

THE TREATMENT OF ROOT CANALS BY A SILVER REDUCTION METHOD.

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THE need for root canal treatment is the outcome of caries. For this reason I shall speak first of the bacteriology of caries, its character, and its penetration into the tooth substance. In addition I shall refer to the efficacy of our present methods of treating the caries action. The classic work of Miller is familiar to all. His work was done when the subject of fermentation, particularly of wines and liquors, occupied the attention of many laboratory students. Miller applied this idea to dental caries and he showed by zinc crystallization that lactic acid was formed by the fermentation of bread with saliva. He regarded caries as due to a mixed infection. Goadby worked and studied it from a more modern standpoint. From deep caries he isolated two micro-organisms *B. necro-dentalis* and *streptococcus*.

At the Forsyth Dental Infirmary for Children, I undertook a study of the subject which comprised a larger number of cases than were ever studied. I chose the twelfth and sixth years molars. Here the carious process is most active. Modern bacteriological methods were used. A full account of the work has been published elsewhere.* We succeeded in isolating from all car-

ies some members of Moro-Tissier group of microorganisms. This highly aciduric flora at least possesses the property of inaugurating decay and in a higher degree than other micro-organisms. I believe that Goadby's *necro-dentalis* belongs to this group. I cannot give an adequate description of these micro-organisms here, but will show a few slides of them. This group is, as I have said, highly aciduric. Some members of the group are highly pleomorphic. It is a known group and has been studied by others in the feces of the nursing, constituting its normal intestinal flora.

Bacillus X (Figures 1, 2 and 3) is somewhat pleomorphic. It is Gram-positive on agar. It most frequently appears as a long chain of short, thick rods, 5×0.5 microns, the chains often showing parallelism. Under certain conditions the individuals are considerably longer and do not occur in chains. Moreover, smears of the organism often show only masses of long, tangled, unbroken threads, occasionally having one long thickened end. On glucose-agar many of the individuals fail to retain the Gram stain. It is an anaerobe facultatively aerobic. It produces a high degree of acidity, often requiring 14 cc. of N/NaOH to neutralize 100 cc. of the bouillon. It ferments glucose, saccharose, and levulose, but does not ferment lactose readily. It coagulates

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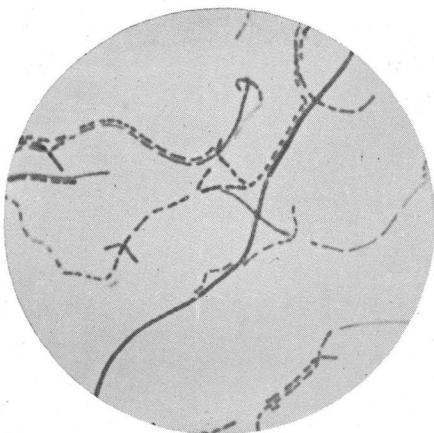
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milk and does not form indol or ammonia. On Petri dishes its colonies are transparent, round, entire, slightly raised.

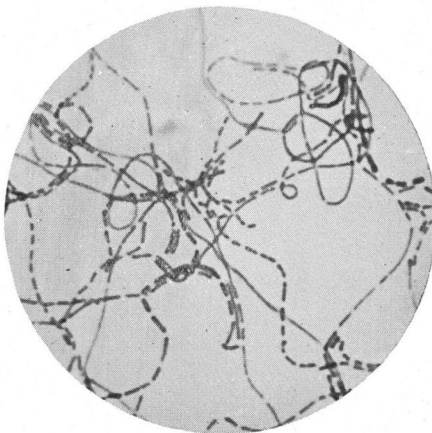
× 2 to 3 microns. It is Gram-positive. On glucose-agar the rods are longer and thinner and more distinctively arranged in groups with the individuals showing

Figure 1.



