ROOT-CANAL TREATMENT[1]

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CONTENTS

I. INTRODUCTION

The attitude of the profession in regard to the treatment of root canals, ranging all the way from vital pulp removal to the final extreme of abscess treatment, has evolved through doubt and uncertainty to a period that seems favorable for progress in this line of work. The interest now being shown is prompted by a wide-spread and genuine desire to save teeth. Because of the destructive practice of extracting all pulpless teeth, which has been more or less common in recent years, study and research have been stimulated in pulp and peridental membrane histology, to counteract such a needless and ruthless sacrifice of useful teeth. Careful technique and aseptic methods have proved that a large percentage of root-canal treatments are successful. Some of the root-canal treatment of the past shows up so well that it is convincing evidence that careful technique has always been rewarded with a high degree of success. In an address before the Illinois State Dental meeting of 1922, Dr. Edmund Noyes (9) reported a review of the root-canal filling of fifty years of his prac-

[1] Read at a meeting of the Pathodontia Section of the First District Dental Society of the State of New York, at the New York Academy of Medicine, on October 25, 1923.

tice, and about 70 per cent of the cases he was able to find showed radiographic evidence of healthy periapical tissue. Dr. Noyes is one of those painstaking operators who have always followed the straight and narrow path, and have not sought short-cut methods of operating. There is little doubt that the disrepute which root-canal treatment has suffered is largely due to failures resulting from a lack of care in operative details. There is no doubt that the use of certain drugs has caused some of the trouble, and lack of asepsis in operating has been generally accepted as the most common cause for periapical infections. The record of the filling that was placed in a root canal twenty-five years ago can furnish us with some very helpful information, if we will study the details of treatment and compare them with what we are doing today. The methods of operating which have proved successful can be duplicated today and we can also correct some of the mistakes of the past.

The histological characteristics of the cementum and the peridental membrane are far better understood today, and there is a clearer comprehension of the way these tissues react to irritation. Considerable study has been devoted to the changes taking place in these tissues following some of our treatments, from which a better and more reliable technique has been evolved. Research by such men as Noyes, Thomas, Hatton, Skillen, Grove, Talbot, Box, and others, is clearing up many of the clinical problems that have been encountered.

The test of the success of a root-canal filling is that the root will withstand the critical examination and scrutiny of our dental confreres, and the physician, or those engaged in any branch of the healing art, without being condemned as a source of infection because of the evidence of pathology, observed by radiogram, existing about the apical area. A root surrounded by healthy tissue cannot be pronounced a menace to the health of the individual in whose mouth it may be found. Radiographic examination and interpretation is not a truly exact science. There is great variation in radiographic evidence as generally furnished and not until several radiograms, taken from different angles, of doubtful areas have been studied, can an accurate diagnosis be made. The interpretation of radiographic evidence is also subject to a certain latitude of variation. One diagnostician may consider slight periapical-tissue change as an infected

area and a menace to the general health of the individual without any consideration of the case history, while another may go to the opposite extreme and overlook dangerous areas.

II. VALUE OF CASE HISTORIES

There are three classes into which roots showing periapical changes may be placed. First, those showing large radiolucent areas where there is considerable bone involvement, with the apex of the root projecting into the cavity, which all would condemn for extraction. Second, those cases showing slight tissue change, with very little loss of bone. Third, the borderline cases which show some evidence of bone involvement of an indistinct outline. If case histories were available for each root-canal filling, showing a complete record of the treatment preceding the canal filling, the radiographs showing the condition of the periapical tissue before and after treatment, they would help greatly in determining more accurately the causes of the pathologic areas found today about the roots of teeth. Quite frequently a radiograph will show periapical tissue changes taking place before pulp removal. If such areas do not clear up after treatment, it does not reflect as much discredit on the operator as when changes take place where the condition was perfectly normal before operating upon the pulp. A reference to the history in such border-line cases is of value in the diagnosis, as it may prevent a useful tooth from being condemned too hastily. A frequent survey of one's root-canal fillings over a period of years, made by radiographic examination, is of great benefit to the operator. One should study the history of both the successful and the unsuccessful cases.

III. DIAGNOSIS OF PULP AND PERIAPICAL CONDITIONS

It has been of considerable help to the writer to follow a very brief classification of the conditions of the pulp and periapical tissue. Of the teeth containing pulps only four conditions are classified. It is desirable to keep a classification as simple as possible where one is called upon to use it in a busy practice.

