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THE DISINFECTION OF DENTAL AND SURGICAL INSTRUMENTS.

BY W. D. MILLER, M.D., D.D.S., BERLIN.

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ASEPSIS and antisepsis form the rock upon which the edifice of modern surgery is founded, and in virtue of which it has registered triumphs in the treatment of diseased conditions of the human body formerly unattainable.

The wonderful progress which has been made by surgery in the last ten years is the legitimate fruit of the growing knowledge of the part performed by microscopic organisms in spreading disease, and of the methods of counteracting or preventing their action.

The necessity of aseptic and antiseptic procedure in all operations in dental or general surgery is to-day, we may say, universally recognized. It is true that there are still some whose appreciation of their duty toward those who commit themselves to their care is so stunted that they insist upon the right to spread infection by unclean instruments or fingers that are not absolutely free from germs. Fortunately, however, such men are rapidly becoming fewer, and will not be able to hold out long against the just condemnation of an advancing profession.

Antisepsis is but one of the means to the production of asepsis. It should be the aim of every surgeon to perform all operations aseptically, and he who comes nearest to attaining this ideal will be more successful than he who lays the chief stress upon the subsequent antiseptic treatment.

If we wish to protect ourselves against robbery, it is a hundred times better to keep the thief out by appropriate locks than to allow him to enter by the open door and then take the chance of a conflict, in which we may possibly be worsted. When, however, the surgeon who uses the most scrupulous care in cleansing the part to be

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operated upon, his hands, towels, instruments, etc., before every operation,—*i.e.*, operates aseptically, and accomplishes results proportionate to his care,—disclaims the use of antiseptics, he is deceiving himself, for the reason that the very means used to bring about the aseptic condition—soap and brush, pure water, etc.—are themselves antiseptics. He is simply accomplishing by those simple means that which he, in most cases at least, might better and more easily do if he would take advantage of the more powerful means of sterilization.

There is no department of surgery in which the demand for antiseptic procedure is more urgent than in dentistry, for the reason that all of our operations are performed upon septic or infected tissues, and we have no means of rendering the territory to be operated upon aseptic except by the use of antiseptics of the highest character. We cannot extract a tooth, cleanse the canal of a pulpless tooth, excavate a cavity of decay or lance the gums ; we cannot even touch any point in the oral cavity without our instrument becoming coated with a layer of infectious material. We are therefore bound to use antiseptics, not only for the purpose of disinfecting the already infected tissues, but for sterilizing our instruments to avoid the transmission of infectious matter from one patient to another.

It is the use of antiseptics for the latter purpose which I have made the subject of a series of experiments to be described.

The necessity of absolute cleanliness on the part of the dentist, of his hands as well as of his instruments, napkins, drinking-glasses, rubber-dam, in short, of everything with which he comes in contact with the patient's mouth, is universally recognized ; at least there can be no one who has the courage to express a contrary opinion. And yet it is not at all difficult to find persons in the practice of dentistry who neglect this matter to an extent that is revolting to the taste and dangerous to the health, and it is anything but creditable to the dental profession that the proposition has been repeatedly made, to have the state of the dentist's instruments inspected from time to time by a health officer. Only a short while ago a surgeon, who fully recognizes the necessity of proper care of the teeth, made the statement that he had been obliged to allow his own to go to ruin because the uncleanliness of the dentist in the place where he resided was so great that he could not run the risk of an infection by his instruments.

That many people shun the dentist for no other reason than the above there is no doubt. It is to be hoped, however, that the number of dentists who still lay themselves open to the charge of uncleanliness is small, and that they will take care to wash this opprobrium from their hands.

I need not refer in particular to the esthetic aspect of the question, or picture the feelings which a refined, sensitive lady, or indeed any-

one of a cleanly habit, must experience on having rusty or unclean instruments and soiled fingers plunged into her mouth. This is a matter which is to a certain extent self-regulating, in that those who have an appreciation of cleanliness will very soon find their way to more congenial hands.

In regard to the possibility of transmission of disease by dental instruments, there have been so many cases reported in dental and medical journals that the matter should be familiar to every practitioner of dentistry. I may call attention, however, to the large number of cases (some forty) reported in my book ("Micro-Organisms of the Human Mouth," pages 248, 274, 338), in which infections of various nature, including septicemia, pyemia, meningitis, and syphilis, followed operations in the mouth ; also to the cases reported by Parker,* in which a whole family was infected with syphilis through the extraction of a tooth ; finally to two cases which recently occurred in Berlin, in one of which syphilis, in the other septicemia followed tooth-extraction.

Anyone who examines carefully into the question will have no great difficulty in finding scores of cases of this kind, notwithstanding the fact that the great majority of them are never published. Of course the cases where infections of a less serious nature occurred are much more numerous.