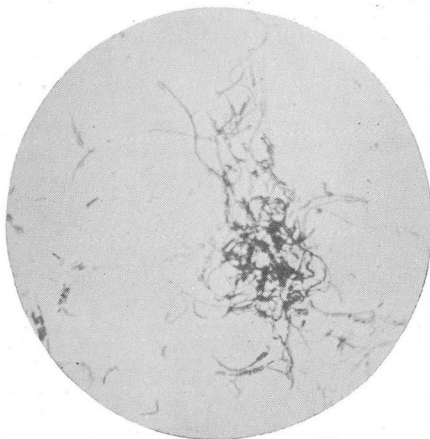
Bac. X: Agar, 48 hrs., Gram st., × 2000.
(Note variation in length of bacilli, also heavy thread forms.)

Figure 2.



Bac. X: Glucose-agar, 48 hrs., Gram st., × 2000.
(Note tangle of threads and chains.)

Figure 3.



Bac. X: Glucose-agar, 48 hrs., Gram st., × 840.
C'f with Goadby's *B. plexiformis*.

Bacillus acidophilus of Moro (Figures 4, 5, and 6) as found in dental caries is a non-mottle, non-pathogenic rod. When grown on agar it is short and thick and measures 0.75

parallelism. They produce turbidity of the media. They are Gram-negative. On blood serum the rods measure 0.1 × 1 micron. They are Gram-negative, grouped as in glucose-agar.

Bacillus acidophilus grows best anaerobically when first isolated by means of acid broth. In milk it clots the lower portion first. In peptone water it produces no indol or ammonia. In broth it

The colonies are slightly raised, round, smooth, opaque and white.

B. bifidus, as it appears in the carious tooth, is to be found in many forms. It is found frequently in its bifurcating

Figure 4.

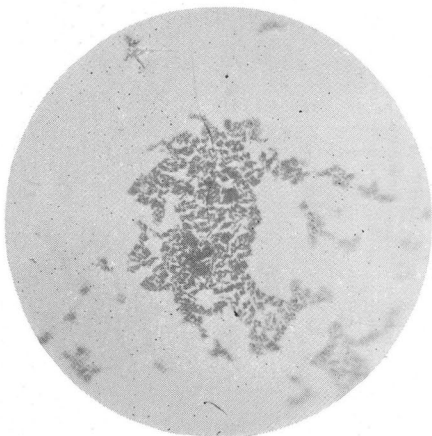


Figure 5.

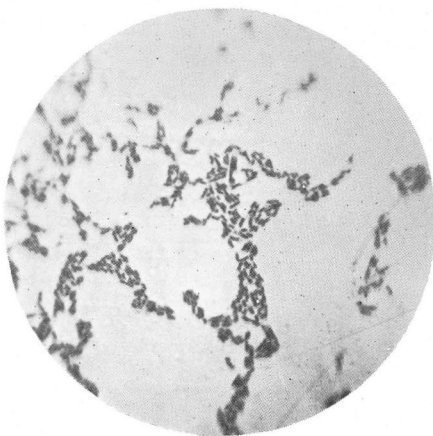
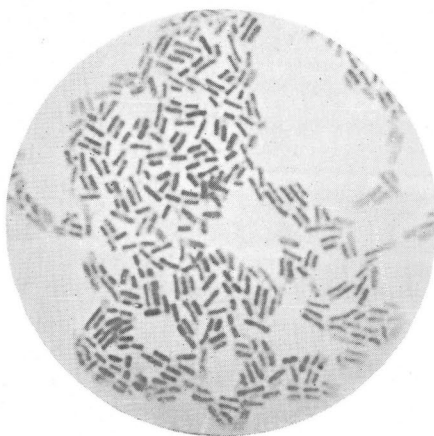


Figure 6.



Figures 4-6. *Bac. acidophilus*: Figure 4, Glucose-agar, 48 hrs., Gram st., $\times 840$. Figure 5, Agar, 18 hrs., Gram st $\times 840$. Figure 6, Glucose-agar, Gram st., $\times 2000$.

forms a heavy sediment with some turbidity. It forms no gas in sugar. It is a facultative anaerobe and should be transplanted every ten days. It is a high acid former.

According to these studies it is not as pleomorphic as has been supposed.