1. Condition of pulp
   (a) Normal
   (b) Hyperemia or inflammation

(c) Exposed by caries
(d) Gangrene
2. Pulpless tooth
(a) Dead pulp
(b) Previous root filling
3. Condition of periapical tissue
(a) Normal
(b) Acute abscess
(c) Granuloma
(d) Liquefaction necrosis
(e) Infection cyst

When the examination is made the classification is recorded upon a form suggested by Dr. Arthur D. Black for the pulp-case history (1). The history when complete will contain all information in regard to diagnosis, the date of every treatment and the drugs used, the method of sealing the tooth, the root canal filling and a blank space for subsequent examination records by radiograph. This blank form is printed on the outside of an envelope which is filled in after each operation, and the measuring wires, radiograms and all other records of the case are kept and filed. The case history becomes more valuable as time passes, and as subsequent examinations are made to determine the condition of the periapical bone and soft tissue.

IV. PULP REMOVAL

Pulp removal is often necessary. It is far better to remove a diseased pulp than to have it die under some mechanical restoration, and better to remove one that is exposed than to attempt pulp capping. Pulp capping is principally indicated for children before fifteen years of age. It may be tried in favorable adult cases of very near exposure or slight exposure, but is usually found unsuccessful.

The radiogram of a root containing a diseased pulp will often show that the periapical tissue is already involved in some pathologic change, while the pulp still reacts to the vitality tests. After carefully removing the pulp and filling the canal with care in every detail of the operation not to injure the periapical tissue, there may still be present a condition that any other operator or diagnostician would suspect. We may not feel assured that such an area is not infected but at least we may feel certain that this pathological area was not directly or indirectly caused by the treatment of the root canal. A radiogram

should always be taken before beginning to operate upon any canal. Dr. Carl Grove has stated (6) that "our present technique of pulp removal has failed to prevent periapical infection because this tissue has not been preserved and not because we failed to make perfect fillings." This statement, backed up by his beautiful histological sections, furnishes convincing evidence that it is not so important to have the root canal so well filled that there is some protrusion of the gutta-percha as it is to avoid injury of the tissue beyond the foramen.

The reports from the histologists have shown us that the peridental membrane reaches up into the foramen of the root and that the pulp tissue begins at the dento-cemental junction, which may be quite a distance from what appears in a radiogram to be the apex of the root. Grove also states (7) that all pulp tissue should be removed without injury to the apical tissue, so that the cementoblasts lining the foramen may continue to function and gradually narrow down the diameter of the cemental foramen to its final closure after the completion of the root canal filling.

V. MULTIPLE FORAMINA

In pulp removal what shall be done with the many branches of the canals and the multiple foramina? At first thought one might easily be discouraged and decide that complete pulp removal is impossible and consequently the success of the operation is hopeless. The canal fillings that were put in before much was thought of multiple foramina have proved successful in many cases. Many partially filled canals have stood the test of time and it would seem that too much importance has been attached to the filling of multiple formina, as stated by Hatton (8). It will be found by looking over current literature that the question of multiple foramina has been overworked. All foramina are formed by cementum and are consequently lined with cementoblasts, while the pulp tissue lies within the dentin (11). As the pulp tissue is removed from the root, the blood vessels and nerve tissue lying within these small openings through the cementum are gradually closed by nature in a way that completely obliterates them, if they are not injured during pulp removal by mechanical or chemical means or by bacterial invasion. This fact seems to be a reasonable argument against the use of arsenic or other caustic drugs

in devitalization and removal of the pulp. The periapical tissue is very susceptible to injury and to consequent inflammatory reaction. More often injury results from an attempt to fill multiple canals than from infection through them, where the main canal is thoroughly cleaned and filled to the dento-cemental junction. Noyes says (10) that he "can see very little difference as to whether you have one opening at the end of a root or three or four, as far as the technic is concerned." New layers of cementum are laid down upon the surface of the root as long as a healthy tissue exists about the root, but not if the attachment of peridental fibers to cementum is interfered with by drugs or mechanical injury of any kind.

The consideration of most importance in pulp removal and in all root canal treatment is to preserve a healthy periapical tissue that will continue to function. New layers of cementum must be laid down to support the attachment of pericemental tissue. Partial pulp removal, injurious drug treatment, mechanical injury, and infection, must be guarded against as causes of periapical changes subsequently found by radiogram. The method of pulp removal has been found to be one of the causes of injury to the periapical tissue.

