnished in four strengths, viz., solution 1, the weakest, 0.5 per cent. novocain with but one-half of the customary suprarenin admixture, *i. e.*, ½ drop from the standard pipette in 1 c.c.; solution 2, being a 1 per cent. novocain solution with two-thirds of the usual suprarenin admixture (2 drops in 3 c.c.); and the 1.5 normal solution, with the usual suprarenin admixture (1 drop from the standard pipette in 1 c.c.).

Solution 4, Producing More Pronounced Anemia.—Besides these solutions, upon repeated requests a solution 4 has recently been kept in stock, containing a larger dose of suprarenal extract. In extended surgical operations, in which greater anemia is desirable for the sake of easier control of the field of operation, local mucous anesthesia is induced in the region to be operated upon. For this purpose solution 4 is employed, which consists of the 1.5 per cent. normal solution with an admixture of more suprarenin (3 drops of 1 to 1000 synthetic suprarenin in 2 c.c. of solution) without involving greater risk of intoxication. This risk is successfully minimized by application of the stasis bandage, which will be described below.

This scale of novocain dosage as described is fully endorsed by Bolten-Husum: "The opinion that different medicaments are required in different cases must be contradicted. Not a different medicament, but a different concentration must be selected. The widely reticulated spongiose tissues in children require a weaker concentration than do the tissues in adults. Dentinal anesthesia, extirpation of a vital pulp, tooth extractions, pericementitis, etc., all require special consideration in regard to selection of the concentration and quantity of novocain and suprarenin to be injected."

Tablets Contraindicated.—Tablets cannot be recommended owing to the inconvenience of dissolving and boiling the same in each case; moreover, great care is necessary in order to keep these tablets sterile. The prepared novocain-thymol solution in ampoules recommended above permits of considerably easier manipulation, and its absolute sterility is guaranteed.

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

It was a matter of great importance to find an effective and reliable method of sterilization for these tablets, and Braun, after renewed experiments, soon arrived at a practical result. He recognized that the source of the contamination of suprarenin solution invariably lies in traces of alkalies which are found in these solutions, and are due partly to the alkaline glass, partly to other causes. In a non-alkaline glass which has been previously treated with hydrochloric acid, suprarenin solutions can be boiled in absolutely non-alkaline sodium chlorid solution or in non-alkaline distilled water, or sterilized in steam, the solution retaining its color and its 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 a lot of soap and soda are used, it is impossible to entirely prevent alkaline traces from getting into the solutions· this difficulty, however, can easily be overcome by other means.

To one liter of the physiological salt solution to be used in dissolving the tablets, 2 drops of dilute hydrochloric acid are added. Solutions of 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 physiological 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 vessels employed, and which invariably remain in the syringes and the needles that have been boiled in soda solution, even if these instruments have been washed in water or sodium chlorid solution." (Peukert.)

In operations in the mouth Braun employs in 25 c.c. 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 up to 150 c.c., containing 0.00096 gram suprarenin, could be safely injected, viz., more than the maximal dose of 0.5 mg.

Ampoules Preferable to Tablets.—For dental practice the tablets do not seem as suitable as the always efficient and sterile ampoules. In the first place, the preparation of the solution is troublesome and successful only if carried out with most painstaking accuracy. In the second place, no tablets with suprarenin admixture, owing to the well-known chemical instability of suprarenin, keep for any length of time, consequently the action of the solution is uncertain. For these reasons we prefer the ampoules in every respect, especially since they are sold in the various concentrations of the normal solution, and can be procured fresh. These ampoules in our experience keep unaltered and sterile for over three months.

Preparation of the Solution.—The injecting solution requires most careful sterilization. Dr. Schönbeck boils the prepared solution for ten minutes, leaves it standing in an aseptic environment for twenty-four hours, and boils it once more for ten minutes on the second or third day, in order to surely destroy any bacilli that might have entered in the meantime. Experiments have shown that occasionally, although rarely, after one single sterilization of ten minutes, cocci were present in the solution, although it had been hermetically sealed in the ampoules. Since the solution is being repeatedly sterilized by heat, the contents of the ampoules remain invariably sterile, as continued bacteriological control tests have shown.

Stability.—The date of manufacture of the solution should be marked on every ampoule, so that there can be no doubt as to the age of the solution. It can then be kept with perfect safety in the manner indicated up to four months, and probably longer. Despite the admixture of suprarenin, no discoloration occurs after several months; the permanent sterility of the solution is further increased by the admixture of 0.05 thymol in 100 c.c. of solution.

Composition.—The 1.5 per cent. normal solution consequently is identical in composition with the solution which we had indicated as being fully efficient and stable as early as 1906, our formula being:

Novocain	0.75
Sod. chlor.	0.45
Thymol	0.033
Sterilized distilled water	50.0

which is equal to Buente and Moral's solution produced by the physico-chemical method. Only the addition of sodium chlorid has since then been more accurately determined at 0.46, following more recent investigations. Since the admixture of thymol does not in the least impair the isotonia of the solution, or in the concentration of 0.033 produces any hemolysis, we have approximately retained the original admixture of thymol in the normal solution (0.025). It should be emphasized that the solution in its present concentration serves all purposes, and that failures in its use are to be attributed to neglect of one of the numerous contributory factors.

Factors Affecting the Successful Administration of the Injection.—Cases of failure are not to be attributed to the solution only. It is well known that a great many factors, all differing in their special effects, contribute to a complete success of the injection To mention only the chief ones: The solution, the glass container, the syringe, the needle, and the field of operation should be most carefully cleansed and sterilized. The time of waiting for beginning the operation proper must be correctly calculated from a consideration of the normal and pathological anatomy of the field of operation; and last, but not least, the technique in each case must be carried out in such a manner as will most fully guarantee success in every respect. The diversity of opinions concerning injection is not at all surprising, since, owing to the complicated nature of this procedure, failure to comply with one minor requirement impairs the effect, and may produce partial or total failure, which is then usually attributed to the anesthetic agent or solutions thereof.

The Normal Solution.—The normal solution, which has been definitely adopted after a series of experiments by the writer's former assistants, Buente and Moral, is composed as follows:

Novocain	1.5
Sod. chlor.	0.92
Thymol	0.025
Distilled water	100.0

Bottles.—For busy hospital clinics the use of ampoules is too expensive, so that, in our opinion, it is advisable to prepare, before consultation hours, a large quantity of solution from the stock solution and to add the suprarenin. We are using large bottles containing 50 c.c. of novocain solution, drawing off 5 c.c. for each case with the graduate, and adding 5 drops of synthetic suprarenin with the standard pipette (see Fig. 4, No. 6). In this way each injection can be individually prepared to the most minute detail; a smaller amount of suprarenin, for instance, is added to the solution in patients affected with heart disease, or in children, thus effectually avoiding intoxication.

So far the solution has proved its ideal action in numerous and most difficult cases, and must be regarded as perfect in every respect, fulfilling all scientific requirements theoretically as well as practically. The osmotic pressure of this solution is identical with that of the tissues, producing no hemolysis of the red blood corpuscles or tissue lesions. By the avoidance of all tissue lesions and by careful disinfection of the point of injection with weak tincture of iodin, edemata which used to occur frequently after injection have been done away with almost entirely, which is another proof of the superiority of the normal solution advocated. In adults with normal constitution the 1.5 per cent. solution guarantees perfect success. The same is to be said of considerably weaker novocain doses in weakly individuals and children. In such cases even a 0.5 per cent. novocain-thymol solution has proved efficient, the toxicity of this solution being correspondingly smaller than that of the 1.5 per cent. solution. One of the greatest advantages of this relatively harmless local anesthetic is that even the weakest patient can be relieved of pain. Although the 1.5 per cent. novocain solution is quite well tolerated by patients of reduced resistive power without untoward effects, it is important to know that the same effect can be produced in weakly patients by a much weaker novocain dose, hence the dose may be varied according to the physical condition of the patient, greatly to the advantage of his general health. Individualization, therefore, which in general medicine is being more and more strongly emphasized in regard to therapeutics, is no less a postulate in dental local anesthesia.

Braun's Latest Experiences with Novocain and its Solutions.—The most enthusiastic champion of novocain solution, Braun,[1] of Zwickau, published last year a comprehensive treatise on the employment of novocain in surgery. From this work it appears, beyond doubt,

[1] Beiträge zur Klinischen Chirurgie, 1910, F. Peukert, Further Contributions to the Application of Local Anesthesia and Suprarenin Anemia.

that novocain is most extensively used in major surgery, especially in small doses, viz., 0.5 per cent. and 1 per cent. solutions.

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 anesthetizing 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. solution 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 in abscess of the brain, *i. e.*, suspected abscess, and in one case removal of a bullet from the brain, were performed under local anesthesia. 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 minimal 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 suppuration in the frontal and the ethmoidal sinuses. All operations of the frontal sinus can be thus performed, 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.

"Braun prefers local anesthesia even in resection of the maxilla, as by the introduction of suprarenin the intensity and duration of the anesthesia are sufficiently guaranteed. Moreover, by inducing scopolamin slumber, we are enabled to do away with the unfavorable psychic impression of the operation upon the partially anesthetized patient.

"The anesthetization of the superior maxillary nerve in the sphenomaxillary fossa has been accomplished in 5 cases successfully and without any difficulty. The point of injection lies closely posterior to the inferior palpable process of the malar bone, whence the needle is advanced inwardly and upwardly, its point immediately back of the zygoma reaching the maxillary tuberosity. Gently palpating along the surface of the latter, 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 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 treated under 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 non-obstruction of the oral 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 equivalent to general anesthesia, but far superior."

In the tongue also major operations can be performed under local anesthesia. Braun undertook even more complicated operations, performing extensive extirpations of glands, temporary separation of the maxillæ, and removal of maxillary fragments under local anesthesia. The anemia produced greatly facilitates the technical execution. 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 and thus unsuitable for extensive clinical practice, which, however, is not true. 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 after all. The operations were thereby prolonged unduly, and the patient as well as the operator received most disagreeable impressions. Not so with the modern method of local anesthesia. All injections are made before the operation, if desirable even before sterilizing 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 preparation requires but a short time if sterile gloves and long-sleeved sterile operating coats are worn. In the meantime the field of operation is sterilized. If the operation is begun after from eight to ten minutes, complete anesthesia will have been established. In large surgical institutions the saving in assistants and anesthetists is a considerable one.

"Since the patients retain their consciousness, and a continual conversation between operator and patient can be carried on, disturbing movements of defence, 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." (Peukert.)

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 these views. 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 [cocain] are, of course, still being sold by supply houses as long as there is a demand for them." This proves that our demand to substitute novocain for cocain is fully justified and requires no further arguments.

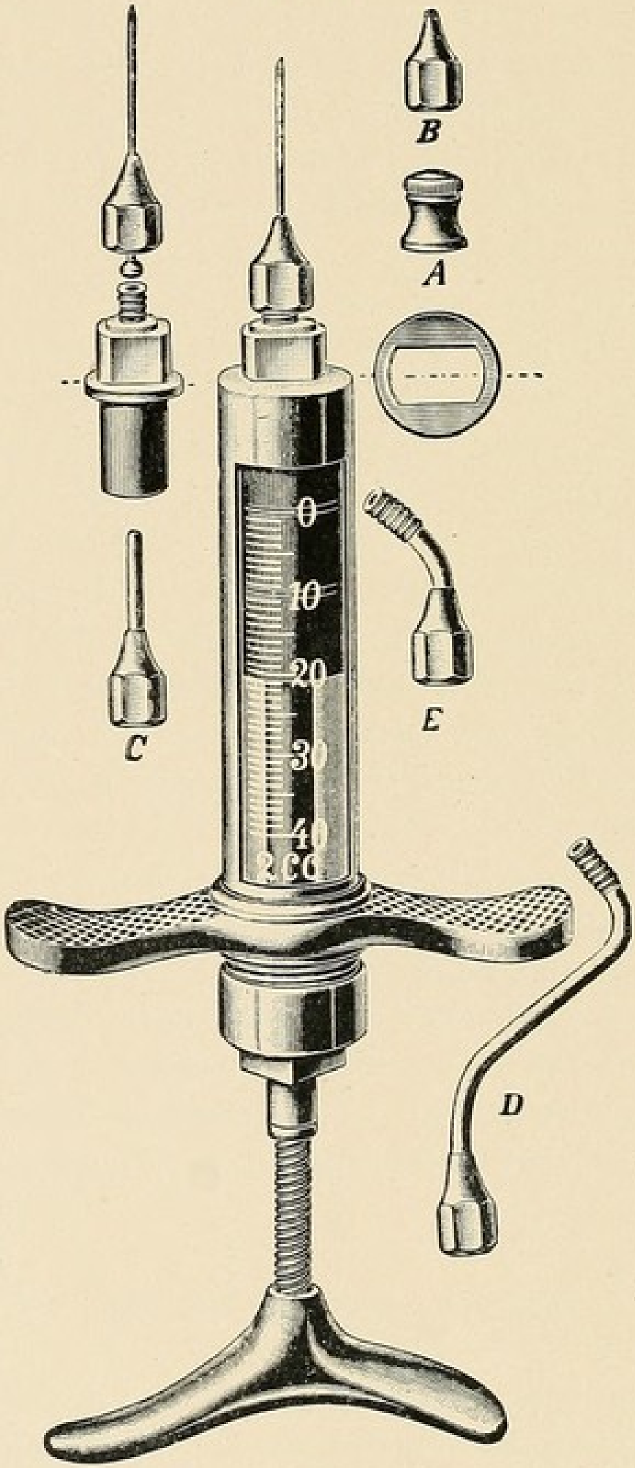
On the other hand, the investigations of Braun show that a considerable reduction in the concentration of the novocain solution is indicated for local anesthesia. In the normal solutions Nos. 1, 2, and 3, as above recommended, this requirement has been taken into account. Just as Braun has produced remarkable results with a 1 per cent. novocain solution, so do solutions ranging from 0.5 to 1.5 per cent. when adapted to individual cases, guarantee full success in dental practice, depending, of course, to a great extent, upon the technique of injection and the cautionary measures employed.

INSTRUMENTARIUM

For injection anesthesia such an instrumentarium must be selected as will fully comply with all modern rules of asepsis, and can be subjected to any form of sterilization, especially boiling.

The Injection Syringe.—These requirements have always involved the greatest difficulties in this most important instrument, because

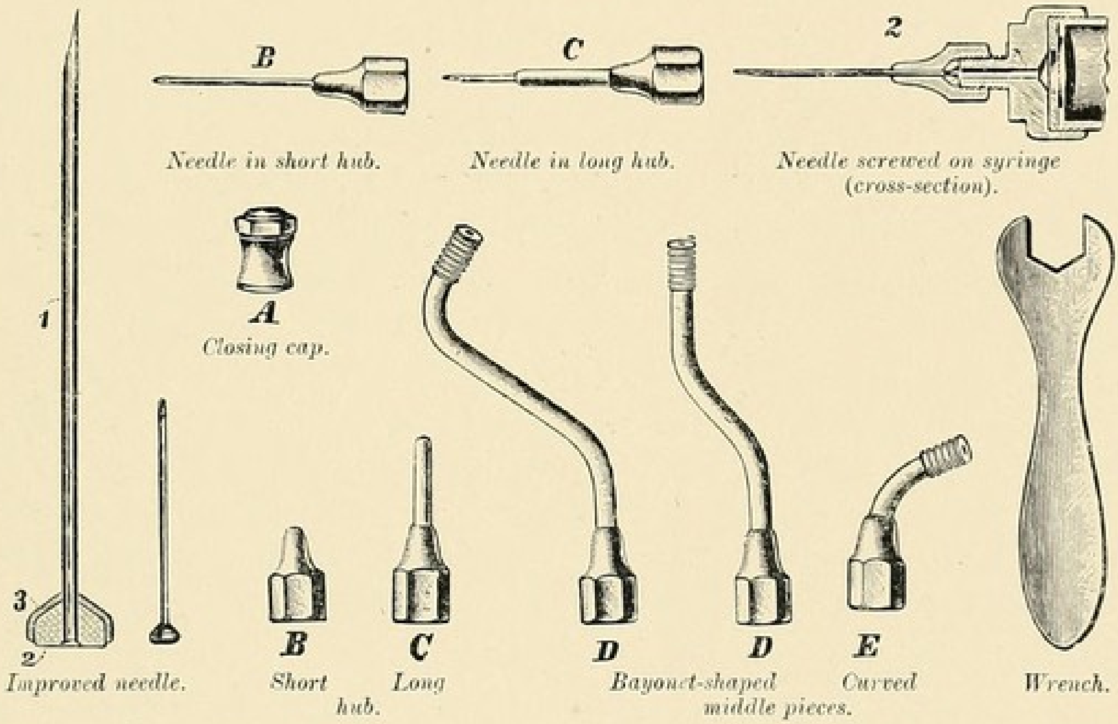
FIG. 1



Injection syringe of glass and metal, designed by Dr. Guido Fischer. (For explanation of lettering see Fig. 2.)

leather-piston syringes, the most tightly closing, must not be exposed to steam, while the glass-and-metal, all-glass, or all-metal syringes never possess an hermetically fitting piston. After examining a great

FIG. 2



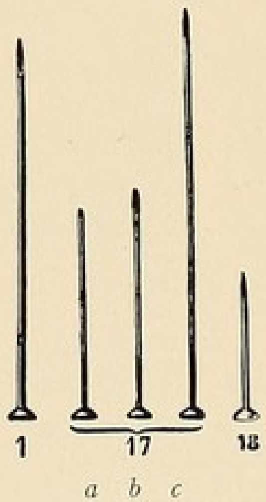
Needles, hubs, and wrench for injection syringe, designed by Dr. G. Fischer. At the left is a considerably enlarged reproduction of the new needle showing the details of construction as follows: 1, the hollow needle, either of seamless steel, pure nickel, gold or iridio-platinum; 2, body of soft metal 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 styles of 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 if 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 easily to manipulate the hubs, which heretofore were milled, the hubs *B* and *C*, also the middle pieces *D* and *E*, 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.

number of models, we have finally, with the assistance of Freienstein, of Berlin, designed a syringe which seems to fulfil all the necessary requirements in every respect.

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 (Fig. 1). The entire outer surface of the syringe is uniformly round and smooth, and the hubs *A* to *E* are tightened with a wrench (Fig. 2). The metal piston is made accurately and fits tightly in the glass barrel, ending 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 easily be shortened or lengthened. To produce the pressure necessary for injection, two wing-like, strong, and milled finger rests are applied, being a little smaller in the 1 c.c. syringe than in the larger size.

Fig. 3



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 model is made in two sizes, the one syringe holding 1 c.c., the other 2 c.c. 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 the required tightness decreases. It is best always to keep three or four syringes of both sizes in stock.

Hubs.—The syringe is sold with various smooth hubs (Figs. 1 and 2, *B* and *E*), which are employed according to the place of injection. The closing cap *A* is used to close up the barrel after use.

Needles.—For our purposes the needles No. 17, with short points (Fig. 3), are employed. The needles Nos. 1 and 18 in the same illustration are suitable for special purposes; No. 1 (diameter 0.9 mm.) for mandibular anesthesia as preferred by Williger, No. 18 for periosteal injection, where a specially short needle is desirable.

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, which are indispensable in anesthesia of the bony tissue (Fig. 3). Long-drawn-out needle points are not suitable, as they easily get stuck in the periosteum and bone, break or bend, and cause complications. Since, however, in mandibular anesthesia the needle is to be advanced along the bone, we prefer needle No. 17 to No. 1, especially since the orifice of the latter needle may cause a too rapid and abundant 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 (Fig. 2, No. 2). The cone of soft metal is protected by a hard metal case of heavily gilded copper; it is open below, whereby, even under firm pressure, flattening of the soft metal cone and sticking of the needle in the hub are prevented, also the exactly central position of the needle is insured, preventing all possibility of leakage, all of which constitutes a great advantage (Fig. 2, left).

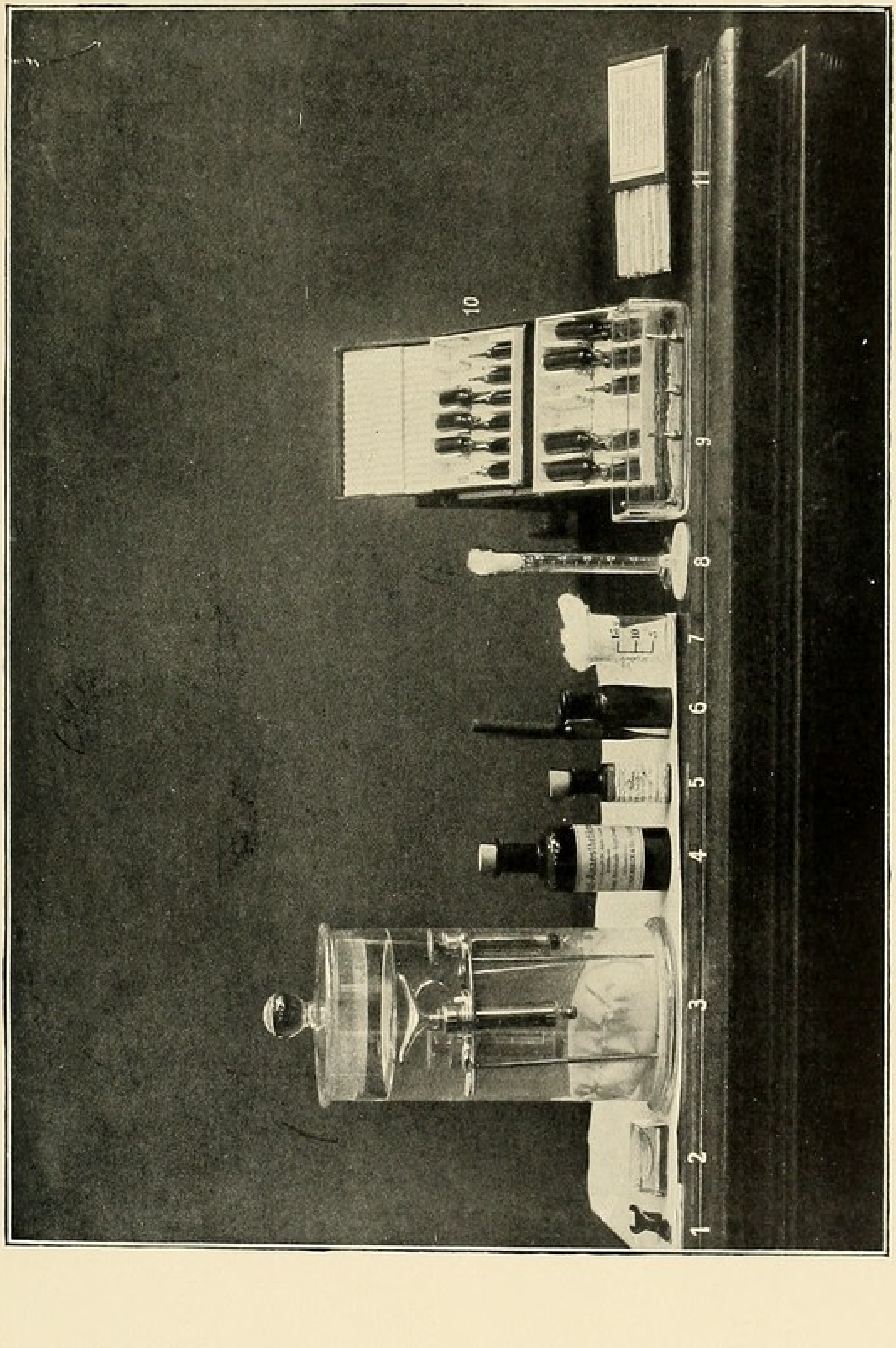
Treatment of the Needles.—Whenever possible, new needles should be used, since steel needles that have been used and have not been perfectly dried rust readily and break easily. After repeated use the needle becomes dull, and is then unfit for our purposes. Our plan is to use a needle for one day's work only, and then discard it. After each using, the needle is placed in a bottle containing absolute alcohol, the bottle is shaken, the needle removed, and the needle canal vigorously blown out with the air syringe; a wire is then introduced, and the needle laid in a dry test-tube until the next injection. Before injecting, the needle is screwed to the filled barrel and sterilized by immersing for one minute in boiling water.

Treatment of the Syringe.—The syringe is best kept in a tall vessel filled with absolute alcohol. Alcohol is bactericidal, does not attack the metal parts, and evaporates as soon as the syringe is removed. After use, hot water is drawn into the barrel several times, the closing cap *A* is screwed on the ferrule (Figs. 1 and 2), the syringe is dried carefully and preserved in absolute alcohol (Fig. 4, No. 3). In order to preserve the alcohol at full strength, we lay on the bottom of the hermetically closing jar with ground-glass cover a small linen bag (Fig. 4, No. 3) containing annealed copper sulphate in white powder form. This chemical absorbs the water introduced into the alcohol from the atmosphere and the syringe, and keeps it relatively anhydrous (about 99 per cent.), until the copper sulphate in the bag has resumed its natural blue color.

Ampoules.—If ampoules are employed (Fig. 4, No. 10) no further instrumentarium is required. In a sterile napkin the neck of the previously sterilized ampoule is broken, and the injecting liquid is drawn into the syringe through the mounted needle. Shortly before this the needle is boiled in water that contains no soda, thereby fulfilling all reasonable requirements of asepsis. Novocain is precipitated in water that contains soda, therefore the water used in boiling the needle must be pure.

Preparation of the Solution for Injecting.—Though less convenient, yet more suitable if larger quantities of injecting solution are required, is the method of adding the suprarenin to the novocain solution shortly before use. In Fig. 4, Nos. 2 to 9, we have assembled the apparatus required for this purpose. The dark rubber-stoppered bottle (No. 4), which holds 50 c.c., contains the novocain-thymol solution, the small suprarenin bottle (No. 5) contains 5 c.c. of 1 to 1000 synthetic suprarenin, which is withdrawn by the finely pointed standard pipette (No. 6, fastened to the bottle). Generally the novocain solution is mixed in a long and narrow graduate (No. 8) holding 5 c.c. We prefer, however, a short and wide glass (No. 7), because from this the solution can be easily withdrawn, while in a long and narrow graduate only the long needles reach deeply enough, and the graduate has to be inclined in withdrawing the liquid. After mixing the solution the

Fig. 4

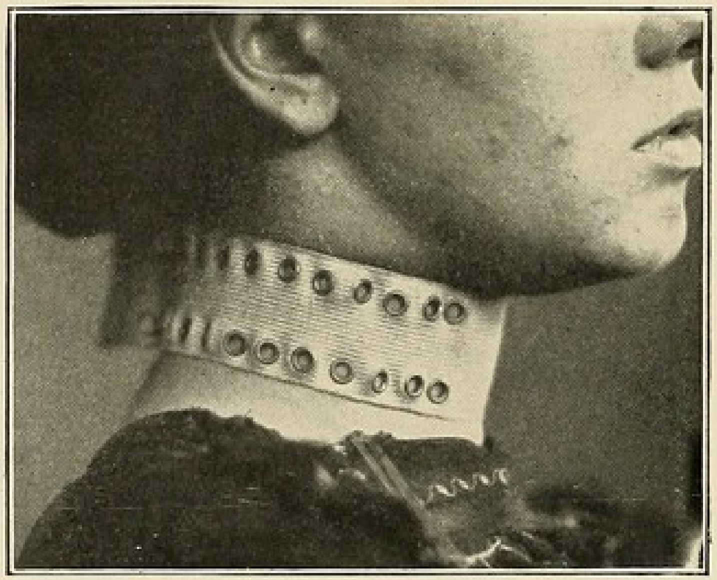


Assembled instrumentarium for injection: 1, wrench for syringe; 2, glass tray; 3, glass jar filled with absolute alcohol, containing metal stand for syringes; 4, novocain-thymol solution; 5, synthetic suprarenin, 1:1000 in original package; 6, glass for pipette and normal pipette; 7, broad measuring glass; 8, small measuring glass; 9, glass tray with alcohol for hubs; 10, ampoules containing 1 and 2 c.c. of solution; 11, needles.

graduate is closed with a cotton wad. The hubs and wrench (No. 1) are kept in a glass tray filled with absolute alcohol (No. 9; the cover is removed).

Small quantities of solution are mixed in the small glass tray (No. 2), which holds 3 c.c. With the exception of the original bottles of novocain and suprarenin, which are filled under aseptic precautions, and therefore require no further disinfection, all instruments should be sterilized by steam, according to the necessary hygienic requirements. Freshly mixed open solutions should be used up as fast as possible. After a short time (from one to two hours) the solution assumes a reddish discoloration, and should then no longer be used, even though it be still effective. A liberal use of fresh solutions is advisable, as economy in this respect or in the use of needles is ill-advised.

FIG. 5



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. 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 (Fig. 5); deep red or blue coloration must be avoided. This bandage produces stasis of the carotid arteries, thus rendering cerebral anemia less likely to occur, retaining the anesthetic in the desired field for a longer period, and still further retarding absorption. 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 lessened. The hyperemia which follows stasis, and is always favorable, seems advantageous for the healing process of wounds. This hyperemia is never pronounced enough to produce hemorrhage, but ranges within moderate physiological limits. For the formation of clot in the wound, the hyperemia following the removal of the bandage is of incalculable value, preventing, as it does, disturbances in the healing process, postoperative pain, necrosis, etc., which often follow excessive anemia. Normal circulation is rapidly reëstablished. So far, this stasis bandage has proved very successful.

DISINFECTION OF THE FIELD OF OPERATION

Disinfection of the Mucosa.—Not only are the instruments and the operator's hands to be sterilized before injection of a local anesthetic, but the oral mucosa, which is always infected, must also be most thoroughly and carefully sterilized. Among disinfectants, iodin occupies a predominant place. Disinfection with iodin (iodo-benzin) plays an important part in modern surgery, hardly any incision in the epidermis being made without previous swabbing with iodin. This antiseptic not only possesses deep 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 well known." 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 impedes bacterial growth. Lewy justly emphasizes that the tanning of the mucosa is an advantage "facilitating 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.

Application of Iodin.—The painting with iodin is accomplished not merely by 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, and the injection then made.

Sterility in Injecting.—As the injection generally precedes surgical intervention, it plays a part in the subsequent healing of the wound. For this reason, even in a very minute injection, full attention must be paid to sterility, 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.

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 inducing anesthesia. 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. 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 anesthesia with ethyl chlorid, which may be used to advantage for producing analgesia in pericemental diseases of the anterior teeth. Many practitioners apply the ether spray, especially in children, for the production of brief anesthesia. 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 when the thermocautery is used, owing to the danger of fire.

Drugs for Injection.—The danger from injected drugs is comparatively greater, first, because the toxic effects of anesthetizing solutions may be variable; secondly, because the injection may be followed by untoward sequelæ. The employment of excessive doses of anesthetics, also any idiosyncrasy on the part of the patient, may produce serious intoxication. If, however, the operator has judged correctly the character of the surgical intervention, the resistive power of the patient, and the maximal dose, *i. e.*, the specific toxicity of the solution, no accidents are ordinarily to be expected if strict asepsis has been observed.

Local Action of Novocain.—Locally the novocain solution recommended involves no risk of tissue lesions whatever. Even when employed in large quantities, this drug behaves innocuously, and is very well tolerated by the tissues. Necrosis used to occur when high per cent. cocain solutions 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, the fragment sometimes disappearing so rapidly in the mucosa that it cannot be found again. These accidents have been increasing in number since the introduction of conductive anesthesia, generally in mandibular injection. In our opinion, very frequently, lack of technical skill and unfamiliarity with the correct method of procedure are responsible. Only new needles, if possible, or those that have been used but a few times, should be employed.

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, and in all such cases, therefore, an attempt should be made to remove it, determining its location by an *x*-ray photograph, and, if necessary, having it removed by a surgeon.

Idiosyncrasy.—Without any fault of the operator, intoxications are sometimes caused by idiosyncrasies, indisposition, and reduced power of resistance in the patient. It is hardly possible to know or diagnosticate, in advance, the patient's disposition to react abnormally to certain drugs. There are persons who do not tolerate cocain and exhibit grave toxic symptoms even after the minutest doses. Others, again, are indifferent to large doses, and do not exhibit the desired anesthesia. Still others who do not tolerate alypin, for instance, react perfectly normally to other salts, as, for instance, 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 assume a threatening color of the face. In doubtful cases small quantities and weak doses should be employed at the start.

Shock and Collapse.—Shock is of great importance during anesthesia. The psychic shock is invariably greater in local than in general anesthesia, the patients imagining that they are to undergo an operation while fully conscious. Hysterical and highly nervous patients are difficult to persuade 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 contraindication 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. Even the slightest pain on introducing the needle may suffice to produce syncope or serious collapse.

In nervous patients of low resistance and in those without self-restraint or courage, special persuasion is required to dissipate all fear before the operation. Herein only that operator will be invariably successful who, by his skill, training, and familiarity with the method of procedure, is capable of fully keeping his promise. It is, therefore, a great mistake for an operator to guarantee full success before the operation, since, in case of failure, he undermines his reputation. Besides being most unprofessional and unscientific, such a guarantee is more apt to arouse 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, from 5 to 7 drops of camphorated validol in a little water are given internally; in more serious affections amyl nitrite, from 1 to 3 drops on a napkin, may be inhaled.

Validol is a colorless liquid of mild, agreeable odor and refreshing taste. It consists of menthyl ester 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 water, constitutes an ideal analeptic in serious cases of collapse.

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

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

Injections may involve two further unpleasant accidents, namely, postoperative pain and hemorrhage.

Postoperative Pain.—Postoperative pain is often due to purely accidental conditions of the wound, *i. e.*, remaining sharp alveolar splinters, sloughing of the margins of the wound, insufficient bleeding 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 normal sooner or later, yet from personal experience we feel certain that after a correctly performed injection no postoperative pain is to be expected. If all the necessary precautionary measures have been observed, even severe periostitic processes behave normally after the effect of the anesthetic has worn off. In such cases, for the sake of prophylaxis, we invariably prescribe cold compresses, which have proved most useful.

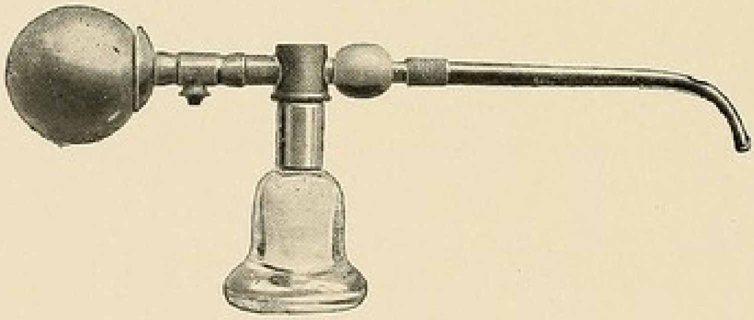
The greatest mistakes are made in regard to asepsis—for there are still many operators who make an injection without having previously disinfected the mucosa. By simply swabbing with iodin, as described above, the great danger of infection, frequently followed by edema, is avoided.

A. Cohn, of Berlin, reports an interesting case 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 after, postoperative hemorrhage occurred, with a sensation of heaviness in the left limb. The hemorrhage was readily stopped. 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 when 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."

Postoperative pain after injection is of psychic origin in many cases, as Cieszynski has pointed out. His assertion, however, that after-pain most frequently follows pulp treatment under anesthesia cannot be maintained, since the normal solution always yields a most favorable result.

Therapeutic Measures in Postoperative Pain.—Postoperative pain is counteracted therapeutically by internal administration of aspirin or pyramidon (0.5 gram per dose). In wounds, tamponing with novocain, as has been indicated, renders surprisingly good service. In all cases of inflammation of wounds novocain powder is applied. The cavity of the wound is carefully cleansed and sterilized with hydrogen peroxid and a 10 per cent. aqueous solution of chlorophenol, 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 conveniently employed a powder-spraying syringe, from which, on compressing a rubber bulb, pure novocain is blown through a hard rubber tube which is held close to the wound (see Fig. 6). This procedure, consisting of disinfection of the wound and novocain tamponade, is repeated every twenty-four hours, when the healing of the wound can be left to itself without any further therapeutic aid. (See chapter on Anesthesia in the Therapy of Inflammation, p. 97.)

FIG. 6



Syringe for spraying novocain powder.

In cases of severe inflammation with general depression due to pain from pulpitis and pericementitis, doses of morphin internally are warmly recommended, especially 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 the pronounced sedative effect of this dose, the wound heals better and with less reaction under the protection of anesthesia, hence anesthesia plays an important role in the therapy of inflammations (see p. 97). Its extensive application is specially indicated in dentistry, and strong emphasis should be laid upon this excellent method. With this therapy by anesthetization in view, the writer compounded his arsenic paste, which contains arsenous acid, novocain, āā 4.0; thymol, iodoform, āā 0.5; glycerin, chlorophenol crystals, āā enough to make a paste; to be incorporated in asbestos fiber. This paste has proved most efficient as tested by many practitioners.

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 tamponade. A normally bleeding wound, however, should never be dressed with tampons. Novocain tamponade is only superficial, the formation of granulating tissue or blood clot in the fundus of the wound not being inhibited.

All in all, the complications that may arise during or after local anesthesia are far less numerous and not as serious as those involved in general anesthesia; consequently, the prognosis in the latter is far more uncertain and unfavorable than in local anesthesia. In this point also the writer's view fully coincides with that of Braun.

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 advanced technical and scientific education, which can be acquired only by practice and experience.

The operator's duty is specially serious owing to the fact that he has to anesthetize as well as to operate. For as the extent and the depth of the anesthesia can be calculated only by the one who has induced it, it therefore seems imperative that the operator himself should make the injection. Of course, his duties are thus much greater than if he performs an operation under general anesthesia. The anesthetist, therefore, must possess great technical skill and ability, circumspection, clearness of observation, and presence of mind, coupled with wide experience and enthusiasm.

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

It is imperative not to leave in the waiting room by themselves or without supervision locally anesthetized patients who have to wait for some time before the operation, but to observe them continually.

The following alarming case has been reported to the writer: A practitioner had induced novocain-suprarenin anesthesia in the maxillary mucosa of a lady who had but just recovered from influenza. Two c.c. of the solution had been injected. After injecting, the operator left the surgery for the laboratory in order to remove the needle, it having stuck firmly in the syringe. Upon returning after not more than one minute, he saw, to his astonishment, the patient in a helpless condition, having fallen back in the chair and being 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 entirely insensible patient from the chair, and laid her on the floor. Respiration ceased, and artificial respiration was induced, which proved successful after about two minutes. The patient recovered relatively quickly after cold cloths, fresh air, and amyl nitrite had been applied, and despite the serious character of the collapse was able to be sent home by carriage after one hour.

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

Anamnesia.—The operator, before inducing anesthesia, must examine the patient's heart, lungs, and nervous condition. The dentist in many cases will be able to gather from an accurate anamnesia the information necessary for making his dispositions, individually gauging the dose to be injected, calculating the time of waiting, etc.

Harmlessness of the Normal Solution.—In some cases it may be difficult to decide whether local anesthesia should be employed at all, or whether general anesthesia would be more favorably indicated. In arteriosclerosis and nephritis great hesitancy has been entertained in injecting anesthetizing solutions, in the former owing to the altered condition of the vascular walls, which often do not tolerate even a moderate change in blood pressure as produced by suprarenin, in the latter owing to the danger of intoxication involved in the passage of the anesthetic through the diseased kidney. Every anesthetic is absorbed by the blood and excreted by the kidney, which is, however, a harmless process when normal doses are employed.

The weak 0.5 and 1 per cent. novocain-thymol solution with the small addition of suprarenin must also be regarded as an agent which in such cases, even in diabetics, renders excellent service and involves no danger for the life or health of the patient. Cocain solutions, even the weakest, cannot be cautioned against too urgently. These statements are fully corroborated by Braun, who has collected convincing evidence from a great number of clinical cases (see p. 39).