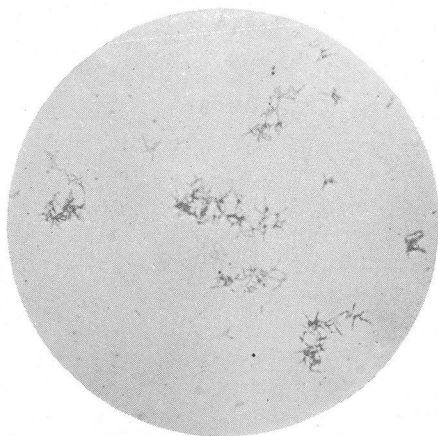
state (Figures 7 and 12) with tapering or with thickened ends, in V and Y forms, in streptococcal forms (Figure 9), as masses of Gram-negative cocci, (Figure 8), as straight rods (Figure 11), in crosses (Figure 11), and as a spore-former (Figure 10). It is Gram-

positive in young cultures. It grows aerobically and anaerobically, altho according to Kendall it is a strict anaerobe.

The colony is raised, white, entire, butyrous.

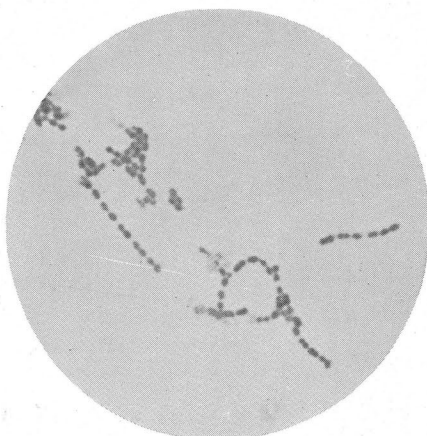
This brief description of the micro-

Figure 7.



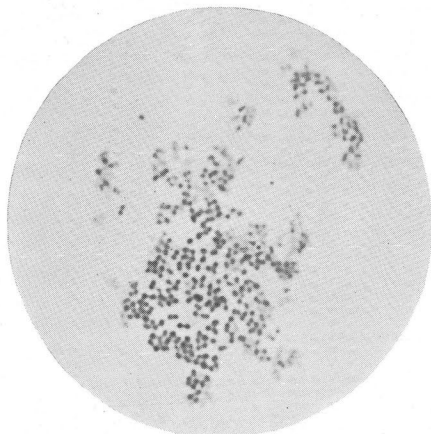
Bac. bifidus: Glucose-agar, 72 hrs., Gram st.,
× 840.

Figure 9.



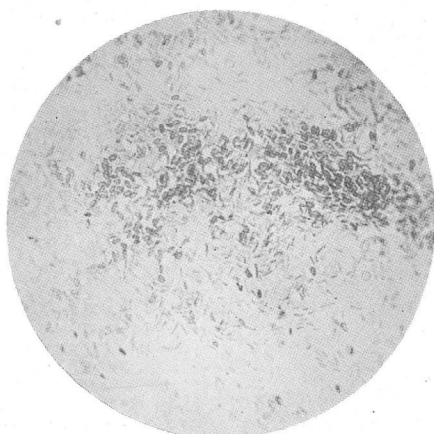
Bac. bifidus: Glucose-agar, 18 days, Gram st.,
× 1250. (Streptococcal form.)

Figure 8.



Bac. bifidus: Agar, 2 days, Gram st., × 1250.
(Staphylococcal form.)

Figure 10.



Bac. bifidus: Glucose-agar, 5 days, Gram st.,
× 840. (Rods and spores.)

Noguchi shows it to have both anaerobic and aerobic phases. In contradistinction to his, the bifurcating form of our organism grows well aerobically after adaptation to artificial media.

organisms is made of excerpts from articles descriptive of this work.

In preparing many ground tooth sections in this study of caries, I was struck with the depth of penetration of caries.