VI. METHOD OF PULP REMOVAL AS A CAUSE OF PERIAPICAL PATHOLOGY

In checking up our records of pulp removal by means of cocain pressure anesthesia (3 and 4), it was found that the radiograms of many cases showed areas of periapical-tissue change, some appearing immediately after root filling and others in a few months. These radiolucent areas vary from small dark lines over the apex of the root to larger areas including some bone absorption. Careful study of these cases revealed the fact that, where the pulps were exposed or nearly exposed by caries, and immediate pulp removal was performed, periapical-tissue involvement followed in a large percentage of the cases. Where an antiseptic dressing was sealed in the cavity for a period of twenty-four hours and the pulp removed at the second sitting, the periapical tissue nearly always appeared normal in the check-up radiogram. *The conclusion arrived at was that all cases of cocain pressure anesthesia should be preceded by an antiseptic dressing, so as not to force infection lying in carious dentin or upon the surface of*

the pulp through the apical foramen to infect the periapical tissue. It is also quite likely that the solution used in cocain pressure anesthesia is frequently too strong. Bastedo states, in his Materia Medica, Pharmacology and Therapeutics, that "cocain is a general protoplasmic poison, capable of irritating and destroying cells, or of stopping the motion of leucocytes, amebae and ciliated cells. Solutions above five per cent in strength, injected hypodermically, may result in the death of the tissue, which shows either as a necrotic area of the skin or as a sterile abscess."

Local anesthesia by infiltration or block anesthesia seems to be the safest method of pulp removal. Even by this method there is danger of periapical infection in the technique of pulp removal and, as a precaution, an antiseptic dressing should always be sealed in the tooth before removing the pulp. The use of phenol, acids, or strong alkalies, to remove remnants of the pulp and open small canals, has also been responsible for some of the destruction of tissue which shows in the radiogram as a radiolucent area soon after the canal is filled.

VII. ROOT-CANAL TREATMENT

The aseptic requirements of root canal operations are of equal importance with those in any branch of surgery. While the immediate health of the patient may not be involved as in major surgery, yet the presence of periapical infection may in the course of time have widespread effects that make it a serious offence needlessly to follow methods that are questionable. A single weak link in our chain of asepsis may counteract all the pains taken in every other step of the operation. Some recommend immediate canal filling, to reduce the danger of periapical infection (7). While this seems to be a reasonable argument, there are several strong reasons against this course. Where the apical foramen is large, it is more difficult to prevent overfilling while the tissue is under the influence of an anesthetic. Again, it would be too severe upon most patients to sit long enough for the operator to remove the pulp thoroughly and prepare the canals for filling. I prefer to make two sittings and rely upon a mild antiseptic dressing such as oil of cloves to keep the canal in a good condition for filling at the second sitting. In regard to the filling of the canal, I have nothing new to offer. There will always be a variance of methods

in technique. It matters little whether the canal is filled with one piece of gutta-percha or several, or whether the gutta-percha is used in one form or another, so long as the canal is completely filled to the dento-cemental junction with a dense mass that will not shrink and leave open spaces for bacterial development. Over-filled canals are more susceptible to apical tissue pathology, and great care should be taken to guard against injury to the cemental attachment of the peri-cemental tissue by forcing any foreign material beyond the dento-cemental junction. It is more difficult to fill the canal that has a large apical foramen without over-filling than to enlarge and fill the small canal successfully. To verify the success of one's method of root-canal treatment and filling, it is necessary to check up a great number of canal fillings by radiogram after a period of time has elapsed, and observe the condition of the periapical tissue. Such reports, if carefully made from accurate and complete case histories, will be of great help in clinical procedure, just as the reports of the research laboratories are furnishing the light for us at the present time by microscopic evidence.

VIII. PULPLESS TEETH

The treatment of pulpless teeth, where the periapical tissue has become involved and shows a radiolucent area about the root apex, is a different problem. The root canal can be mechanically cleaned and, by judicious use of antiseptic drugs, it can be put into a satisfactory condition for safe filling. However, the periapical tissue that is pathologic needs much consideration, and no result can be determined until sufficient time has elapsed after the treatment to observe its changes.