From these observations it appears that the anesthetist has a great responsibility toward the patient, as he is liable for every damage, even the smallest, inflicted upon the patient by his negligence. Thus in local anesthesia fulfilment of duty must be of prime consideration, and the operator's conscience must be clear in regard to his perfect mastery of the science and technique of anesthesia.

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 noted before inducing local anesthesia. Such a record is the best proof for the operator's conscientiousness, and is always of decisive importance in legal proceedings.

ACCIDENTS AFTER NOVOCAIN INJECTIONS

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

Narcotic Slumber after Novocain.—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 were employed, to which, immediately before injecting, 3 drops of fresh synthetic suprarenin in 1 to 1000 solution had been added. The injection, as in all patients of strong constitution, was completed without notable 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, and in the meantime two upper cavities on the same (left) side were to be excavated. Very soon after the injection (after about one minute) the patient noted considerable numbness in the entire left mandible, similar to that produced by conductive anesthesia, and five minutes after 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, a slight acceleration in pulse occurring for some two or three minutes, whereupon the patient lapsed into a condition of half-slumber (sopor or coma), and seemed to have difficulty in keeping the mouth open for the preparation of the defective upper teeth. Pulse and respiration soon resumed their normal functions, and the woman gave the impression of a person comfortably sleeping. As in hypnotic sleep, she answered every question, and rinsed, opened and closed her mouth, in short followed all directions, without, however, opening her eyes or realizing what she was doing. The upper cavities, which had been excavated without any pain, despite close proximity to the pulp, were filled with amalgam after inserting a protective layer. 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 with a start, opened her eyes and, according to directions, vigorously rinsed the mouth. From this moment she appeared as if changed, acted perfectly normally, and stated that a pain as from pressure had suddenly startled her. She still felt the numbness in the left mandible, and was almost ashamed when told of her having slumbered. She boasted of always having had an exceptionally strong constitution, and, as if to excuse herself, mentioned that her system always reacted with extraordinary readiness and intensity to any medicament. To this peculiarity she ascribed the light 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. The patient left in normal possession of her senses and feeling quite well, nor did she experience any further sequelæ.

In the writer's opinion, in this case a brief "hypnotic" slumber occurred, due exclusively to the action of the novocain and the unusual susceptibility of the patient's system. 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 during such a slumber ensuing 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 lady'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,

6

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 left radialis region." After about one-half hour's general malaise, normal comfort was reëstablished.

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 with pure novocain-thymol solutions. Liebl also emphasizes that no change in pulse and complexion was noted.

At any rate, it is interesting and important 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 one whose organism, as in the case reported, seems to react even to the lightest chemical stimuli, and in which the protoplasm must be extremely sensitive, requires an individual maximal dose of novocain far below the heretofore accepted one, although in the case reported a larger dose than the mean was injected. 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 employed in its introduction. If introduced into the blood suddenly, or in concentrated solution—in our own 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 the dose of novocain in the capillaries of this organ at no time exceeds the toxic dose."

Klein also claims to have observed pronounced symptoms of intoxication from novocain in 5 cases, 3 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 2 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 2 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 the writer's own experience with the use of novocain, now extending over a period of six years, he 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 tolerable and insignificant 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 "surely possesses extremely favorable properties, if, like novocain, it 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, in a 10 per cent. solution at body heat, and only in the high dose of 0.75 gram, as Liebl definitely established, which is never employed in local anesthesia. Even 0.4 gram of a 10 per cent. solution produces no toxic symptoms." Thus cases of intoxication from novocain are very exceptional, and no great importance can be attached to them, since the vast majority of experiences with this drug have been extraordinarily favorable, as Klein fully acknowledges.

Personally, in a practice comprising over 15,000 cases, the writer has not had a single serious case of intoxication after injection, while he will ever remember the grave accidents after cocain injections. Nevertheless, the few interesting observations of abnormal action of novocain emphasize the old experience that individual discrimination must be made in the employment of every drug, and must positively be reckoned with in all cases. Cocain, moreover, readily produces general disorders, and is known to be responsible frequently for local processes of gangrene in the injected tissue, especially if the solution is not absolutely pure. Such processes have never been noted after novocain, injections of which are followed by postoperative pain only in extremely rare cases, while with cocain this is almost the rule.

Hysterical Attacks after Novocain.—Several cases of hysterical attacks 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 patient was subject to hysteria, which broke out under the added stimulus of novocain injection. In the last case reported, the patient had formerly taken novocain and had tolerated it well, which proves that the novocain had produced no specifically toxic effect, but was merely the final contributing factor to a long preparing new hysterical outbreak, the predisposition to which was greatly pronounced at the time of the last injection, while during previous injections the disease lay 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." In dental disorders "the low toxicity of novocain plays naturally a most important role." (Braun.)

These cases reported corroborated what has already been discussed, namely, that even entirely harmless doses of novocain occasionally may act toxically by producing a spasm in already established nervous diseases, above all in hysteria. These spasms, however, would have been induced by any other nerve irritation. The procedure of injection and operation in itself is an unusual experience which a highly excitable patient overcomes only with difficulty, or not at all. In hysteria, therefore, as has been said before, special precaution is required on the part of the operator.

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

INDICATIONS FOR LOCAL ANESTHESIA

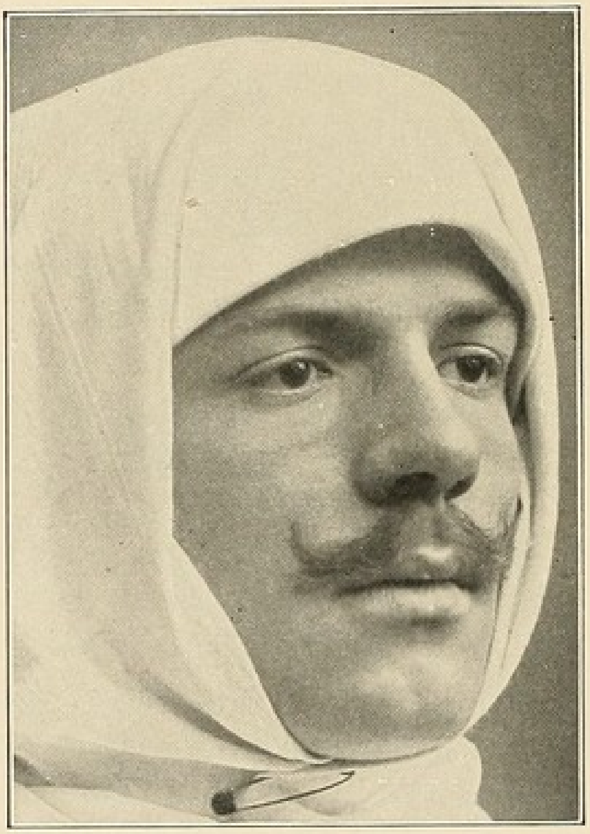
The question as to when local anesthesia is indicated cannot be solved within the limitations of this book, as it depends more or less upon the conditions presented in each individual case. For the dentist, local anesthesia offers a wide field of application, and in its present state of perfection is most favorably indicated. Dentistry, being a branch of minor surgery, should employ this method all the more, since in major surgery local anesthesia is rapidly gaining ground, and is destined to be applied in the future even almost 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. Most of these men do not sufficiently master the method of local anesthesia and do not have sufficient interest in their profession or in their patients to remedy this deficiency in their knowledge. It is the writer's firm conviction that the modern dentist should make the same progress in this special branch of his profession as he has always made in the purely technical branches.

Dental Surgery.—In dental surgery the method of injection can be employed in an infinite variety of ways, and it is needless to enter into a further discussion of this familiar field. Besides extractions, all incisions in the mucosa, resections of roots, bone chiselling, cystic operations, partial resections, extirpation of small tumors, etc., come under this heading. In all major 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. 7).

Dentinal and Pulpal Anesthesia.—Various authors have recommended the method of injection for dentinal and pulpal anesthesia. Its application in the preservative treatment of teeth is, indeed, most opportune. The principles governing the technique of anesthesia are the same for preservative interventions as those for the surgical measures described above. The purpose of injection also remains the same, *i. e.*, production of painlessness, regardless of the nature of the operation to be performed under the anesthesia.

Root Treatment under Anesthesia in One Sitting in Cases of Pulpitis Contraindicated.—The employment of local anesthesia in treating teeth with diseased pulps should be limited, as it involves various disadvantages which will be pointed out briefly here, as follows: Unless a most painstaking diagnosis of the tooth to be treated has

FIG. 7



Head protection, designed by J. Witzel.

been made, local anesthesia should not be employed; for as soon as the anesthetic begins to act, important diagnostic symptoms about the tooth, especially pain, are eliminated, and we are no longer able to secure proper definition in our work. The same is true even in simple anesthesia of the dentin.

Injection Suitable for Dentinal Anesthesia.—After it had been ascertained that no drug introduced directly into the cavity or applied to the dentin for the production of anesthesia acted with sufficient certainty and without danger to the vital pulp, experiments with injection anesthesia were conducted for this purpose. These experiments with novocain-thymol solution, in the writer's experience, have yielded such splendid results in regard to the efficiency and harmlessness of this anesthetic, that, in his opinion, the injection method is at present the best for dentinal anesthesia. If before the anesthesia the condition of the pulp has been accurately ascertained by the induction current, we can carry out our measures without jeopardizing the metabolism in such teeth, and, in some cases, fill the tooth. After the anesthesia has worn off, the pulp will exhibit a slightly reduced hypersensibility, and will soon return to normal conditions. According to Euler's and Scheff's experiments, no danger exists for the pulp, provided that the technique together with the precautionary measures have been carefully followed. It is, indeed, a blessing for highly sensitive persons to have the tormenting pain abolished which is usually produced by any attempts at excavating the dentin in their teeth.

The injection, as is well known, simultaneously with analgesia, also produces anemia, which is characterized externally by a paleness of the pulp tissue. Extreme care is therefore required in the preparation of the cavity, in order to avoid the danger of inserting a filling too closely to or directly upon an exposed pulp without protecting it, by an aseptic pulp capping, or of overlooking the initial stages of an already existing pulpitis. Such mistakes are likely to occur owing to the indifference of the pulp artificially produced by the paralyzation of the nerve tract. Death of the pulp would be the inevitable consequence of such treatment. The cocain-adrenalin mixtures which were formerly employed for the purpose of dentinal anesthesia only too often caused keen disappointment, as numerous pulps that had been anesthetized with these agents before treatment of the tooth subsequently fell victims to atrophy or necrosis. These failures were justly attributed in part to the adrenalin, and the initially higher dose was consequently more and more reduced. Cocain, which is still frequently used, possesses in itself ischemic properties which were so intensified by the formerly practised excessive addition of an adrenalin preparation that the artificial atrophy of the injected tissue was maintained for an appallingly long period of time. Unless the pulp was exceptionally strongly constituted, it was incapable of recovery, and consequently doomed to mortification. With the recommended dosage of injecting fluid, however, the process of absorption seems so greatly improved that a normal pulp is not affected thereby.

Quinin.—In highly sensitive, hysterical, or neurasthenic patients, in whom anesthesia is contraindicated, it is of advantage before the operation to administer internally doses of quinin sulphate, 0.5 gram, or chloral hydrate, 1 gram, for quieting the nervous system in preparation for the ordeal. Le Monnier, of Nizza, is said to have been the first to apply quinin in dentistry, according to his own report:

"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. The agents usually employed had no effect. Especially teeth with advanced 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 days. The same effect as in the former case was observed, and his teeth could be filled during the next sitting. The quinin seemed to affect the patients' nervousness in such a way as to reduce the sensitivity of the teeth, this systemic treatment being much more effective than the local application of caustics.

"In the same year I had occasion to treat a woman patient who exhibited the same symptoms, and again I prescribed 0.5 gram of quinin daily for two days. I was agreeably surprised to see the patient return the following morning and submit to the operation as readily as the previous patients. My experience has recently been frequently corroborated, and I believe that in quinin sulphate has been found a valuable addition to our medication, at least in nervous patients."

Chloral Hydrate.—Chloral hydrate also (from 0.5 to 1 gram) has a similar sedative effect, obtunding the brain function, reducing at the same time the sensitivity of the teeth. Apropos of this drug, Seitz reports as follows: "In 1899 a young woman, aged eighteen years, who was undergoing nerve treatment in a sanatorium, presented for dental treatment. She had had a misfortune a year previously, 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 by the slightest touch. In a year's time this hyperesthesia had somewhat abated after treatments of various sorts, yet it had remained in the trigeminal region, so that the mere touching of the teeth with the finger still caused great pain, and for the time being dental treatment could not be instituted. When, however, idiopathic toothache set in, every therapeutic means had to be tried to give relief, and, since local application of chloral hydrate was impossible, 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, one-half hour before the operation. The sensibility was actually reduced to such a degree that even the dental engine could be employed. During the operation the patient was in a semi-narcotic condition, completely indifferent, and showed not the least sign of pain. Half an hour later she was able to return to the sanatorium in a 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 sensibility, we have come to the conclusion that internal medication of this nature in suitable cases is very advantageous. Anesthesia sets in after from four to five minutes, characterized by a notable reduction in the sensibility of the dentin, which varies in different individuals. In highly excitable persons this effect is frequently noted to a remarkably extensive degree. While harmless in itself, this method has one disadvantage, inasmuch as the certainty of success is not invariably uniform. Before either general or local anesthesia, however, it is of great value, in fortifying the psychic condition in nervous patients. Bromural and its application will be discussed on page 102.

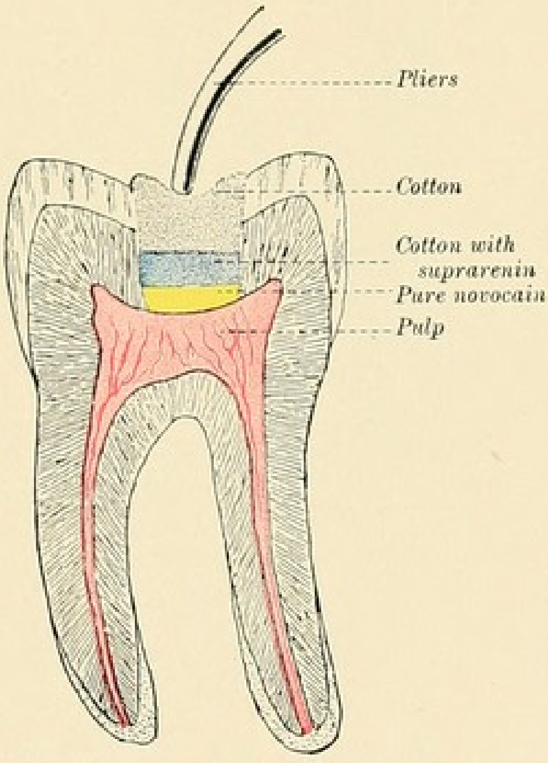
In my experience, direct anesthesia of the dentin and pulp is still an unreliable measure. For the sake of completeness I shall cite from Dependorf's[1] article a method which seems most suitable for pressure anesthesia: Griffin prefers for pressure anesthesia the hypodermic tablets No. 81, of Parke, Davis & Co., which contain 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 for a few seconds on the exposed pulp. Novocain tablets are better for this purpose. Then a piece of unvulcanized rubber slightly smaller than the cavity is laid over this pellet, and gentle pressure is exerted. 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 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 up without displacing the rubber. After from one to two minutes, when the pressure is no longer plainly felt, the rubber and cotton pellet are removed, the pulp chamber is opened, and the pulp can then be immediately extirpated without pain or hemorrhage. A repetition of the pressure anesthesia within the pulp chamber is rarely necessary. This method is most convenient in exposed pulps, though it is efficient even when the

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

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 obtaining complete anesthesia, Griffin takes from one-half to three minutes.

Anesthesia with Subsequent Preservation of Vital Pulp Stumps Indicated.—In some cases the pulp stumps in the roots may be preserved. In hypertrophy of the pulp this has been tried very successfully. In such cases anesthesia offers the enormous advantage of rendering possible the exposure and amputation of the coronal portion of a diseased pulp, the root portions of which are capable of remaining vital.

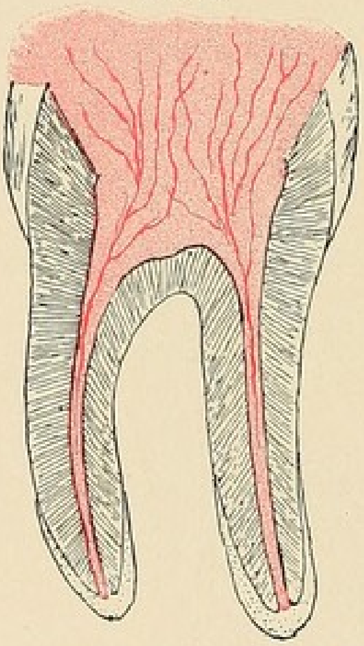
FIG. 8



Pressure anesthesia in exposure of the pulp.

Pressure Anesthesia.—Just as the method of injection anesthesia, so that of pressure anesthesia has yielded very favorable results in these cases. The uppermost portion of the pulp, which in hypertrophic pulps is almost insensible, is removed with a sharp spoon excavator, and upon the commonly profusely bleeding pulp a layer of novocain powder is dusted, over which a cotton pellet saturated with 1 to 1000 synthetic suprarenin is laid, which is finally covered with a larger cotton dressing (see Fig. 8). Then with a pair of blunt pliers or a round-head plugger, gradually increasing pressure is exerted for from four to five minutes. The coronal portion of the pulp can then be painlessly amputated. From this method very favorable results have been derived in very resistant pulps, the great vitality of which is shown by the hypertrophic neoformation (see Fig. 9). The hypertrophied portions of such pulps were amputated together with the coronal portions under local anesthesia (see Fig. 10). The carious portion of the cavity is

FIG. 9



Polypoid (hypertrophic) degeneration of pulp, symptom of great vitality of tissues.

carefully excavated with burs, and the bleeding pulp stumps are sealed with the thermocautery (see Fig. 10). A layer of thinly mixed Fletcher cement is inserted, and, after this has hardened, the cavity is filled with ordinary dental cement (see Fig. 11). Within over three years none of the teeth thus treated have caused any trouble, but react to the electric current like healthy teeth. On the other hand, in the writer's opinion, very many pulps, including all those in sickly persons, resist every attempt at preservation, and the relatively few cases of success in strongly resistant pulps are to be attributed mainly to the unusual power of resistance of the pulpal tissue.

FIG. 10

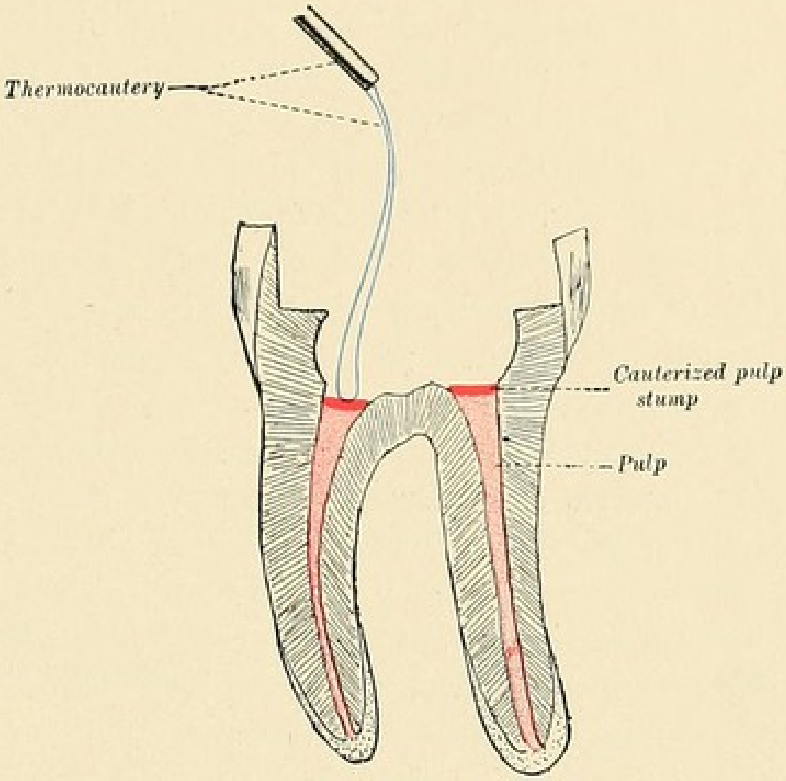


Diagram showing preservative pulp treatment in hypertrophic degeneration. Second stage: The anesthetized vital pulp stumps are cauterized with the thermocautery.

FIG. 11

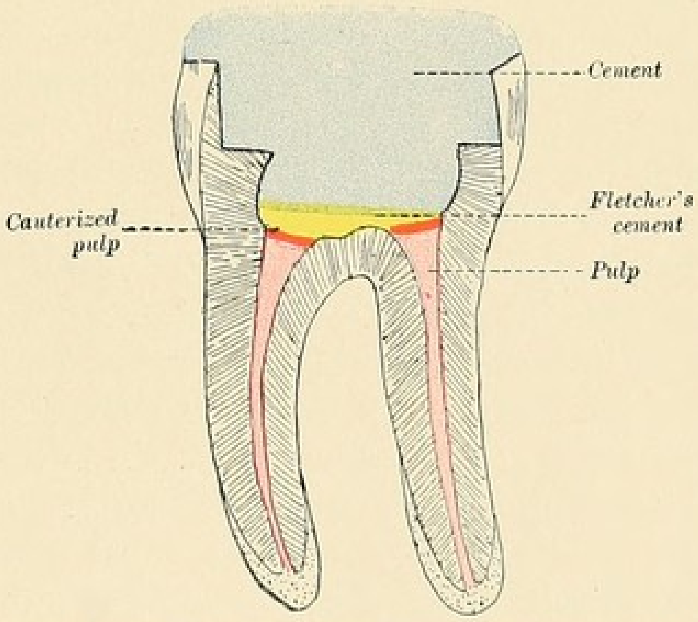


Diagram showing preservative pulp treatment in hypertrophic degeneration. Third stage: Filling the tooth.

Root Canal Treatment.—Pulps affected with pulpitis must be subjected to root canal treatment. In exposing the diseased pulp under anesthesia a part of the coronal portion may be amputated, but no further treatment should be instituted under anesthesia. Anesthesia is especially indicated in opening into those teeth which, owing to the presence of pulp stones, are affected with pulpitis, especially if the crown is not perfectly preserved. In such cases the writer introduces his readily acting caustic dressing as indicated above, followed several days later by root canal treatment; generally no notable pain is observed in the meantime.

Root canal treatment under anesthesia is contraindicated for the additional reason that the fresh pulp tissue which has not been coagulated by the dressing clings very tenaciously to the dentin and cannot be entirely removed, as experience has shown. Even the cauterized pulps of incisors and canines, which are so suitable for total extirpation, tear frequently into shreds, the complete removal of which is most difficult and uncertain, not to mention the difficulties involved in extirpation of the pulps in bicuspids and molars. Moreover, the hemorrhage in the deep portions of pulp stumps is very difficult to arrest, creating an unsafe edematous zone of demarcation at the apical foramen which disappears only gradually after subsequent pericementitis, and, in case of infection by way of the root canal, produces suppurative pericementitis which seriously endangers the preservation of the tooth.

Pulp debris that has not been removed becomes the cause of protracted irritations of pulpitic and pericementitic nature, which can be combated only by means of cauterization. Even granting that there are many teeth which remain quiet even in such cases, it is a well-known fact that the pain in pulps may be of very varying intensity. We only need to mention the case of patients who present gangrenous teeth without ever having suffered any pain. It is therefore to be laid down as a principle that anesthesia should never be employed as a means for "rapid cure" in pulp and root canal treatment, else discredit may be reflected upon the invaluable method of injection anesthesia by its injudicious application.

Someone might suggest that pain arising after such treatment must be due to the injection or the toxicity of the drug. In this regard the writer fully agrees with Schröder, who recently issued renewed warnings against abandoning caustics in favor of local anesthesia. Rapid pulp and root treatment is not desirable, yet anesthesia may be employed to allay the pain connected therewith. Anesthesia is a welcome aid, but it is not intended to take the place of caustics.

Crown and Bridge Work.—Local anesthesia is gaining more and more ground also in crown and bridge work. Numerous minor operations, such as the grinding down of sound teeth or the preparation of roots, are so painful that it is most desirable to abolish pain and insure the patient's comfort. The mode of application of novocain-thymol solution remains the same as described. Occasionally the mucosa can be anesthetized by novocain tamponade as described above, or by painting the gums with from 20 to 30 per cent. novocain solution.

Indications in General Disease.—Local injection anesthesia may be applied safely in arteriosclerosis, diabetes, nephritis, cardiac and pulmonary disorders, anemia, chlorosis, gestation, and lactation. In these conditions novocain alone is indicated in weaker doses, *i. e.*, Nos. 1 and 2 of the normal solution. Cocain is absolutely contraindicated, especially in cardiac and pulmonary disease, as substantiated by Williger.

Individual Judgment.—In local anesthesia a great deal of individual judgment is required. The operator must recognize with keen insight what quantity and dilution is indicated in a given case. In children a smaller quantity and weaker dose is selected than in robust adults, and in the feeble aged the normal dose is also to be reduced. Generally, however, in healthy old persons the full dose may be employed, as diffusion in the bone is much less favorable in such patients than in youthful ones. It is needless to say that convalescents also require special care.

Contraindications.—Novocain-thymol solution seems contraindicated only by the technical impossibility to successfully make the injection, as in ankylosis, severe purulent periostitis, and phlegmon so extended that normal tissue in the vicinity of the centre of infection can not be reached. It is also contraindicated in stubborn, especially excited and neurasthenic patients who insist upon general anesthesia. In these the morphin-hyoscin medication should be tried first, as generally an injection can after all be made, which in cases of simple and easy extractions is decidedly to be preferred to general anesthesia. Local anesthesia cannot be recommended in cases of serious hysteria, which may give rise to the complications observed even after novocain within recent years.

General Anesthetics.—If general anesthesia must be induced, the writer prefers, like Euler and Williger, the mild anesthetics, such as ethyl chlorid, ethyl bromid, and ether to chloroform. The general principle is that the smaller and easier the operation the less the dangers likely to arise.

"After all these observations I do not hesitate to maintain that general anesthesia, above all, chloroform anesthesia, with the few exceptions enumerated, is unnecessary in operations in the oral cavity, and that, as a legal expert, I should be unable to protect an operator from indictment in case of fatal accident from general anesthesia." (Kupfer.)

Drugs for Injection.—The patient, to be sure, must possess a certain amount of vitality in order to satisfy the requirements of anesthesia. It is, therefore, important to select such a method of injection and such a solution as will produce the least toxic symptoms. Thus, novocain, which is but one-seventh as toxic as cocain, is to be preferred in every case, without jeopardizing success in the least. As novocain is only one-third as toxic as the other substitutes for cocain, it occupies the place of preference also among these substitutes.

The extensive application of local anesthesia, owing to the growing prevalence of enervation in modern life, is especially called for in dentistry, even for very minor operations. The patients often demand that the mucosa be completely anesthetized before the hypodermic needle is inserted; this is, however, superfluous if the proper technique is followed. Local anesthesia should be not applied to such excess, since the most important diagnostic aid is thereby sacrificed, as has been shown previously.

At all events, local anesthesia deserves the place of preference in the prevention of pain in dentistry, and it is the duty of every conscientious practitioner to aspire to that lofty ideal of our science so welcome to patient and operator alike. General anesthesia is and must be a general intoxication which is never free from risk for the patient's life. Such a risk can be justly regarded as non-existing if our modern solutions are employed, especially the generally advocated novocain solution in the composition indicated. In dental operations, moreover, the doses and quantities of this solution, as employed in each case, are fully efficient, though far below toxicity.

ANESTHESIA IN THE THERAPY OF INFLAMMATION

For the combating of inflammatory processes in the oral cavity the writer recommended as early as 1907 the liberal employment 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 the subjective painful sensations are prevented or reduced to a minimum." (Spiess.)

The patient's condition corresponds exactly with the appearance of the wound and the intensity of the inflammation. The total or partial absence of pain permits of a safe conclusion as to the total or partial absence of inflammatory reaction.

Practical Experiences in the Oral Cavity.—In a large number of throat operations, also of surgical interventions in the tongue, the cheeks, and the mucosa of the lips, anesthesia has been therapeutically applied by Spiess in various ways, according to individual cases. When superficial analgesia proved insufficient for these operations, submucous injections were made. These were employed also in postoperative treatment in cases where dressings of anesthetizing agents were technically impossible. The object was to anesthetize wounds in inflamed tissue areas and the inflamed tissue itself, and to keep both in an analgetic condition as long as possible.

7

Tongue.—In minor injuries of the tongue due to an awkward bite, or to sharp edges and corners of carious teeth, and in the frequent and intensely painful desquamations at the tongue margin, pain rapidly disappeared after several applications made in quick succession.

Coryza.—If the disagreeable sensations of incipient nasal catarrh are relieved by insufflation of orthoform or novocain into the nasopharyngeal cavity, repeated until normal sensation is reëstablished, coryza can be aborted with absolute certainty.

Lacerations.—If minor bruises, lacerations, also wasp and fly stings are painted with orthoform or novocain in the form of a thick, watery paste or in solution, until all pain has ceased, no further reddening and swelling of the wound will occur. On the contrary, the edges will be smoother, paler, and without sensation, the wound undergoing rapid healing. By all these observations, extending over a long period of years, the fact has been established beyond doubt that local anesthetics inhibit pain; that wounds, if the absence of pain is maintained by means of analgesia, heal without inflammation; and that established inflammations heal in a very short time.

Modifying the Process of Healing.—Numerous experiments have shown that, together with the pain, the redness also disappears. It was heretofore impossible to modify an inflammation at the climax of its development in such a way as to cause the redness to disappear. With the above anesthetics this can be accomplished in a very short time, often within a few minutes; more—the pain can be absolutely abolished. This rapid abatement of the 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 the irritation of sensory nerves produces hyperemia by way of reflex, so the inhibition of this irritation prevents hyperemia or abolishes it.

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

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

Examples from General Pathology.—*Insanity.*—These postulates are entirely fulfilled in the cases of anesthesia occurring in the hysterical and the insane, alienists having noted many cases in which injuries, burns, and wounds in such patients healed completely without any reaction whatever. Thus it has happened that insane patients tore open their abdominal wound after laparotomy, played with the wound with their unclean fingers, and nevertheless 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 paralysis of sensibility, dipped his hands repeatedly in boiling water without being scalded in the least. The explanation may be that the afferent nerves, owing to the existing paralysis, 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.

Animal experiments with spinal anesthesia have confirmed the above observations, the anesthetized tissue exhibiting no blisters or even reddening upon being touched with a test-tube filled with boiling water.

Local Processes.—Not in hysteria alone is the sensory sphere paralyzed, but there are also pathological processes 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 due to drugs, in which the above factors probably play a part. If carbolic acid is allowed to act too long and too intensely, besides the well-known phenomena of thrombosis, not only the conductivity of the afferent fibers is inhibited, but the vessels also are directly affected, inasmuch as they become paralyzed, and their function is destroyed in the same manner as that of the nerves. Cold in sufficient intensity is also able to abolish sensation, as 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 experiments.

Combating Local Irritability.—Pain, which is a specially pronounced specific sensation of discomfort, hence a condition of conscious sensation, undoubtedly intensifies not only the general irritability, but also the local irritability and excitation in inflamed areas by conscious and wilful acts, furthermore and notably by way of unconscious reflexes, *i. e.*, by the centripetal (afferent) nerve supply of specially irritated portions of the brain. This, however, is after all not the primary or most important cause of these local processes. It is, therefore, the first aim of therapeutic measures to reduce the increased local irritability—the cause of the abnormal central processes—either directly or by generally influencing the normally or pathologically sensitive nervous system. The former in light cases may be accomplished by very simple measures, namely, by covering and soothing the inflamed areas. Since, however, despite the protection from external stimuli, owing to the continually recurrent action of internal tissue stimuli the 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, whereby the disposition to abnormal irritability is reduced, and the blood supply and internal process of repair are indirectly regulated. For this purpose, Spiess' method is specially efficient, as it acts in both directions, first, by the thick layer of orthoform or novocain powder furnishing protection against external stimuli, and secondly and more important, by directly preventing the irritability of the morbid tissue. The latter effect is obtained to a specially high degree by morphin, which is intended to act not as a 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 from the periphery. Simultaneously with the alteration of the tissue, and only as an indirect result of the altered activity of the nervous system, 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 no longer any abnormal influence is exerted upon the nerves.

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

Effects of Anesthesia.—"No inflammation will develop if the reflexes conveyed from the centre of inflammation by way of the afferent sensory nerves are successfully inhibited by anesthesia. Rapid healing in an inflammation already established is induced by anesthetization of the centre of inflammation, providing such anesthetization affects only the sensory nerves, and does not interfere with the normal function of the sympathetic (vasomotor) nerves." (Spiess.)

This much is certain, it is of great importance to withhold external irritation, and, if this is no longer possible, to treat the area that favors the formation of internal irritation in such a way as to transform the excess of sensibility of the tissues into a state of normal sensibility, which is accomplished by anesthetics.

Duration of Painlessness.—*Process of Healing.*—In all cases which the writer has had occasion to observe personally, the painlessness lasted until the termination of treatment, and in prophylactic cases inflammation of the wound after extraction did not set in, which otherwise, considering the severe nature of this operation, would surely have occurred. It might be suggested that antiseptic precautions alone would suffice to bring about a mitigation of pain and subsequent inflammation. Judging from experience, however, the new method of wound therapy marks a pronounced improvement in the healing process over the older procedures, inasmuch as usually no relapses of postoperative pain occur, which formerly were the invariable rule. The process of healing is characterized especially by the absence of pain. Novocain tamponade is particularly useful in painful wounds from extraction or other surgical operations.

We must not omit to emphasize that anesthesia possesses the double value of being a prophylactic as well as a curative measure in inflammations. This relatively novel method of treating inflamed tissues will permit of still further elaboration, to the great advantage of our patients as well as to our own. By the extensive application of anesthesia we approach very closely one of our noblest aims, namely, to operate painlessly as well as to render the postoperative treatment of exceedingly painful inflammatory processes permanently painless, at the same time hastening the repair of abnormal tissue lesions.

Prophylactic Treatment of Timid and Sensitive Patients.—According to Williger's experience, bromural or scopolamin-morphin have exhibited a very favorable action in the prophylactic treatment of timid and sensitive patients. The general sensibility is considerably reduced without untoward sequelæ. In thyroidism, however, scopolamin-morphin is contraindicated. Williger prescribes these two drugs as follows:

℞—Scopolamin hydrobromid	0.006
Morphin	0.15
Water	10.00

M. D. S.—From three to six divisions of a Pravaz syringe, according to the patient's physical condition, to be injected one hour before operation.

℞—Bromural	0.3 (one tablet) for children
	0.6 (two tablets) for adults

M. D. S.—To be taken internally forty-five minutes before operation. (Williger.)

PART III

TECHNIQUE OF LOCAL ANESTHESIA

ANATOMICAL STRUCTURE OF THE OSSEOUS FRAME OF THE MAXILLÆ

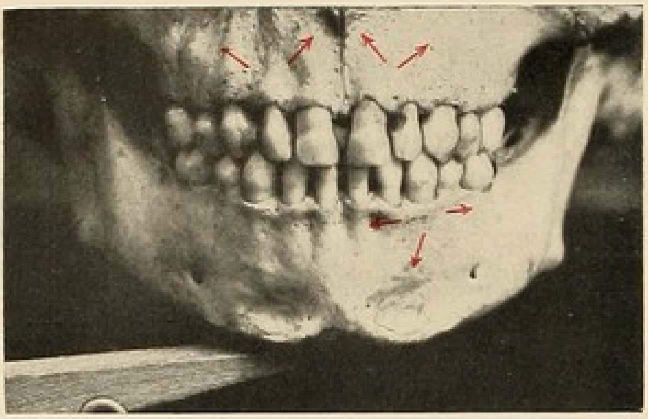
THE osseous frame of the maxillæ, which is formed by the maxilla and the mandible, possesses a number of peculiarities which are of special importance for the technique of local anesthesia and the diffusion of the solutions injected. The pressure exerted in injecting is intended to force the anesthetic agent 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 such areas of diffusion are constantly found.

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

MAXILLA.—The latter compact substance extends in the maxilla especially 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 with moderate pressure and without causing lesions through the bone into the alveolus, flooding and anesthetizing the entire, profusely innervated environment of the tooth root (see Fig. 46).

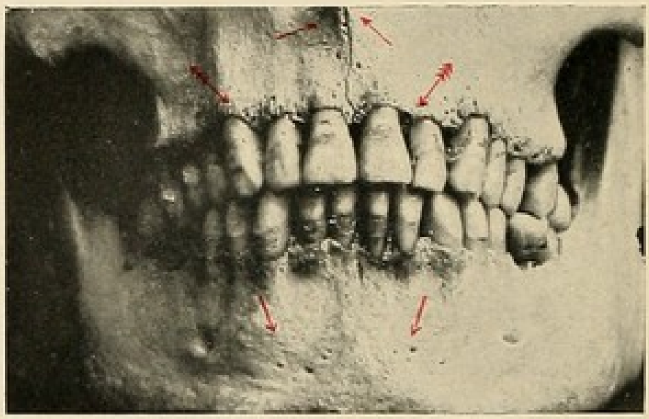
Anterior Surfaces of the Maxillary Bones.—In Figs. 12 to 18 the anterior views of several skulls of different sex and age are presented in order to show the various stages in the development of the sieve-

Fig. 12



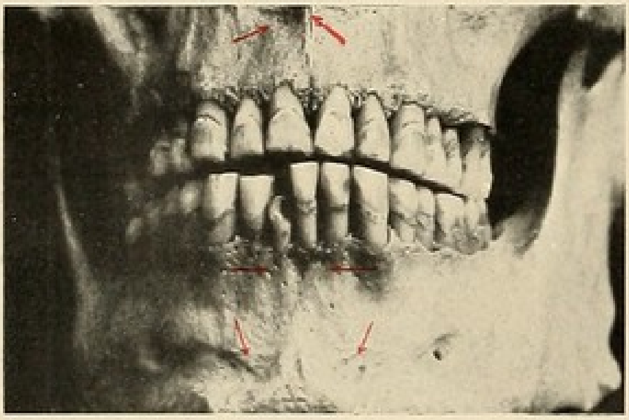
Maxillæ of child, aged seven, showing extensive cancellous areas.

Fig. 13



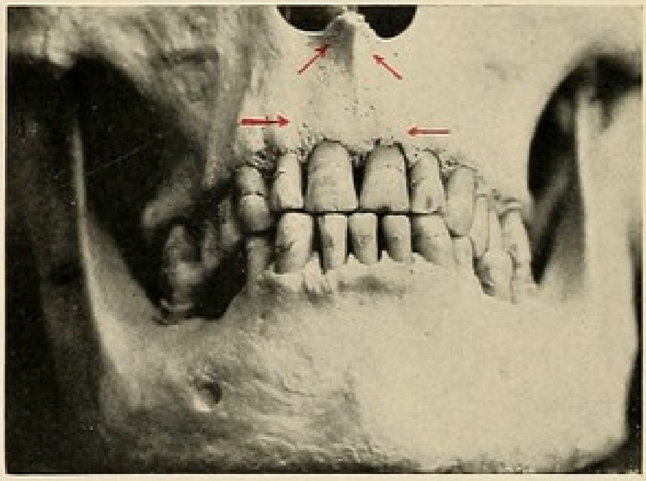
Maxillæ of young person, showing extensive cancellous areas.

Fig. 14



Maxillæ of young person, showing extensive cancellous areas.