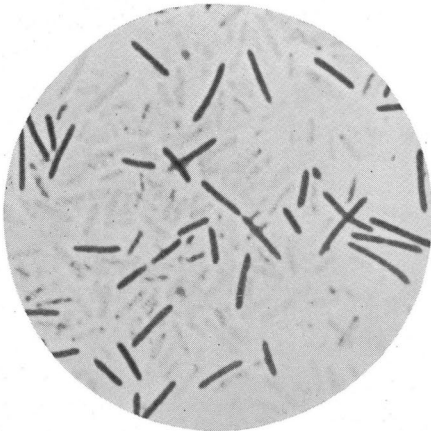
A flatly ground slide does not always show this but in many apparently superficial carious spots it is evident that the decay extends nearly if not quite to the pulp.

A bacterial examination of many nicely prepared cavities shows that they are not sterile. This fact together with the foregoing statement shows that it is not practical to attempt to sterilize a cavity with a bur. If we are to proceed upon surgical principles then we must

should be applied to children's teeth as a routine matter. It will enter any defect in structure, destroy the bacterial flora, and block the tubuli with finely divided silver. It will not enter, nor stain sound structure.

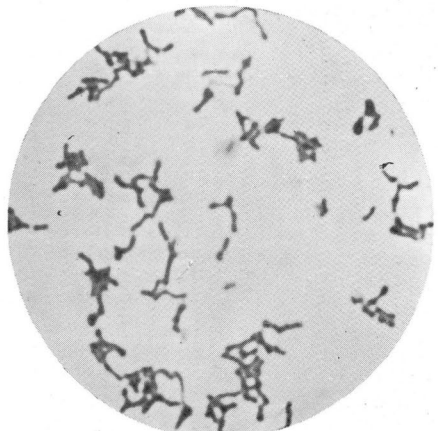
In a simple cavity make a good edge; clean out the loose debris, and wash out with alcohol to get rid of fatty substances; then apply this material. This will fill the disorganized dentin in an infinitely more perfect manner than is

Figure 11.



Bac. bifidus: Glucose-agar, 11 days, Gram st.,
× 2000.

Figure 12.



Bac. bifidus: Blood serum, 2 days, Gram st.,
× 2000.

sterilize our cavities. If we wish to do as much as we can to avoid pulp complication and still to proceed upon surgical in contradistinction to mechanical ideas, then we should excavate as little as possible consistent with retention, and sterilize our cavities.

*The method that I am about to describe to you will affect this sterilization; it will do more; it will impregnate all affected dental structure with finely divided metallic silver; it will not enter sound dentin. It is intended as a preventive measure. It will absolutely kill the carious process and it protects against a secondary attack. I believe that it

otherwise possible. Fill the bulk of the cavity with anything you desire. You have avoided to the fullest possible extent encroachment toward the pulp. What I want to especially emphasize at this point is the value of this method as a preventive measure. If children's teeth were treated with this material thoroly beginning with the very young, and if it were periodically followed up, I believe caries would be entirely forestalled or obliterated. The mechanical using up of tooth structure is largely done away with. Before I go on to describe the principles to be observed in the treatment of any root canal work, and before I describe the technic of applications in

*Dental Cosmos, Sept., 1917.

various other dental conditions, let me tell you how to prepare the material and something of the chemical action.

Prepare two solutions as follows:

Solution A.: Three grams of silver nitrate crystals, dissolve in 1 c. c. of water. When dissolved cool a little and add 2.5 c. c. of 28% ammonia.

This will give a murky solution. It should have no odor of ammonia. Allow it to settle; the clear top solution should be used. Keep in a dark glass bottle; then prepare.

Solution B.: which consists of a twenty-five per cent solution of formalin, and keep this in a separate bottle.

If some of solution A is poured into a test-tube, or small glass vial and solution B is added, a heavy precipitate of metallic silver occurs, making a mirror upon the sides of the receptacle. The chemical reaction that occurs is one of reduction. Many substances will reduce the silver from this solution, but we believe formalin to be the best for our purpose. I have written an account of this method which has appeared elsewhere, and because there is much to be said upon the technical side of the question I shall here confine myself to that part of the treatment.