There is a diversity of methods of treatment of the periapical tissue, each seemingly successful from the reports given. This variance is referred to in an editorial of one of our leading journals (5) as "the anomalous, not to say uncertain position in which we find dental practice today." It seems, however, that iodin is becoming more generally used as the treatment where periapical-tissue regeneration is desired. It matters little whether Churchil's tincture, Lugol's solution, or the official tincture is used, as far as the result obtained is concerned. I use the official tincture of iodin without ionization

and find the results very gratifying. No drug that will coagulate albumin and cause tissue destruction should be used in any canal treatment. The successful treatment of canals of this class is dependent upon the condition of the apical cementum. If the cementum is denuded and suppurative products have destroyed the cementoblasts of an area of the root, no amount of treatment can cause a regeneration of tissue over such an area. Dr. Noyes states (10) "that infection passing through the foramen does not spread along the surface of the root but passes out between the fibers, following the course of the vessels, especially the lymphatics." He also states "that the surface of the cementum is the last area upon which these tissues are destroyed and it seems to me that is one of the items of hope in our problem." It is not possible to determine, in the diagnosis, whether there is a destruction of tissue on the surface of the cementum; but, with this thought in mind, by extraction one can eliminate certain types of conditions, with large, distinct and well defined outlines of bone absorption about the root apex. The small radiolucent areas and those of indistinct outline will very often clear up entirely after proper treatment. The sacrifice of useful teeth because of suspicion only is not consistent with the best methods of practice, and it is a serious mistake to deprive a patient of a useful tooth unless it is hopelessly diseased. Black says (1) that teeth are too often sacrificed on suspicion and that "the determination whether or not to extract the tooth will nearly always require a demonstration that the cementum of the root has been denuded." Careful treatment and complete records of these cases, together with subsequent examination by radiogram, will soon reveal the conditions, and many teeth will be retained that would otherwise be sacrificed.

IX. SUMMARY

(1) It is necessary to have faith in the possibilities of saving teeth with exposed pulps and pulpless teeth that will respond to treatment. The basis upon which pulpless teeth with periapical tissue involvement can be made healthy is that the cementum be protected by live tissue. It is not easy to determine this, but careful study of radiographic evidence is of great help in determining whether treatment should be undertaken or not. The condition of the patient's health,

the age of the patient, and the importance of the tooth in the reconstruction of the mouth, are other factors to be considered in determining what teeth shall be saved.

(2) Careful and aseptic technic has been and always will be the greatest factor in successful root-canal operations. The use of every precaution to prevent infection of the periapical tissue is necessary; and any injury, whether mechanical or chemical, is harmful to the health of this tissue. Caustic and irritating drugs are contra-indicated.

(3) Pulp removal is preferable to acute alveolar abscesses. When operating upon a pulp covered by carious dentin, or exposed, precaution should be taken against periapical infection by sealing an antiseptic drug over the pulp for twenty-four hours before pulp removal. All foramina are formed by cementum and the pulp lies within the dentin. Vital tissue lining the cemental foramina should not be disturbed.

(4) The success or failure of root-canal filling can only be determined by subsequent examination by radiograph. These check-up examinations should be made every year or two, or until assurance is established that the periapical tissue is healthy.

The saving of useful teeth is worthy of our best service. The success of a large percentage of root-canal fillings can be assured, if the teeth are treated in conformity with the teaching of the latest histological research. The great service to humanity that has been rendered by such research cannot be overestimated. Now it remains for the clinical force to conduct their operations so that every act will be consistent with the knowledge given us.

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DISCUSSION

M. L. Rhein, M.D., D.D.S. (New York City): It is a great honor to the Section on Pathodontia to welcome among its lecturers a man who has distinguished himself as has Dr. Coolidge in the specialty that has been the basis for the foundation of our Section. We can assure Dr. Coolidge of one thing—that we are in thorough accord with him as to the advisability of strenuously combating the evil of unnecessary extraction of teeth. While we may differ in many of our views on the subject under discussion, nevertheless he and the Section are united on the desirability of maintaining in the jaws pulpless teeth which show no pathologic lesion in their immediate environment.