Fig. 15

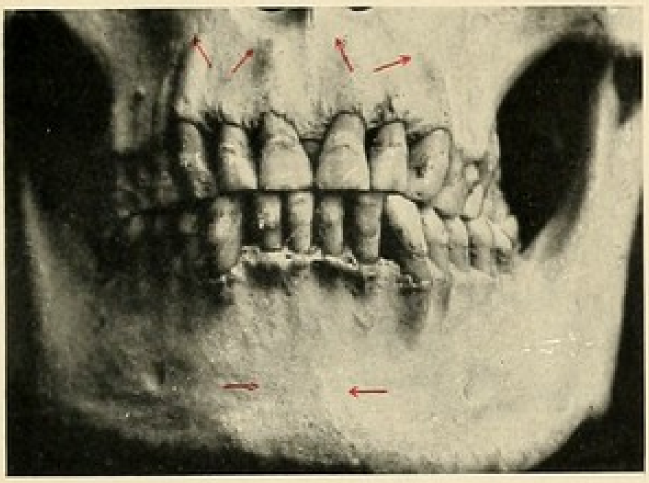


Maxillæ of old person, showing few perforations.

like cancellous, spongiose areas, and their varying extent in different skulls. Red arrows indicate specially pronounced areas which guarantee a good diffusion of the solution. Fig. 12 shows the skull of a child, aged seven years, in which the conditions are extremely favorable for diffusion; Fig. 13, the skull of a man, aged twenty years, in which the characteristic cancellous areas plainly appear.

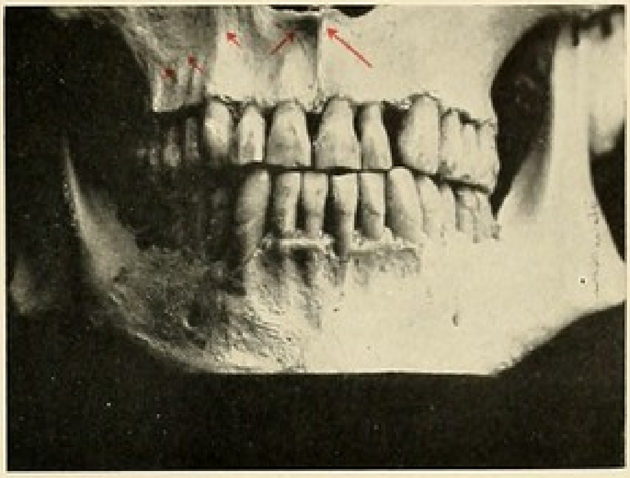
In the maxilla as well as in the mandible the *alveolar ridges* at the necks of the teeth always exhibit sieve-like perforations, as does the

FIG. 16



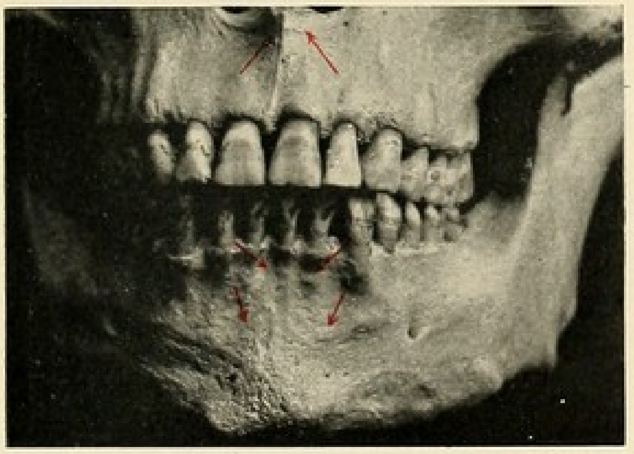
Maxillæ of old person, showing few perforations.

FIG. 17



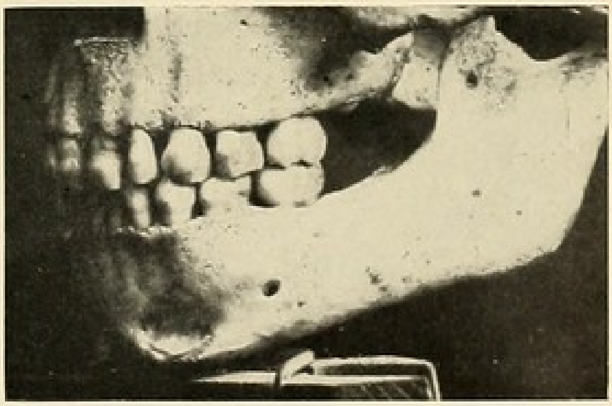
Maxillæ of adult, showing numerous perforations.

FIG. 18



Maxillæ of adult, showing numerous perforations.

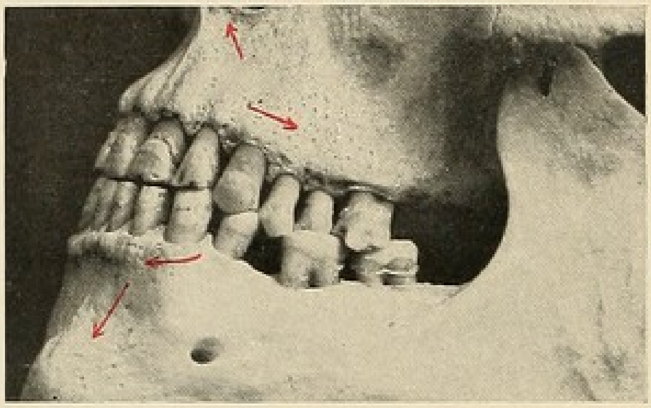
FIG. 19



Lateral view of Fig. 12.

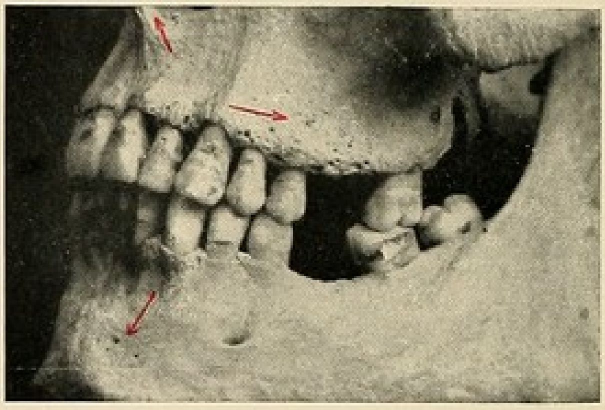
depression at the *anterior nasal spine*, or incisive fossa in the region of the root apices of the upper central incisors. In the mandible the cancellous areas are otherwise limited to the anterior portion in the region of the chin (see Figs. 13 and 18). Mesially from the root apex of the canine, in the *mental fossa*, groups of small *foramina* are distributed which sometimes extend up to the alveolar ridge (see Figs. 12, 14, 17, and 18). Especially Fig. 18 shows plainly how finely perforated the *mental portion* may be. The skulls of *older persons*, especially in

FIG. 20



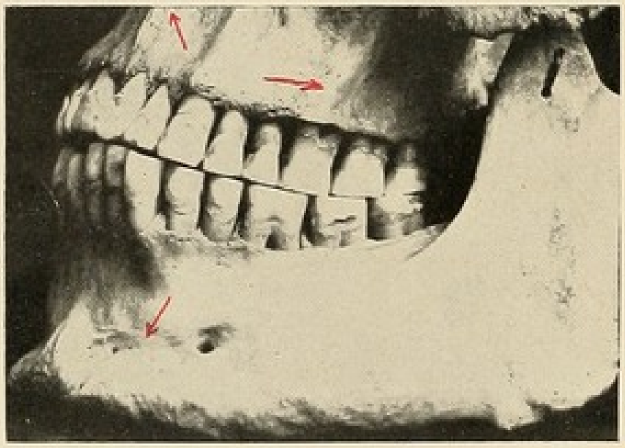
Lateral view of Fig. 13.

FIG. 21



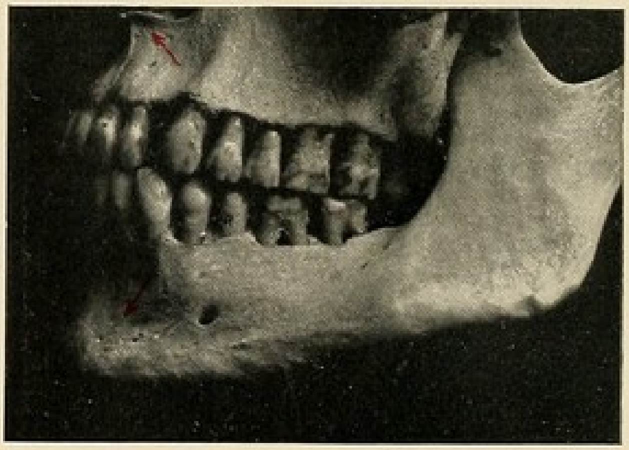
Lateral view of Fig. 14.

FIG. 22



Lateral view of Fig. 15.

FIG. 23

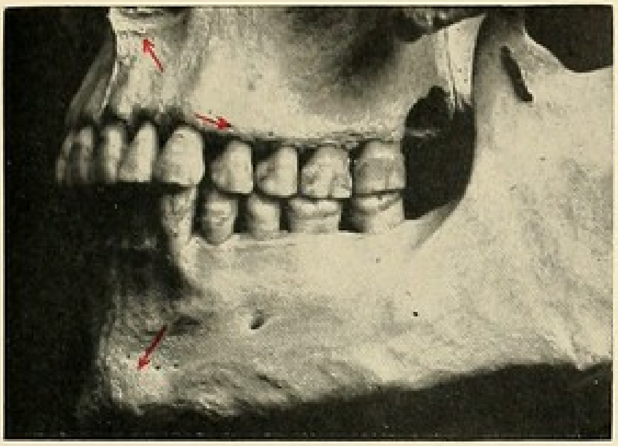


Lateral view of Fig. 16.

the mandibular portions, show very few perforations (see Figs. 15, 16, and 17).

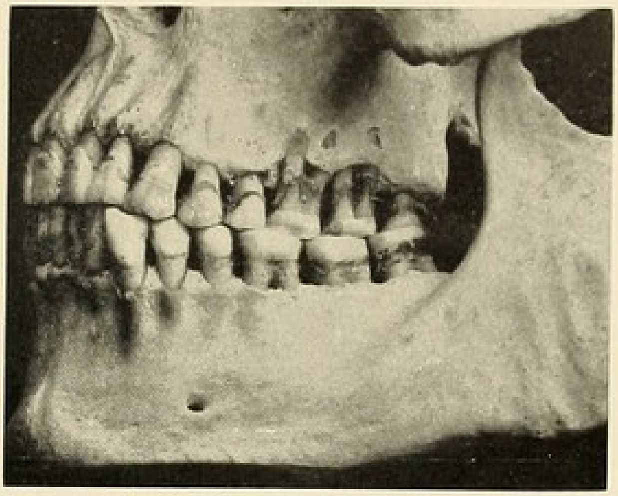
The lateral aspect of the same skulls shows that the cancellous areas in the maxilla are fewer toward the molars, while in the mandible they are lacking entirely (see Figs. 19 to 25). In the latter only the alveolar ridge is perforated, while toward the base a thick cortical layer prevails. The *youthful jaw* (see Fig. 19) exhibits the widest extent

Fig. 24



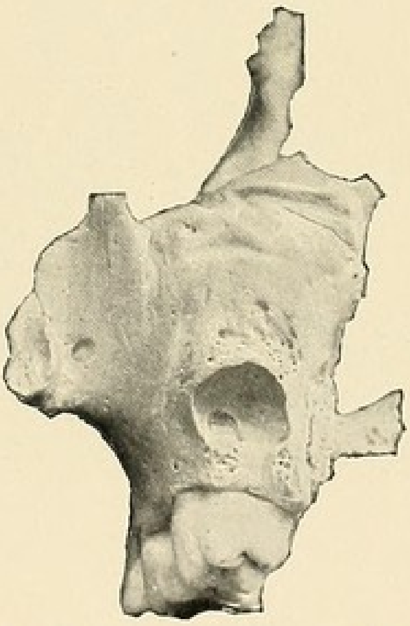
Lateral view of Fig. 17.

Fig. 25



Lateral view of Fig. 18.

Fig. 26

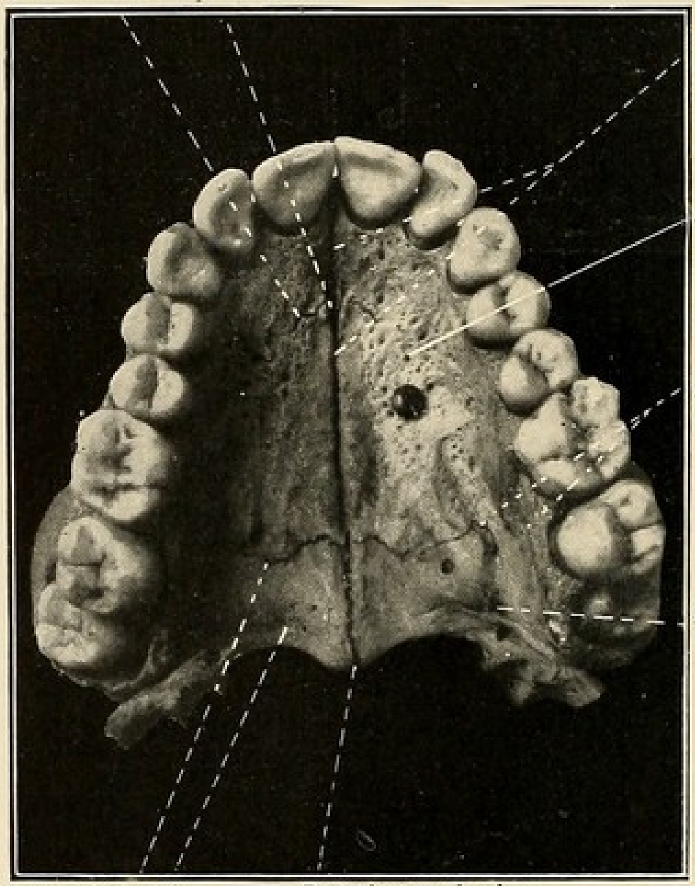


Extent of cancellous bony tissue at the maxillary tuberosity. Above the empty alveolus of the third molar large foramina are seen, by which the posterior superior dental nerves enter the maxilla.

of cancellous area, even the mandible being traversed by canaliculi. Fig. 20 gives a good view of the cancellous fossa at the level of the *root of the upper canine*, this fossa in all skulls being more or less pronouncedly canaliculated. The middle root portion in these teeth, however, is often covered by a dense cortical layer (see Figs. 21 to 23).

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. 20 and 21).

FIG. 27

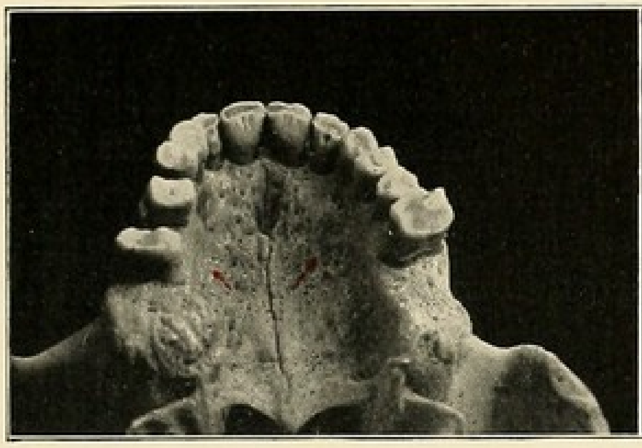


View of palatal surface of maxilla.

The upper molars are covered by an osseous plate of chiefly cortical character, which over the third molars usually is again closely perforated, as a glance at the tuberosity in Fig. 26 plainly shows.

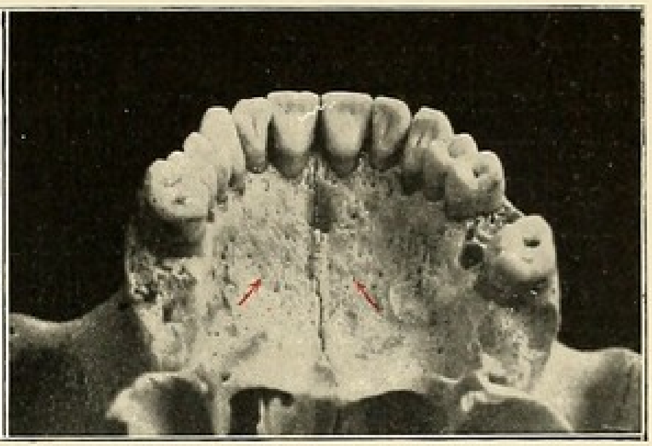
FORAMINA IN THE ANTERIOR SURFACE.—The anterior surfaces of the maxillary bones present two very important large foramina which permit the passage of important nerves and vessels, namely, in the maxilla the *infra-orbital foramen* above the root of the first bicuspid, in the mandible the *mental foramen*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

Fig. 28



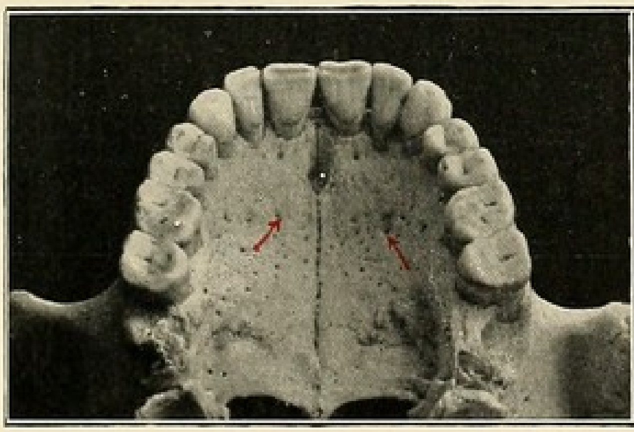
Palatal surface of maxilla of youthful person, showing extensive cancellous areas.

Fig. 29



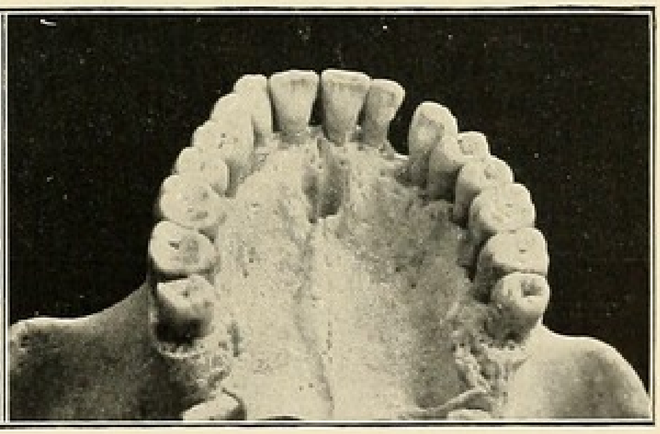
Palatal surface of maxilla of youthful person showing extensive cancellous areas.

Fig. 30



Palatal surface of maxilla of adult, showing few perforations.

Fig. 31

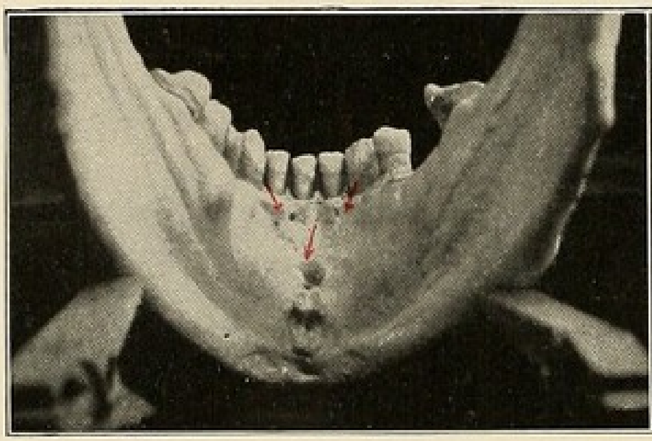


Palatal surface of maxilla of old person, showing few perforations.

The Posterior Surfaces of the Maxillary Bones.—Maxilla.—*Palatal Surface of the Maxilla.*—The *posterior surface* of the maxilla is traversed by numerous canals which are distributed very regularly. Fig. 27 shows the palatal view of the maxilla, the hard palate in its anterior and median portions being greatly perforated. At the bicuspids the cancellous arrangement of the alveolar bone decreases at the middle portion of the root, and gradually disappears toward the molars. Here we find the large posterior palatine foramen.

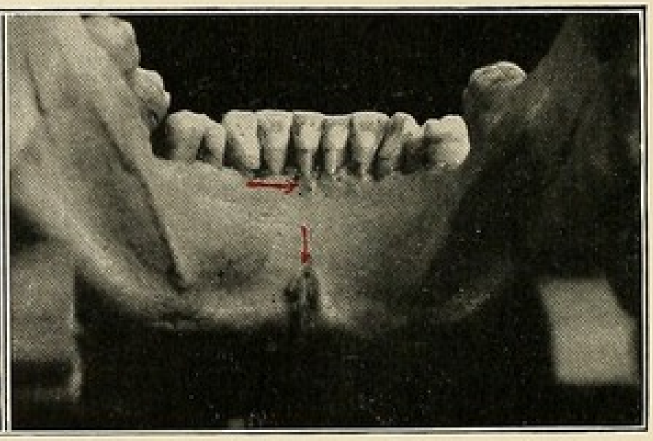
Hence it appears that the *molars* are covered also palatally with a relatively dense mass of bone, while the osseous cover of the bicuspids above the root apices possesses fine foramina, and the incisors and canines are surrounded on all sides with cancellated bony tissue. This is shown equally clearly in Figs. 28 to 31. These illustrations furthermore disclose the fact that the cancellous areas in the palatal surface vary in different individuals. Figs. 28 and 29 represent greatly perforated *youthful skulls;* Figs. 30 and 31, considerably less cancellated maxillæ of *older subjects.*

Fig. 32



Inner surface of mandible, showing dense bone.

Fig. 33

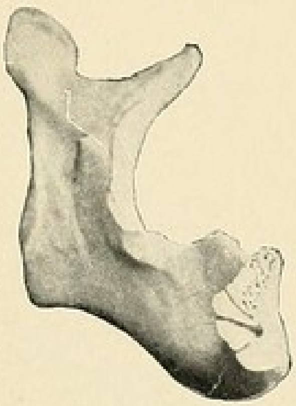


Foramina are noted at the symphysis.

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 palatal foramina* at the level of the third molars, as clearly illustrated in Fig. 27 (see also Figs. 28 to 31).

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*, 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. 34, also Figs. 32 and 33), while the entire posterior portion up to the third molars is almost impenetrable and non-canalicular (see Fig. 35). At the angle of the jaw, however, in the ascending ramus we find a very large aperture, namely, the *mandibular*, *oblique*, or *inferior dental foramen* (see Figs. 35 to 37, and 60), which is important for local anesthesia of the mandible.

Fig. 34

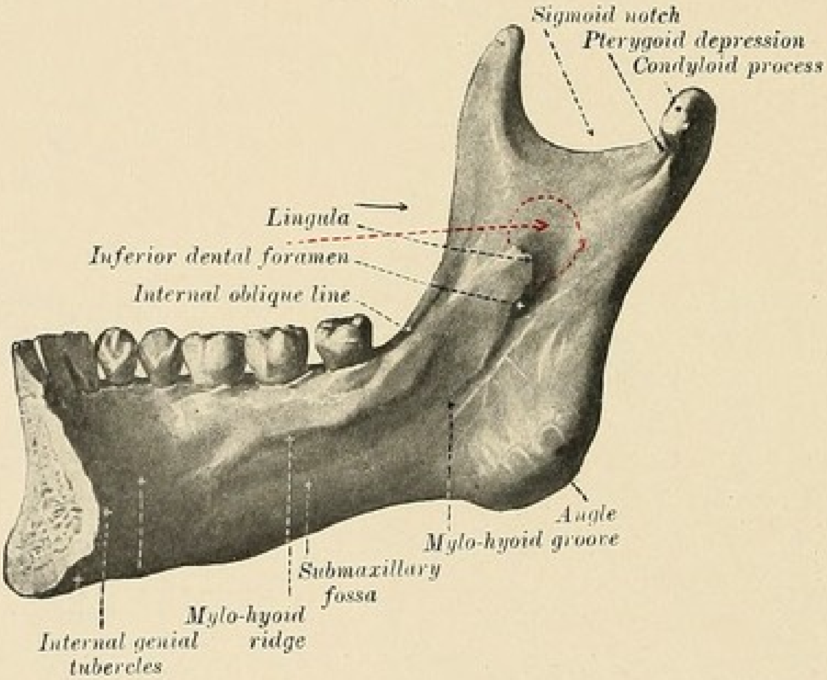


Section through symphysis of mandible. Some of the foramina on the inner surface communicate with the inferior dental canal, fibers of the lingual nerve probably joining the inferior dental nerve.

THE INFERIOR DENTAL OR MANDIBULAR FORAMEN

In adults the *ascending ramus* begins a little behind the third molar, sometimes in an abruptly ascending surface. At its basis, which must be 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. 35 to 39). 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. 36, 38, and 39). Above this fossa the mucosa is slightly depressed in what might be called the *retromolar triangle*. About the middle of the internal surface portion of the ascending ramus the large *inferior dental* or *mandibular foramen* is situated, extending downward and forward (see Figs. 35 to 37, and 39), at the same time marking the termination of the mylohyoid groove which ascends from below anteriorly to above posteriorly (see Figs. 35, 37, and 39). The orifice of the foramen itself is more or less protected anteriorly by a spiculum of bone of varying size, the *mandibular lingula* (see Figs. 35, 37, and 39). This lingula may be developed as a pointed plate of bone, or as a tongue-like cover,

FIG. 35

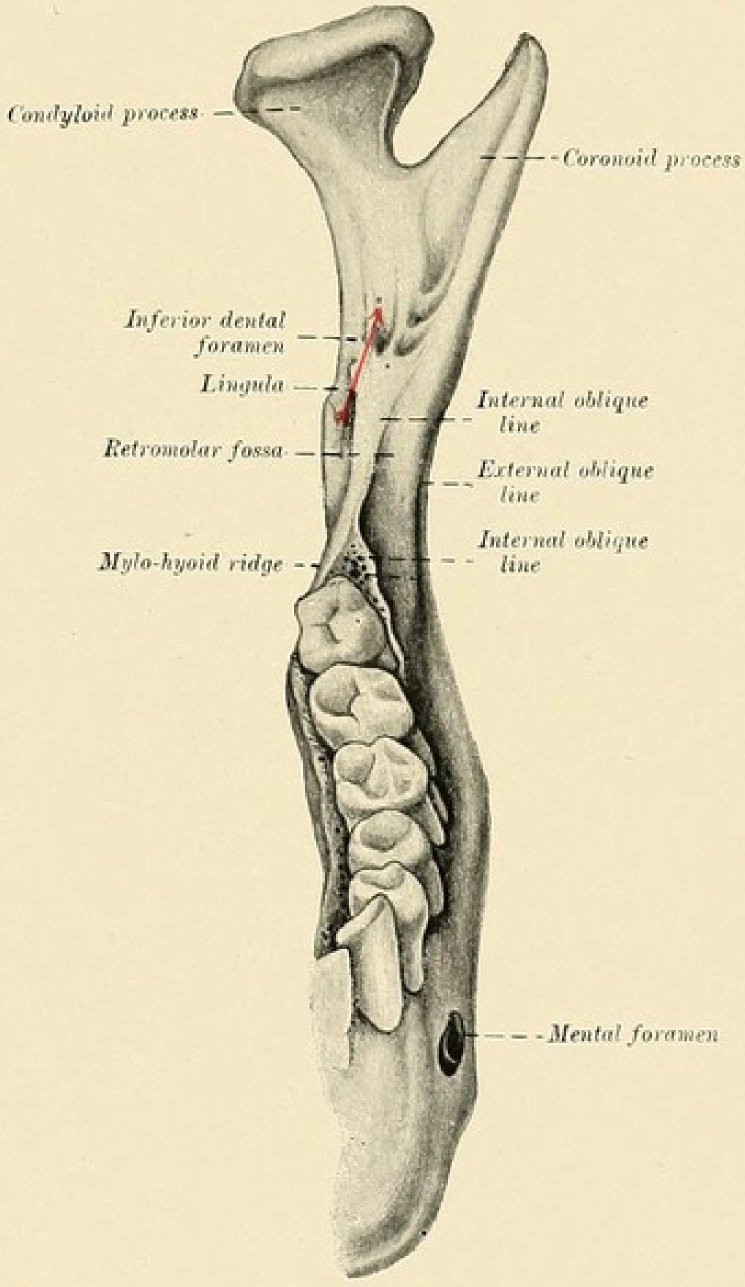


Side view of inner surface of right half of mandible. The red arrow indicates the direction in which the needle should be pushed forward over the lingula. The red circle indicates the area of injection.

or only as a thickened process on the anterior margin (see Fig. 37). Sometimes the lingula is connected with the lower free margin of the orifice of the foramen by a small spiculum or bridge.

The foramen itself, in adults, 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. 37, *C*, and 39). The two halves of the mandible, when viewed from in front, gradually diverge toward the angle, so that the inner surface of the angle with the mandibular foramen is inclined posteriorly and pharyngeally, and appears to be entirely covered by the internal oblique line (see Figs. 36, 37, 83, and 88).

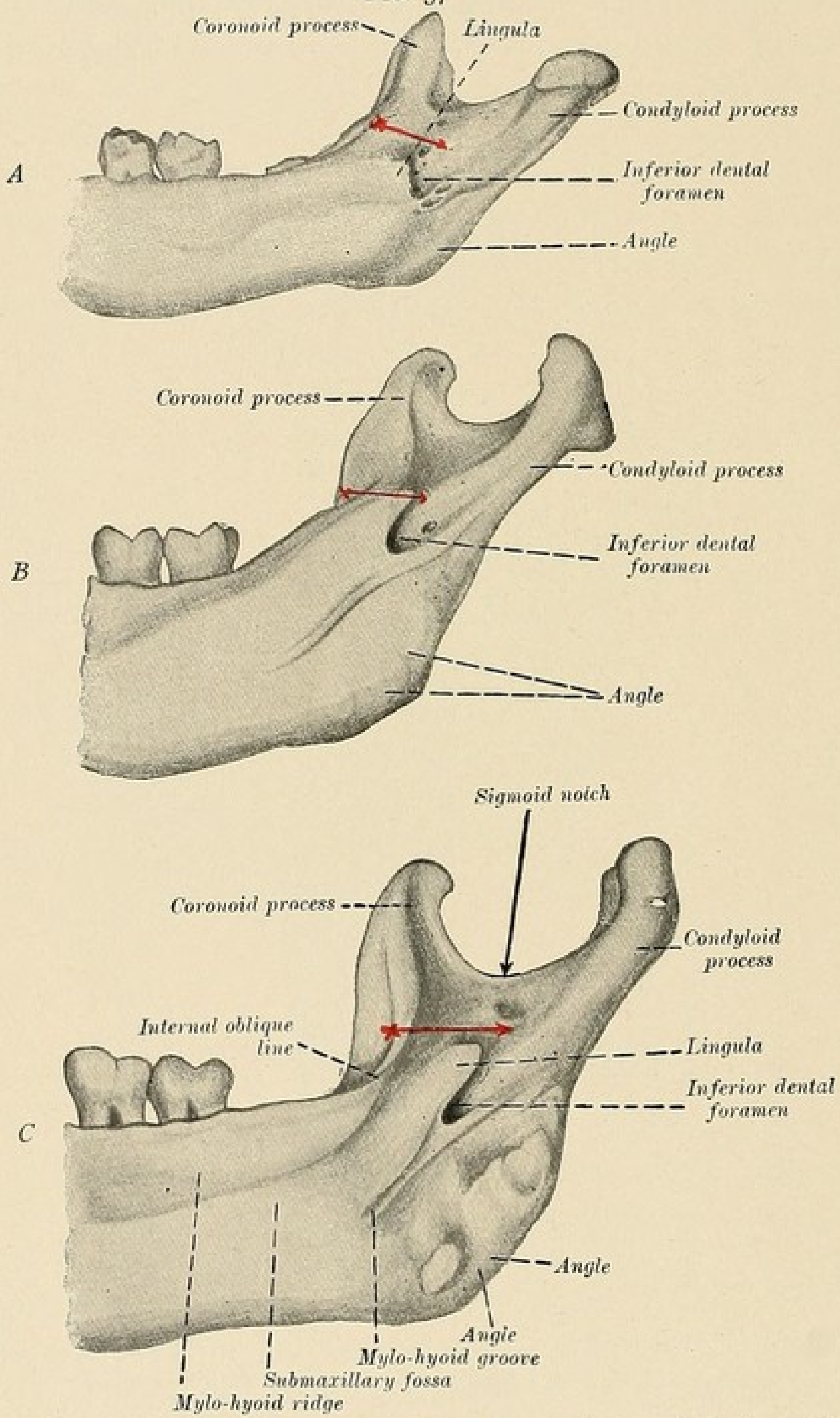
FIG. 36



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

In *mandibular anesthesia* the insertion of the needle is to be made *closely above the lingula*, and the solution is to be deposited in the

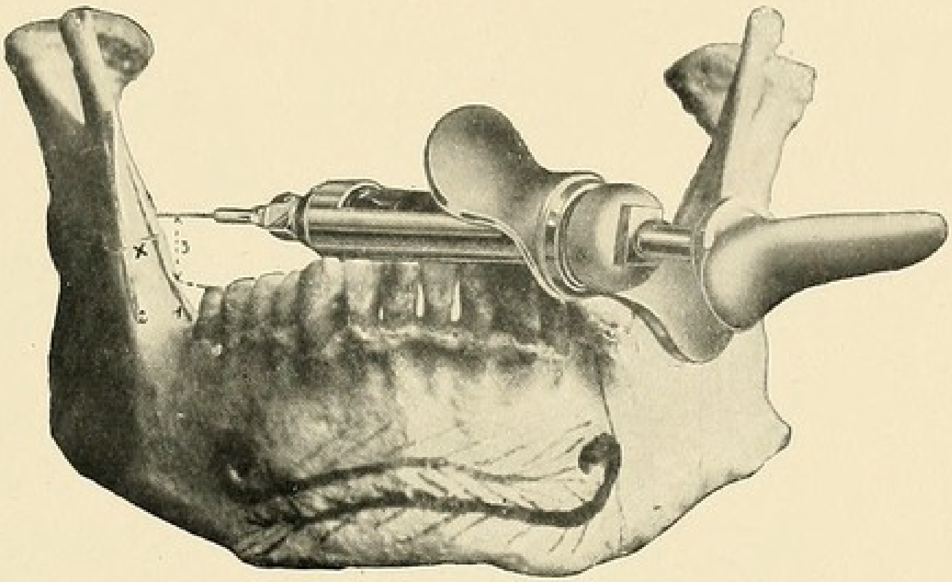
FIG. 37



Variations of the 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.

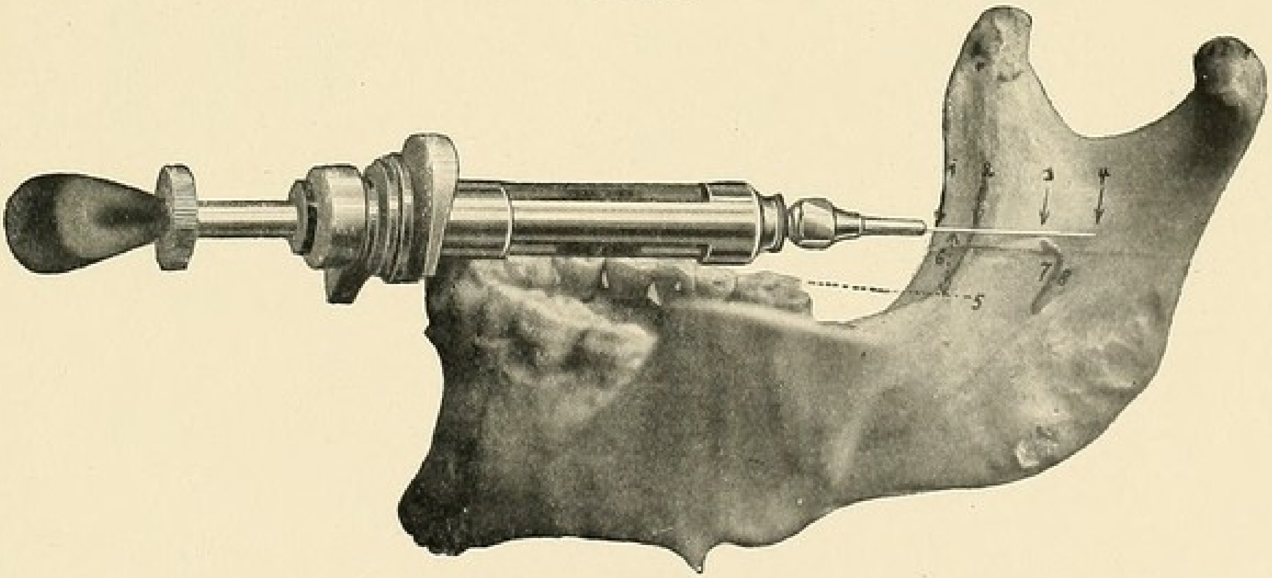
neighborhood of the nerve trunk that enters there (see Figs. 38, 39, and 97; note the red arrows in Figs. 35 to 37).

FIG. 38



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. 39



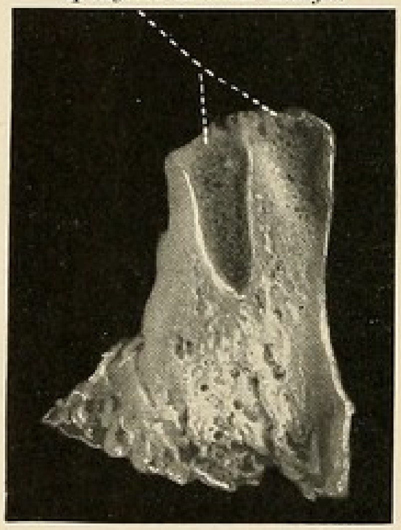
Position of needle in mandibular anesthesia: 1, external oblique line; 2, internal oblique line; 3, position of needle at superior margin of lingula; 4, most suitable length of needle behind lingula (a further advancement would result in failure); 6, position of needle, 1 cm. above level of masticating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

THE 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 are continually found, namely, the sparingly canaliculated substance, the *compact substance*, and the richly cancellous and medullated tissue,

FIG. 40

Spongiose alveolar margin



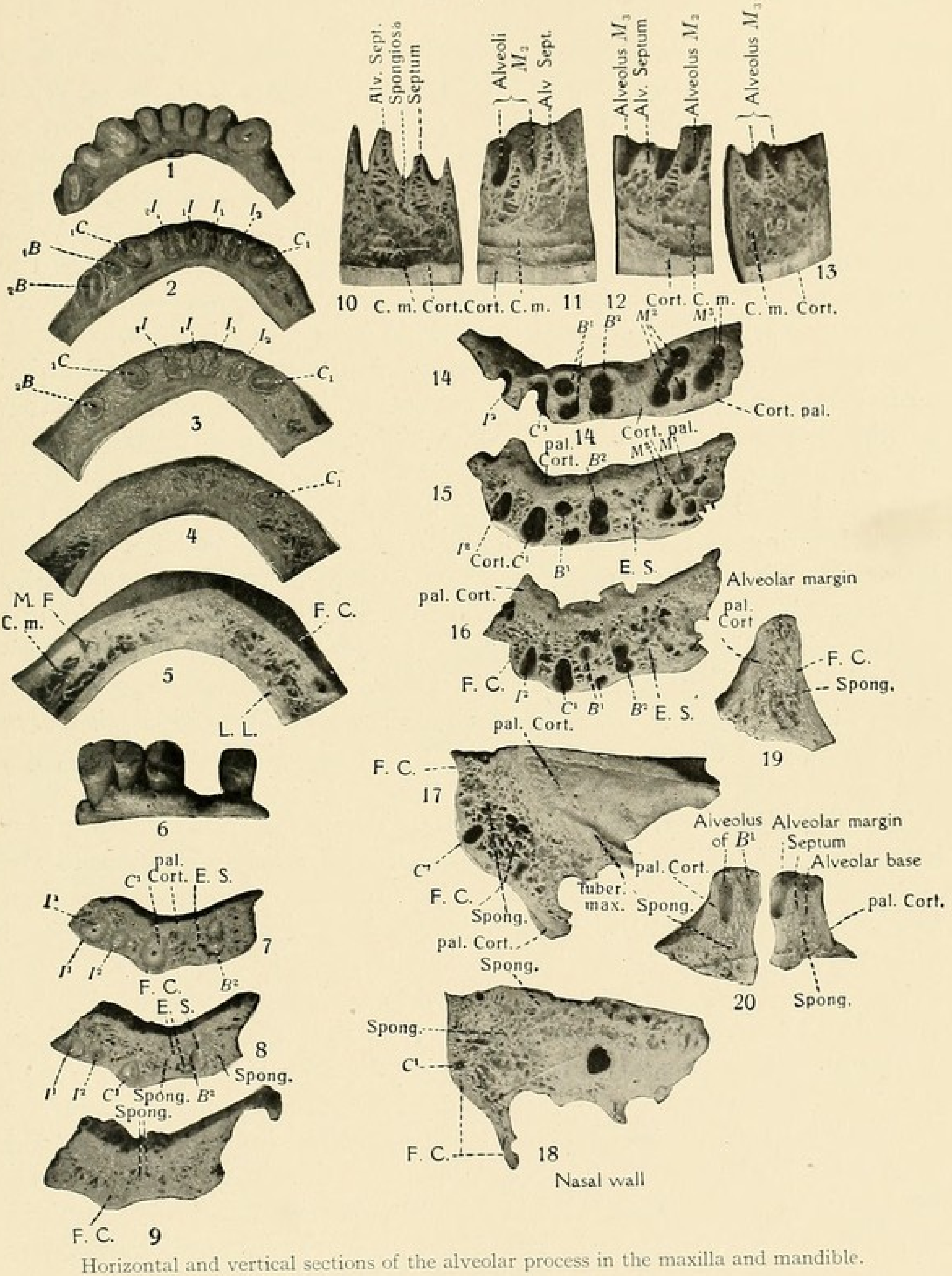
Extent of spongiose (cancellous) substance within an exposed alveolus.

the *spongiose substance*. The former in the *mandible* shows a 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 arrange-

EXPLANATION OF ABBREVIATIONS ON FIG. 41

${}_2B$, 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. 41



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

ment 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 Figs. 44, Nos. 1 to 21).