We are dealing with a powerful antiseptic. There is no question as to its ability to produce sterility. This, we have demonstrated by many careful tests. Anyone who does not get sterility has not mastered the technic, or does not carry out his tests with the exactness demanded in such work. It is then to be remembered that any antiseptic will destroy living tissue before it will bacteria, and it is better to confine this solution to the tooth proper. If it goes thru a root-end it will cause pain, if the tissue about the root-end is intact. We may use it within the tooth substance and under certain circumstances we may use it outside the tooth-root. We must always hold in mind the distinction between dentin and cellular tissue. The proper antiseptics to use in the soft tissues are

Dakin's solution, Eusol, Physiological Salt, or drainage. These solutions mentioned are somewhat antiseptic. They are solvent of mucin, pus and other detritus, and eusol has a different osmotic pressure than the blood causing an exudation of the serum, which is, of course, the best of antiseptics. These preparations then, clean the tissue and induce the destruction of bacteria in the natural way, promoting healing. They do not injure healthy tissues. There are a number of preparations on the market that are based on these principles, but for convenience I will give here the method of preparing these solutions. Dakin's solution is prepared as follows:

20 gms. lime chlorinated.

1 liter water.

Let this stand 6 to 12 hours, shaking from time to time.

Filter—Estimate the chlorine in solution as follows:

To 10 cc of filtrate add 20 cc of a 10% solution iodide of potassium and 2 cc of glacial acetic acid or strong HCL.

Titrate against N/10 sodium thiosulphate decolorization marks the end point.

Number of c. c. of thiosulphate of soda required $X 1.775 =$ per cent of chlorine in 100 gms. of the chlorinated lime used. Carry on work from Dausfresne's table.

E. g. Thus if 14 c. c. of N/10 thiosulphate is required $14 X 1.775 = 24.85$.

Twenty-five titer of cal. chlorid sample means chlorinated lime 184 gms. must be used for 10 liters.

Dry Soda Carb. 93 gms.

Bicarb. 72 gms.

Place chlorinated lime into one bottle and sodium carb. and bicarb. into another. Let stand 6 to 12 hours, shaking from time to time. Mix, let stand half hour and filter thru double paper—test for strength. N/10 sodium thiosulphate consists of 25 gms. to liter.

Eusol is prepared by adding 25 grams of equal parts by weight of chlorinated

lime and Boric acid to a liter of water. Dichloramine-T paste is made as follows:

Stearic acid, 16 grms.

Water, 200 c. c.

Chlorazene, 4.6 grains.

Enough sodium hydroxide is added to completely saponify the acid. Dichloramine-T is an attempt to render Dakin's solutions more stable. We have used it in root canals with enlarged foramina with nothing but good results.

never known one to ache when this was done.

Before I describe its application in root canal work, I want to show you some slides showing that whenever a pulp or the peridentium is inflamed for any length of time a structural change occurs in the tooth substance. The dentinal tubuli disappear and the structure becomes hyaline. Compare Figures 13 and 14 with Figures 15, 16 and 17. This hyaline condition com-

DAUFRESNE'S TABLE.

Titer	Chlorinated Lime.	Chlorinated Lime	Dry Carb. of Soda.	Bicarb. Soda.
		Gms.	Gms.	Gms.
20		230	115	96
21		220	110	92
22		210	105	88
23		200	100	84
24		192	96	80
25		184	92	76
26		177	89	72
27		170	85	70
28		164	82	68
29		159	80	66
30		154	77	64
31		148	74	62
32		144	72	60
33		140	70	59
34		135	68	57
35		132	66	55
36		128	64	53
37		124	62	52

(Based on 10 liters and to contain .45—.5% Chlorine.)

Dichloramine-T has been used in bone infection.

Now in the treatment of deep caries we are approaching the pulp, and this is cellular tissue. This silver preparation would injure it, therefore, I recommend mixing a paste of zinc oxide and eugenol, adding to it a crystal or so of silver nitrate, and smearing this over the bottom of deep cavities. This will become quite hard. Follow by applying, first, a drop of solution A, followed with a drop of solution B; repeat about three times in order to reduce a considerable amount of silver. Dry the cavity and fill with any material you like. The cavity is sterile and the fine anatomy of the tooth is filled with finely divided silver.