We recognize the right of difference of opinion as to the method of accomplishing certain results. Who that has studied the wonderful mechanism of the human body, and its working in health and disease, is bold enough to feel that only his method can produce a successful issue? A short time ago a vicious "yellow journal" attack was made against the manner of discussing scientific problems by the First District Dental Society. We were severely criticized for not showing sufficient courtesy to visiting dentists, and for the wrangling discussions that took place on our rostrum. To my mind no greater praise could be bestowed upon our Society than that we had broken away from the old tradition of covering our guests with pails of soft soap and never disagreeing with the views that they might present. This classic method of professional treatment has been the great stumbling block in the path of dental evolution. There is no reason why, in the earnest endeavor for truth which should always be uppermost in the minds of professional men, we should not be able to express the strongest opposing views on any subject without in any way endangering any existing friendship. Let this be the slogan of dentistry, and it will do more to forward progress than the rehashing of that statement of Dr. Mayo's, that the next

great move must come from the dentist. I hope that our distinguished guest will realize that, while we agree with the major part of his utterances, there are many points in his estimable paper with which we thoroughly disagree. We may be right and we may be wrong; but, knowing Dr. Coolidge as I feel I do, I am sure that the expression of these differences will have no effect upon our personal relationship.

When the essayist speaks of the many successes in root-canal therapy of thirty and forty years ago, he has said something of great value. I would strongly emphasize the statement that he made, that these successes were due to the very great care which the operators of that period took in work of this kind. In my recollection there were more great men in dentistry in our country forty years ago than we find today—men who were not so much actuated by the sordidness of commercialism, men who were willing to devote every minute necessary to successful accomplishment, men who were big enough to recognize that absolute cleanliness in the person of the operator and his armamentarium was needed for successful root canal operations. If I were asked to state the greatest individual point for successful results in root-canal therapy, I would unhesitatingly reply, "asepsis." Surgical asepsis, as we know it today, is only about forty-two years old in the United States. Before that time we relied on de-odorizers, embalming agents, and so-called antiseptics to camouflage us into the belief that we were using aseptic methods. It was at this period in 1882, very early in my career, that I had the good fortune to welcome Sir Lawson Tait of Birmingham to this country, and to accompany him to Albany, where I assisted him in a number of ovariotomies. This was, I believe, the first exposition of the present acceptation of surgical asepsis in America; and, upon my return to New York a few days later, I immediately introduced this principle into root-canal therapy. In the furtherance of this principle, at this period in 1882, I introduced the solution of bichloride of mercury in hydrogen peroxide for the irrigation of root canals, and have never since that time used any form of phenol or de-odorizing medium in root-canal therapy. I have no recollection of operating on any root canal without the use of the rubber dam since the day, in 1882, when I began boiling all my root-canal instruments prior to using them.

It might be well to emphasize the value that the essayist places on a correct diagnosis of root-canal cases, with special reference to those where the pulp has been dead for a long time. Personally, I think the essayist places too great an importance on the so-called histories of these cases. In the first place most of these histories are more or less obscure, especially as to minute details of procedure. Generalities of form of procedure mean

very little from a diagnostic point of view. Successful roentgenograms taken from every possible angle, before anything is done, are unquestionably of the greatest diagnostic value. There are two points about a successful roentgenographic diagnosis. First, we must realize the utter unreliability of a picture focused only from one angle, and must have it taken from every possible angle. Second, each of these pictures must be a more or less ideal roentgenogram. Good technicians are continually obtaining pictures which, by one accident or another, have some inherent defect that prevents a proper study of the picture; and all pictures that fail to be of first-grade quality of reproduction should be thrown into the discard.

Having satisfied ourselves as to the histological conditions that are present, our next and perhaps most important step is to determine the existing physical condition. For this purpose it is important to obtain a history of the patient's physical condition as to defects or diseases that have existed or are present. We must determine whether the patient has in any way been injured from the presence of this pathologic condition of the alveolar structure. With this object in view, it is most important not only that a thorough physical examination of the patient be made by a competent internist, but also that there should be the most thorough urinalysis and blood examination at the same time. When the presence of malnutrition complications can be set aside, or injuries to any important organs, then the restoration of pulpless teeth to a condition where they can not be a menace to the rest of the body can be safely undertaken. If, however, we find some type of malnutrition, or some important organ like the ear or the eye involved directly from some focal infection, it then becomes a matter of serious judgment whether the system can stand the rigorous treatment needed in root-canal therapy. While we are unalterably opposed to the needless extraction of teeth, it is wise to remember that in a choice between the value of the heart, or the eye, or the ear, and the tooth, it is always wiser to lose the tooth rather than to impair some important function or risk a complication that will shorten the life of the individual.