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.

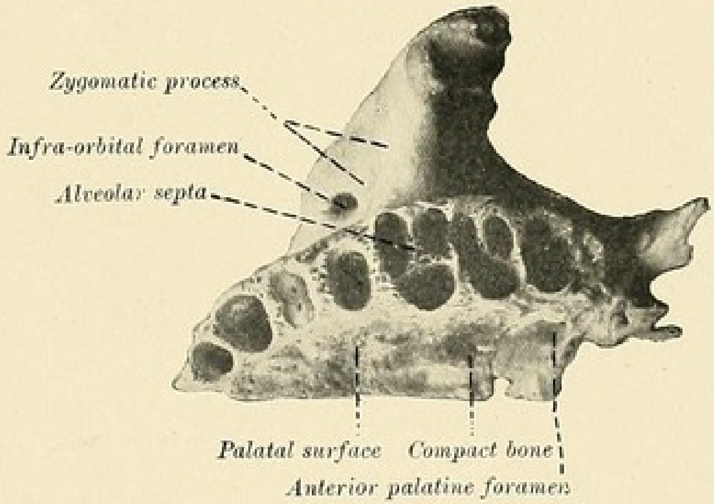
Structure of the Alveoli.—The *dental alveolus* may be regarded as a crater-shaped depression in the spongiose substance consisting of highly porous osseous tissue, in which the root is contained (see Fig. 41, No. 19; Fig. 44, Nos. 17 and 19). The individual alveoli are separated by *septa*, consisting of thin and porous lamellæ from two approximating alveoli and of spongiose tissue developed between the latter (see Figs. 41, 42, and 44). The alveoli of the upper, especially the first bicuspids, also those of the lower bicuspids in their fundus contain ridge-like eminences, *septal processes*, which fit in the longitudinal depressions in the roots of these teeth. The *alveolar walls* always exhibit fine, sieve-like (cribriform) perforations, which increase in number and diameter toward the upper margin (see Figs. 41, 42, and 44).

These perforations, which are always present in varying numbers in the alveolar ridge, and seem to permit of ready diffusion of the anesthetizing fluid, have heretofore been unduly neglected, inasmuch as they furnish us with valuable landmarks in the technique of local injection anesthesia.

Transverse Sections of the Jaws.—Fig. 41, Nos. 1 to 20, shows a number of instructive bone sections, in which the various relations of the dental roots to their alveoli, and the structure of the body of the jaws themselves can be studied. Nos. 1 to 5 exhibit lamellar portions of the anterior section of the mandible from the left second bicuspid to the right canine.

Maxilla and Mandible.—Besides the instructive transverse sections of the roots, we can trace in No. 2 the gradually increasing thickness of the outer and inner cortical layers, and the manner in which, between them, 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 recognized, 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 here appears to extend remarkably, this condition contributing largely to the firmness of the supporting abutments of the denture, namely the canines.

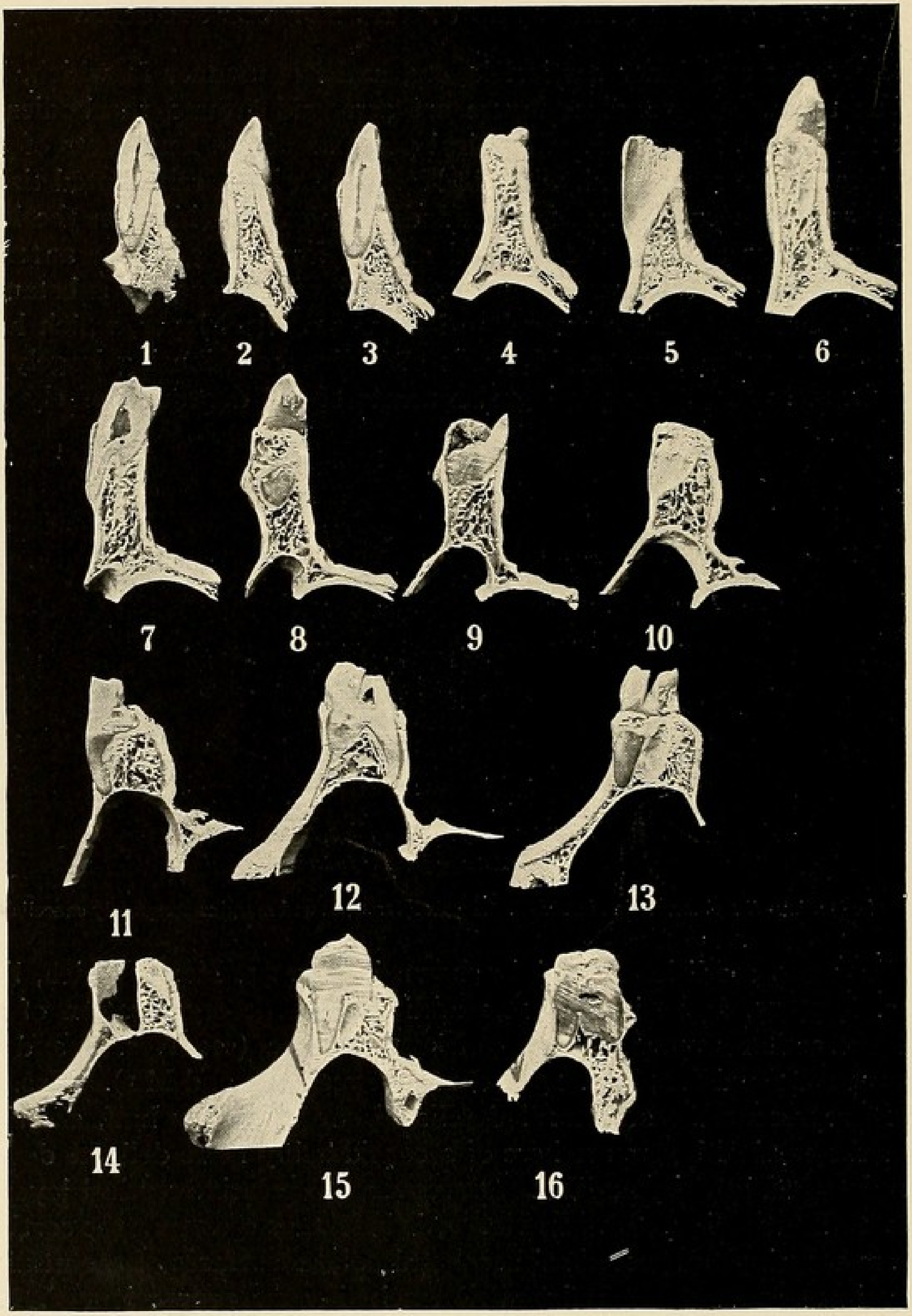
Fig. 42



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

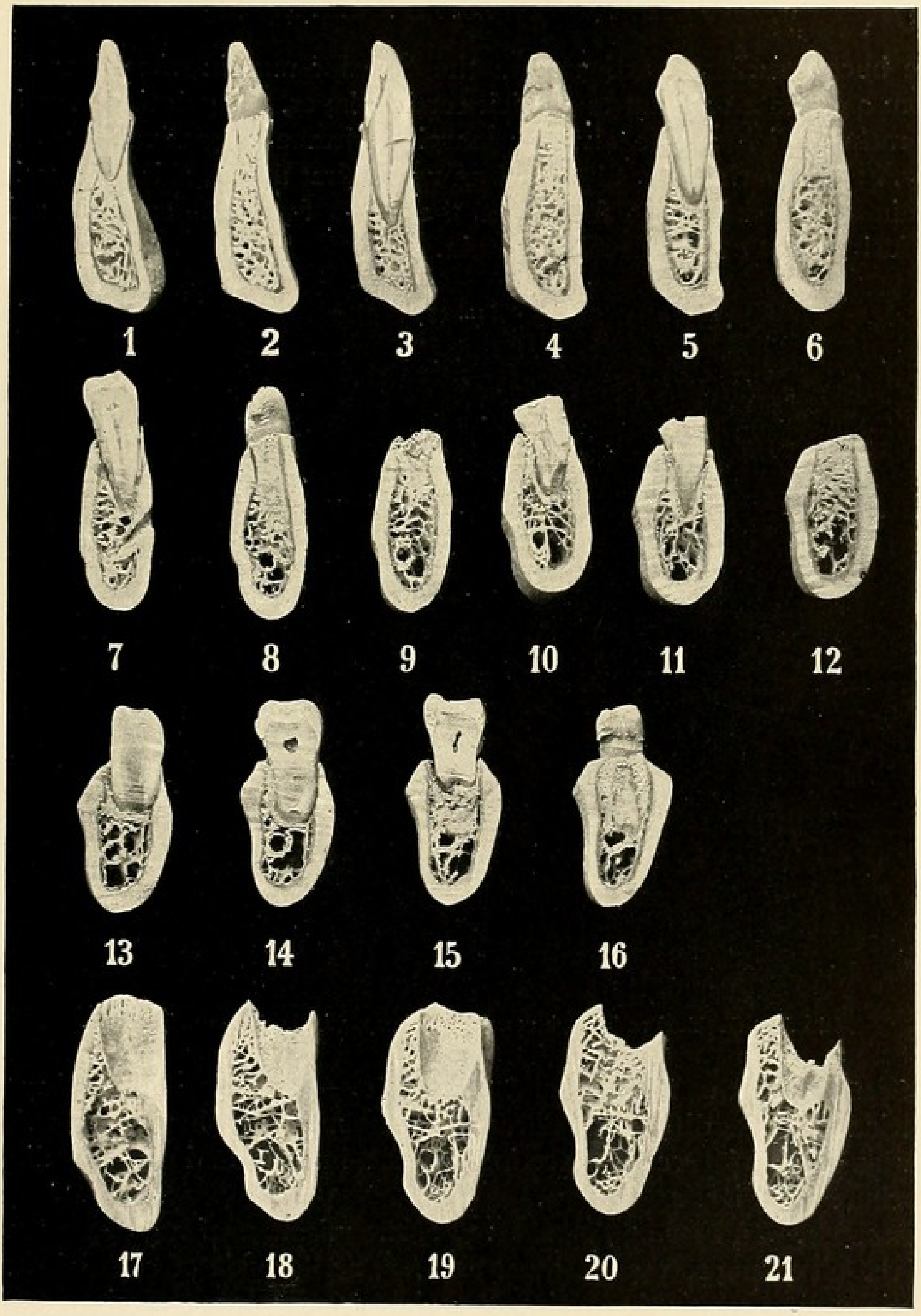
The same condition is plainly shown in Fig. 41, No. 7, which, like Nos. 8, 9, 15, and 16, illustrates additionally the organization of an old extraction wound into spongiose substance (see Nos. 8 and 9, between C 1 and B 2, Nos. 15 and 16, between B 2 and M 1). Nos. 14 to 18 represent the structural details of one maxillary half, showing that the cortical layers are here of a considerably more delicate development than in the mandible. Moreover the palatine cortical layer is seen to be canaliculated. In No. 19 it is further seen that the cortical layers covering the posterior buccal and palatal surfaces of the maxilla may increase or decrease in thickness in inverse proportion. While

Fig. 43



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

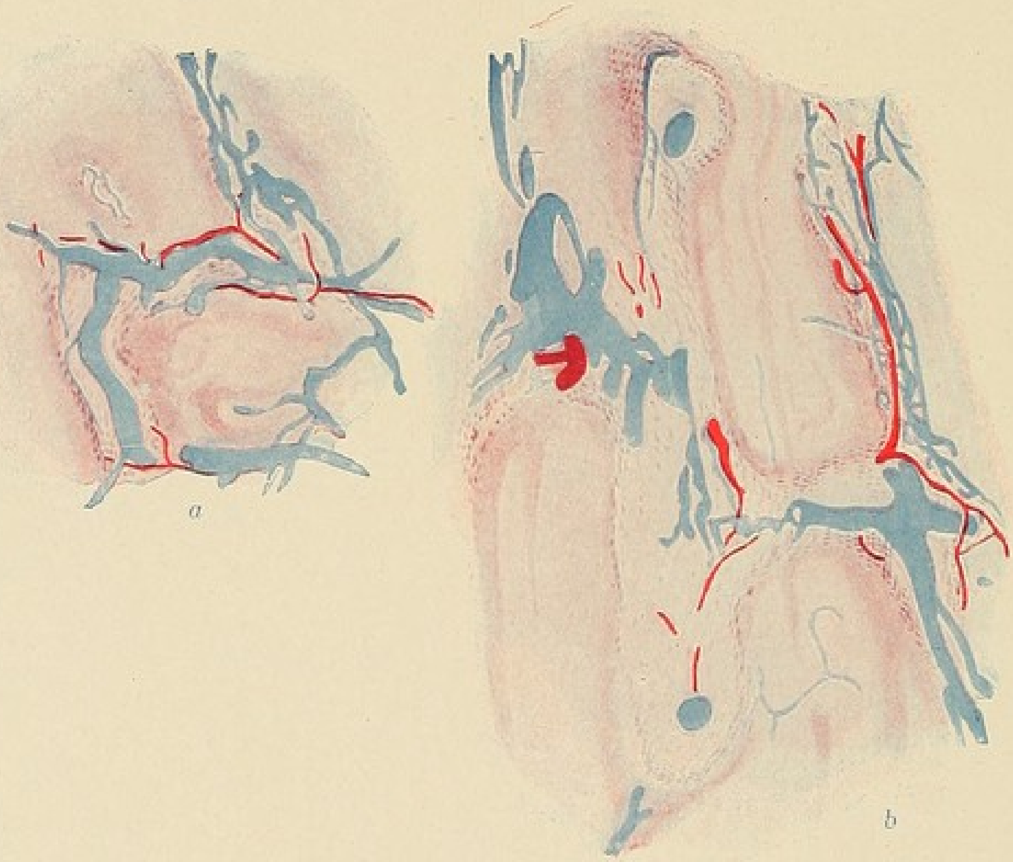
Fig. 44



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

the buccal surface starting from the alveolar margin often increases from a delicate stratum to a thick cortical layer, the palatine covering is rather thick at the alveolar margin, whence it gradually tapers. Fig. 42 shows the open alveoli of an upper first molar, this illustration again emphasizing the fact that the most favorable conditions for diffusion exist at the alveolar margin.

FIG. 45



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, the writer has made special vertical sections of the maxilla and the mandible, as shown in Figs. 43 and 44.

Maxilla.—In Figs. 43, 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 on the palatal surface present a broad osseous layer, which varies on the facial surface. It is delicate and lamellar for the greater part, and

Fig. 46

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

up to the bicuspids specially thin in the proximity of the root apices, *i. e.*, in the area which 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 at the third molar. This tooth, by way of compensation, in the region of its root apices is surrounded by richly cancellated tissue, so that it can be perfectly well anesthetized by inserting the needle high up (see Fig. 93).

FIG. 47

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

Mandible.—The sections through the mandible plainly show the massive nature of the cortical layer on both sides (see Fig. 44). While in the anterior teeth the facial surface of the bone (on the right in the illustrations) is of relatively thin construction, its thickness increases considerably from the bicuspids on, and finally reaches at the molars (Nos. 10 to 16), the same proportions as the lingual surface. If in the mandible local anesthesia by way of the mucosa is of any value at all, it can be effected only by injection at the cervical margin of the gum, the alveolar ridges in all lower teeth being of spongiose character. This fine, spongiose, cancellous tissue of the alveoli, even in the molars, is present, however, only in the upper marginal portion, as illustrated in Fig. 44, Nos. 17 to 21, also in Fig. 41, and in Fig. 84.

The foregoing renders it sufficiently apparent that the technique of local injection anesthesia depends not only upon the nerve supply of the masticatory apparatus, but also, and to a great extent, upon the special character of the bony substance. We shall have occasion to prove that the technique of local anesthesia as demonstrated subsequently is based on these anatomic 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 the manner of diffusion of injected solutions in the jaws, the writer has injected the periosteum of the maxilla and the mandible in various animals, such as cats, with isotonic staining solutions in the same manner as for the purpose of local anesthesia. In all cases the cancellated mass was permeated, and, where cortical substance was present, the red carmine solution penetrated by way of the foramina (see Fig. 45). Spongiose cancellous bone tissue absorbs the stain with uniform avidity, permitting it to penetrate into the medullary spaces. After five minutes, in most cases, the anterior of the jaw was entirely permeated with the colored solution; up to 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. 47), while within the osseous canaliculi red-stained lymph vessels are found chiefly in perivascular arrangement (see Fig. 45). This is conclusive proof that an isotonic injecting solution, such as the novocain-thymol solution, reaches the interior of the alveolar process in a short time, most rapidly and to the greatest extent in spongiose substance, in the cortical areas, however, only by way of the few and generally large foramina.

THE NERVE SUPPLY OF THE MASTICATORY APPARATUS

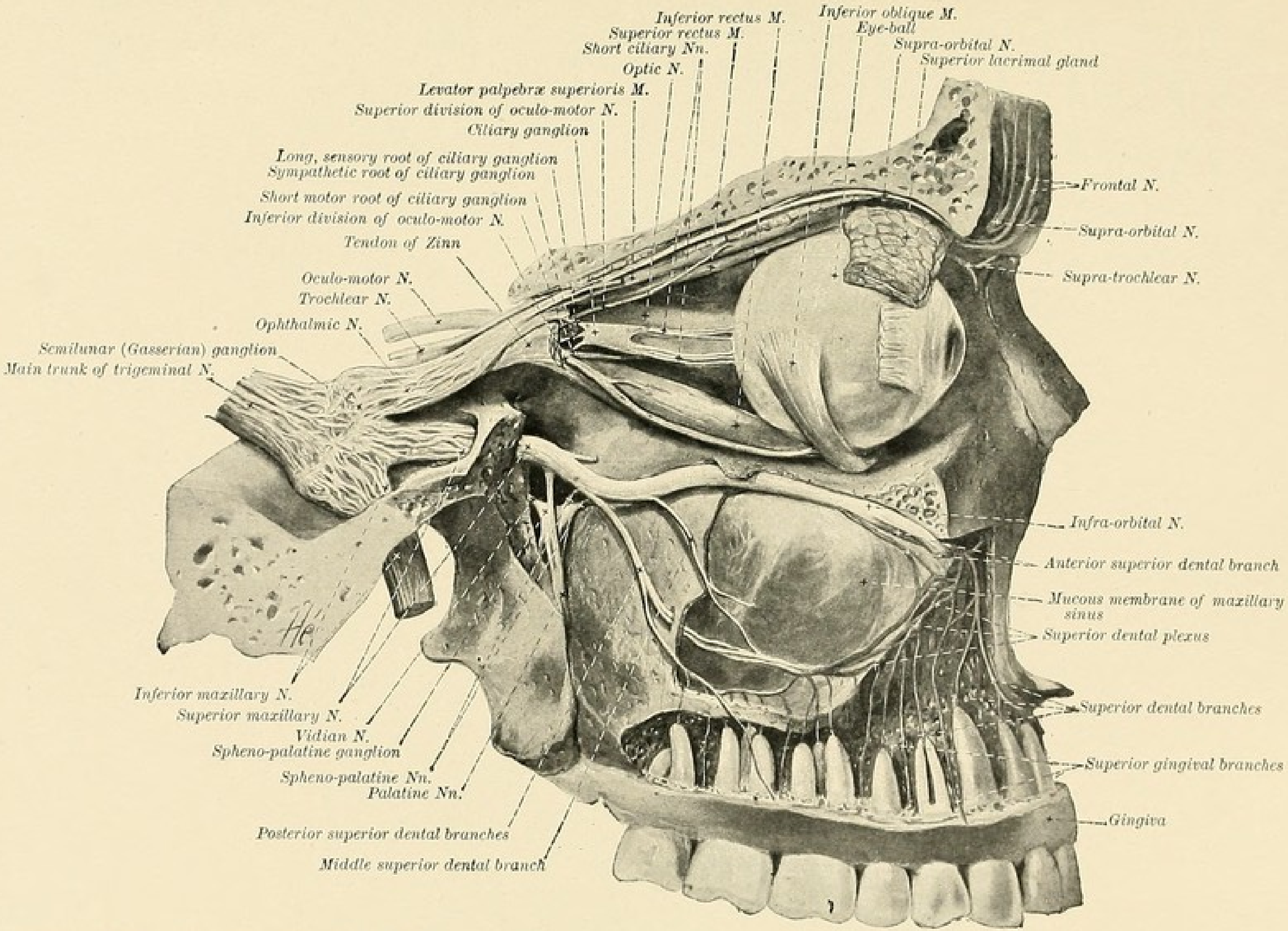
The sensibility of the masticatory apparatus is controlled by the fifth cranial nerve, the *trigeminal*.

Root 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. 48). 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. 49). The *motor root* passes beneath the ganglion without having any connection with it, to the *third division*, which thereby, as a *mixed* nerve consisting of *sensory* and *motor* fibers, is distinguished from the exclusively sensory *first* and *second divisions*.

The Ophthalmic Nerve.—The ophthalmic nerve, or first division of the trigeminal, passes from the Gasserian ganglion through the lateral wall of the cavernous sinus to the superior orbital or sphenoidal fissure, and through this to the *orbit*. To the first division of the trigeminal nerve belongs the *ciliary ganglion*, situated in the posterior third of the orbit laterally to the optic nerve (the second cranial nerve), and possessing three roots, one short *motor root* (radix brevis), one long *sensory root* (radix longa), and one *sympathetic root* (radix sympathetica) (see Fig. 48).

Branches of Distribution of the First Division of the Trigeminal Nerve.—The *lacrimal nerve*, which belongs to the first division, passes forward along the lateral wall of the orbit above the lateral rectus muscle, and supplies the lacrimal gland, as well as the distal corner of the eye and the conjunctiva. The *frontal nerve* enters the orbit above the muscles through the sphenoidal fissure, and runs forward along the middle line, between the levator palpebræ and the periosteum, giving off through the supra-orbital foramen the *supra-orbital nerve*, and as a second branch the *supratrochlear nerve* above the trochlea or pulley of the superior oblique muscle, supplying the eyelids, the integument of the lower part of the forehead on either side of the middle line, and the root of the nose. The *nasal nerve* enters the orbit by way of the sphenoidal fissure between the two heads of the external rectus, spreading here between the *oculomotor* and the *external* or *abducent oculomotor nerves*. It passes obliquely inward across the upper portion of the *optic nerve*, sending a long root to the ciliary ganglion,

Fig. 48



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.)

and giving off the *long ciliary nerves*, which, arranged around the optic nerve together with the *short ciliary nerves* from the ciliary ganglion in the orbital adipose tissue, run forward and enter through the sclera near the entrance of the optic nerves. The continuation of the *nasal nerve* runs to the median wall of the orbit, giving off the *spheno-ethmoidal nerve* to the cribriform plate of the ethmoid bone, also the *infratrochlear nerve* to the integument at the mesial corner of the eye, the lacrimal sac, and the eyelids (see Fig. 48).

The Maxillary Nerve.—The *second* or *maxillary division* of the trigeminal passes from the Gasserian ganglion through the foramen rotundum to the sphenomaxillary fossa, after giving off the meningeal branch to the dura mater. At the sphenomaxillary fossa the second branch is divided into the following subdivisions: The *orbital* or *temporomalar branch*, the *infra-orbital branch*, with the *posterior*, *middle*, and *anterior superior dental branches*, and the *sphenopalatine branches* (see Figs. 48, 49, 51, and 52).

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 palatine muscles, excepting the tensor palati muscle, with motor filaments (see Figs. 48, 50, and 52).

Branches of Distribution of the Maxillary Nerve.—The second division of the trigeminal passes through the *infra-orbital canal* to the *infra-orbital region* of the facial surface of the maxilla, giving off numerous branches in its course (see Figs. 48, 51, and 52). In passing through the infra-orbital canal it gives off the *superior dental branches* at various intervals through the minute canals into the body of the maxilla (see Figs. 48, 49, and 52). These *posterior*, *middle*, and *anterior superior dental branches* supply the alveolar process, sending off small twigs to the teeth. At the sphenopalatine (Meckel's) ganglion

FIG. 49

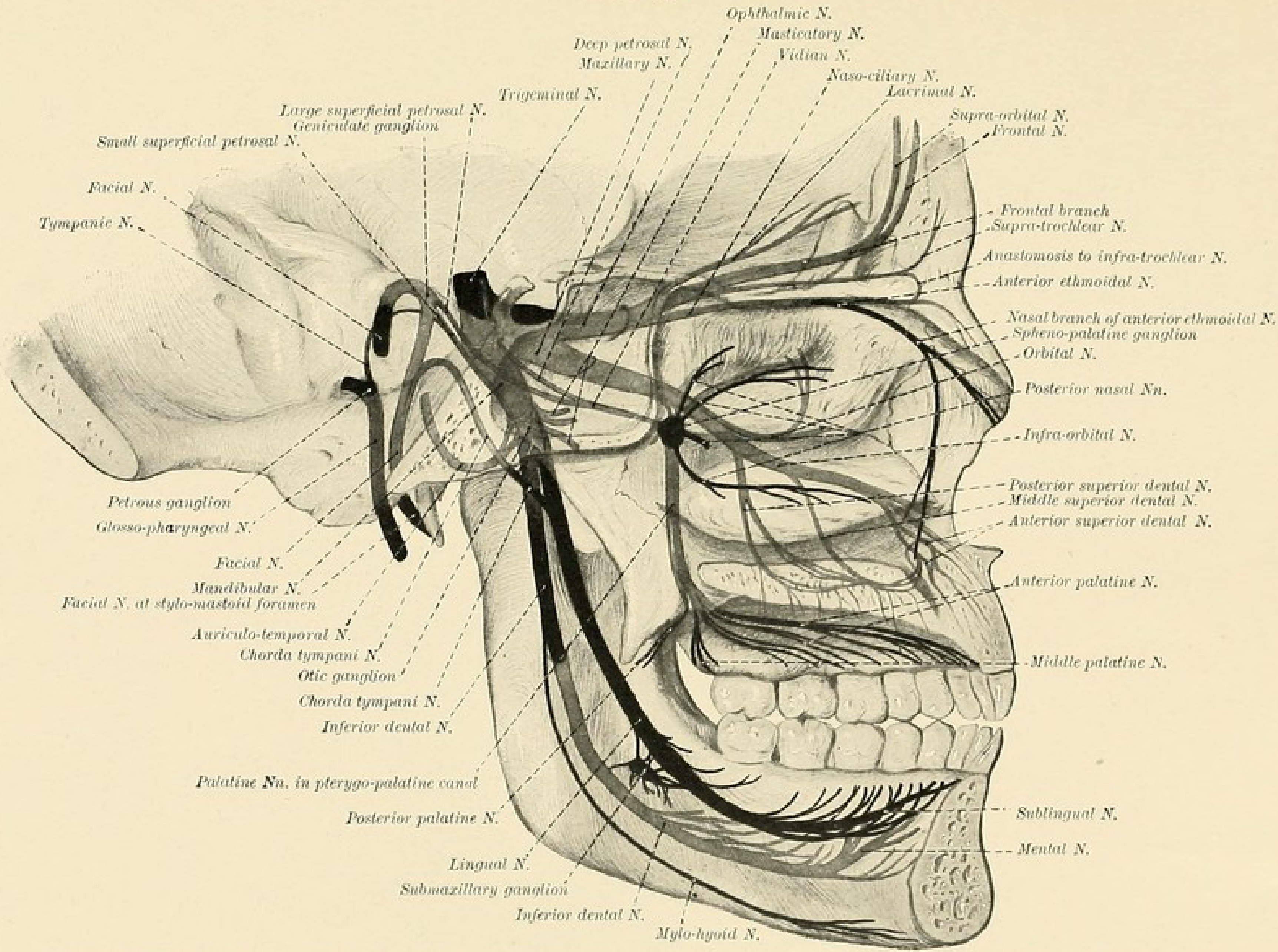


Diagram showing distribution of the fifth or trigeminal nerve. The black lines indicate the branches embedded in soft tissue, the gray lines those embedded in bony tissue. (After Sobotta.)

the maxillary nerve gives off several branches, which partly follow the arteries, partly pass through their own foramina into the maxillary tuberosity (Figs. 48, 51, and 52) and the body of the maxilla. Following the arteries, they pass forward above the molars, branching out within the facial maxillary wall, and finally communicate with the *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. 51 and 52).

The Infra-orbital Branch.—The infra-orbital branch frequently divides into from two to four branches, which arise closely together from the infra-orbital foramen (see Fig. 51). They run in a curve from behind and above downward to forward and inward. The numerous branches that pass off form a thick nerve plexus, which in turn sends off finer branches to the palatine mucosa, the floor of the nasal cavity, the incisors and canines, the oral mucosa, and the spongiose substance (see Fig. 51). Above the root of the canine this plexus unravels itself into separate branches, which give off delicate tendrils downward to the anterior and bicuspid teeth (see Figs. 48, 49, and 52).

From within the alveolar process the thicker nerve trunks send off branches to the teeth and the oral mucosa (see Figs. 48 and 52).

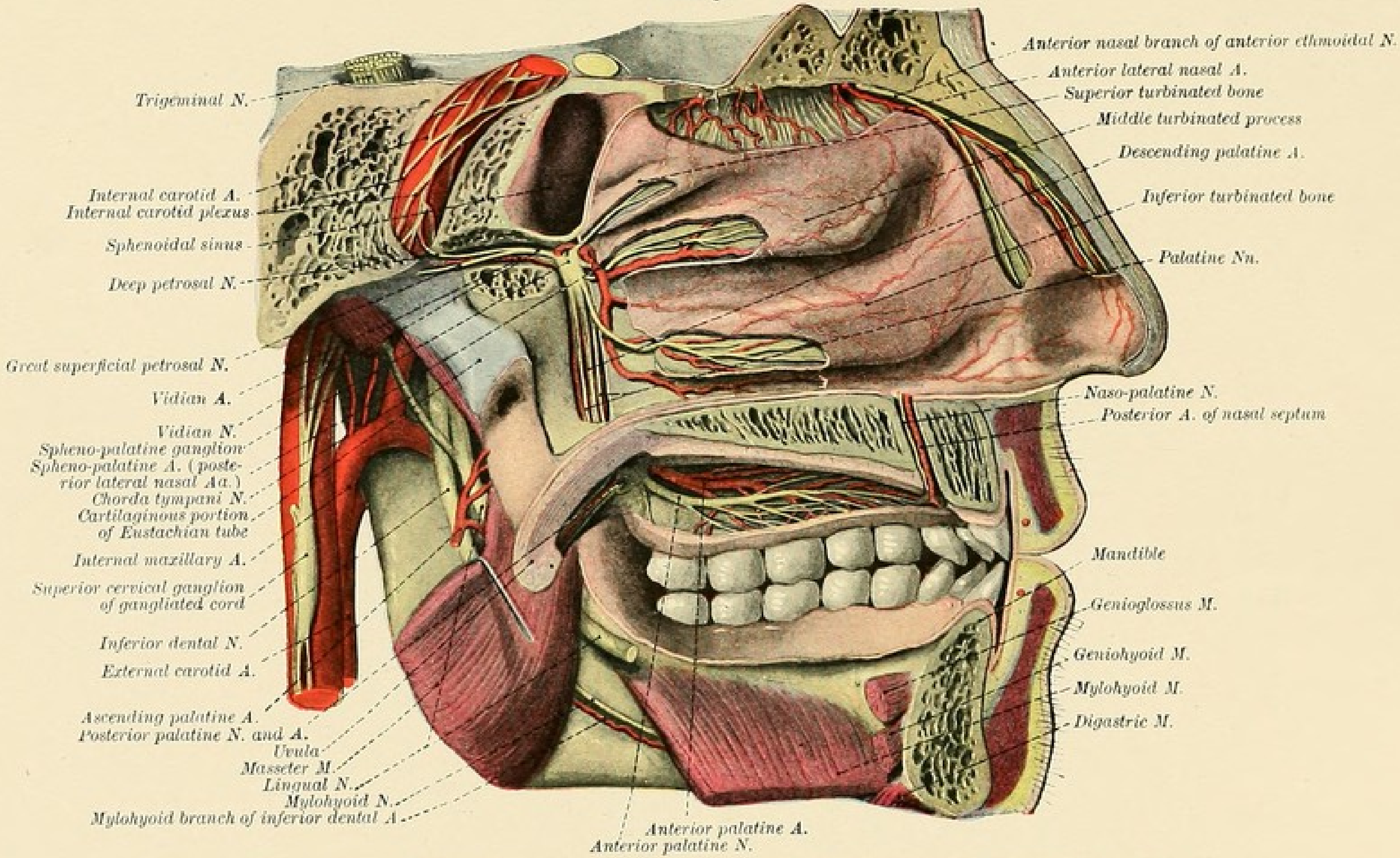
The Mandibular Nerve.—The third or mandibular division of the trigeminal makes its exit from the skull through the foramen ovale, dividing into a *superior*, chiefly *motor root*, and an *inferior*, chiefly *sensory root*. Through the foramen spinosum the mandibular nerve gives off the recurrent or meningeal branch to the dura mater (see Fig. 49).

From the superior motor root the masticatory muscles are supplied by the following branches: The *masseteric*, the *internal* and *external pterygoid*, the *deep temporal*, and the *buccinator branches*.

From the inferior root the *inferior dental*, the *lingual*, and the *auriculotemporal branches* are given off (see Figs. 49 and 50).

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. 49 and 50).

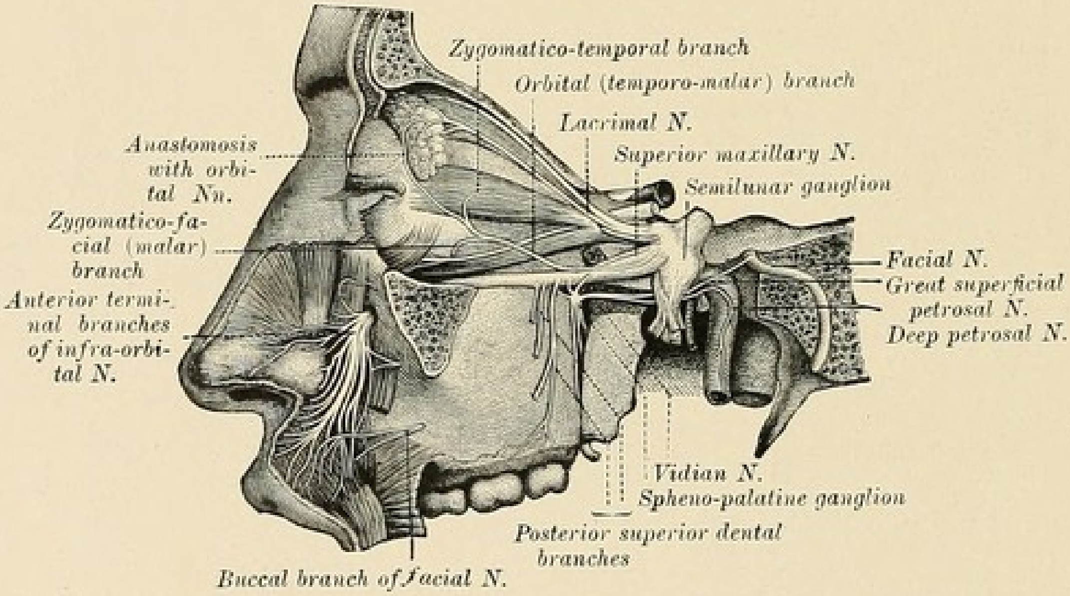
Fig. 50



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

The *lingual nerve* supplies the tongue and the floor of the oral cavity with sensory filaments (see Figs. 50 and 53). From the *chorda tympani nerve*, which is a branch of the *facial nerve* (the seventh), it receives secretory filaments which it conveys to the large mandibular glands. Besides, the chorda tympani nerve receives filaments from the glossopharyngeal nerve (the ninth) by anastomosis of the facial with the glossopharyngeal nerve in the tympanic cavity, or through the nervus intermedius, which is supposed to come from the glossopharyngeal nucleus and to pass into the chorda (see Fig. 52).