An application of the zinc oxide-eugenol-silver-nitrate paste may be put directly over an exposed pulp. I have

pleted is impervious to the most penetrating stains. It is sealed by nature. It occurs in chronic abscesses, and while, undoubtedly it is a degenerative condition, it is at the same time a protective one. A modified form of this is seen in the protection nature tries to establish before the inroads of caries. Previous to the completion of this process the tooth undergoes a disintegrating condition, where the tubuli stain deeply, and are also full of infection. This treatment kills the bacterial life and fills these tubuli with metallic silver. Figures 21, 22, 23, 24, 25. We have something besides the canal to consider then in root treatment, we have the tooth substance itself to treat.

An examination of the cuts shows what change has taken place and it also shows the penetration of the tooth substance by the silver.

In the case of a dead pulp, apply the material freely before entering the canal with the instruments. If the putrescent pulp is left intact the material will follow along its entire length, no matter

the silver, being careful not to work it thru the end of the root. The treatment has rendered the canal sterile and impregnated the diseased dentinal structure with metallic silver. The bulk of

Figure 13.

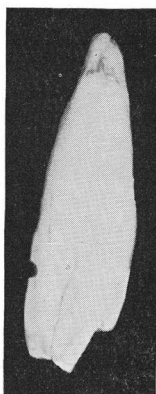
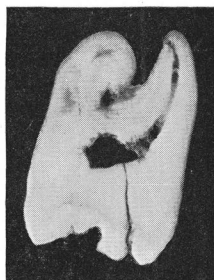


Figure 14.



These are sound teeth from patients twenty-two and twenty-five years of age respectively. The dentinal structure is white, opaque, and uniform in appearance.

Figure 15



Figure 16

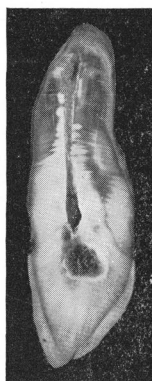
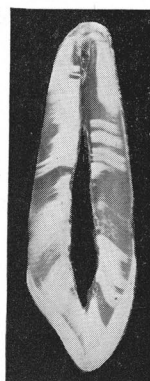


Figure 17



Show abscessed teeth. Figure 16 shows pyorrhetic tooth. Note in Figure 17 that both the pulp and the pericementum have taken part in this dentinal change.

how fine or how crooked the canal, and it will render the pulp stiff, dry, and sterile. The material will stop short at the point where the tissue is living. This pulp never need be removed, but I should remove it and treat again with

the canal may be filled with anything. It does not matter. The anatomy and the apices of the tooth are already filled.

The sterilization of any pulp canal is affected in the same way. I depend largely on capillary attraction for con-

ducting the material to its proper place. If you will take a laboratory tooth and open the pulp chamber and flood it, you will see that the silver comes out at

used. Pain means that the material has been forced thru the apex, and it means nothing else. Place a broach into the canal, apply a drop of the silver solu-

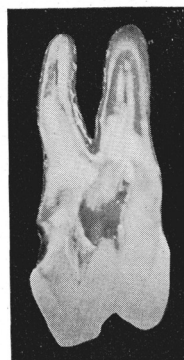
Figure 18



Figure 19



Figure 20



Showing localized areas where the dentin has become completely hyaline, with no dentinal fibrils to be seen. These areas will not take stain. They are absolutely sealed.

Figure 21

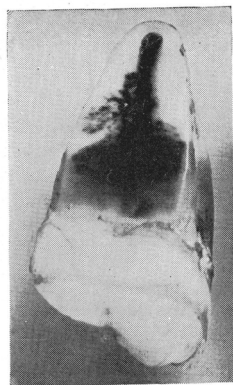
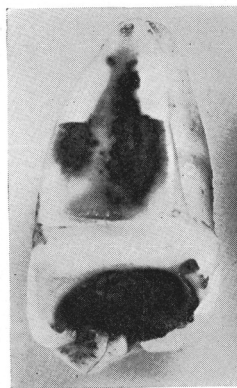


Figure 22



These teeth were treated in the mouth and then extracted. The sides were ground off and the penetration of the silver is shown. The healthy tissue is not penetrated, but the unsound structure is.

apices of the root, no matter how fine the canal.