It is the ability to distinguish between cases where there is sufficient immunity and those in which this immunity is lacking that really constitutes the successful diagnostician. It is my experience that this ability is a natural possession which cannot be acquired by education, and is an inherent part of the makeup of the fortunate individual who possesses it. A very interesting case in my practice last Spring illustrates a phase of this question of diagnosis. One of the prominent musical directors in the country came to me for consultation in regard to his mouth. He was at the same time suffering greatly with ear trouble, so that for a period of

six months his hearing had been becoming more and more impaired. His ear specialist was making plans to put him in a hospital for a serious operation, which I personally could not appreciate. By some peculiar intuition the patient of his own accord wondered if the bad condition of his teeth on the right side might not have something to do with the failing condition of his hearing on that side. We found the two molars and bicuspid—all three—involved with granulomas at the end of their roots. Realizing at once the possibility that this condition was the direct cause of the deafness, which was increasing daily, and the supreme importance of good hearing to a musical director, I cast aside any idea of attempting to save these teeth, but within twenty-four hours had thoroughly removed all traces of alveolar pathology from this portion of the jaw. The improvement in his ear condition manifested itself almost immediately. He did not go to a hospital for any operation, and today his hearing has become normal.

In like manner, if a patient shows the presence of severe nephritis or heart disease, it is a question whether his vitality and endurance are sufficient to warrant root-canal therapy. It is the lack of good judgment among capable root-canal technicians on this point of insufficient immunity that has given the greatest amount of ammunition to the members of the "100 per cent club." The knowledge that we can derive from expert blood examinations is increasing daily. The differential blood counts, and the comparative amounts of uric acid in the blood, are well known clinical factors at present, and I have no doubt that their value will be further increased when we have a more complete chemical knowledge of the blood. We can, however, fearlessly state that there are very many cases of pulpless teeth that can be left in a condition of more security to the individual than some with living pulps, and we unanimously and unhesitatingly decry the absurdity of speaking of a pulpless tooth as necessarily a dead tooth.

It is a satisfaction to endorse the view of the essayist as being opposed to pulp-capping, and his reference to the value of the removal of many living pulps. The ignorant clamor for general tooth extraction by many physicians who are unable to diagnose the maladies of their patients, has brought about among dentists a strong feeling against disturbing the pulp of any tooth so long as it responds to a vitality test. The public today is very likely suffering to an unheard-of degree from the retention in teeth of diseased pulps which forty years ago, according to my recollection, would have been unhesitatingly removed by men who were naturally constituted to be dentists. Henrici's valuable contribution, showing the large percentage of living pulps that are infected, should open our eyes to the importance of not leaving such pulps in the teeth. This is one of the most

difficult lessons for the dentist of today to learn, that there are very many teeth with diseased pulps in which it is essential that either the pulps or the teeth should be removed, if we are to consider the welfare of the patient.

It was a pleasure to note the author's objection to immediate root filling after living pulps have been removed. He modifies it by stating that he would fill the canal at the following sitting. I have never found a root canal in which a living pulp has been removed that I felt safe in filling at the following sitting. This is due to the fact that our objectives are different. While we insist that every portion of organic material in the canal must be removed and replaced with a solid, homogeneous mass of gutta-percha which shall hermetically seal every orifice, Dr. Coolidge not only finds this unnecessary, but objects to too tight a filling. In our opinion a filling cannot be too tight to avoid the danger of infection against which we are especially warned by the essayist.

Agreeing thoroughly with Noyes' description of the cementum, we feel that we must disagree entirely with the deductions made by Dr. Coolidge against wounding the periapical tissue. When he mentions Noyes, as his authority, he quotes what actually demonstrates the safety of aseptically wounding the periapical area. Noyes' statement is thoroughly borne out by my observations, carefully made for over forty-three years and much more positively determined during the past twenty years, since we have had the benefit of x-ray checking, and has been the basis upon which our encapsulating surgery has been built—the fact that the periapical region can be freely injured without disturbing the pericemental membrane. In our opinion the essayist confounds the results of aseptic traumatism to the periapical region with infection of this region. This error is very likely due to the difficulty of wounding the delicate periapical tissue without infecting it at the same time. When Schreier's sodium-potassium is used for the destruction of every remnant of organic tissue, it is automatically impossible to infect the periapical region because no infected substance remains in the canal. It is a surgical axiom that if a portion of any tissue is removed, it will invariably regenerate unless infection takes place. The best illustration of this is the callus formation following a fracture. I know of no exception to this rule. It is on this account that we fearlessly destroy part of the alveolus in order to seal foraminal openings hermetically. We also believe in frequent x-ray surveys of our root-canal work, and we find that our regenerated alveolar tissues remain ideal. When we fail to obtain alveolar regeneration, we look upon our operation as a failure and resort to apicoectomy or extraction.