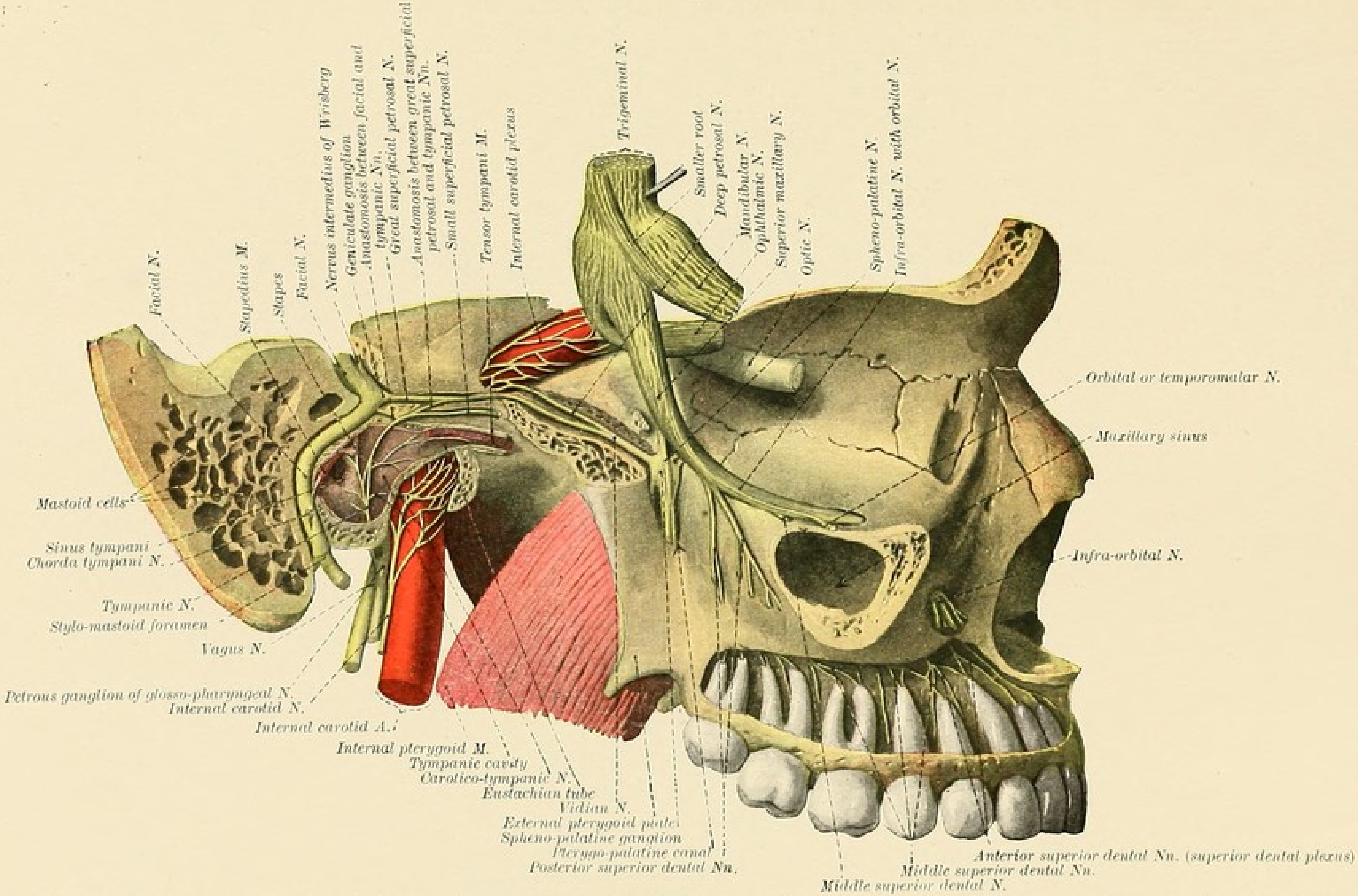
FIG. 51



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.)

To the third division of the trigeminal belongs also the *otic ganglion* (Fig. 49), which is situated immediately below the foramen ovale. The *small superficial petrosal nerve*, continued from the *tympanic plexus*, conveys to the ganglion secretory and sympathetic filaments. 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*.

FIG. 52



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

The sensory root of the ganglion communicates with the trigeminal through filaments from the *internal pterygoid nerve.*

The otic ganglion also sends *motor* filaments to the *tensor palati* and the *tensor tympani muscles, secretory* filaments to the *carotid artery.*

The Mandibular Nerve with the Inferior Dental Nerve.—The largest branch of the *third division* of the trigeminal is the *inferior dental nerve.* After giving off the mylohyoid branch, it enters the long inferior dental or mandibular canal (Fig. 50), passing along with the artery and the venous plexus below the roots of the molars (see Figs. 49 and 50). It 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. 49). 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 dental and the mental foramina to the bicuspids.

In front of the inferior dental nerve (Figs. 49 and 50) 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. 53). In the bicuspid region it ascends, finely distributing itself in the periosteum as far as the genial tubercles.

Branches Constituting the Trigeminal Nerve.—The trigeminal nerve is made up of the following branches:

Sensory, supplying the integument of the head and face, dura mater, ball of the eye, mucous membrane of the nose and mouth, anterior surface of the outer ear (the posterior surface of the ear being supplied by the cervical nerves), external auditory canal (see Fig. 54).

Motor, supplying the masticatory muscles, mylohyoid, anterior belly of the digastric, tensor of the soft palate, tensor tympani.

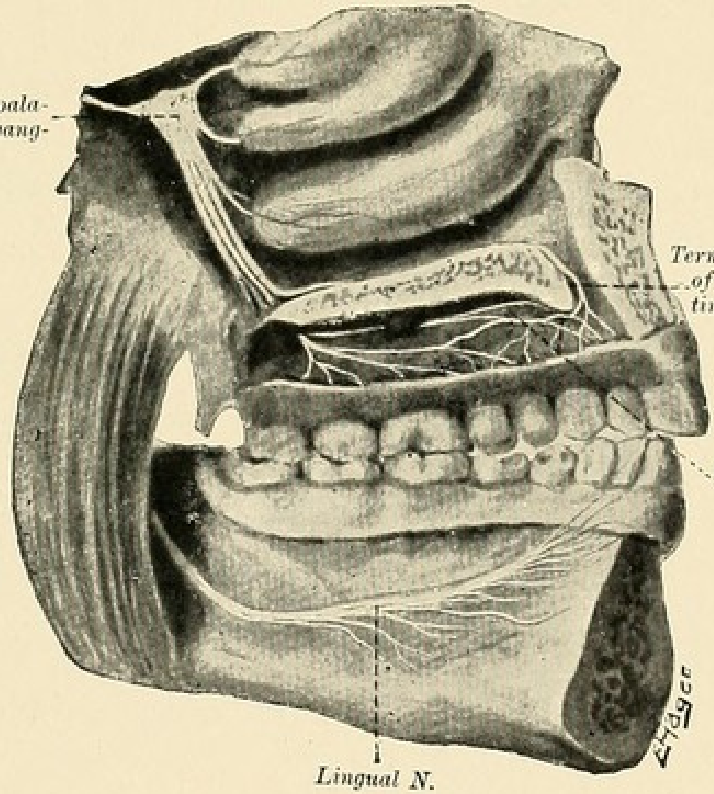
Gustatory, supplying the anterior two-thirds of the tongue, through the chorda tympani, to the lingual nerve from the glossopharyngeus.

Secretory filaments in the lingual branch, supplying the submaxillary and the sublingual.

Vasoconstrictor filaments, belonging to the cervical sympathetic system.

Plexuses of the Trigeminal Branches.—Bünte and Moral have recently emphasized, more strongly than this had been done before, the anastomoses within the trigeminal area, which are of greatest importance in dentistry. These investigators use the term "interlacing of nerves" for the intercommunication of some of the branches

Fig. 53



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

of the trigeminal nerve, the most important of which are the following: The *anterior palatine nerve* (second division) communicates in the anterior palatine canal with the *nasopalatine nerve* (second division) (see Figs. 49, 50, and 53). On the anterior surface of the mandible the *posterior, middle,* and *anterior superior dental nerves* anastomose with one another (Figs. 48 and 52), as do the *infra-orbital nerves* in the median line at the nasal spine. In the mandible, the *inferior dental* *nerves* of either side communicate with one another at the symphysis. Numerous terminal plexuses of the second and third divisions, which supply the alveolar processes, are distributed in the oral mucosa as the *posterior* and *anterior superior dental nerves*, and the *large* and *small palatine nerves*. From the *auriculotemporal nerve*, which is a branch of the third division of the trigeminal, the *parotid branches* pass to the parotid gland. The tensor palati and the tensor tympani muscles are supplied by the palatine and the tympanic nerves which, being motor, are given off from the otic ganglion.

Stimuli Referred by Anastomoses.—The nerves supplying the individual teeth are really nerve terminals, which, at their bases, are in communication with the central nervous system by larger tracts of supply. Since they stand, however, in direct relationship to neighboring areas, it is easily understood why pathological processes 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 to that side. By the relations of the trigeminal nerve to the *facial nerve*, in diseases of the *lower teeth*, pain is often referred to the *ear* by way of the tympanic branch, the mandibular nerve communicating through the auriculotemporal nerve with the nerves of the external auditory meatus, the tympanic branch of which supplies the tympanic membrane. Radiation of pain from the alveolar process in the *maxilla* to the regions of the temples, the eyes, the forehead, the neck, or even the upper arm, is frequently noted. The same corresponding relationships are noted in anesthesia.

Communications between the Divisions of the Trigeminal Nerve, Especially the First and Second Divisions.—It is a very interesting fact that strong electric currents applied to the teeth or the oral mucosa disclose certain relationships existing between the different areas of nerve supply in the facial 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, thereby stimulating the second and third divisions of the trigeminal nerve.

Stimulation of the soft palate is followed generally only by an increase in lacrimal secretion. These relationships are of the greatest importance in regard to pathology, as serious disorders of the teeth may involve the organs of the *first branch* of the trigeminal nerve, and may affect even other neighboring nerve trunks, as, for instance, in neuritis of the optic nerve. For a clear understanding of these conditions the anatomy of the divisions of the trigeminal nerve must be fully considered.

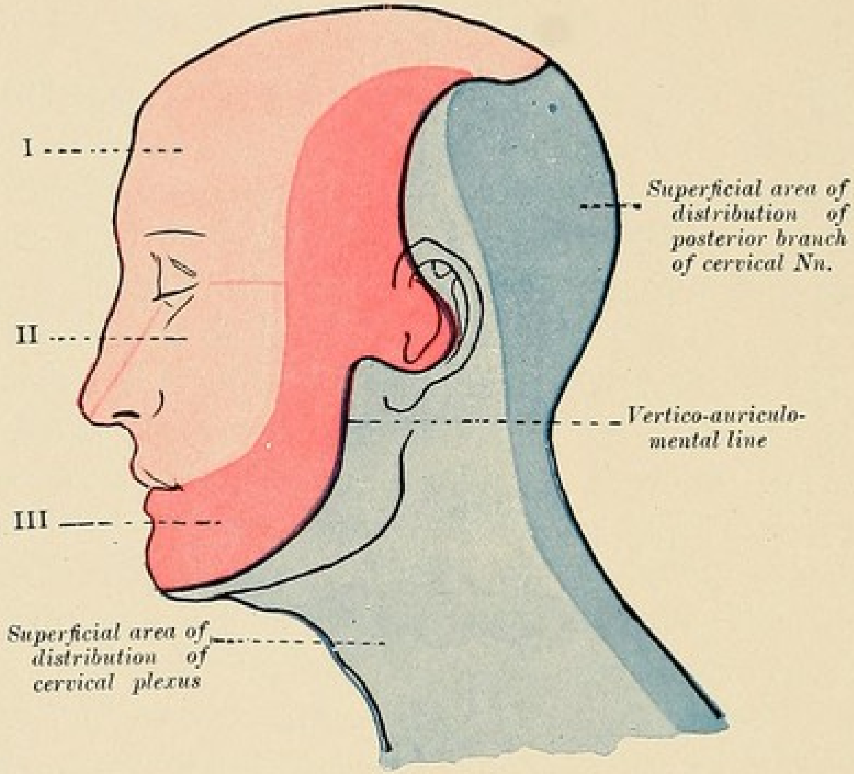
The first division of the trigeminal, as has been said before, sends three branches to the orbital region (Fig. 48), the *nasal nerve* entering the orbit by way of the sphenoidal fissure between the two heads of the external rectus, while the *lacrimal nerve* and the *frontal nerve* enter the orbit through the upper portion of the fissure.

It seems beyond all doubt that especially the *nasal nerve*, by its relationships to the *oculomotor* and the *optic nerves*, as well as to the *lacrimal sac*, conveys impressions from the second and third divisions of the trigeminal nerve to the first division, producing *oscillation of the eye* and increase in *lacrimal secretion.* The sensory nerves of the palate also being derived from the second division of the trigeminal (the anterior palatine nerve supplying the hard palate, the middle and posterior palatine nerves supplying the soft palate), these too may influence the first division of the trigeminal. The tensor palati muscle, on the other hand, is supplied by branches of the third division of the trigeminal. The diagram in Fig. 49 illustrates the intimate relations existing between the trigeminal nerve and the branches of other cranial nerves invading its area of distribution.

AREAS OF NERVE SUPPLY OF THE MASTICATORY APPARATUS

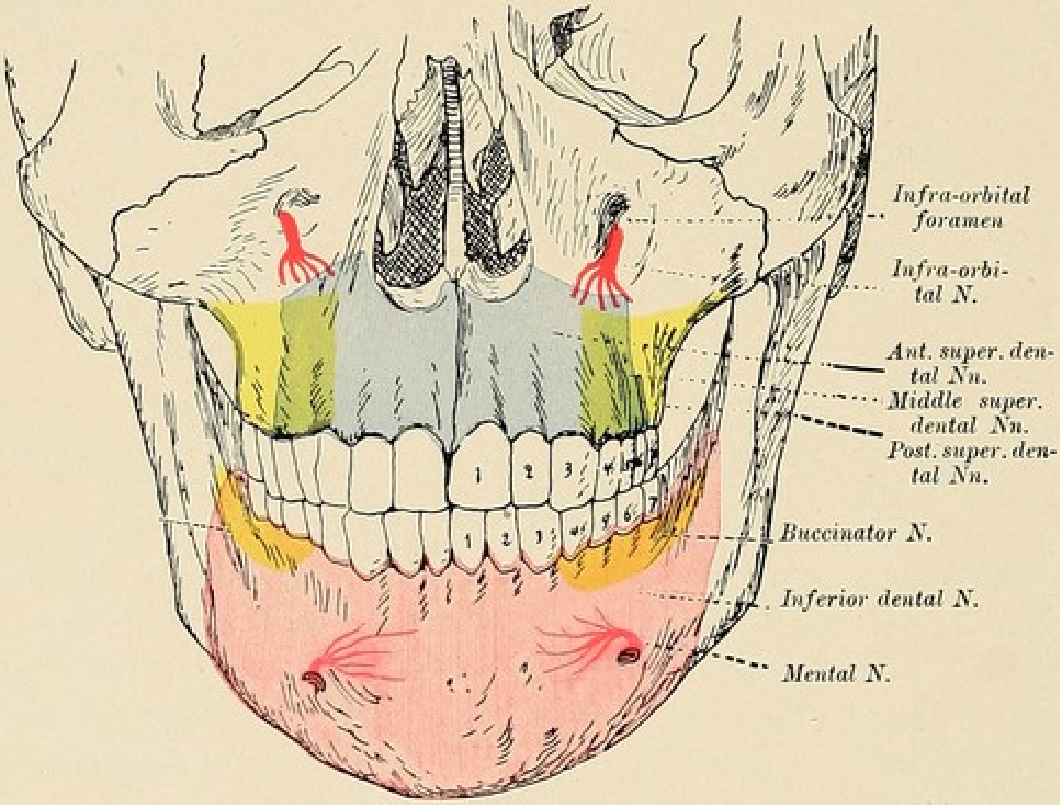
In order to offer a clear picture of the general distribution of the individual nerve trunks in the masticatory apparatus, especially for the purpose of local anesthesia, the different areas have been marked in colors in the diagrams (see Figs. 54 to 60). In the head generally three definite nerve areas are distinguished, supplied by the divisions of the trigeminal nerve, as illustrated in Fig. 54.

FIG. 54



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

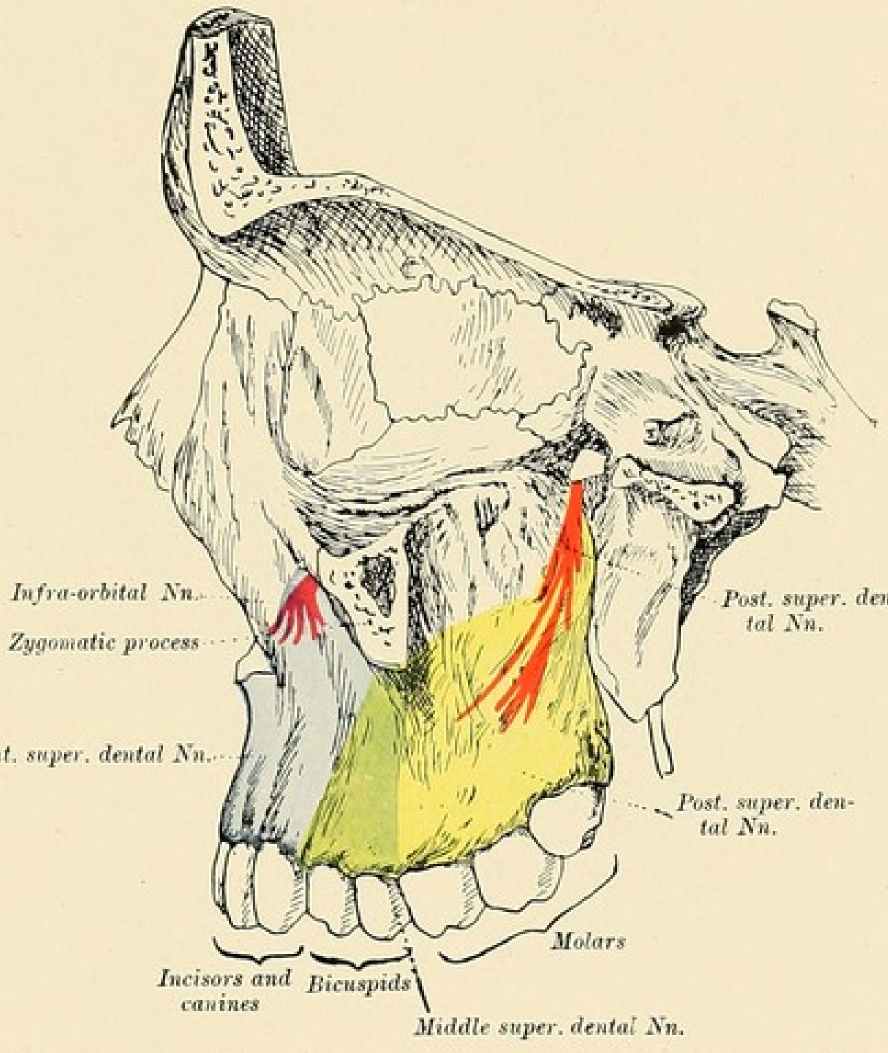
FIG. 55



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

Superficial Areas.—Looking at the anterior surface of the skull, in the *maxilla* three, in the mandible two areas are distinguished (see Fig. 55). The upper incisors and canines belong to the *blue* area supplied by the *anterior superior dental nerves*, the molars to the *yellow*

FIG. 56

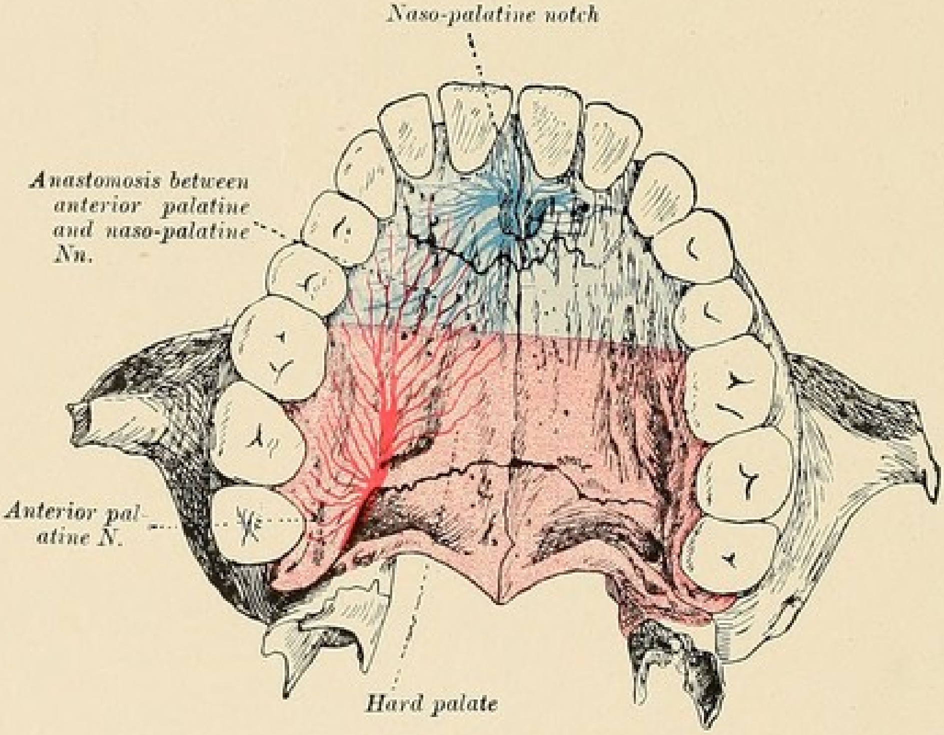


Areas of nerve supply of maxilla. Blue area: anterior superior dental Nn. (incisor and canine region). Green area: middle superior dental N. (bicuspid region). Yellow area: posterior superior dental Nn. (molar region).

area supplied by the *posterior superior dental nerves*, while the bicuspids are related to both sides, being supplied, in the *green* area, 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 areas are mixed. In the latter we find three branches, 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. 48). The suborbital nerve issues by the infra-orbital foramen (see Fig. 51).

In the *mandible*, the *red* area supplied by the inferior dental nerve is the predominant one (see Fig. 55). Only in the posterior section, the mucosa at the molars is supplied by sensory filaments from the *buccinator nerve* (see the orange area in Fig. 55).

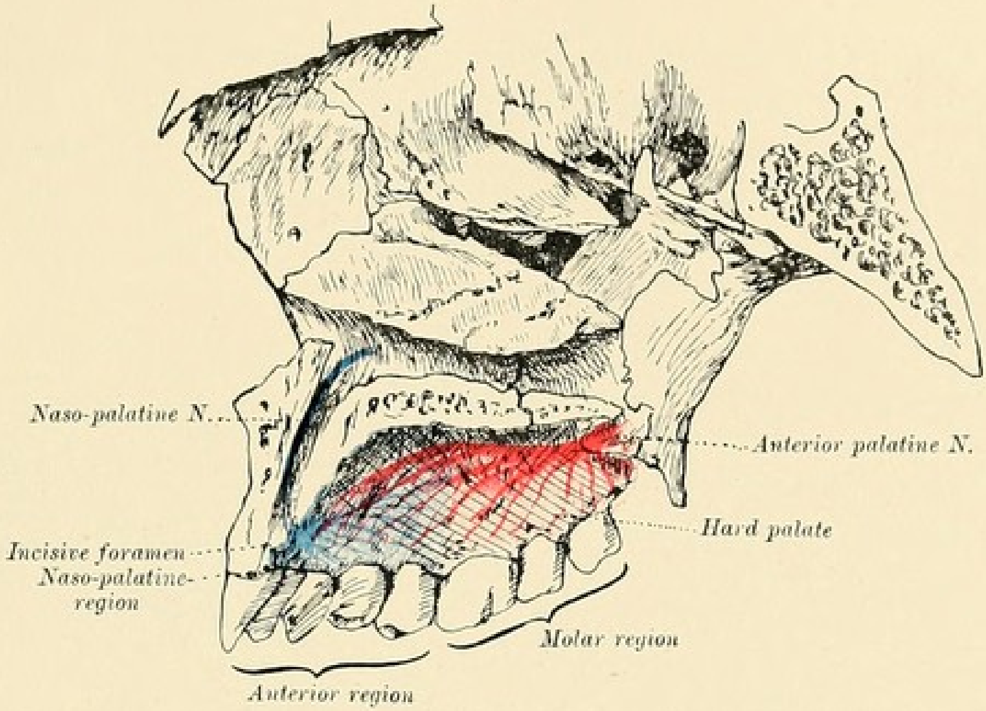
FIG. 57



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

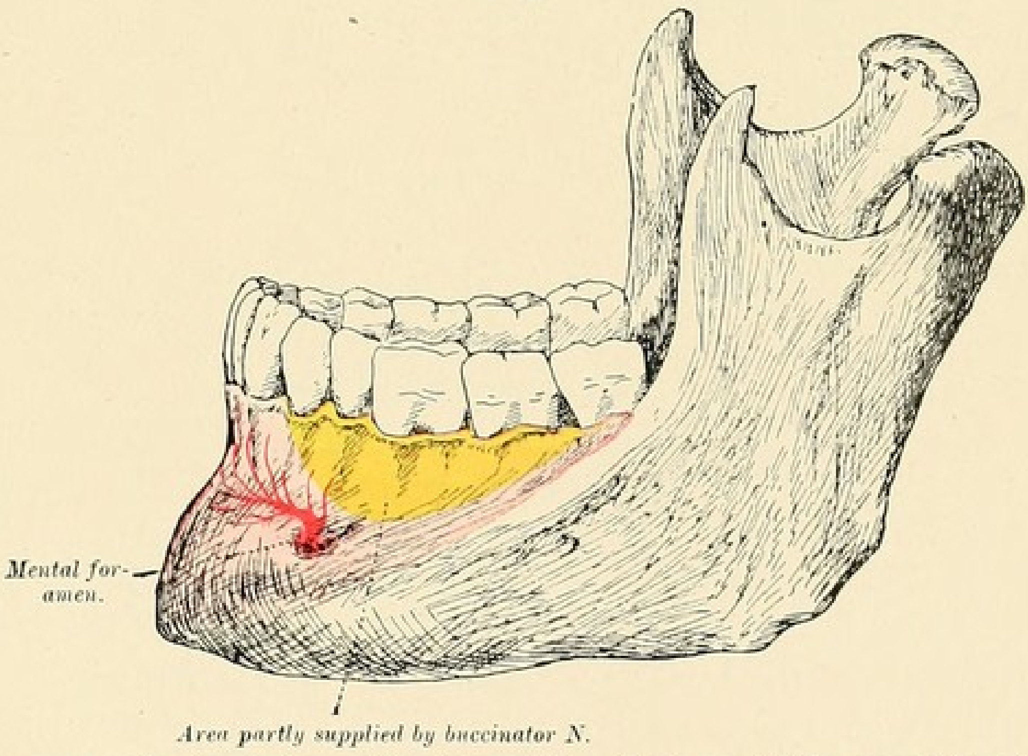
Maxilla.—Viewing it laterally, the *maxilla* may be divided into three areas, shown as *blue*, *green*, and *yellow* in Fig. 56, being sharply demarcated at the teeth supplied. At the level of the tuberosity the individual *posterior superior dental nerves* penetrate in several branches the facial wall (see Figs. 48, 51, and 52). These nerve branches, in their course to the tuberosity, can be reached by the hypodermic needle and anesthetized by *injection at the tuberosity* of the superior maxillary

FIG. 58



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

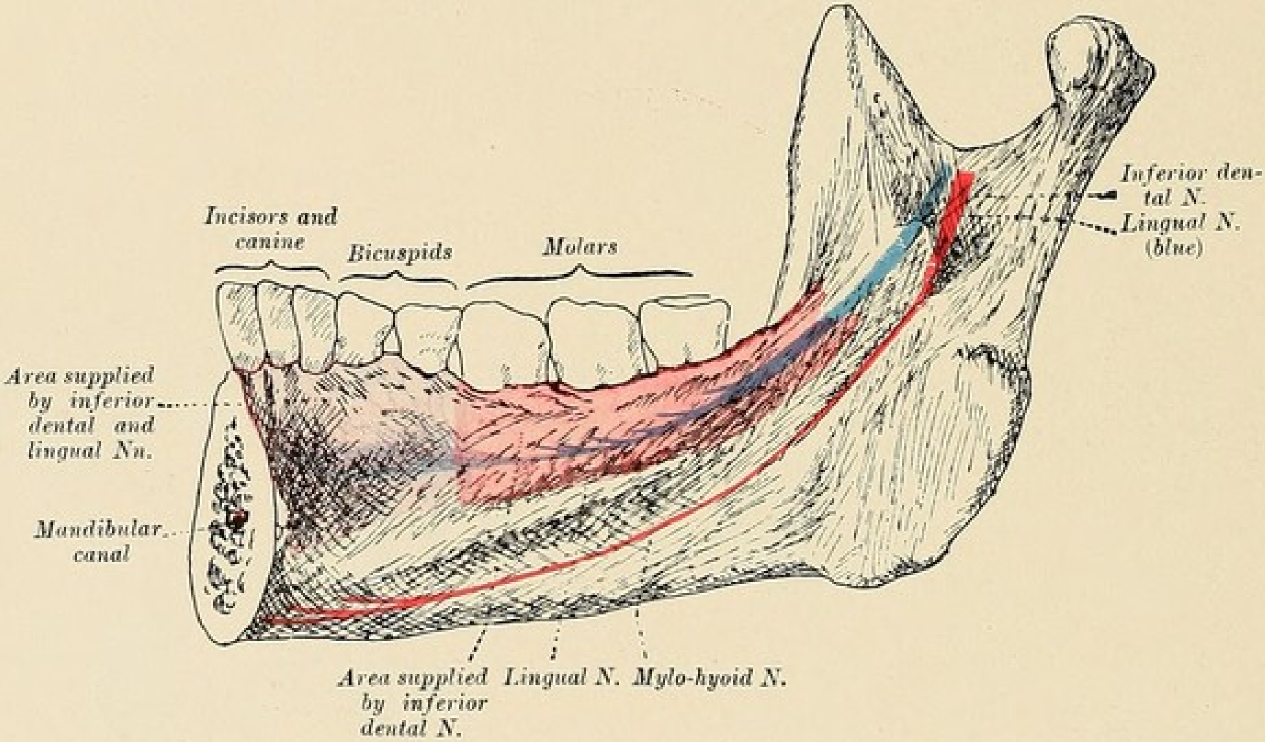
FIG. 59



Area of nerve supply of anterior section of mandible. Red area: inferior dental N. From the mental foramen emerges the mental N. The mucous membrane in the molar region is partly supplied by sensory fibers of the buccinator N.

bone. The nerves supplying the green and blue areas pass behind the facial plate of the alveolar process, partly into the maxillary sinus (see Figs. 48 and 52). This plate, as has been pointed out before, is cancellous in certain portions (see Fig. 20), and, being rather thin generally (Fig. 43), is most favorable for the diffusion of injected fluids.

FIG. 60



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

Palatal Surface.—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. 57), which emerges upon the hard palate at the posterior palatine foramen above the third molar (see Figs. 50, 51, and 53), and, passing forward and toward the median line, communicates in front with the *nasopalatine nerve* (see Figs. 50 and 53). The filaments of the latter supply the area at the *anterior teeth* as far as the bicuspids which, as in the mandible, are in communication with both branches. Viewed laterally, these two nerve branches, then, are distributed over the area just described (see Figs. 50, 53 and 58).

Mandible.—The nerve supply of the *mandible* is simpler. It is dominated entirely by the inferior dental nerve, which passes forward in the mandibular canal (see Fig. 49). A lateral view, therefore, shows a predominant *red* area which is interrupted by the emerging *mental nerve*, which is a branch of the inferior dental (see Figs. 49 and 59). Only in the region of the molars, an *orange-yellow* area indicates another invading nerve branch, the *buccinator nerve*, which supplies the anterior mucosa of the molars and bicuspids (see Figs. 55 and 59).

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 of the inferior dental nerve and ascending in the region of the first bicuspid to the alveolar process as far as the incisors, where it is finely distributed in the periosteum (see Figs. 53 and 60). Some of its terminal filaments in the vicinity of the genial tubercles probably extend through foramina to the anterior mandibular canal (see Fig. 34). Shortly before entering the inferior dental foramen the inferior dental nerve gives off a motor branch, the *mylohyoid nerve* (see Figs. 49, 50, and 60).

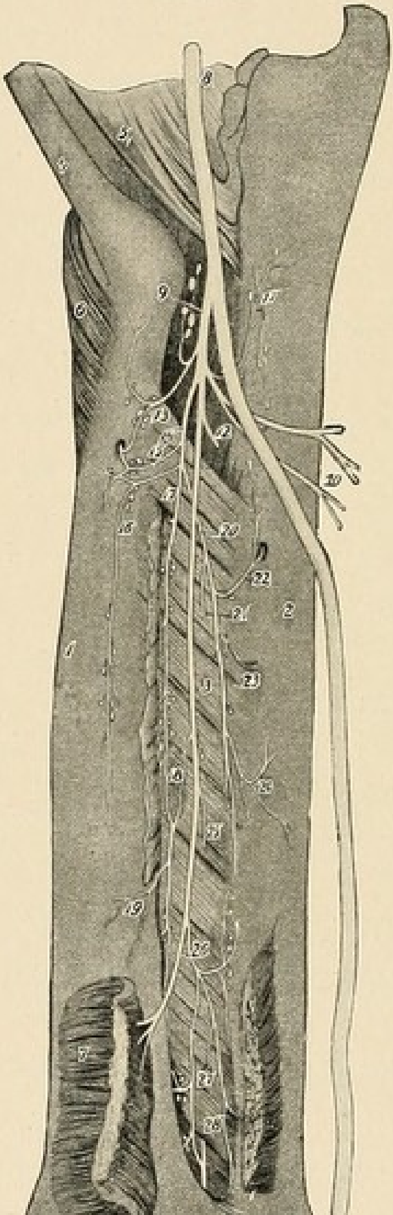
THE MINUTE DISTRIBUTION OF NERVES IN THE ALVEOLAR PROCESS AND THE PULP

Periosteum.—Within the alveolar processes the nerve trunks are most minutely distributed. The *periosteum* as well as the *pericementum* are specially richly endowed with sensory filaments. Fig. 61 represents *Vater's* or *Pacini's corpuscles*, sensory end organs, which are always present in the periosteum.

Pulp.—The nerve trunks of the *pulp* are generally large nerve fiber bundles branching out at the periphery of as well as laterally in the odontoblastic layer (Fig. 62), where they break up into delicate, long, *non-medullated* fibrils, which terminate in a delicate end plexus at the internal terminal lamina (see Fig. 64).

In osmium preparations we note in this end plexus delicate *button-shaped end bulbs*, these being characteristic of sensory nerve terminals.

FIG. 61

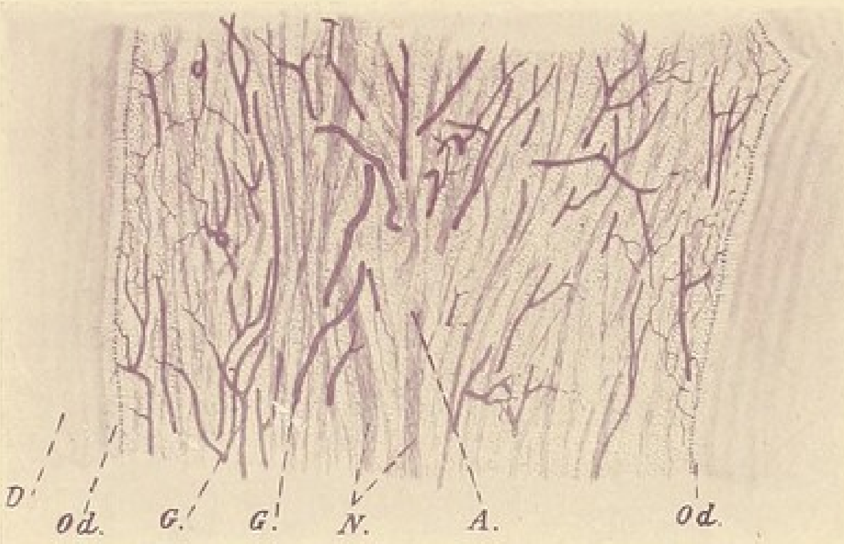


Nerves in the periosteum and interosseous ligament in the forearm with Pacinian corpuscles: 1, radius; 2, ulna; 3, interosseous membrane; 4, tendon of biceps brachii M.; 5, tendon of brachialis M.; 6, supinator M.; 7, pronator quadratus M.; 8, median N.; 9, interosseus antebrachii volaris N.; 10, branches 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 interosseus antebrachii volaris N.; 19, 20, 21, branches of interosseous Nn.; 22, ulnar N.; 23, 24, branches of interosseous Nn.; 25, 26, 27, branches of interosseus volaris N.; 28, interosseus antebrachii posterior N. (From Rauber and Kopsch.)

In their course, they arborize around the *odontoblasts*, and in oblique cross-sections the reticulum issuing from larger fibers and surrounding the odontoblasts can be plainly observed (see Fig. 65).

Sensibility 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, together with a graceful network of lymphatic capillaries, around the odontoblasts, the bloodvessels also breaking up here into innumerable capillary loops.

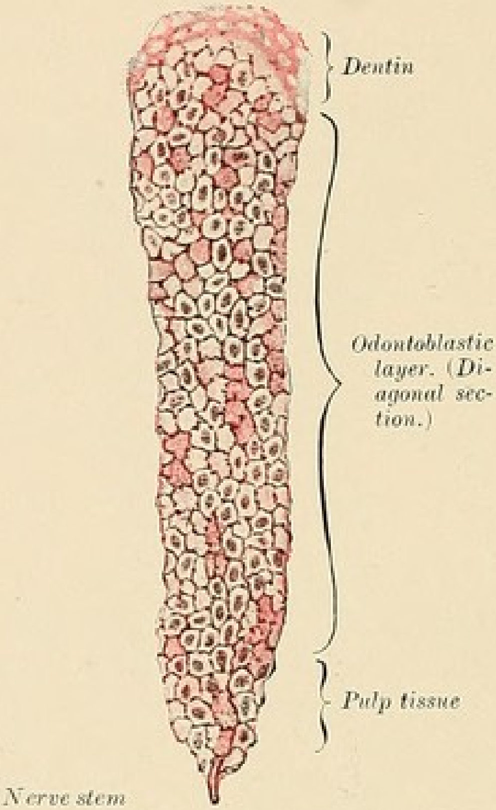
Fig. 62



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

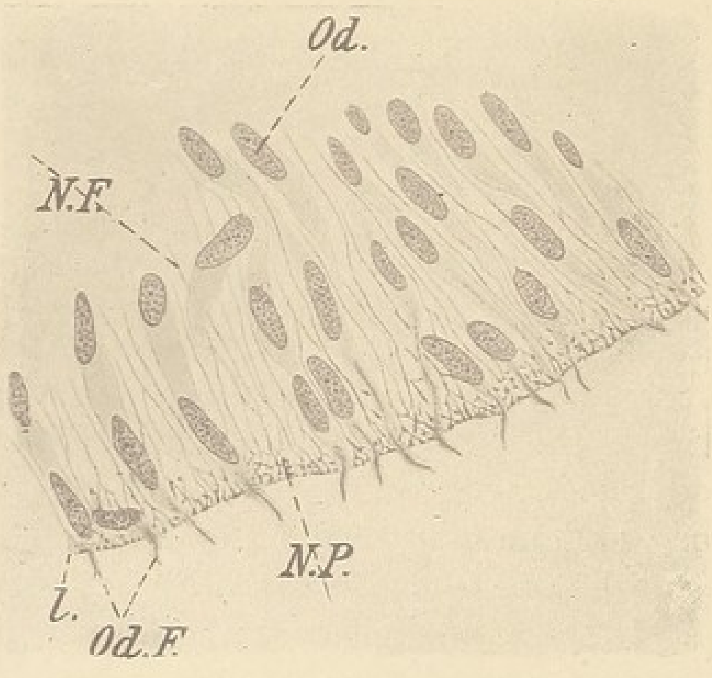
Since the odontoblasts with their cell processes control the nutrition and the sensitiveness of the dentin, which forms the bulk of the tooth, their relationship to the nervous and lymphatic system is not only easily understood, but is a matter of course. Since, on the other hand, Tomes' fibrils are undoubtedly of a protoplasmic nature, nerve tendrils, however, can be traced only beneath the odontoblastic layer, the transmission of stimuli in the dentin can be effected only by the medium of the protoplasm, whence they are conveyed to the sensory end organs at the odontoblastic cells.

Fig. 63



Distribution of bundle of nerve fibrillæ in odontoblastic layer. Stained with osmium.