It is a very fortunate provision that the gums, in a healthy state, offer so powerful a resistance to the invasion of the germs *of most infectious diseases.* For this reason a wound in the gums may be followed by scarcely any reaction whatever, while a similar wound on the hand with the same instrument may produce most disastrous results. It has been attempted to account for this fact on the *supposition that the saliva has an antiseptic action*, in evidence of which we are often reminded that dogs lick their wounds, and that these heal rapidly. It is scarcely necessary to say, however, that reasoning of this kind, based upon a comparison of the strongly alkaline saliva of the dog with the neutral saliva of man, is inadmissible. Others attribute, with more show of reason, the comparative immunity of the lower front teeth from decay to an antiseptic action of the saliva ; but since the lower molars are decidedly more subject to decay than the upper, they are obliged to restrict the antiseptic action to the secretion of the sublingual and submaxillary glands, which they assume to bathe only the front teeth, and to come not at all, or very little, into contact with the back teeth. These assumptions, besides being rather gratuitous, lead us into a dilemma when we attempt to apply them to other

* *Western Dental Journal*, February, 1890. See also Bulkley, "On the Dangers arising from Syphilis in the Practice of Dentistry."

infectious diseases of the human mouth ; for instance, pyorrhea alveolaris, which shows a preference for the lower front teeth.

I doubt if there is anyone who would wish us to believe that the dead saliva has even the slightest antiseptic properties, in consideration of the fact that saliva, especially when it contains much organic matter, very readily putrefies. If the saliva possesses any such property, it must be sought for in its living histological elements, *i.e.*, in the living leucocytes or "phagocytes." Since these are furnished chiefly by the tonsils, it follows that they should afford their protection most of all to the lower molars, with which they first come in contact. If such were the case, we should hardly expect the lower molars to be the most liable to decay of all the teeth in the mouth. Besides, on the whole, it does not well harmonize with our views of what constitutes an antiseptic to apply this term to a liquid in which processes of fermentation are constantly going on. Finally, it is a very well-known and universally recognized fact that wherever an infection has been brought about by an unclean instrument, by a bite, etc., the most active antiseptics must be resorted to in order to check or prevent a general infection. There certainly could be no hope of accomplishing this end by application of a substance whose antiseptic action, if it has any at all, is so weak that no one has as yet been able to detect it.

I therefore attribute the fact that wounds in the mouth heal so rapidly, exclusively to the recuperative power of the parts, a view which is supported by the observation that where this power is lost, putrefactive processes may make most fearful ravages, as seen in cases of noma, stomacace, stomatitis scorbutica, stomatitis mercurialis, etc., notwithstanding the fact that these diseases are always accompanied by an increased flow of saliva.

It is consequently never safe to trust to the usually pronounced immunity of the gums toward infections, since they, under many abnormal conditions, lose their power of resistance altogether ; and more than this, the mucous membrane of the mouth appears, *under all conditions* when slightly wounded, to furnish ready entrance to the germs of syphilis, if not to those of tuberculosis, diphtheria, etc.

We can never know what virus may be clinging to our instruments, nor can we with certainty predict the result of a wound upon the gums, cheeks, or lips with an unclean instrument. The case of the Amsterdam physician, who died from an infection caused by lancing the gums, should be a warning to us.

It is therefore our duty to our patients, to ourselves, and to our profession to see to it that the possibility of conveying virus from one mouth to another during dental operations is excluded with absolute certainty. It also stands to reason that in all operations upon the

jaws and teeth we should, as far as possible, sterilize the field to be operated upon, since the danger of infecting the pulp or pericementum, or of producing a general infection through the germs in the patient's own mouth, is always present. This point, however, will be considered more fully on another occasion.

Methods of Sterilizing Instruments and Accessories.

Napkins

become sterilized by the boiling process to which they are subjected in washing.

A napkin which was badly soiled with blood and mucus from the mouth was cut into a number of small pieces and placed upon the surface of a plate of agar-agar. In no case in which the boiling was continued for ten minutes did any development of bacteria take place, and generally the pieces were found to be sterile in six minutes. We may therefore safely say that boiling for ten to fifteen minutes in soap-water furnishes a certain means of sterilizing napkins.

Coffer-dam

is a most fertile means for conveying infection from one mouth to another, and the number of germs I have found on pieces of rubber supposed to be well cleansed was surprising.

Small pieces of rubber-dam can be sterilized, as a rule, by exposing them for thirty minutes to a five per cent. solution of carbolic acid. It would not be safe, however, to count upon a perfect sterilization of large pieces such as we use in practice in less than two to three hours, and then only when the whole surface of each piece is freely exposed to the action of the antiseptic. The same object may be accomplished in about one-tenth of the time by boiling water.