There should be no wavering in our diagnosis of failure, if regeneration

has not occurred in a reasonable time. Root-canal surgery will never reach its proper recognition until it is generally admitted that failure to obtain absolute regeneration of destroyed alveolus indicates that the operation has not been a success. Nothing in the history of the case can alter the premise that regeneration of missing alveolar bone must occur in successful operations. When we use sodium-potassium, it finds its way into every crevice, into every byway and path leading to any number of multiple foramina. The organic tissue is virtually cremated; and when the gutta-percha canal filling is inserted by mortarization, the gutta-percha is carried equally to the end of every opening, and not only to the end of the central foramen. One anatomical fact must not be lost sight of, and that is that the histological anatomy of root ends has many variations, especially as to the diameter of the foramen and the thickness of the lamellae of cementum, which frequently keep forming upon the ends of roots. In a small percentage of cases, owing to excessive pulp irritation, the lamellae have practically obliterated the foramina. In such cases the technic of forcing gutta-percha as far as possible is permissible; and even here, if the actual foramen could be penetrated, it would be preferable. This type of operation requires much more frequent x-ray observation than where encapsulation has resulted.

In all cases of pulpless teeth we must ever remember that miraculous successes have very little real significance, so far as confirmation of the success of any particular technique is concerned, because of our inability properly to estimate the prevailing *immunity*. How long may infection have been present before showing any alveolar destruction? How much toxin is being absorbed and what part of the body is succumbing to the absorbed poison? These questions are almost unanswerable in the incipient stages of infection. Let it be understood that, as in every other branch of surgery, there is always a percentage of failures; but we repeat, what we have so often said and what has been confirmed by many x-ray surveys, that "the crux of success in root-canal therapy consists in successful encapsulation." If encapsulation is correct in operating for pulp removal, how much more positive is our need for it in root-canal cases where periapical infection exists? The practical eradication of periapical infection is an essential factor before root-canal filling. This should have substantial laboratory confirmation before its success can be claimed. The topical application of iodine or any other remedy must necessarily fail to act on the deeper portions of infected alveolar structure. After thirty-four years in the use of electrolytic medication, I am convinced it is invaluable for the eradication of alveolar pathology. Iodine is very likely one of the most

valuable remedies that can be used, but it can only reach the deep portions of the infected area when it is forced there by electric means. I have in course of preparation a statistical compilation of the past few years' use of electrolytic medication, and it fully bears out what we have claimed.

Once more we disagree with the statement that, because the end of the root has lost its pericementum and the cementum is partly absorbed, the tooth cannot be successfully treated. If the alveolar pathological condition has been eradicated and the exposed cementum entirely covered with gutta-percha, we shall have as successful a result as can be desired. We say this with the assurance of success in cases which have been under years of x-ray observation. By no means do we desire to decry the possibilities of success by other means, but we do deny the right of any one to condemn our technique and question our results without proper investigation by properly qualified dentists, and that excludes the majority of our colleagues.

In conclusion permit me to say that the substantial benefits of scientific root-canal therapy will never reach the public until this branch of dentistry becomes as highly specialized as orthodontia.

C. William Rubsam, D.D.S. (New York City): Though I shall differ with our essayist on a few points, I wish to say that a long time has elapsed since I have read a paper on this subject that has appealed to me as being so sane and well taken as has this paper. Our essayist makes no extravagant claims for the efficacy of any pet technique; he holds out no hope for the teeth with considerable areas of periapical involvement; and, above all, he has had the good sense to put his ear to the ground and welcome some teaching by our histologists. I am always inclined to put trust in the man who is ready to look beyond his own horizon for advice; and, between the lines of this evening's paper, one reads the slight uncertainty, the willingness to admit that failure is possible, and that the last word in technique has not been spoken. I knew that time would not permit a lengthy discussion so I shall merely touch upon several major points of the paper.