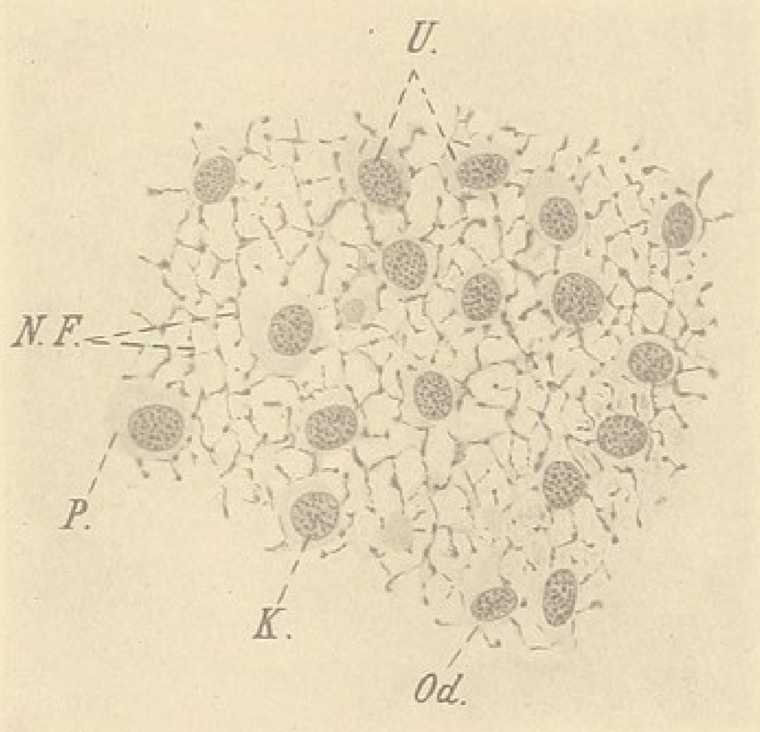
Fig. 64



Nerve fibers extending between the odontoblasts to the dentinal layer. × 940. *N.F.*, nerve fibers; *Od.*, odontoblasts; *l*, internal terminal lamina; *Od.F.*, odontoblastic processes; *N.P.*, terminal nerve plexus.

Structure of the Nerve Filaments in the Pulp.—The nerves of the pulp are derived from the sensory filaments of the trigeminal nerve, and enter the pulp in one or more thick trunks at the apical foramen together with the bloodvessels. In the middle portion of the pulp canal these trunks branch out so much that, in incisors, for instance, from thirty to forty bundles may be counted. These bundles

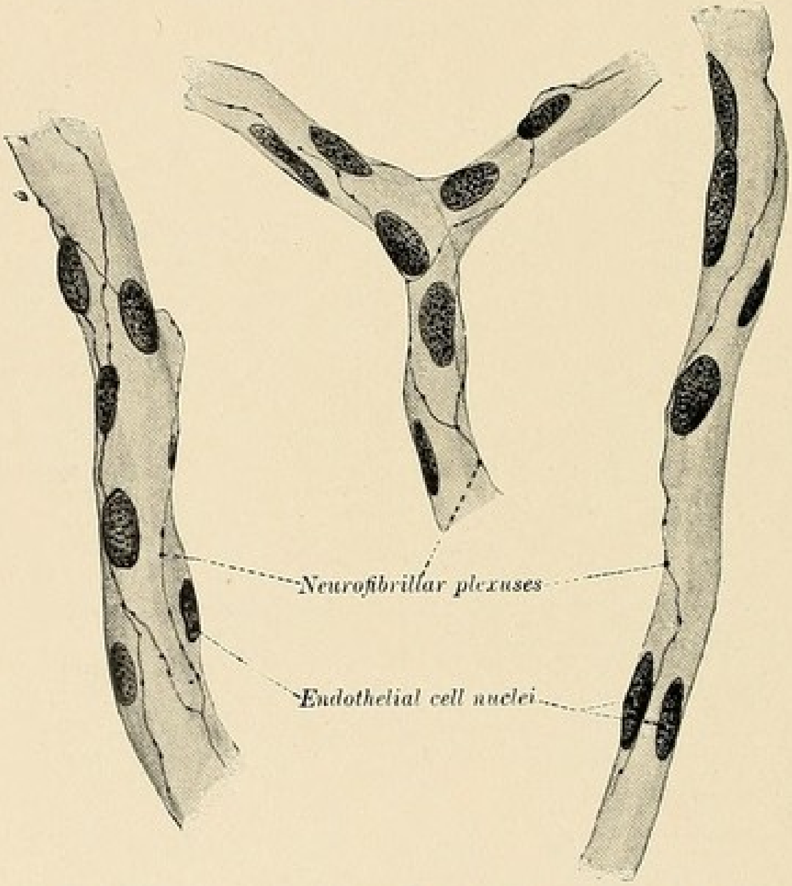
FIG. 65



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

are cylindrical and composed of a group of medullated nerve fibers of from about 6 to 10 microns' thickness (see Fig. 65). Each bundle is surrounded by a sheath of connective tissue similar to the perineurium. The fibrillæ in these bundles run mostly in the direction of the long axis of the tooth. They break up, by repeated *dichotomous* division (see Fig. 62), into innumerable brush-like amyelinic filaments, terminating beneath the dentin (at the internal terminal lamina) in a delicate plexus, these non-medullated telodendrions of from 2 to 3 microns' thickness exhibiting generally button-shaped, delicate end bulbs (see Figs. 63 and 64). These telodendrions surround the odontoblasts on all sides, partly in rings, partly in spirals, and represent complicated, free peripheral endings similar to the telodendrions of the sensory nerves of the muscles and tendons.

FIG. 66



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

Nerve Supply of the Vascular Walls.—A final word should be said as to 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*, generally terminating within the adventitious coat (tunica adventitia) and the tunica media in a sensory end plate. The capillaries are enmeshed in a reticulum of delicate neurofibrillæ, as illustrated in Fig. 66. These fibrillæ, when acted upon by suprarenin, bring about the contraction of the vascular walls, maintaining the vascular constriction so desirable during anesthesia.

THE TECHNIQUE OF LOCAL INJECTION

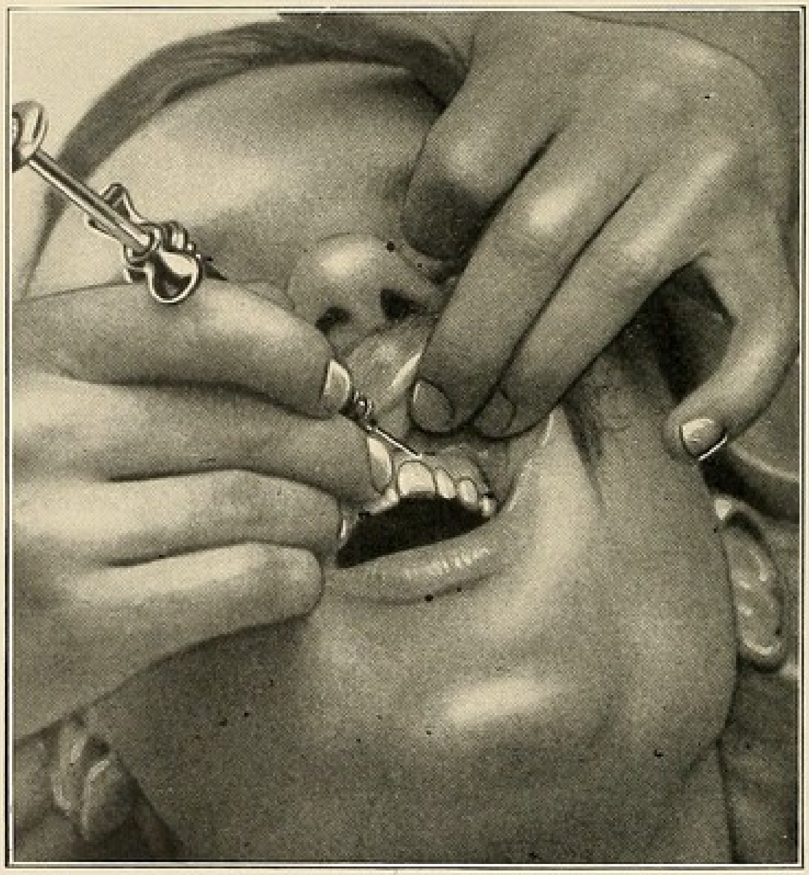
After the above considerations, the technique of injection is merely a question of logical utilization of the factors observed. After having gained definite points by which to follow our lines of procedure, based partly on the peculiarities of the bony structures, partly on the nerve supply, we are now on a well-marked road which is sure to lead us to the desired goal. That the tactics of injection to be demonstrated are the correct ones, has been evinced by the excellent results obtained so far.

Local injection anesthesia in the masticatory apparatus as formerly employed comprised merely *anesthesia of the mucous membrane*, until within recent years *conductive anesthesia* was introduced. It was not until the adoption of this method that our successes in this field became truly phenomenal, to mention only the effect of *mandibular anesthesia*, which method is, indeed, the first to guarantee complete and reliable anesthesia of the mandible. It is, indeed, an unassailable fact that anesthesia of lower molars by the old method of injection into the mucosa is successful only in certain favorable cases, whereas generally it is a more or less complete failure.

MUCOUS ANESTHESIA

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

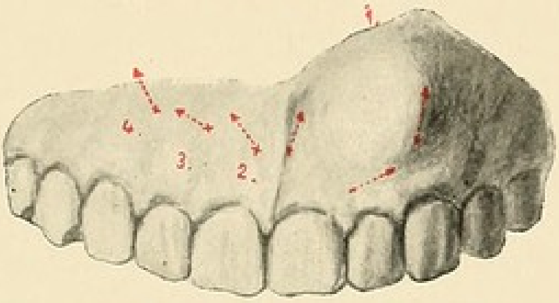
Fig. 67



Mucous anesthesia in maxilla in case of abscessed 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. Syringe is held like penholder.

Since mucous anesthesia in the jaws depends primarily upon intervention in the periosteum and its constituent tissue elements, the mucosa proper playing but a secondary role, it would be more correct to speak of *periosteal anesthesia*. Success depends less upon injection into the submucous tissue than into the periosteum. The periosteum in the jaws covers the bony surfaces in an extremely taut and firm layer; injection below this layer, therefore, requires considerable pressure.

FIG. 68



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. 69

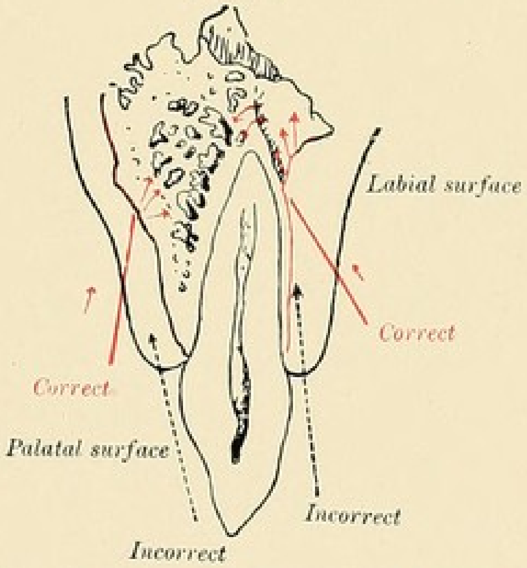
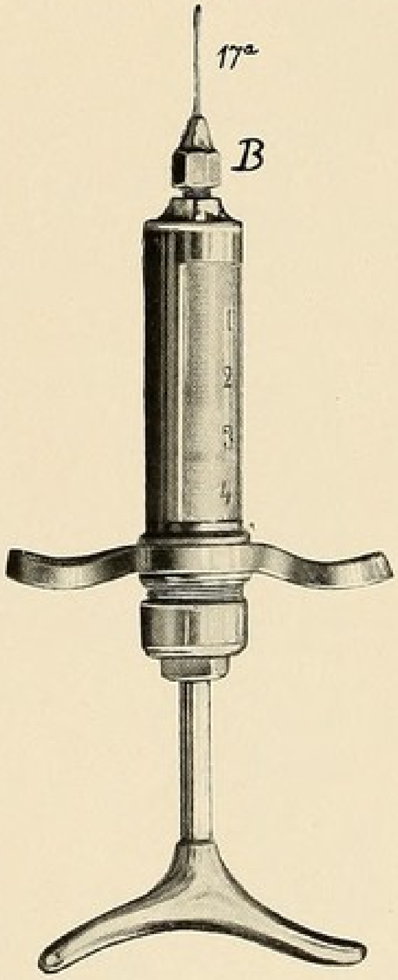


Diagram showing method of injection in maxilla (upper right canine). The red arrows indicate the correct, the black arrows the incorrect position of the needle.

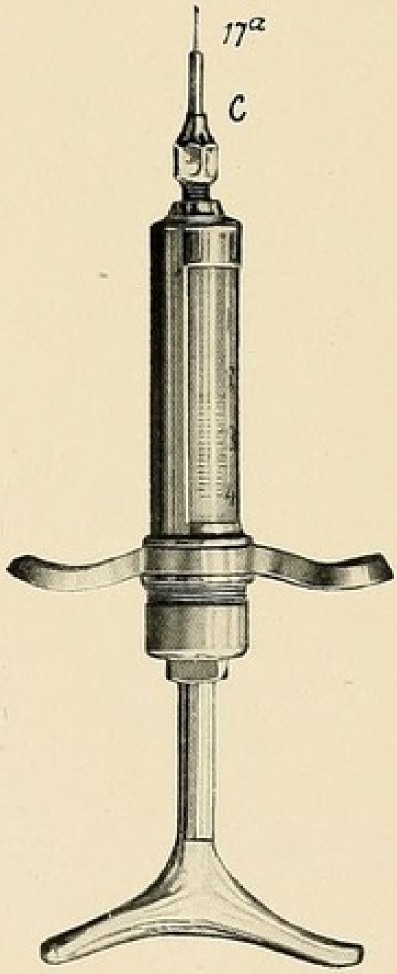
Injection into the Mucosa.—Before inducing anesthesia, the neck band, described above, is placed upon the patient, not too tightly (see Fig. 5). The injecting syringe is held like a pen (see Fig. 67), and the needle is placed at an almost right angle upon the mucosa, which has been disinfected with tincture of iodin (see Fig. 81). The needle is then slowly pushed through to the periosteum, and the syringe inclined so that the direction of the needle canal is at an acute angle to the bone (see Figs. 68 and 69). The needle is then advanced a short distance under the periosteum, and the needle point fixed with the left hand, while the right hand is holding the syringe in position (see Fig. 103). The syringe is mounted with hub *B* or *C* and needle

Fig. 70



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

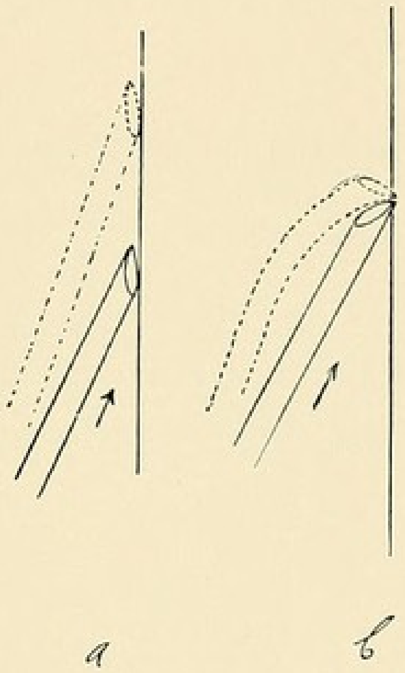
Fig. 71



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

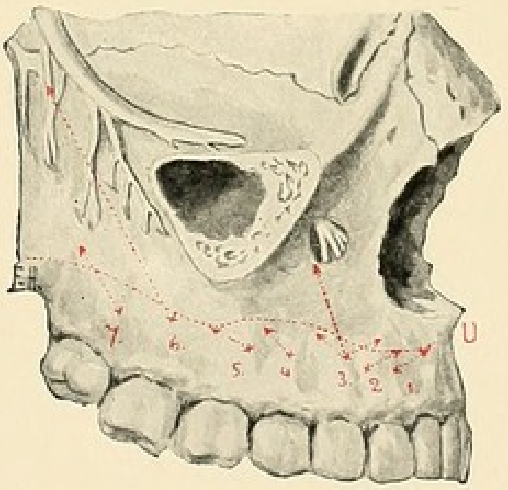
No. 17 *a* (see Figs. 70 and 71). The orifice of the needle should always be pointed toward the bone in the manner illustrated in Fig. 72. While with the left hand the lip is lifted away as much as possible to gain an unobstructed field of vision (see Fig. 67), a quantity of liquid is injected without further advancing the needle along the bone. The syringe is

FIG. 72



Position of needle in mucous anesthesia, aperture of 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.)

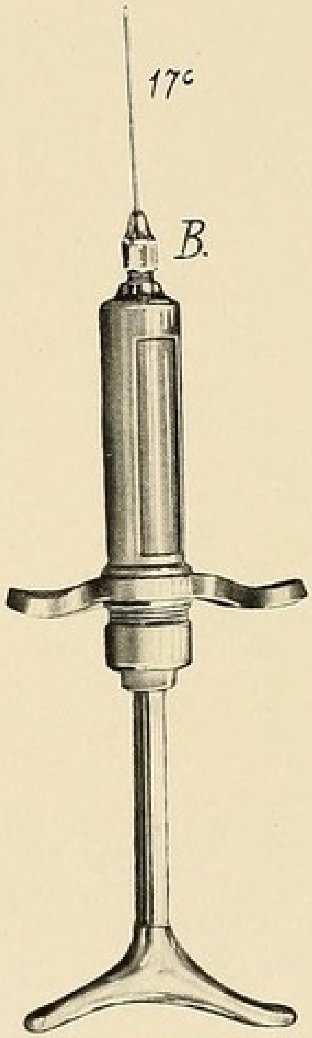
FIG. 73



Points of injection in 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 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.

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. 74

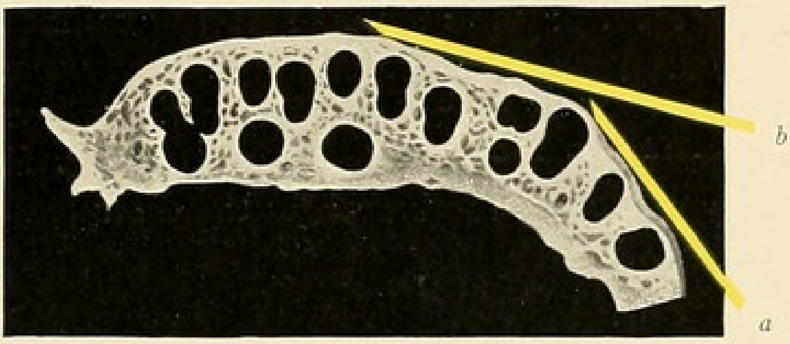


Syringe mounted with hub *B* and needle No. 17 *c*, for injection in posterior teeth.

In the posterior portions of the gums, owing to the interference of the cheek, the needle cannot be placed at a right angle, and must therefore be advanced obliquely (see Figs. 73 and 75), the main object being to reach the periosteum as quickly as possible, slide under it, and there inject. In this case the syringe is mounted with hub *A* and needle No. 17 *c*, as illustrated in Fig. 74.

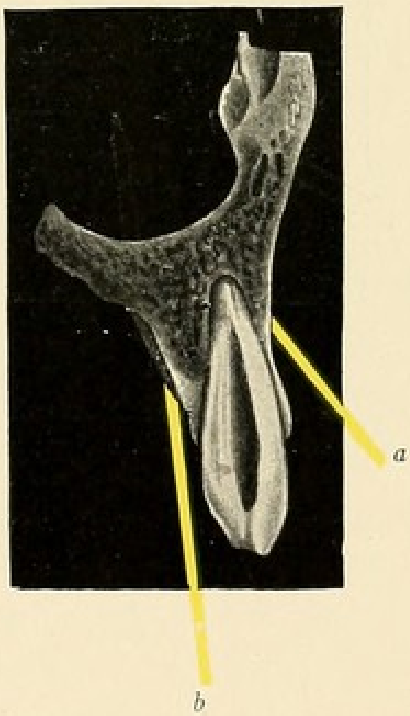
Maxilla.—*Buccal and Labial Injection.*—Injections in the buccal mucosa are generally made in the manner just described. Repeated insertions of the needle should be avoided as much as possible, and an effort be made to infiltrate the desired area at one insertion, which is

Fig. 75



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

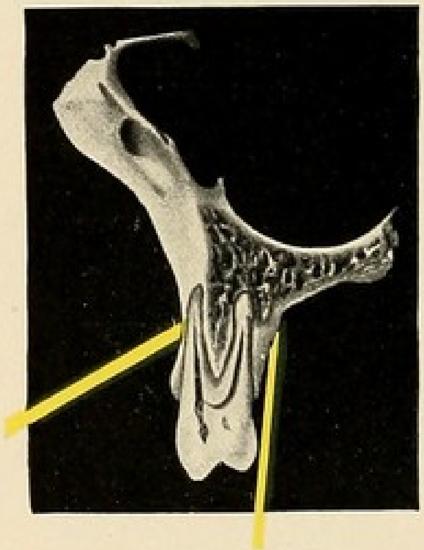
Fig. 76



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

always possible in single teeth. The anesthetization even of several teeth can be accomplished at one buccal insertion, especially in bicuspids and molars, which permit of straightforward palpation with the long needle (see Fig. 75). In these teeth the needle is inserted at the level of the middle root portion at a right angle to the vertical axis of the roots. At the sharp curve in the canine region, however (see Fig. 75), the needle is inserted at the level of the root apex of the canine and advanced under the periosteum, where the injection is slowly made under pressure (see Fig. 76). If the incisors and bicuspids on the same side are also to be anesthetized, the needle is pushed forward from the canine root, while slowly emptying the barrel, in the direction of the anterior

Fig. 77

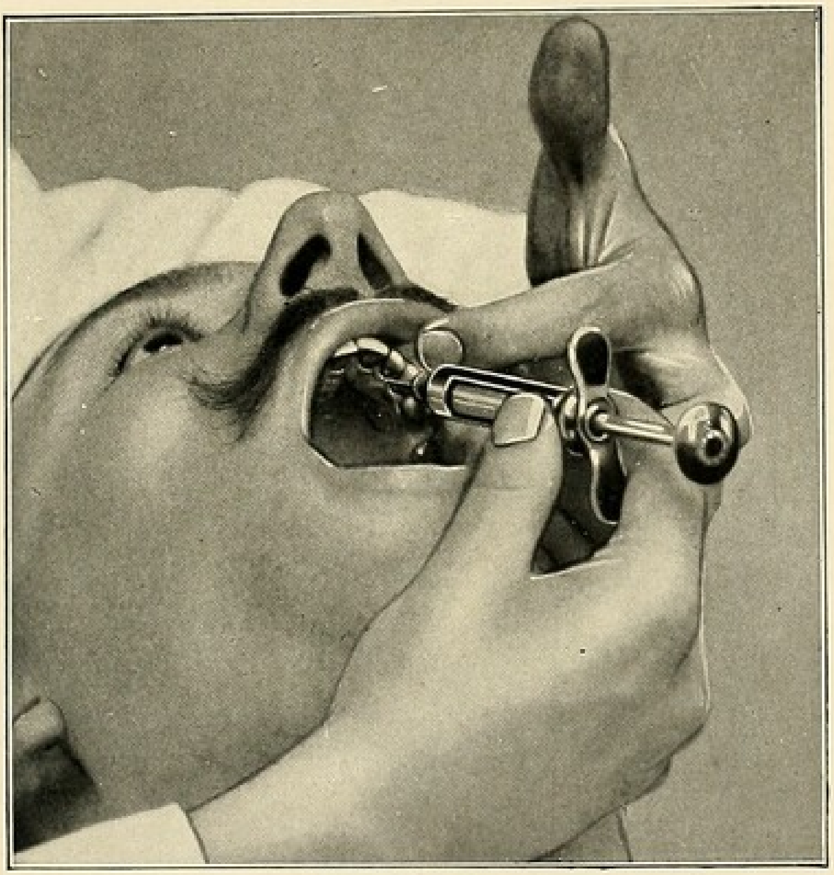


Position of needle for mucous anesthesia in upper first bicuspid. Needle yellow. Above is seen the infra-orbital foramen: *a*, buccal injection; *b*, palatal injection.

nasal spine into the region of the root apex of the central incisor, where the remainder of the solution is injected (see Fig. 73). After the syringe has been refilled, the needle is again inserted at the former point at the canine root, but in the direction of the root apices of the bicuspids, where the barrel is also slowly emptied. If the second bicuspid is also to be anesthetized, the needle must be advanced to the root apex of that tooth (see Fig. 77).

If mucous anesthesia has been correctly executed no swelling occurs, the formerly reddish mucous membrane becoming pale and sometimes entirely anemic. In spongy gingival tissue, however, swelling cannot be prevented, as in such cases the periosteum generally does not firmly cover the bone surface. The gradual expansion of the anemic area should always be carefully noted. After successful injection the anemia frequently involves the palate, owing to diffusion within the interdental papilla.

FIG. 78

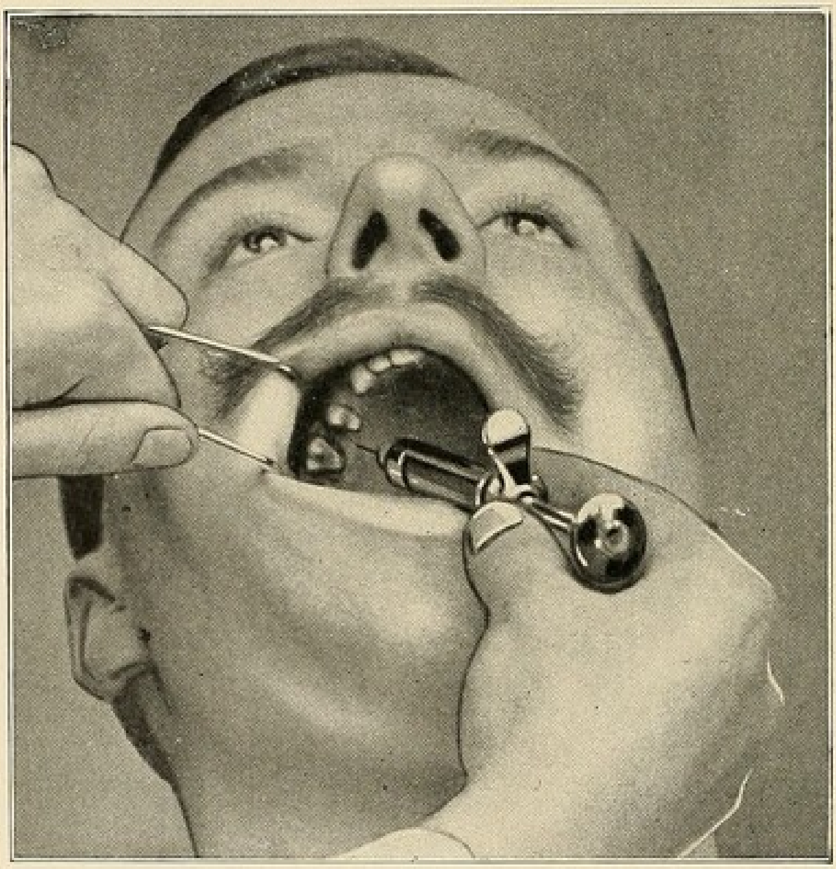


Injection in palatal mucous membrane at lateral incisor region. Syringe is held like penholder.

Palatal Injection.—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. 69, 75 to 79), and is at once cautiously and slowly advanced parallel to the alveolar process into the vicinity of the root apex (see Figs. 69 and 79), where a small quantity of the solution, *i. e.*, from $\frac{1}{8}$ to $\frac{1}{4}$ c.c., is deposited (see Fig. 68). In the deep strata of the anterior palatine area the conditions for diffusion are most favorable, and the injection can be made much more easily, with less pressure and less pain, than near the cervical margin of the gingival tissue, where the taut circular ligament offers considerable resistance (see Figs. 80 and 81).

Injection at the Posterior Palatine Foramen.—The above procedure is followed for all upper incisors, canines, and bicuspids, but not for upper molars. In these, one single insertion of the needle at the

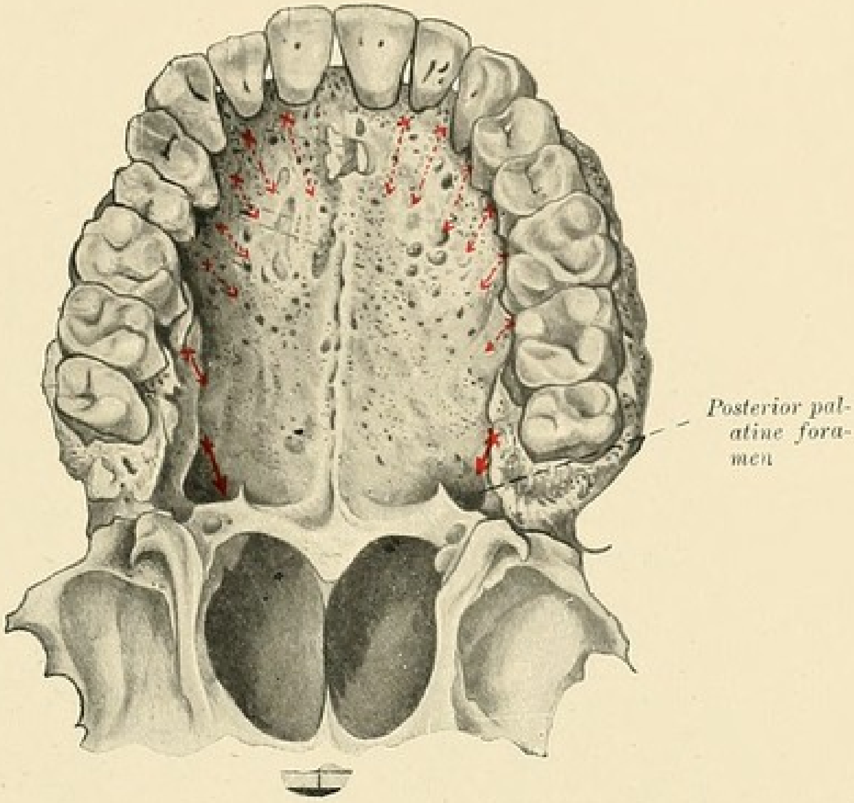
FIG. 79



Injection in palatal mucous membrane in bicuspid region. Syringe is held like penholder.

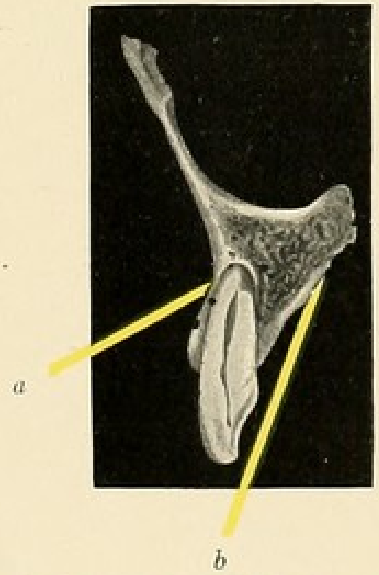
posterior palatine foramen suffices, this foramen being situated under a slight depression in the mucosa near the root apices of the third molar (see Fig. 82). The posterior palatine foramen is usually located $\frac{1}{2}$ cm. from the posterior limit of the alveolar process and above the last erupted molar (see Figs. 50, 53, 80, and 82), up to the tenth or eleventh year of life above the first molar, after the eruption of the second molar above this tooth, and finally above the third molar (see Figs. 27 to 31,

Fig. 80



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

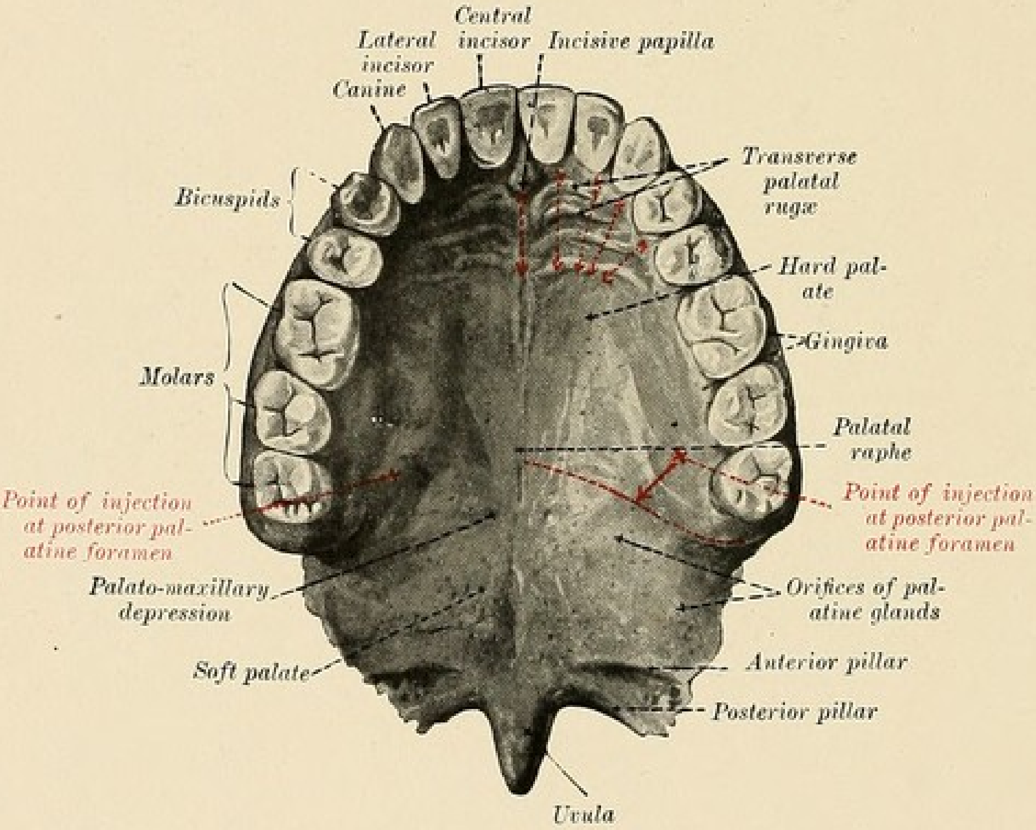
Fig. 81



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

49, 50, and 82). 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. The needle is inserted in the mucous fossa, the syringe being directed almost parallel to the alveolar arch and the molar root and inclined slightly backward to the tuberosity; the needle is then advanced into the foramen and from 6 to 10 drops of the solution are evacuated. If a larger quantity

Fig. 82

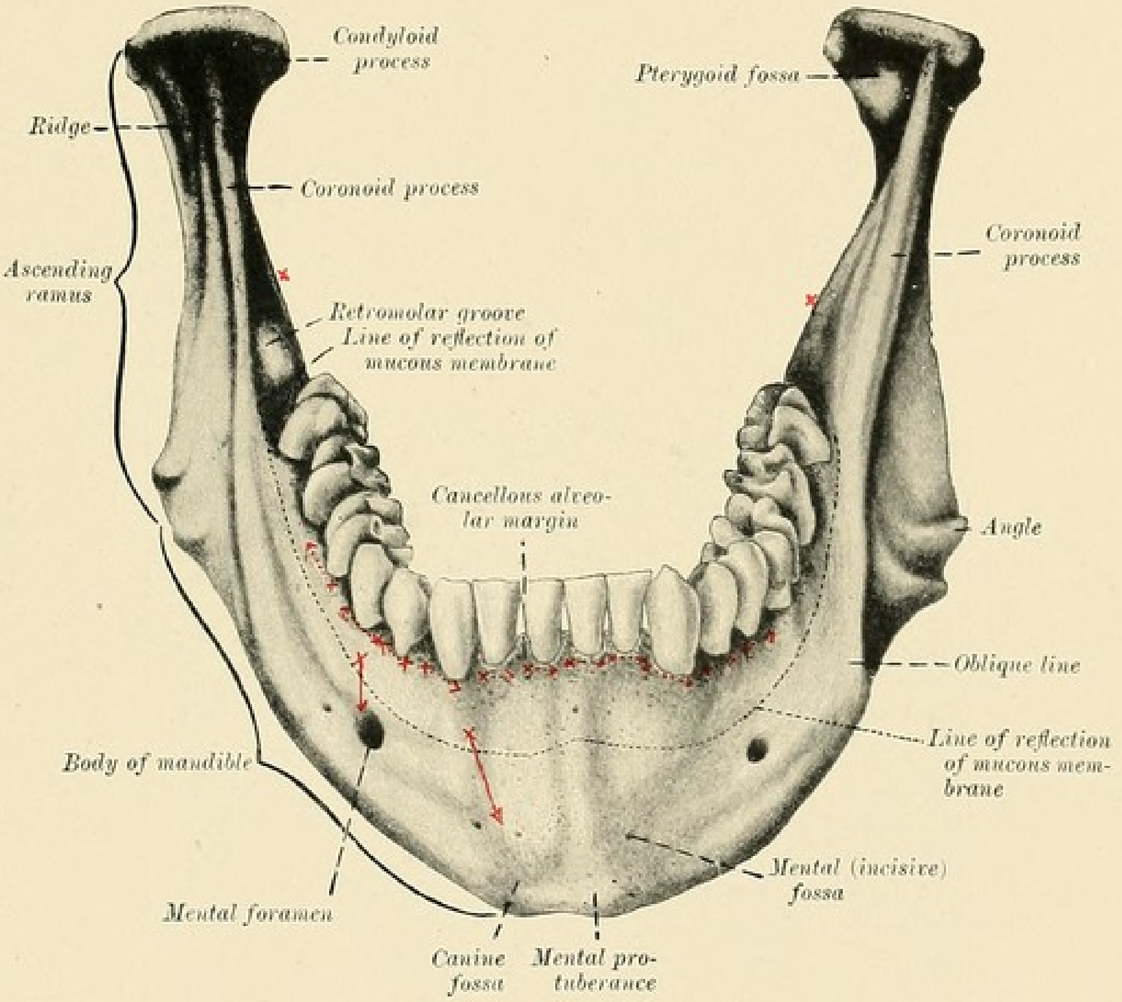


Mucous surface of palate. The red cross marks the point of injection at the posterior palatine foramen on either side. (After Spalteholz.)

is employed, there is danger of injecting the solution into the loose pharyngeal tissue, thereby producing disagreeable difficulties in deglutition. Strictly speaking, conductive anesthesia is produced by this method, as the anterior palatine nerve trunk is blocked at its descent from the posterior palatine foramen (see Figs. 50 and 53). The posterior portion of the alveolus in the molar region is completely anesthetized by this injection.

Injection in the Anterior Palatine Fossa Contraindicated.—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 location for anesthesia, as injection in these foramina for the sake of

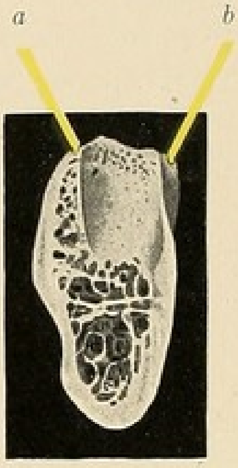
FIG. 83



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 the ramus are marked the points for injection at mandibular foramen.