Personally I never use the same piece of coffer-dam twice under any circumstances. The only excuse for doing so is the cost of the material; but by properly cutting we can get a piece large enough for the incisors and cuspids for one and one-half to two cents, for the bicuspids for two to three cents, and for the molars for three to four cents in the upper jaw; for the lower jaw add one cent to each category. The plea that the expense would be too great is therefore altogether illusory, because there is not, I venture to say, one practice in a hundred which will not remunerate the dentist a hundred-fold for this slight expenditure, since there is nothing about which patients are more skeptical that the subject of coffer-dam, and nothing which they appreciate more than a fresh piece for every operation.

Where, however, the necessity exists for repeatedly using the same piece of rubber-dam, boiling water is the proper, and, in fact, the only safe antiseptic that can be made use of.

Small pieces of rubber were, with very few exceptions, found to be completely sterile after boiling for six minutes. In practice, larger pieces should be boiled for fifteen minutes.

Drinking or rinsing glasses should be sterilized by boiling in pure water.

Instruments.

The question of the disinfection of surgical instruments is one which has given both surgeons and bacteriologists much to think and work upon, and only recently can it be said to have approached a definite solution. The method of sterilizing instruments by dry heat requires so much time that its application to dental instruments is out of the question.

The ideal antiseptic is a liquid which acts immediately upon bacteria without in any way injuring the instrument. While it might appear that quite a number of the antiseptics at our command would meet this requirement, it is in reality not the case. There is a vast difference between sterilizing liquids and sterilizing solid bodies, and an antiseptic which sterilizes a drop of water brought into it almost instantaneously may require a quarter of an hour or more to sterilize a solid body, particularly when it is coated with a layer of dried albuminous material, as our instruments are liable to be.

In order to test the efficiency of various antiseptics in sterilizing instruments, I have adopted the following

METHOD OF PROCEDURE.

Small cylindrical pieces of glass about 5 mm. in diameter and 4 to 8 mm. long were brought into a vessel containing a number of freshly-extracted teeth, and a few drops of water added. Here they were stirred about with a glass rod, so that they became coated with infectious matter. They were then dried at room temperature for twenty-four hours, or for two to three hours at blood temperature.

A number of them were then placed in a small sterilized glass vessel, covered with the liquid whose sterilizing power was to be tested, and a somewhat larger glass vessel placed over it, after the manner of a bell jar, to avoid the possibility of germs falling in from the air.

At given intervals the cover was lifted and a glass cylinder removed with sterilized pliers, washed in a small stream of sterile water, and conveyed to a tube of bouillon, which was then put into the incubator and kept at a temperature of 35° to 37°. If the bouillon remains clear for twenty-four to forty-eight hours we have evidence that the piece was sterile ; if it becomes cloudy, we know that the contrary is true. We are accordingly able in this way to determine how much time is necessary for sterilization by different antiseptic solutions.

Naturally great precautions are requisite to avoid errors of experiment. We must be absolutely sure that every thing used, particularly the pliers and the rinsing water, is free from living germs, excepting of course the infected piece to be acted upon. We must also avoid coming into contact with anything on the way while conveying the glass piece to the tube of bouillon. It is advisable to especially prepare the culture-tubes by pushing the cotton stopper into the tube about half an inch beyond the mouth, and holding the mouth in a gas flame until the cotton becomes slightly charred, then drawing the cotton out with sterilized pliers, so that it may be readily grasped with the fingers. The object of this is to sterilize the mouth of the culture-tube, so that if we come in contact with it with the glass cylinder there will be no danger of the latter becoming infected thereby.

Other precautions which will suggest themselves to the bacteriological reader need not be referred to in detail.

I have satisfied myself by a large number of control experiments that there is no danger, on the one hand, of carrying over to the culture-tube so much of the antiseptic as to prevent the growth of such living bacteria as may still be present; nor, on the other hand, of an accidental infection by air germs, provided the experiment is carried out with proper precautions.

Besides glass cylinders I have made use of leaden bullets, shot, peas, and roots of teeth after filling the canals with cement.

Furthermore, in my later experiments I have used a pure culture of one of the most resistive bacteria found in the mouth, instead of decayed teeth for coating the glass cylinders, since we thereby obtain a more uniform coating, and consequently more uniform results.*

Tests were made with the following substances:

Carbolic acid in five per cent. aqueous solution and in pure form.

Lysol in five per cent. aqueous solutions.

Trichlorphenol in five per cent. aqueous solutions.

Sublimate in five per cent. aqueous solutions, also in the strength of 1 to 1000 water.

Benzoic acid in the strength of 1 to 300 water.

Permanganate of potash in five per cent. aqueous solutions.

Resorcine in ten per cent. aqueous solutions.

Peroxide of hydrogen in ten per cent. aqueous solutions.