The first is that of completely filling a canal to the dento-cementral junction with the express purpose of shutting out bacterial life. This presents a mechanical problem with finite limitations of space and matter. These are concrete factors leading to the science of measurement. However, it is amazing with what naive innocence we have completely ignored the science of mathematics in our canal filling. We will admit that to fill a root against microbic invasion is a mechanical procedure. Then can you conceive of any mechanical operation that is not related to the science of mathematics, either expressed or implied? A six-inch mesh wire may be

all right for confining a flock of sheep, but of what use is it in keeping a flock of ducks in an enclosure? In exactly the same manner, your gutta-percha root filling to, through, beyond the apex is sufficient to produce a radiographic result showing precision in filling. But does that mean that it holds back the microbic form which ranges around one fifty-thousandth of an inch in diameter? Are we not presuming a great deal when we assume that our naked eye can discern in a radiograph a discrepancy about a root-filling small enough to permit the passage of microbic life?

This is too preposterous to be worthy of critical consideration, and yet on this delicate point hinges the efficacy of root filling. The undisputed fact remains that the apical tissue at many a carefully filled root in the past has remained normal through the years. From this it was deduced that a mysterious potency in our root work was the cause. I believe this to be utterly fallacious. The failure of infection to become established in that root was due, I believe, to an aseptic handling of the canal and to the broad influence of immunity.

Now we find that both our essayist and my co-discusser lay emphasis on being able to seal out microbic life by a root-filling technique. Having made this announcement, the burden of proof devolves upon each of them to furnish us with microscopic—please note that—microscopic evidence of their mathematical precision in attaining this ideal result. Some of you may know how difficult it is to construct removable appliances where the standard of accuracy is on two-thousandth of an inch. Now multiply this difficulty by twenty-five and then place your field of operation into the furthermost recesses of a root canal, and only by a violent stretch of your imagination can you microscopically exclude bone fluid and microbic life. Present this case to a microscopist, acquaint him in detail with all the factors involved—the moisture around the apex, the volatility of the medium used to soften the gutta-percha, the irregularity of conformation of canal surfaces and many other hazards—and see whether he thinks our root-canal claims are reasonable?

Our essayist intimates that he uses iodine solutions in treating infected canals. May I inquire whether he uses iodine for sterilization of periapical tissue? If so, does he believe that iodine, confined in a bone cavity that way, can be depended upon to leave the healthy, living bone unmolested? Will he admit that iodine left in contact with mucous membrane in the mouth for a few minutes actually produces a slight superficial necrosis of the tissues? What must it do in bone, if confined that way until it is completely absorbed? Is not iodine poisoning a fact and not a fancy?

The use of strong disinfectants and strong chemical agents near or through

the apex has been one of the principal abominations in root work through its history. We know that surgery has long since discarded them, bag and baggage. It is said that sodium-potassium is an exception to the rule, that it cleanses tissue as does the surgeon's knife, etc. How unfortunate that our able surgeons have not the intelligence to apply this freely in their bone work, if it is so effective! Or is it possible that they have rejected such a method as totally unfit for use on human tissue?

In the matter of injuring periapical tissue, I am heartily in accord with Dr. Coolidge. Whether you burn with an acid, roast with an alkali, cremate with a coal-tar derivative, or macerate with a broach, you leave the apical tissue in a condition that impairs its vital resistance to subsequent chance contact with microbic life. The whole drift of opinion is toward this side of the subject and eventually we shall hear nothing more about treating apical lesions by tissue-destroying chemical agents or catapulting gutta-percha through the apices for their encapsulation. In regard to multiple canals, our essayist says their cleansing and filling is unnecessary, as they are lined with cementoblasts and therefore capable of closure by cemental deposition; and he says the pulp is confined to the dentine. This leads to a curious situation that you can readily visualize, and leaves pulp fragments entirely unprovided for. They must not be charred with caustics lest the pericemental tissues be injured. Would it not be of interest to hear our essayist's explanation of this phase of the matter.

It is clear that our essayist is open-minded on his subject and that most of us sympathize with him in his desire to save pulpless teeth. The "100 per cent vitality" men must come forward with more trustworthy proof than they have presented in the past, before they can convince us that all pulpless teeth are infected teeth. As matters stand, I believe our success in root-canal work occurs in spite of our ramming and cramming, not because of it.

The germ-proof root-filling has not arrived. However, let us not forget that the individual immunity that protected pulpless teeth years ago is still a living, active force and some day we may know more about making it amenable to our ends. In time, I hope to find that aseptic technique and a high immunity to periapical infection, plus the prevention of factors leading to the loss of the dental pulp, will relegate this troublesome question to the background.