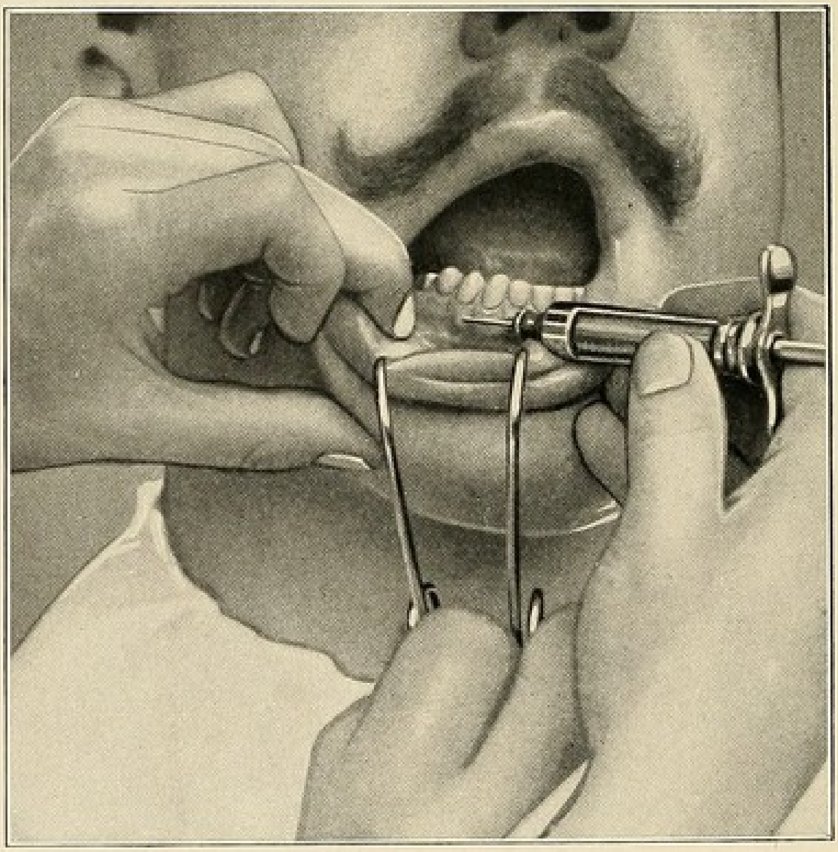
paralyzing the *nasopalatine nerves* usually involves severe pain, possibly owing to compression of these nerve trunks. Moreover, in regard to effect no advantages are to be derived from such an injection, and the advocated palatal injection behind each tooth (see Figs. 69, 78, and 79)

FIG. 84



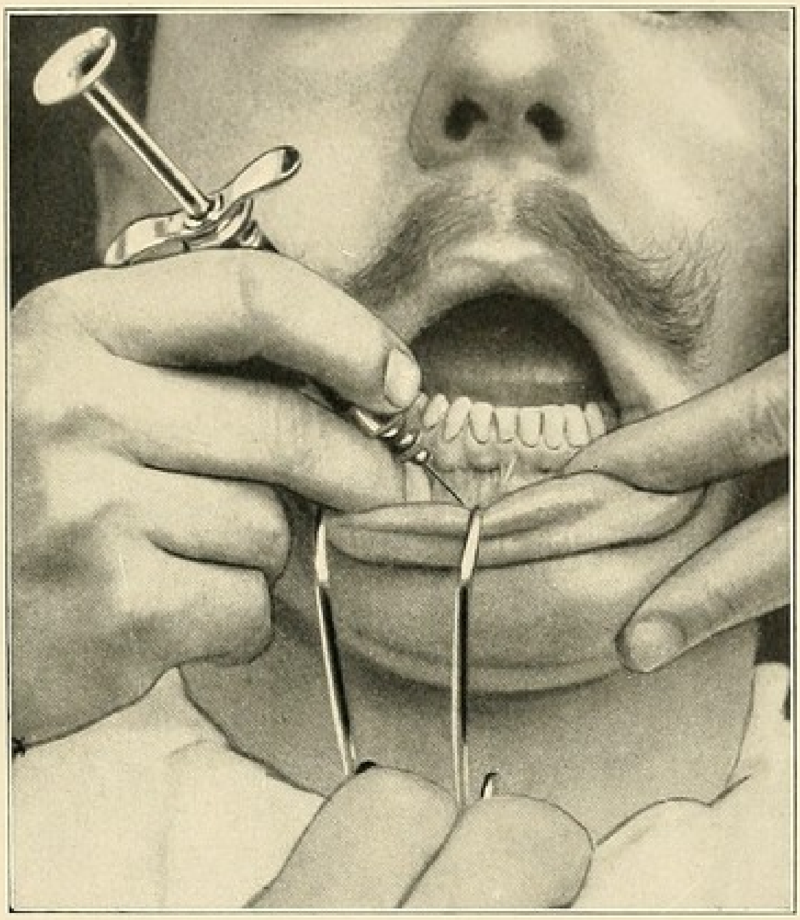
Position of needle for injection in lower molars. Needle yellow: *a*, buccal injection; *b*, lingual injection.

FIG. 85



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

FIG. 86



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

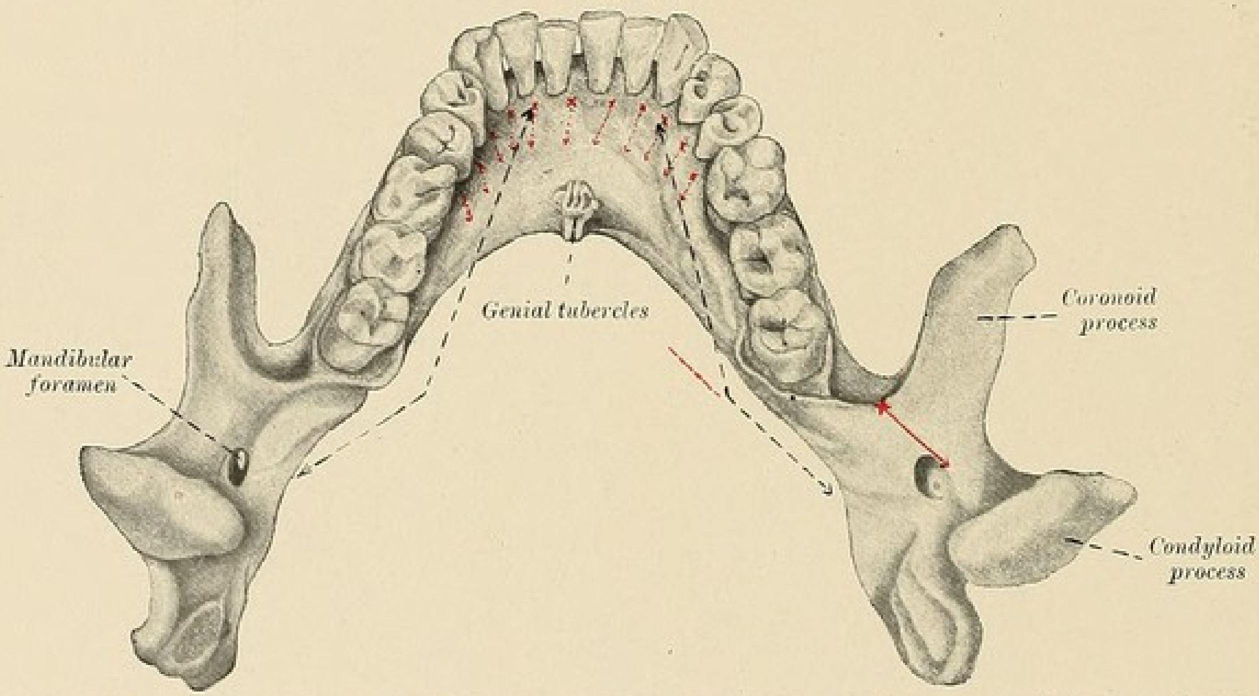
FIG. 87

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

is more expedient and successful, and above all is tolerated surprisingly well and causes a minimum of pain.

Mandible.—In the mandible, mucous anesthesia is employed as an adjuvant to mandibular anesthesia. In loose roots and teeth and in anterior teeth it may be successfully employed alone (see Fig. 83).

FIG. 88

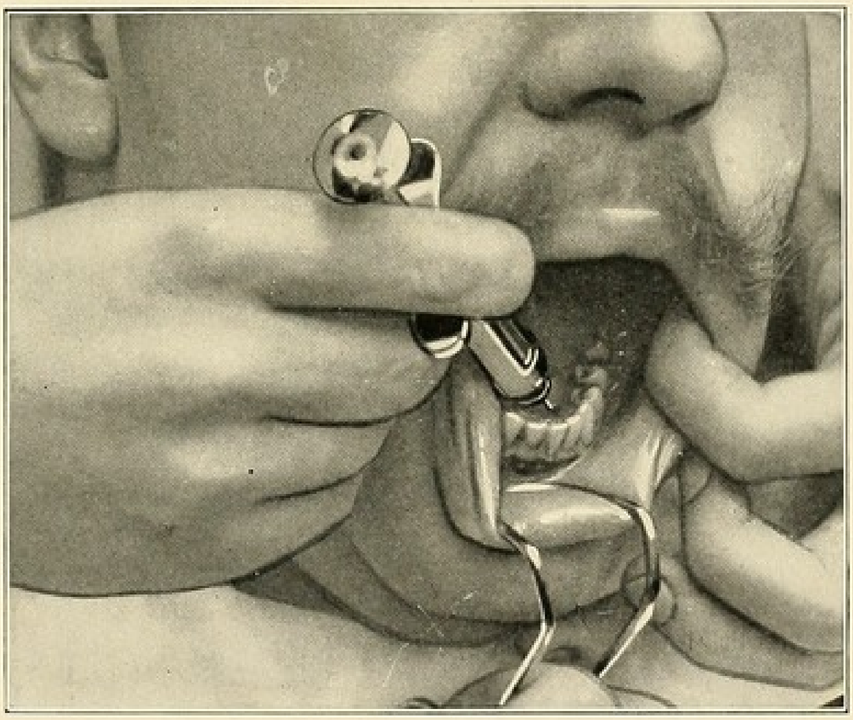


Lingual points of injection for mucous anesthesia of mandible. Red crosses indicate points of injection; red arrows, direction of needle; black-dotted line, the angle of the ramus to the body of the jaw.

Injection in the Gingival Papillæ in the Mandible.—Anesthesia of the anterior teeth must be clearly distinguished from anesthesia of the posterior teeth, including the first bicuspid. While injection in the latter is always to be made in the region of the gingival papillæ, advancing the needle horizontally along the alveolar margin (see Figs. 83 and 84), which is the only favorable place for diffusion into the fundus of the alveoli (see Figs. 41, 44, and 85), anesthesia of the anterior teeth, including the canines, is obtained in the following manner:

Injection in the Mental Fossa.—The lip is raised and the needle is inserted in 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. 86 and 87), and pushed forward and downward with a slight inclination mesially, until the *mental fossa* is reached (see Figs. 18, 20, 21, 22, 24, 86, and 87). This fossa is situated below the root apex of the canine and that of the lateral incisor, and has numerous foramina through which the injected solution penetrates into the interior of the jaw (see Figs. 12 to 25). While advancing the needle, a few drops of the solution are evacuated, while the bulk of the solution (about 1 c.c.) is injected in the fossa, thereby invariably producing complete anesthesia of the canine and the two incisors on the injected side.

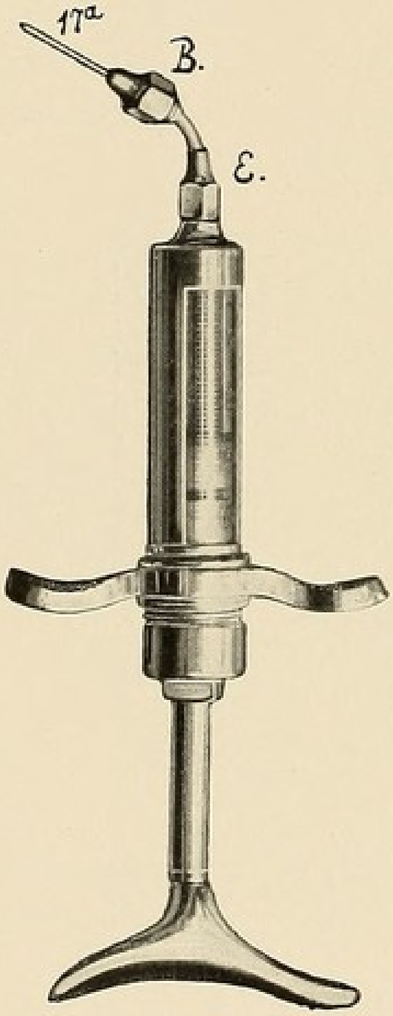
FIG. 89



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

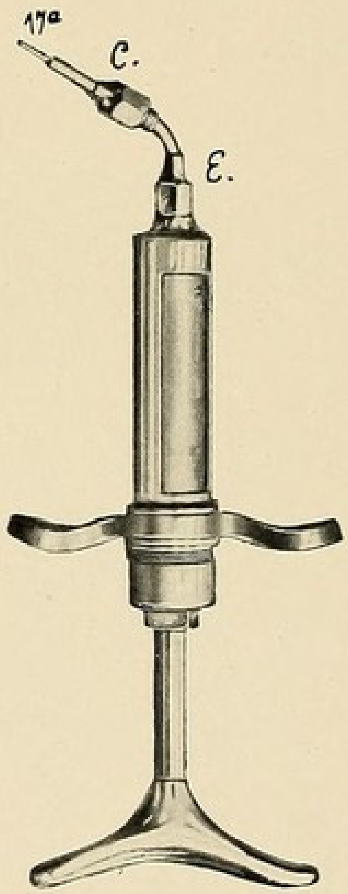
Lingual Injection.—The small quantity of solution left in the syringe after the last procedure should be injected lingually behind the central incisors and in the line of their long axis (see Fig. 88), also between the canine and the first bicuspid (see Fig. 89), in order to paralyze the filaments of the lingual nerve (see Fig. 53) 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. 32 and 33). The syringe is mounted with the curved middle piece *E*, the hub *B*, and the needle No. 17*a* (see Figs. 2 and 90), and the needle is inserted below the taut mucous membrane of the central incisor and at once slowly advanced along the periosteum, while discharging some solution, parallel with the mandib-

FIG. 90



Syringe mounted with middle piece *E*, hub *B*, and needle No. 17*a*, for lingual injection.

FIG. 91



Syringe mounted with middle piece *E*, hub *C*, and needle No. 17*a*, for lingual injection in lower molars.

ular process, to the vicinity of the root apex. An injection is also made between the canine and bicuspid (see Figs. 87 and 89), advancing the needle directly, while slowly discharging, to about the middle of the canine root length, in both cases injecting about $\frac{1}{4}$ c.c. of the solution.

Thus in anterior lower teeth it is possible to inject locally, but if several teeth are to be anesthetized simultaneously, it is advisable to resort to mandibular anesthesia. The method described is invariably successful, even in periostitis, the mental fossa being a most excellent place of vantage for injection at a distance from the alveolar process and for diffusion of the solution.

Mucous Anesthesia in Lower Molars.—In all lower molars only one procedure of mucous anesthesia is applicable as an adjuvant to conductive anesthesia, this procedure being as follows: The needle is inserted slightly below the cervical margin of the gingiva in the centre of the tooth lying anteriorly to the tooth to be anesthetized, advancing, as in the maxilla, buccally and straight to the periosteum, gliding under it a little forward, but not farther than the centre of the tooth to be anesthetized, and injecting there from 1 to $1\frac{1}{2}$ c.c. of the solution (see Figs. 83 and 85). The syringe is mounted with the hub *B* and the needle No. 17*a* (see Fig. 70). For several teeth the long needle and the hub *B* or *C* are employed (see Fig. 74). Again, the point of insertion is compressed with the finger after the injection; massage of the injected portion is of special advantage in the mandible.

Lingual Injection in Lower Molars.—Lingually the tooth to be anesthetized is always injected by way of the cervical margin of the gingival tissue, the needle being advanced only as far as the periosteum of the alveolar margin, where from about 10 drops to $\frac{1}{4}$ c.c. are deposited in the firm tissue (see Fig. 84). The syringe is mounted with middle piece *E* and hub *C*, and needle No. 17 *a* (see Fig. 91), in this way obtaining only a short free needle point which withstands the pressure exerted and does not break easily.

So much for mucous anesthesia in firm normal tissue; in spongy tissue the technique is more difficult, yet success is insured, if the periosteum is infiltrated.

Anesthesia in Inflammatory Swelling.—*Mucous Anesthesia in Inflammatory Swelling.*—Mention should be made of mucous anesthesia in the presence of parulis or alveolar abscess. In such cases conductive anesthesia should always be attempted. If this is unsuccessful or inadvisable, mucous anesthesia alone is the last and only resort.

Anesthesia with Ethyl Chlorid.—In the anterior teeth, both upper and lower, in many cases the old method of the ether spray can be employed with great success. The diseased gingival tissue is disinfected with tincture of iodin and carefully dried; right and left of the swelling the alveolar process is 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 to be anesthetized, 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 thirty seconds the extraction can be performed, being in most cases painless, or at least very tolerable.

For the extraction of putrescent deciduous teeth this method is particularly practical, as 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 gum-boils or in extraction of loose putrescent teeth or roots. In such cases local injection anesthesia would be detrimental rather than useful, the risk of infiltrating an abscess or inflamed tissue being too great, as under certain conditions it involves general sepsis with possibly fatal results.

If, nevertheless, mucous anesthesia is preferred to the far more advisable conductive anesthesia, the injection should always be made in the healthy mucous membrane in the vicinity of the centre of infection (see Figs. 67 and 68). In such cases, however, several injections on either side of the abscess must be made into the periosteum only, emptying the solution immediately upon introducing the needle and without advancing it.

Injection in Swollen Areas.—Fig. 68 illustrates the method of anesthetizing a putrescent upper lateral incisor when a swelling is present. One injection is made above the central incisor, the needle pointing in the direction of the root apex of this tooth. A second injection is made above the gingival margin of the lateral incisor, the needle pointing distally, provided no abscessed tissue is met with. The third and final injection is made above the canine, the needle being pushed toward the root apex of the canine. In all these injections, 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, injection at that place must be immediately discontinued. If these injections have been successfully carried out, compression with the finger over the places of insertion 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. Anesthesia lasts from twenty to sixty minutes.

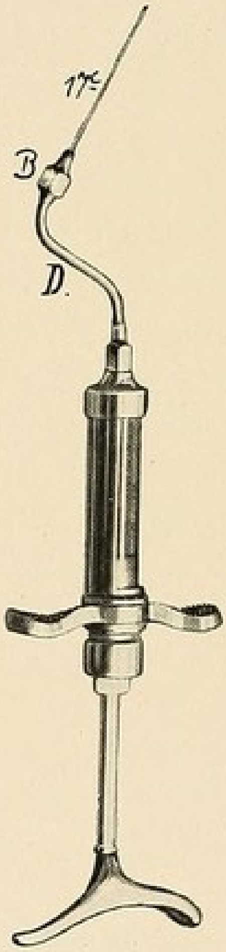
Principles of Mucous Anesthesia.—Besides the above-mentioned cautionary measures, such as asepsis, isotonia of the solution, etc., the following technically important conditions must be fulfilled to insure the success of mucous anesthesia:

1. Application of the stasis bandage.
2. Thorough sterilization with tincture of iodin.
3. The periosteum, not the submucous tissue, must be infiltrated.
4. One injection on each side of the teeth; the fewer injections, the better the effect.
5. The orifice of the sterile needle must always point toward the bone.
6. Slow, moderately strong pressure during the injection.
7. Dosage and quantity of solution must be gauged according to each individual case.
8. Compression of the point of injection with the finger after withdrawing the needle.
9. A waiting period of from eight to ten minutes.
10. The patient to be watched after the anesthesia.

CONDUCTIVE ANESTHESIA

If an anesthetizing solution is injected in the vicinity of a fair-sized nerve trunk, it penetrates by way of the perineurium into the central nerve substance and inhibits its function, thereby paralyzing the entire peripheral area supplied by this nerve. Upon blocking the conductivity of a certain nerve trunk, sensory irritations of the terminal filaments are no longer perceived in the central organ. "The sensory nerve tracts are easily and readily susceptible to nerve blocking by perineurial injection, if their minute terminal branches are inundated with an anesthetizing solution while the interruption of conductivity

FIG. 92

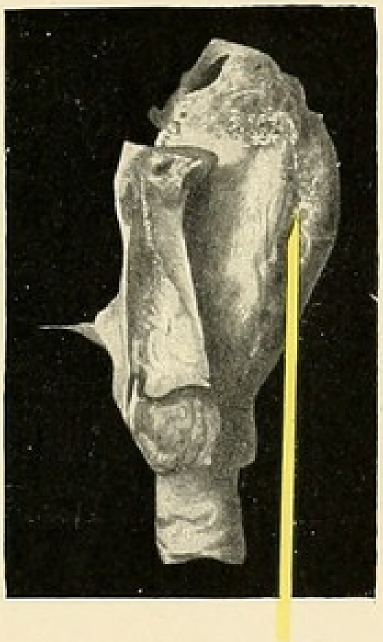


Syringe mounted with middle piece *D*, hub *B*, and needle No. 17*c*, for injection at maxillary tuberosity.

becomes more difficult, ensues more slowly and requires a larger quantity and more highly concentrated solution of the anesthetic, 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 in the periosteum and the pericementum are paralyzed in the shortest and speediest way by mucous anesthesia, sometimes within five minutes. Anesthesia at the maxillary tuberosity, which represents a modified form of conductive anesthesia, ensues with almost equal rapidity, *i. e.*, in ten minutes. Anesthesia by way of the inferior dental foramen, or mandibular anesthesia, according to the size of the nerve trunk involved, requires the longest period of time, namely, twenty minutes, since the large inferior dental nerve must be inundated and permeated by the anesthetic.

Fig. 93

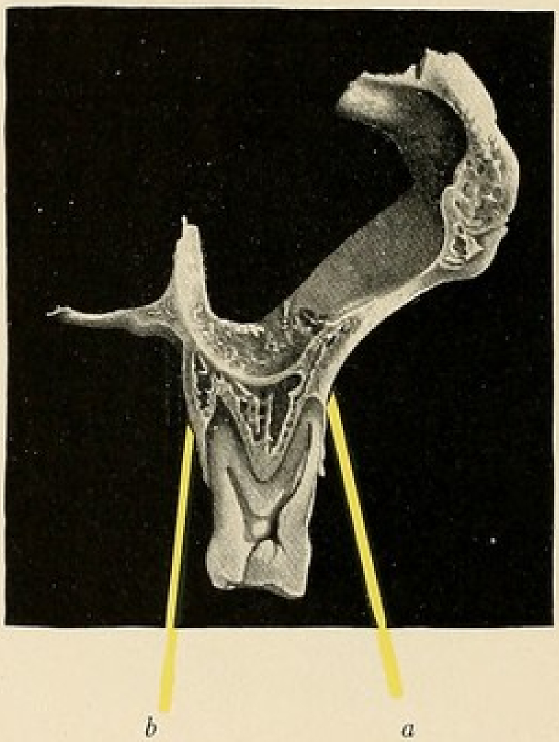


Position of needle for injection at maxillary tuberosity. Needle yellow.

For our purposes, the following methods of conductive anesthesia must be considered: (1) In the maxilla, (*a*) injection at the maxillary tuberosity; (*b*) infra-orbital injection. (2) In the mandible, (*c*) injection in the inferior dental or oblique or mandibular foramen, combined, if necessary, with lingual anesthesia; (*d*) injection in the mental foramen.

Injection at the Maxillary Tuberosity.—*The Maxillary Tuberosity.*—Behind the zygomatic process and above the root apices of the upper molars, a varying number of foramina is found in the alveolar process (see Figs. 26, 48, 52, and 56). Through these foramina large nerve branches, the *posterior superior dental nerves*, enter the maxilla, after having run for a short distance with the main trunk, the *superior maxillary nerve*, on the bony surface of the tuberosity (see Figs. 48, 51, and 52). These nerves supply the three molars with sensory filaments, and must therefore be blocked in order to obtain anesthesia of these teeth (see Fig. 56).

FIG. 94



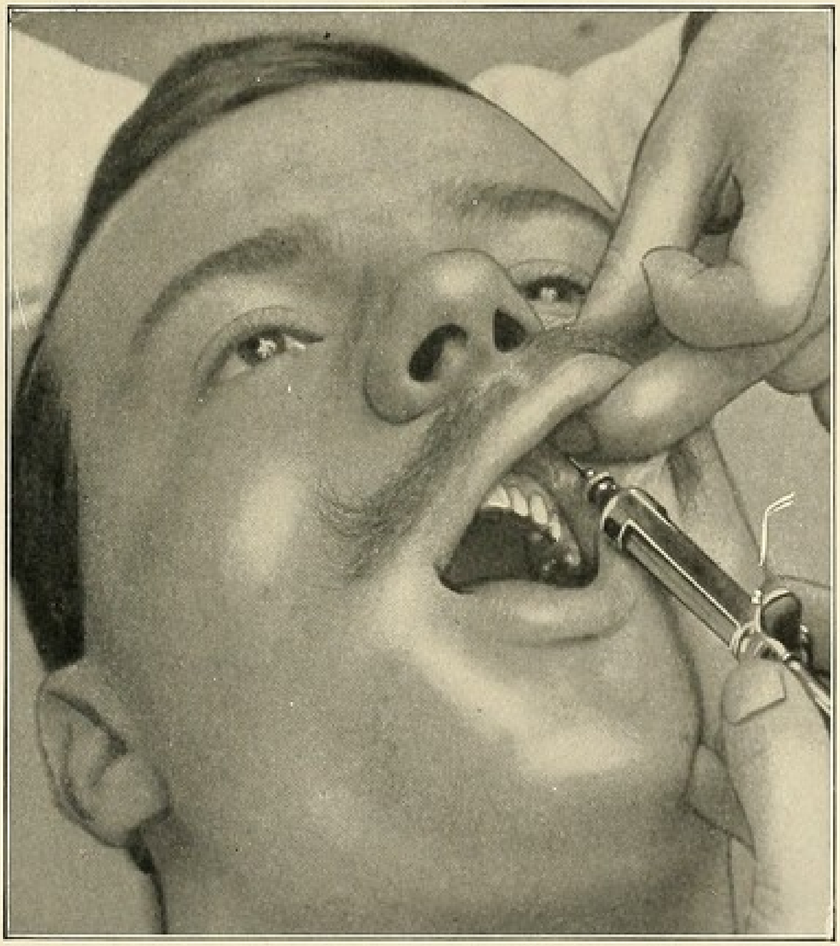
Position of needle for injection in mucous anesthesia of upper first molar. Needle yellow: *a*, buccal injection; *b*, palatal injection.

Technique of Injection.—In the half-open mouth the zygomatic process is palpated, the cheek is drawn upward, and the long needle No. 17*c*, which has been mounted upon the syringe with the middle piece *D* and hub *B* (see Fig. 92), is introduced high up in the mucous membrane slightly laterally to the bone (see Fig. 93). The needle is then advanced with a slight backward and upward inclination (see Fig. 73, red arrow No. 6). The syringe is held away from the maxilla, while the needle is kept as closely as possible to the slightly convex tuberosity (see Fig. 93). When the needle, which has a length of

42 mm., has been inserted half-way, about 1 c.c. of the solution is injected while pushing the needle into the tissues to its full length.

To intensify the effect in first molars, mucous anesthesia is additionally produced buccally at about the centre of the root of the tooth. A short needle is introduced into the periosteum, and an injection of about $\frac{1}{4}$ c.c. of the solution is made, followed by digital compression (see Fig. 94).

Fig. 95



Conductive anesthesia by way of infra-orbital foramen.

Palatally, the injection into the mucosa, as above described, is made at the *posterior palatine foramen* (see Figs. 80 and 82). Within ten minutes, as a rule, complete anesthesia of the three upper molars ensues.

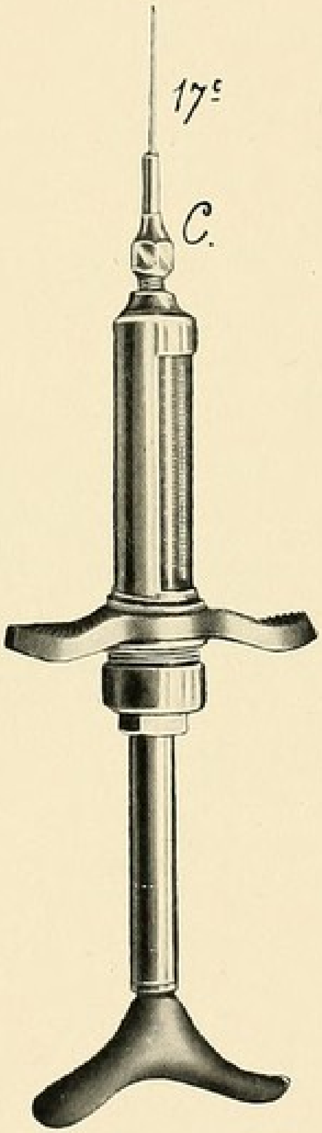
Infra-orbital Injection.—*The Infra-orbital Foramen.*—The anterior region of the maxilla is dominated by a superficial and easily reached nerve plexus, the *anterior superior dental nerves* (see Figs. 48, 52, 55, and 56). These are given off from the superior maxillary nerve just before its exit from 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. 48 and 52). In acute periostitis and abscess, mucous anesthesia at the root apex is contraindicated, as it involves a risk of general sepsis.

Technique of Infra-orbital Injection.—Injection in the canine fossa at the *infra-orbital foramen* is invariably followed by the desired result. The inferior margin 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. 95). The infra-orbital foramen is situated $\frac{1}{2}$ cm. below the lower margin of the orbit, almost exactly above the first bicuspid (see Figs. 48, 52, and 73). The needle is inserted in the reflection of the mucous membrane slightly posteriorly to the root apex of the canine in the mucous membrane closely to the lip muscles, and advanced obliquely upward and slightly backward. As soon as the long needle No. 17*c*, which is mounted with the hub *C* (Fig. 96), is felt below the compressing finger tip, from 0.5 to 1 c.c. of the solution is injected. After the injection massage may be applied to good advantage.

This form of injection requires a certain amount of pressure to force the solution through the foramen, since it is not the nerve trunks emerging therefrom, but those situated more deeply, namely, the *anterior superior dental nerves*, which are to be anesthetized. This method, therefore, constitutes an indirect form of conductive anesthesia, the solution having to pass through the foramen in order to become effective.

This method is indicated only in cases of acute abscesses and in major operations, such as resection, when injection in the infra-orbital foramina on either side proves most successful. In the majority of cases, mucous anesthesia at the root apex of the canine (see Fig. 76) or at the *anterior nasal spine* (see Fig. 73) insures complete success, being also of easier execution, and invariably and promptly effective.

Fig. 96



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

Palatally, again, the injection is not made in the *incisive papilla*, which would be 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, injecting from 8 to 10 drops, as has been described in detail in the paragraph on mucous anesthesia (see Figs. 69, 78, and 80).

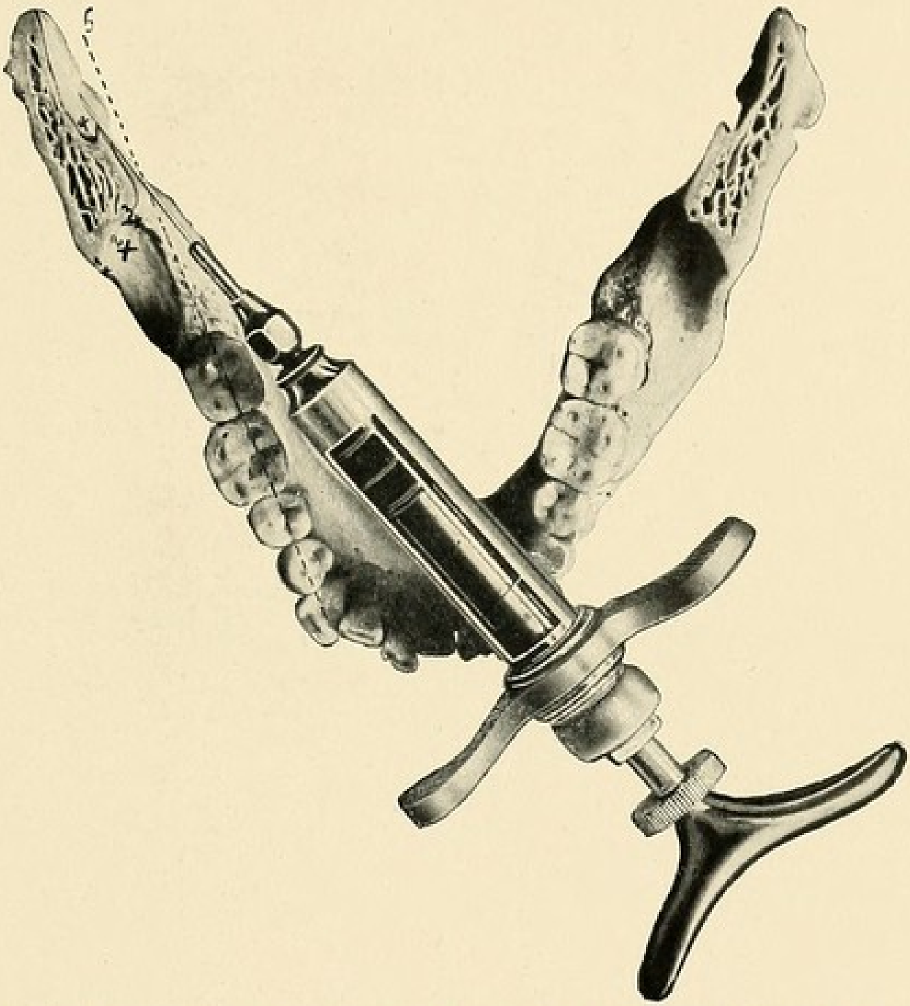
After ten minutes the anterior teeth on the injected side are completely anesthetized.

Injection in the Inferior Dental or Oblique or Mandibular Foramen (Mandibular Injection).—*The Inferior Dental or Mandibular Foramen.*—The inferior dental or oblique or mandibular foramen in the internal surface of the ascending ramus permits the passage of the inferior dental nerve, which, with the inferior dental artery, passes forward in the dental canal of the mandible as far as the mental foramen, where it divides into two terminal branches, incisor and mental. For the technique of injection in the oblique foramen the relationship of the body of the jaw to the ascending ramus and that of the muscles to the foramen is of vital importance.

Position of the Syringe.—The line of the body of the mandible is not horizontally continuous in a straight line to the ascending ramus, but presents a lateral bulging 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. 36, 83, and 88). The ramus opens posteriorly (see Figs. 38, 39, 83, and 97). If, therefore, the oblique foramen is to be reached, we must never advance posteriorly parallel with the teeth (Figs. 97 and 98), but with the internal surface of the ramus, at an acute angle to the plane of the teeth (see Figs. 38, 97, 98, and 101). If the direction of the ascending ramus is projected anteriorly, the line will meet the other side in the canine region between the canine and bicuspid (see Figs. 38, 39, 97, 98, and 101). Thus in order to reach the inferior dental foramen the syringe must be rested behind the canine on the opposite side (see Figs. 38, 97, 98, and 101). The foramen in adults is situated at a higher level than in children; the horizontal direction of the needle must therefore be modified in children by slightly lowering it posteriorly and pharyngeally in order to reach the foramen directly (see Fig. 37, *A*, *B*, *C*).

Character of the Tissues.—The character of the tissues encountered is most favorable for injection in the oblique foramen. The temporal and external pterygoid muscles are inserted above, the internal pterygoid below the foramen, leaving the close proximity of the foramen free from muscular fibers (see Fig. 99). Instead we find considerable accumulations of loose interstitial connective and adipose tissue which readily absorbs and retains the injected solution (see Fig. 100). This cushion of tissue is situated about 1 or 2 cm. above the alveolar process.

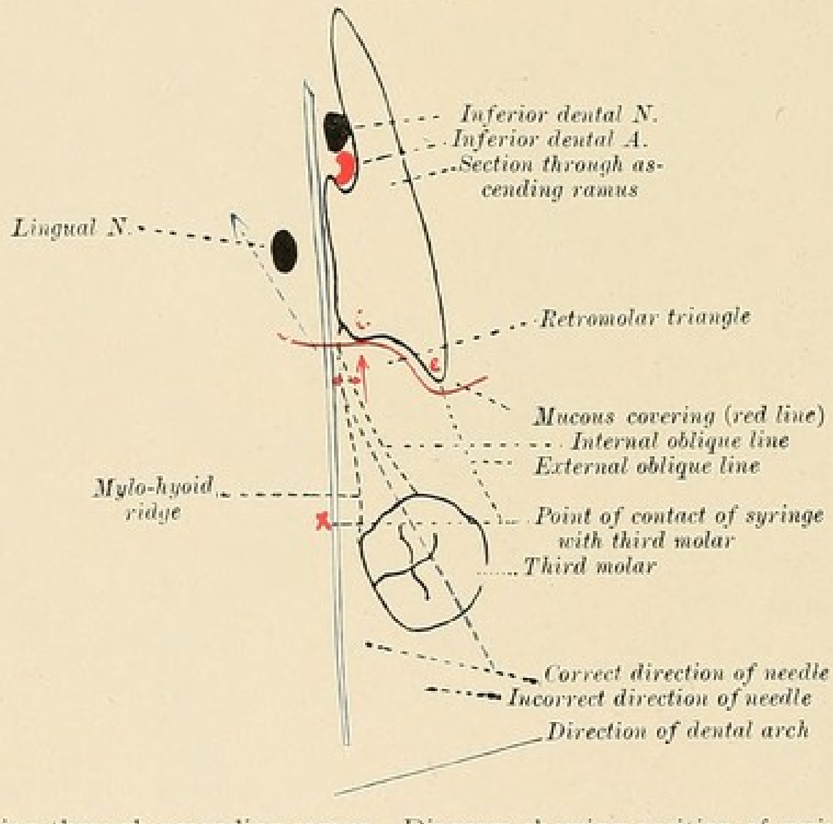
FIG. 97



Position of 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 syringe, parallel to teeth.

Technique of Injection.—With the left index finger, the anterior portion of the base of the ascending ramus is palpated, the patient's mouth being opened widely. 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. 38, 39, 97, 98, and 100). Between these two lines at the root of the ascending ramus a shallow bony groove is situated, which might be properly called the *retromolar fossa*, into which the palpating finger tip sinks (see Figs. 38, 97, 98, and 101). The mucous membrane is caved in over this fossa in somewhat triangular shape; Braun therefore calls it the *retromolar triangle* (see Figs. 98 and 100). 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 edge of the bone (see Figs. 38, 97, and 98).

FIG. 98



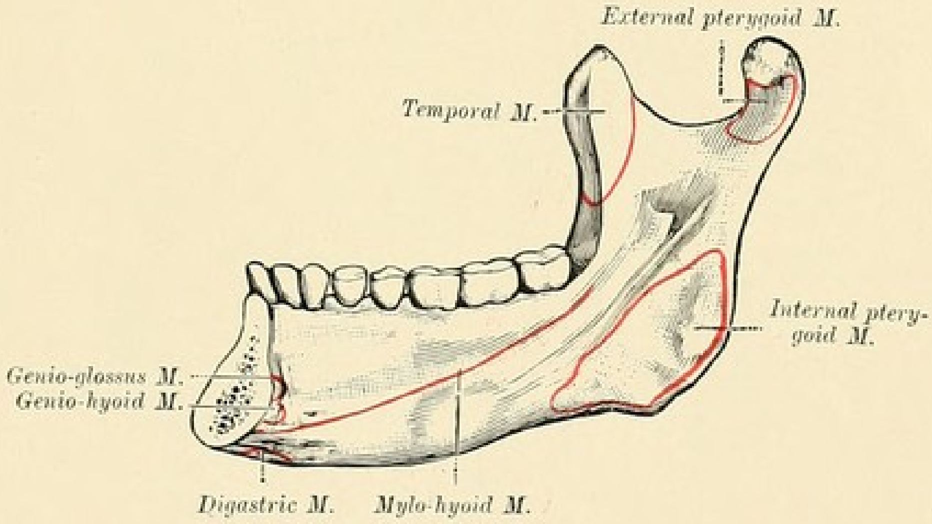
Horizontal section through ascending ramus. Diagram showing position of syringe and needle: *i*, eminence of internal oblique line; *e*, eminence of external oblique line.

The syringe is pushed forward horizontally and posteriorly from the canine on the opposite side along the internal surface of the mandibular half to be anesthetized (Figs. 38, 39, 97, 98, 101, and 102), until the needle has disappeared entirely (see Figs. 39 and 98). The needle should be introduced to a depth of not more than from 1.5 to 2 cm. under the mucosa (Figs. 39, 97, and 98), lest it advance too far beyond the foramen, and the correct point for the deposition of the solution be missed.