Reports have come to me of severe after-pain. This is due to faulty technique and to disregard of the principles upon which antiseptics are to be

tion; let it run along the broach, lightly lift the broach and lower it. The material will go to the very end. Then apply in the same manner the formalin. The silver reduction immediately occurs. Repeat three times; then dry, apply

solution A, alone; follow with eugenol, dry and fill. This last application removes any possibility of formalin excess. Such men as are accustomed to handling formalin will have no trouble. Formalin is a most excellent root canal antiseptic, but there are men who do not understand its use and they have nothing but trouble. There should be no pain whatever. If there is it will subside and no harm is done, but it means that one should correct his technic. Keep away from the apical region with

With a blind abscess do the same thing.

I have a record here, at the Forsyth, of more than four hundred cases treated by six or eight operators and we have extracted only three teeth. We have treated every description of cases. Operators have to master the technic, however, or they have their troubles. The efficacy of the treatment remains even if it is impaired thru the lack of understanding of surgical and therapeutical principles.

Figure 23

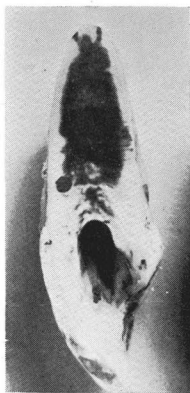


Figure 24

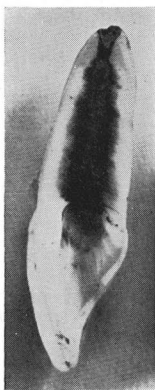


Figure 25



These are laboratory teeth. The tooth in Figure 23 had five foramina. All foramina are filled. Note the healthy structure in the root of the tooth in Figure 25, just above the gum margin.

instruments. What the object is in forcing a foreign material thru a root end in any case is, I cannot see. Such a process disturbs the delicate adjustment of vessels and tissue that should properly cover the root-end and is unscientific. Nature is wonderfully tolerant and will encyst many foreign substances, but why ask it of her.

When we have a fistula, treat the tooth once with the silver solution; force Dakin's solution thru the fistula, once or twice, and if this does not cure it, repeat again. At the last treatment apply the silver treatment several times in succession and fill.

Formalin alone does not effect the sterility that this process does, neither does the silver nitrate alone. It is during the activity of the chemical action that this is attained.

For a nicely cleaned cavity, phenol five minutes, followed by seventy per cent alcohol is very effective as a sterilization process.

Eugenol and zinc oxide is quite antiseptic. Antiseptic cements have but little antiseptic value according to my experiments and they have been extensive.

All my studies have been conducted in the teeth in the head of the patient. Other experiments upon laboratory teeth

do not represent the true state of affairs, and are limited in value. From what I have shown regarding the hyaline areas that occur in chronic abscessed conditions, it is evident that nature attends to such a condition in a very perfect manner when the cause is removed. The so-called granuloma is an attempt on nature's part to repair and wall-off the effect of instrumentation or of the mild tooth infection. We must bear this in mind in X-ray interpretation. Many an established protective process has been condemned by wrong interpretations. I believe that when we remember that nature as a rule is perfectly competent to take care of minor infections, that all protection against bacterial invasion comes from within the body, and that all processes of repair likewise are done by the bodily tissue, we shall feel that we have little fear from the teeth from an infective point of view.

There is no question but that there

has been a great deal of needless extraction on the theory that the teeth are a causative factor in disease. In certain cases they may be, but this I believe to be the exception. The teeth are necessary organs. They are instruments in the digestive act. No one knows much about these general diseases attributed to the teeth. All are agreed that infections in and about the teeth are low in virulency. By injecting these organisms even in enormous doses one cannot produce a blind abscess or pyorrhea. The infection is secondary in my opinion. Clean up such areas of course, but do not condemn the teeth for obscure conditions, the cause of which is unknown. We should bear in mind the principles of immunity, a topic of too great magnitude for me to discuss here. I believe that we know how to safely conserve teeth, and that we should clean, fill, and treat oral conditions according to surgical principles and only as a last resort fall back upon extraction.