It is best to mount the syringe with the hub *C* and the needle No. 17 *c* (Fig. 96), so that from 3 to 5 cm. of the needle remain visible above the mucosa (see Figs. 39, 97, and 98), when failure to reach the correct point for injection is hardly to be feared. The injecting solution is then deposited, beginning to inject soon after insertion of the needle in order to anesthetize the *lingual nerve* at the same time. The bulk of the solution, however, should be injected in the mandibular foramen.

Insertion of the Needle.—The point of injection is selected so that the needle is introduced in the mucous triangle about 1 cm. above the level of the masticating surfaces of the molars (Figs. 97, 98, 99, 100,

Fig. 99



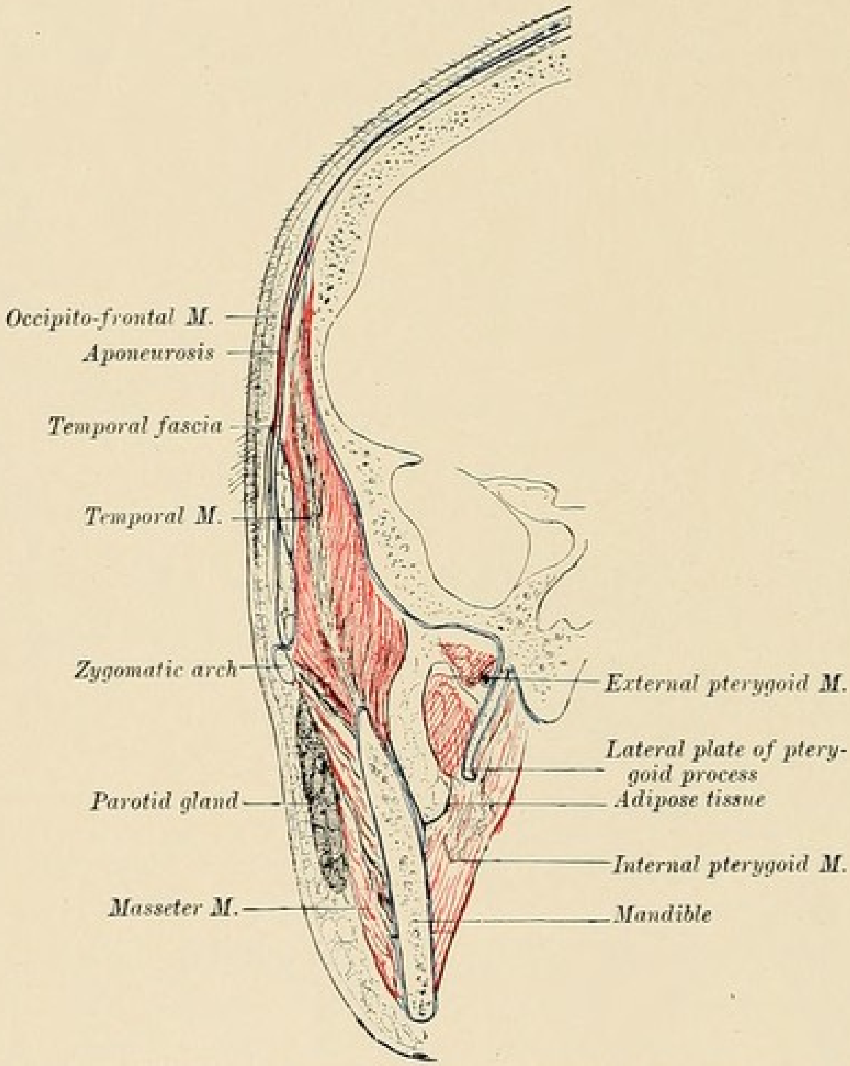
Origins and insertions of muscles upon inner surface of mandible. (From Rauber and Kopsch.)

and 104), in children and youthful persons advancing a little farther posteriorly while slightly lowering the needle, in old persons slightly raising the long needle (see Fig. 37). Besides, in the buccal mucosa near the cervical margin of the gingiva of the teeth to be anesthetized about $\frac{1}{2}$ c.c. of the solution is injected, thereby combining conductive with mucous anesthesia. In adults after about twenty minutes, in children after from ten to fifteen minutes, as a rule, every tooth including the first bicuspid is anesthetized.

The syringe is mounted with the hub *C* and the needle No. 17*c* (see Fig. 96).

Difficulties.—The technique of this form of injection offers some difficulties which, however, after some practice are easily overcome. Above all it must be observed that the insertion of the needle is made not directly at the edge of the bone in the *internal oblique line,* but

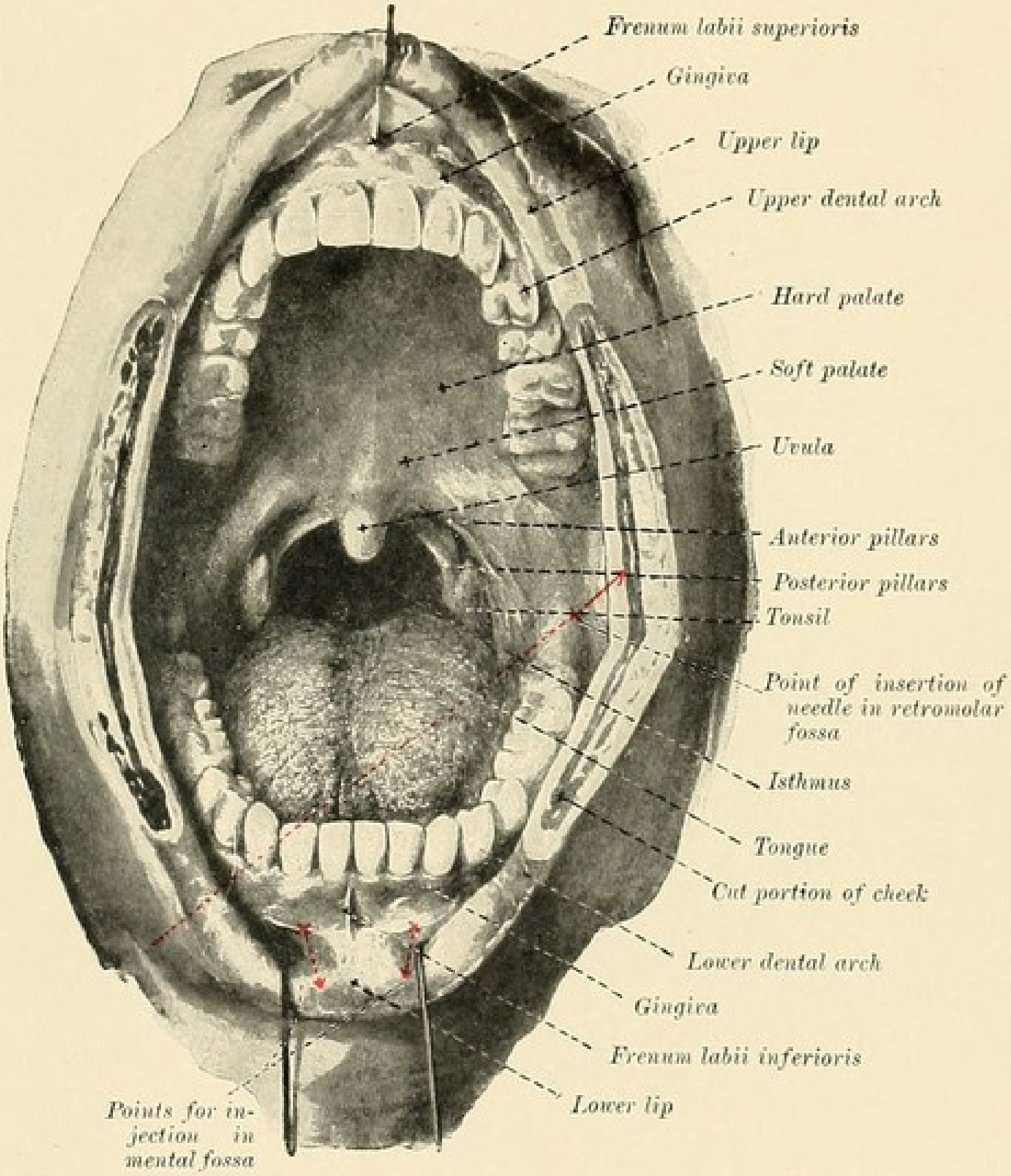
FIG. 100



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

somewhat lingually from the bone (see Figs. 38, 97, and 98). Behind this internal ridge the bony substance bulges still farther lingually, running over into the *lingula,* after having first formed a second convex excrescence (see Figs. 39, 97, and 98). After the correct point of insertion, about 1 cm. above the level of the masticating surface of the last molar, has been found, the oblique foramen is reached just above the

FIG. 101

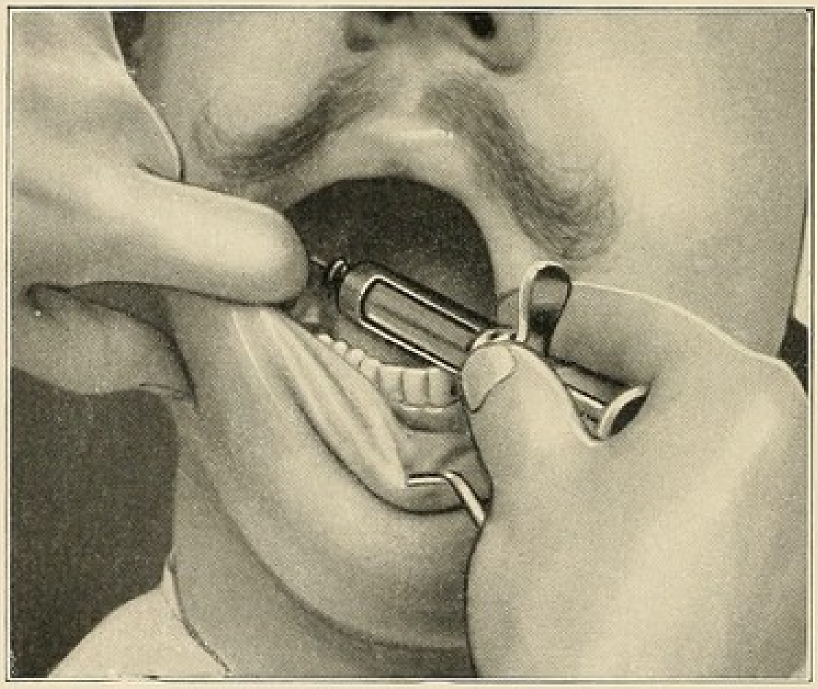


Oral cavity, widely opened. The dotted red line indicates the correct position of the syringe for mandibular anesthesia. The red arrows at the anterior portion of the mandible indicate the points of insertion of the needle in the reflection of mucous membrane for injection in canine fossa. (After Spalteholz.)

lingula with the needle No. 17 *c* and the hub *C* (see Figs. 39, 97, and 98). The distance from the anterior margin of the internal oblique line to the posterior margin of the lingula is about 15 mm., while the needle

No. 17 *c* protrudes 25 mm. from the hub *C* (Figs. 39, 97, and 98), so that the needle has the correct practical length for passing through the mucous layer (which is not seen in the illustrations of skulls) and for reaching from about 5 to 8 mm. beyond the lingula (see Figs. 39, 97, and 98). It is not advisable to use the full length of the needle, which is 42 mm., as one might penetrate too far posteriorly, thereby missing the point most favorable for the deposition of the solution (see Figs. 39, 97, and 98). During the injection it is best, as has been

Fig. 102

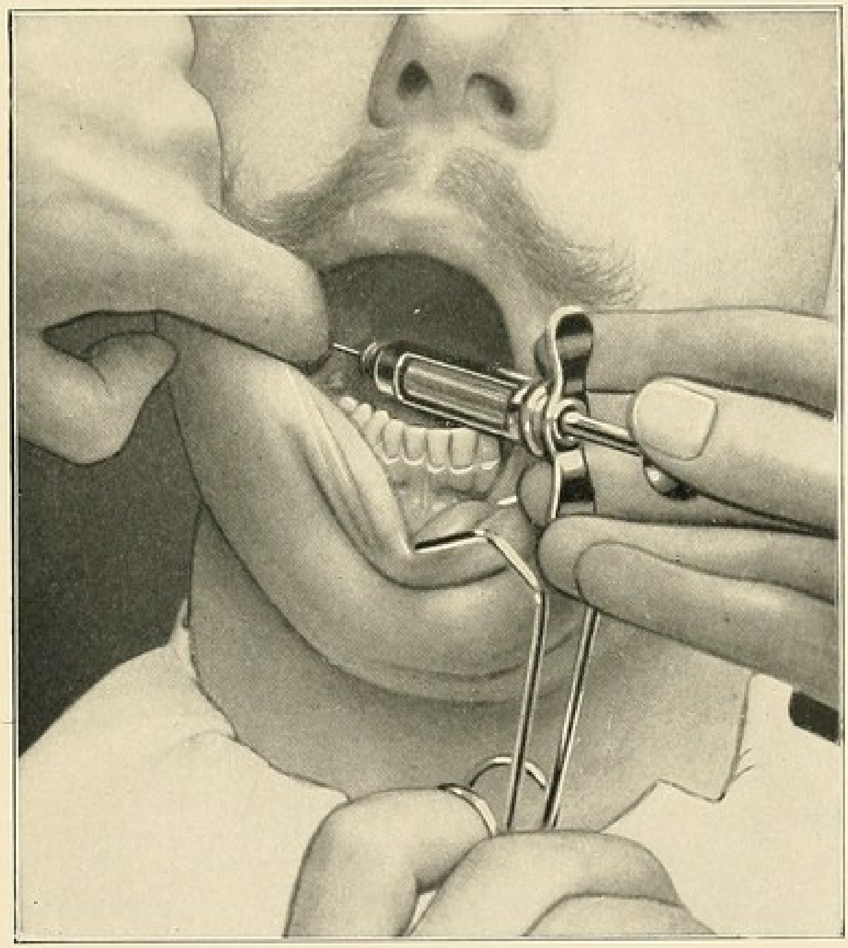


Position of syringe for injection in mandibular foramen and palpation of retromolar triangle. Syringe is held like a penholder.

correctly emphasized by Williger, to rest the syringe barrel on the bicuspid or between the canine and first bicuspid of the opposite side, thus securing a certain support for the syringe and an indication for the correct level for the insertion of the needle (see Figs. 38, 39, 97, 101, and 102).

Management of the Needle.—After insertion, the needle is advanced to the bone without entering the periosteum (see Figs. 97 and 98). A certain touch is soon acquired as to whether the needle is being advanced in the correct direction, not too far pharyngeally, yet closely enough to the bone. If, in case of a very sharp angle of the bone, the periosteum is found to offer resistance, even though moderately, the needle should not be advanced any farther, and under no condition by force, else the needle bores into the periosteum of the bone and is

FIG. 103

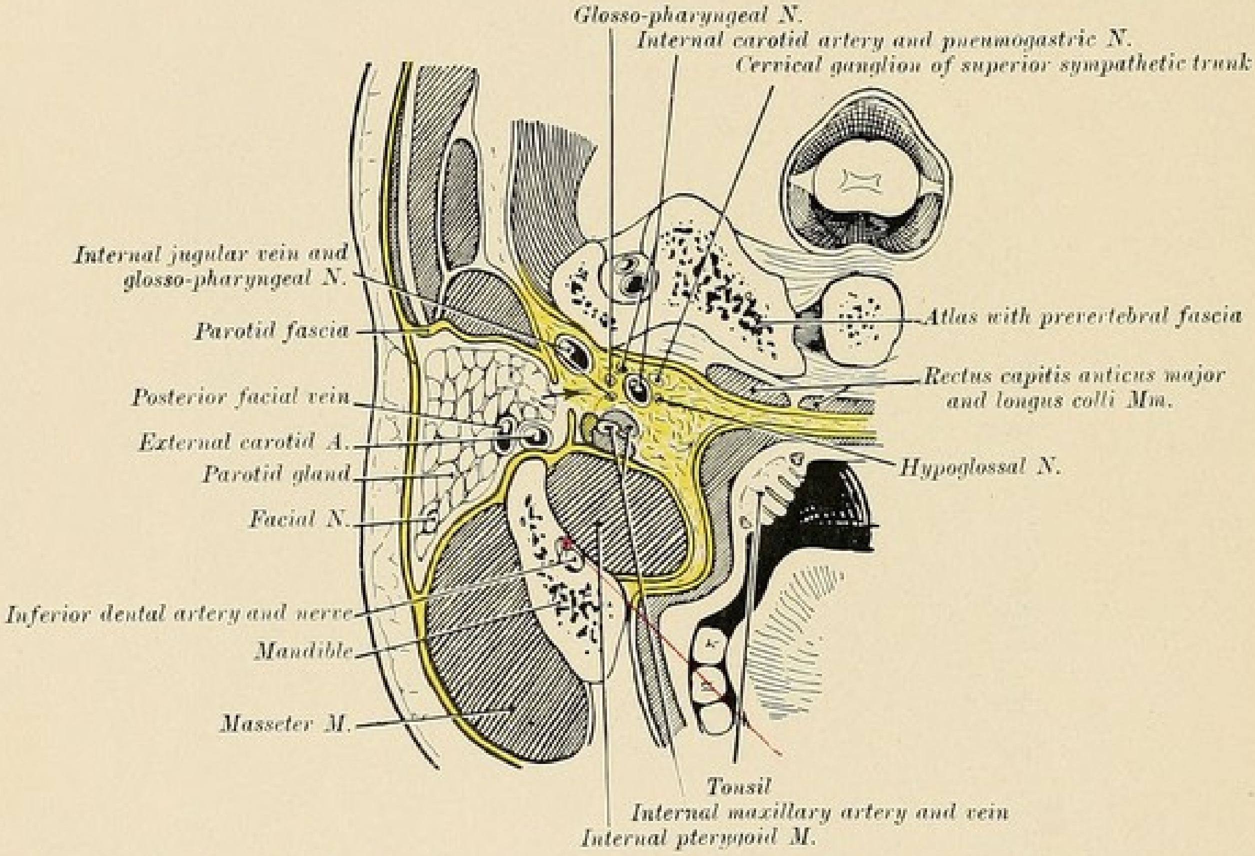


Position of syringe during injection in mandibular foramen. The finger of the left hand rests in the retromolar fossa.

sure to break. It is best to carefully withdraw the needle for a short distance, and after slightly altering its direction pharyngeally to advance again posteriorly. The bone should not be reached before the needle has gone for a certain distance from the point of introduction (Figs. 39, 97, and 98), yet not immediately at the *internal oblique line*, as has already been demonstrated. The needle has reached a sufficient depth when 5 mm. of its length remains visible.

Injection of the Solution.—The solution should be emptied slowly and carefully, beginning immediately upon insertion of the needle, in order to anesthetize simultaneously the *lingual nerve*, which descends in front of the inferior dental nerve (see Figs. 49 and 60). The bulk

FIG. 104



Horizontal section through lower portion of oral cavity. Relationship of lower teeth to ascending ramus and mandibular foramen. Red arrow indicates the correct position of syringe and needle for mandibular injection. (Corning.)

of the solution, however, is deposited at the oblique foramen. The adipose and loose connective tissues overlying this foramen readily absorb the solution without any pain to the patient (see Fig. 100). Penetration of the muscles in this region is out of the question, as has been shown above (see Figs. 99 and 100). Neither is there any danger of puncturing the artery, which possesses thick walls, is protected by the lingula and has enough space to evade into the loose surrounding tissues or into the depth of the inferior dental canal (see Fig. 98). The corresponding vein is arranged around the artery in form of an

FIG. 105

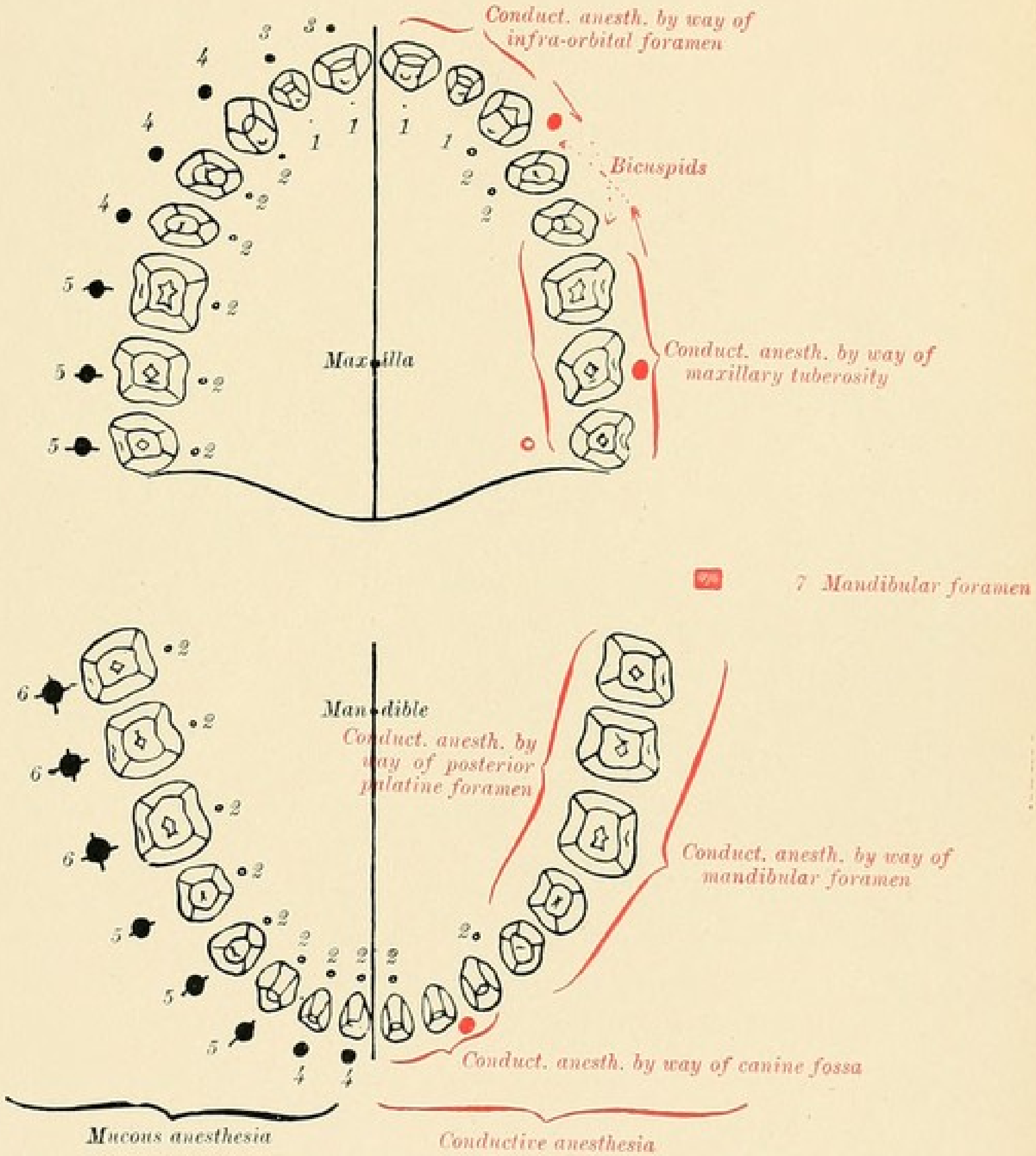


Diagram illustrating the technique and dosage for local injection anesthesia. On the left, black figures indicate technique and dosage for mucous anesthesia. On the right, red figures indicate technique and dosage for conductive anesthesia. Dosage: 1 = about 10 drops; 2 = 0.25 c.c.; 3 = 0.5 c.c.; 4 = 1 c.c.; 5 = 1.25 c.c.; 6 = 1.5 c.c.; 7 = 2 c.c. In the maxilla conductive anesthesia by way of the infra-orbital foramen and the maxillary tuberosity involves the entire half of the jaw, including the bicuspids.

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.

The injection in the left ramus offers somewhat greater difficulties. While in the right oblique foramen 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, palpating and fixing the retromolar triangle with the right.

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 is the best indication as to the correct execution of the injection. 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 sensation as if the margin of the glass were cut in semilunar shape. The lip on the anesthetized side depends slightly, exhibiting symptoms of partial paralysis, and the patient usually feels as if it were greatly swollen. Difficult deglutition is absent if the technique has been executed correctly. Its presence indicates that the injection has been made too far pharyngeally and posteriorly. The concomitant symptoms persist for about one hour, after which they gradually subside, the former normal condition being reëstablished after about three hours.

Paralyzation of the Buccal Nerve.—As has been pointed out before, it is necessary to make an injection in the buccal mucosa at the lower molars and bicuspids in order to anesthetize the *buccal nerve*, which is distributed over the region of the second and first molars and the second bicuspid (see Figs. 55 and 59). Williger recommends for this purpose an injection in the mucous membrane of the cheek below Stenson's duct, whereby "absolute insensibility of the mandible and its cover of soft tissues is produced." This method of Williger is highly to be commended in cases associated with inflammatory symptoms in the bicuspid and molar regions.

Mandibular anesthesia is not concerned with periosteal injection as much as is mucous anesthesia, but has the sole purpose of making a deposit of solution in the environment of a large nerve trunk. For this reason conductive anesthesia calls for no pressure, which, to a moderate degree at least, plays a role in every periosteal injection.

Injection in the Mental Foramen.—As in the case of infra-orbital injection, the method of producing anesthesia by way of the *mental foramen* consists in making an injection under moderate pressure and forcing the solution through this large foramen into the inferior dental canal. Buente and Moral advocate mental anesthesia, which has been indicated also by Braun and Schleich, for paralyzation of the anastomosis with the opposite side.

The Purpose of Injection in the Mental Foramen.—"While Schleich anesthetizes the mental nerve on the side on which he wishes to operate, we introduce the anesthetic in the mental foramen of the opposite side as has been previously suggested by Peckert. After careful experiments and observations in patients, we may assume with a fair degree of certainty that the sphere of the anastomosis does not extend beyond the canine of the opposite side. When the entire anterior portion was to be anesthetized, we have inundated both foramina with the anesthetic solution." (Buente and Moral.) In such cases it suffices, however, to inject labially in the *mental fossæ* on either side (Figs. 83 and 86), and lingually between the canine and bicuspid on either side in order to anesthetize the lingual nerves (see Fig. 89).

Technique of Injection.—The mental foramen is situated, as a rule, between the first and second bicuspids at the base of the alveolar process, below the root apices of the bicuspids (see Figs. 19 to 25, 55, 59, and 83). The needle is introduced in the reflection of the mucous membrane below the second bicuspid, penetrating the periosteum while slowly injecting and pushing downward on the bone for several millimeters. About 1 c.c. of the solution is injected, and the point of insertion is compressed with the finger after the injection. The syringe is mounted with hub *B* and needle No. 17*a* (see Figs. 70 and 90).

Anesthetization of the Opposite Side.—Anesthesia by way of the mental foramen is important above all as an accessory, as it can be advantageously employed for paralyzing the anastomosis of the opposite side as well as for anesthesia of the entire anterior portion of the mandible. Occasionally this method renders good service in mucous anesthesia of the bicuspids. Its main value, however, on the principle of conductive anesthesia, consists in abolishing sensibility of the delicate nerve filaments radiating beyond the median line to the opposite side. To recapitulate: If the right side of the mandible up to the symphysis is to be anesthetized, injections are made in the right inferior dental foramen and the left mental foramen, moreover lingually behind the left canine, the right lingual nerve branch being paralyzed by the first injection.

Principles of Conductive Anesthesia.—1. Application of the stasis bandage.

2. Thorough sterilization with tincture of iodin.

3. Infiltration of the perineurial tissue.

4. Only one insertion of the needle. Insertion at the incisive foramen to be avoided.

5. The orifice of the sterile needle must always point toward the bone.

6. The solution is emptied during insertion of the needle under cautious pressure.

7. Dosage and quantity of solution must be gauged according to each individual case.

8. In the posterior palatine foramen only from 8 to 10 drops should be injected.

9. For injection at the maxillary tuberosity the zygomatic process is palpated; the needle is inserted in the mucous membrane behind the process; the needle of 42 mm. length mounted with hubs *B* and *D* is only gradually advanced to the convexity of the tuberosity, the syringe being held away from the bone at an acute angle, and the needle being advanced upward and slightly posteriorly in the direction of the temple.

10. In mandibular anesthesia, *i. e.*, injection in the inferior dental or oblique foramen, 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 from 3 to 5 mm. laterally from the internal oblique line of the ascending ramus; the syringe is

mounted with hub *C* and needle No. 17*c* and rested upon the first bicuspid or canine of the opposite side. The needle is advanced posteriorly and outwardly, in adults straight, in children slightly inclined, until only 5 mm. of its length remains visible; the bone is reached not immediately, but some distance from the point of insertion of the needle, about half of its inserted length.

11. A waiting period of ten minutes; after injection in the inferior dental foramen, twenty minutes.

12. The patient to be watched after the anesthesia.

EXTENT OF ANESTHESIA OBTAINED

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 incisor, a diminution in the sensibility of the pulp is noted after two minutes, gradually decreasing, 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 paralysis, strong electric currents still exert an influence upon the eye, sometimes producing a slight oscillation as well as lacrimal secretion, owing to the relations to the first trigeminal division (see p. 126, and Figs. 48, 49, and 51). 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 irritability is reëstablished in the individual teeth, while the mucosa, especially in the vicinity of the maxillary tuberosity, remains 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 inherent to extirpation of the pulp produced no pain, while electric irritation was still perceived, presumably because, in contradistinction to the irritation from localized pressure, it was conveyed intracellularly to remote areas. 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 (Fig. 51), 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.

Anesthesia in the Mandible.—The action of mucous anesthesia in the mandible appears to be rather less favorable. This form of anesthesia was applied to a lower first bicuspid affected with pulpitis, the sensibility of the pulp not being notably reduced even after eight minutes. Anesthesia by way of the inferior dental foramen was thereupon immediately induced, and within three minutes the sensibility of the pulpitic tooth was considerably reduced, complete analgesia ensuing within fourteen minutes from the beginning of the experiment.

Anesthesia by Way of the Inferior Dental Foramen.—In another case it was observed that within three minutes after injection in the inferior dental 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 anesthetized 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 in one-half 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, when it gradually subsided. The central incisors were the first to regain sensibility, followed in rapid succession by the remainder of the teeth. The tongue had become normal after ninety-seven minutes, while the mucosa remained insensible even after one hundred and twenty-five minutes, and normal sensibility was not reëstablished until three hours after injection.

TABLES FOR INJECTION ANESTHESIA

In order to avoid repetitions such as the histories of a series of practical cases would entail, and at the same time to afford 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 individual tooth. Consideration of the practical requirements of each special case may, of course, call for modifications of these tables, which are intended to be a general guide to those who intend to become practical experts in this somewhat difficult technique.

After some practice and experience, the methods of local anesthesia which have been demonstrated can be perfectly mastered by every operator, and will materially enhance the efficiency of his work and prove a boon to his patients.

TEETH. I. UPPER.	Technique of injection employed. (a) in simple cases.	(b) in cases complicated by periostitis, parulis, etc.	Mountings of syringe.	Quantity of solution in labial or buccal injections.	in palatal or lingual injections.
1. Central incisors.	Needle inserted at root centre of lateral, and directed to root apex of central. Palatally, injection at central.	Needle inserted at root centres of canine, and central of opposite side, whose root apices are infiltrated with solution. Palatally, injections at lateral, and central of opposite side, or conductive anesthesia from infra-orbital foramen, and mucous anesthesia at central of opposite side, palatally.	Hubs B or C. Needle No. 17a. 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. (See Fig. 81.)
2. Lateral incisors.	Needle inserted at root centre of canine, and directed to root apex of lateral. Palatally, injection of 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 back of root apex of canine, where some solution is deposited, and directed toward canine. Palatally, injection at the canine.	Conductive anesthesia from 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. (See Fig. 76.)
4. First bicuspids.	Needle inserted in centre of canine, and directed to root apex of first bicuspid. Palatally, injection at first bicuspid.	Conductive anesthesia from infra-orbital foramen, or injections at root apices of canine and second bicuspid. Palatally, injection at first bicuspid, or second bicuspid and canine.	(a) As in 1. (b) As in 3.	(a) 1.0 c.c. (b) 1.5 c.c.	(a) 0.5 c.c. (b) 0.5 c.c. (See Fig. 77.)
5. Second bicuspids.	Needle inserted in centre of first bicuspid and directed to root apex of second bicuspid. Palatally, injection at second bicuspid.	Conductive anesthesia from infra-orbital foramen, and injection at maxillary tuberosity. Palatally, injection at second bicuspid and posterior palatine foramen.	(a) As in 1. (b) As in 3.	(a) 1.5 c.c. (b) 2.0 c.c.	(a) 0.50 c.c. (b) 0.25 c.c.
6. First molars.	Injections at maxillary tuberosity and root centre of first molar. Palatally, injection at posterior palatine foramen.	Injection at maxillary tuberosity and infra-orbital foramen. Palatally, injection at posterior palatine foramen.	(a) and (b) Hub B and needle No. 17 c; if desirable in injection at maxillary tuberosity, middle piece D.	(a) 1.5 c.c. (b) about 10 drops.	(a) 0.25 c.c. (b) about 10 drops. (See Fig. 94.)

TEETH. I. UPPER.	Technique of injection employed. (a) in simple cases.	(b) in cases complicated by periostitis, parulis, etc.	Mountings of syringe.	Quantity of solution in labial or buccal injections.	in palatal or lingual injections.
7. Second molars.	Injection at maxillary tuberosity and root centre of second molar. Palatally, injection at posterior palatine foramen.	Injection at maxillary tuberosity and infra-orbital foramen. Palatally, injection at posterior palatine foramen.	As in 6.	As in 6.	As in 6.
8. Third molars.	Injection at maxillary tuberosity and root centre of third molar. Palatally, injection at posterior palatine foramen.	Injection at maxillary tuberosity. Palatally, injection at posterior palatine foramen.	As in 6.	As in 6.	As in 6. (See Fig. 93.)
II. LOWER.					
9. Central incisors.	Needle inserted at root centre of lateral, and directed to root apex of central. Lingually, injection at central.	Needle inserted at reflection of mucous membrane below central, and directed to mental fossa, where solution is deposited. Lingually, injection at lateral.	(a) Hub B and needle No. 17 a. (b) Hub C and needle No. 17 c. Palatally, always middle piece E and needle No. 17 a.	(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 root centre of canine, and directed to lateral. Lingually, injection at lateral.	Needle inserted at reflection of mucous membrane below canine, and directed to mental fossa, where solution is deposited. Lingually, injection at canine.	(a) As in 9. (b) As in 9.	(a) 0.6 c.c. (b) 1.0 c.c.	(a) 0.25 c.c. (b) 0.25 c.c.
11. Canines	Needle inserted at reflection of mucous membrane below canine, and directed to mental fossa, where solution is deposited. Lingually, injection at canine or first bicuspid, or conductive anesthesia from mandibular foramen.	Needle inserted at reflection of mucous membrane, below canine, and directed to mental fossa, where solution is deposited. Conductive anesthesia from mandibular foramen. Lingually, injection at first bicuspid.	(a) and (b) Hub C and needle No. 17 c. Lingually, Hub E and needle No. 17 a.	(a) 1.0 c.c. (b) 2.0 c.c.	(a) 0.25 c.c. (b) 0.25 c.c. (See Fig. 87.)
12. First bicuspids.	Needle inserted in gingival papilla of canine, and directed horizontally to first bicuspid. Lingually, injection at first bicuspid, or conductive anesthesia from mandibular foramen.	Conductive anesthesia from mandibular foramen, and injection buccally in papilla of first bicuspid. Lingually, injection at second bicuspid.	(a) Hub B and needle No. 17 a. (b) Hub B or C and needle No. 17 c. Lingually, middle piece E and needle No. 17 a.	(a) 1.0 c.c. (b) 2.5 c.c.	(a) 0.25 c.c. (b) 0.25 c.c.

Teeth. II. Lower.	Technique of injection employed. (a) in simple cases.	(b) in cases complicated by periostitis, parulis, etc.	Mountings of syringe.	Quantity of solution in labial or buccal injections.	in palatal or lingual injections.
13. Second bicuspids.	Conductive anesthesia from mandibular foramen, and injection buccally at second bicuspid.	Conductive anesthesia from mandibular foramen, and injection buccally in papilla of first bicuspid.	(a) and (b) Hub C and needle No. 17 c.	(a) 1.5 c.c. (b) 2.5 c.c.	
14. First molars.	Conductive anesthesia from mandibular foramen, and injection buccally in papilla of first molar.	Conductive anesthesia from mandibular foramen, and injection buccally in papilla of second bicuspid.	(a) and (b) Hub C and needle No. 17 c.	(a) 2.5 c.c. (b) 2.5 c.c.	
15. Second molars.	Conductive anesthesia from mandibular foramen, and injection buccally in papilla of second molar.	Conductive anesthesia from mandibular foramen, and injection buccally in papilla of first molar.	(a) and (b) Hub C and needle No. 17 c.	(a) 2.5 c.c. (b) 2.5 c.c.	
16. Third molars.	Conductive anesthesia from mandibular foramen, and injection buccally in papilla of third molar.	Conductive anesthesia from mandibular foramen, and injection buccally in papilla of second molar.	(a) and (b) Hub C and needle No. 17 c.	(a) 2.5 c.c. (b) 2.5 c.c.	

ADDITIONAL EXPLANATION OF TABLES

The period of waiting in cases Nos. 1 to 10 is about ten minutes; after injection in the inferior dental foramen, as in Nos. 11 to 16, twenty minutes. In Nos. 13 to 16 no injection lingually is required. All combinations of anesthesia of several teeth on one side can easily be calculated by applying to the first and the last tooth of the series to be anesthetized the technique specially indicated for the same in the tables. If, for example, the right half of the upper jaw from the canine to the third molar is to be anesthetized, an injection is made in the canine fossa at the root apex of the canine; the needle is then advanced along the periosteum to the root apex of the second bicuspid, injecting altogether 2 c.c. Then 1 c.c. is injected at the maxillary tuberosity, about 10 drops in the posterior palatine foramen, and about 0.25 c.c. palatally between the canine and first bicuspid.

In order to anesthetize the lower teeth from the lateral incisor to the third molar, injections are made in the inferior dental and the mental foramina, also in the mental fossa on the same side, and lingually behind the canine in order to paralyze the lingual nerve, employing about 0.5 c.c. of the solution. If necessary, no hesitation need be felt about injecting in the inferior dental foramina on both sides simultaneously. Untoward sequelæ, alarming symptoms of paralysis or tongue-biting have not been observed so far. In the same way the entire upper jaw can be anesthetized by injections at the maxillary tuberosity, and in the infra-orbital foramen on either side. For major operations especially, conductive anesthesia is most favorably indicated and of great value, in fact an indispensable substitute for general anesthesia as formerly employed in such cases.

CONCLUSION

In closing it should be said that these pages are intended above all to stimulate a careful study of the practical application of local anesthesia, and for this reason numerous questions of a theoretical nature have been merely grazed on the surface or left untouched. This policy seemed specially advisable since Braun in his great text-book on *Local Anesthesia* has entered into the most minute details.

May these pages contribute to popularize local anesthesia more and more, so as to render it the common property of all dentists. The numerous recent efforts in advocacy of general anesthesia in dentistry are in all probability doomed to failure, owing to the far greater advantages afforded by local anesthesia applied by skilled hands. The injection method of local anesthesia is equally suitable for the surgical as for the conservative practice of dentistry, and, despite the contentions to the contrary that have been raised, is to-day most favorably indicated for dentinal anesthesia. To be sure, success in this accessory field cannot be obtained by superficial study, but must be acquired by painstaking practice, especially in the technique of injection. On the other hand, by obtaining such success we shall be not only enhancing the confidence of our patients, but materially contributing to substantiate the great importance of dentistry as a science, and to raise its professional standard in the eyes of the whole civilized world.

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