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* I have used glass cylinders, bullets, etc., in these experiments simply because they are much more convenient to work with than instruments.

I gave them a coating of infectious material, not because our instruments are supposed, in practice, always to be in this condition, but because they *may be*, and I am afraid sometimes are, and our methods of sterilization should be sufficient for all cases.

Saccharin in concentrated alcoholic and aqueous solutions.
β-naphthol in five per cent. alcoholic solutions.
Pyoktanin in concentrated aqueous solutions.
Absolute alcohol.
Antiseptin in five per cent. aqueous solutions.
Sulphite of zinc in concentrated aqueous solutions.
The essential oils in five per cent. emulsions and in pure form.

Results.

Some general results of interest were obtained, which may be first given :

1. The length of time necessary to sterilize a body by a chemical agent depends greatly upon the character of the body as well as upon the character of the matter with which it is coated. Porous bodies, as may be readily understood, are more difficult to sterilize than non-porous ones. Peas, for example, required more time for sterilization than the glass cylinders.

Again, small bodies are more readily rendered sterile than larger ones ; for example, shot more readily than large bullets, and, by inference, excavators probably more readily than forceps.* Also the drier and more insoluble the material with which the body is coated, and the more liable it is to form inert compounds with the antiseptic, the more difficult it will be to sterilize. It is consequently above all things desirable to employ the antiseptic in a form in which the infectious matter is soluble, and this, in the vast majority of cases, will be in an aqueous solution.

Carbolic Acid.

The two per cent. to five per cent. aqueous solutions of this antiseptic have long been the most popular means of disinfecting instruments of whatever nature, and the impression exists among a great many that it is but necessary to dip the instrument in the solution for a fraction of a minute in order to render it completely sterile. This, however, is far from being the case, as will easily be seen from the record of experiments given below :

* I do not mean to say that this principle will invariably hold good. This question would have to be settled by experiment. In the case referred to, it may be that the bullets resisted the action of the antiseptic longer than the shot because they have a larger surface of contact with the bottom of the vessel.

Body experimented upon.	Time of exposure.	Number of tests.	Sterile.	Not sterile.
Glass cylinders. ..	3 minutes.	6	0	6
" "	5 "	6	0	6
" "	7 "	2	0	2
" "	8 "	21	3	18
" "	9 "	8	3	5
" "	10 "	3	2	1
" "	12 "	7	4	3
" "	15 "	8	5	3
" "	20 "	9	7	2
Peas	10 "	6	0	6
"	14 "	4	0	4
"	18 "	3	0	3
Bullets	16 "	8	2	6
Shot	16 "	8	3	5

It will be seen from these results that even twenty minutes will not always suffice to sterilize small bodies by a five per cent. solution of carbolic acid. We cannot, even with moderate certainty, count upon a thorough sterilization in less than an hour. A large bur from the instrumentarium of a dental student, after being exposed for two hours to the action of the five per cent. solution, was found still to contain living germs.

The results obtained by Miguel* and Redard† are still more unfavorable to the carbolic acid solutions. These authors found that bodies infected with pus still carried living germs after being exposed to the action of a five per cent. solution of carbolic acid for twelve to twenty-four hours ; while Fränkel‡ kept threads carrying spores of anthrax for forty days in a five per cent. solution, and at the end of that time found that the spores still retained their power of development.

The experiments with concentrated carbolic acid gave results which are still more surprising. I have for some months been in the habit of dipping every instrument which I use in the mouth into concentrated carbolic acid immediately before using it, and labored under the impression that all micro-organisms would be devitalized instantaneously. I was consequently not a little surprised to find that of twenty-one pieces that had been exposed for varying periods of time ranging from one to twelve minutes, only two were sterilized.

This result is, however, not so very surprising when we take into consideration that the antiseptic, however powerful, cannot act upon the micro-organisms until it has dissolved or permeated the material in which they are imbedded.

* Annuaire de Mont-Souris, 1880.
† Revue de Chirurgie, 1888.
‡ Zeitschrift für Hygiene, 1889. Bd. 6.

Trichlorphenol

was also made use of in five per cent. aqueous solutions, with the results seen in the following table :

Body experimented upon.	Time of exposure.	Number of tests.	Sterile.	Not sterile.
Glass cylinders ...	7 minutes.	3	1	2
" "	8 "	19	5	14
" "	9 "	6	4	2
" " ...	12 "	6	4	2
" "	20 "	4	2	2
Peas	6 "	2	0	2
"	10 "	2	0	2
"	14 "	4	1	3
"	18 "	5	1	4
Bullets	16 "	7	1	6
Shot	16 "	7	5	2

A comparison of these two tables indicates a slight advantage in favor of trichlorphenol ; but shows, however, at the same time that the five per cent. solution is not adapted for the purpose of sterilizing dental instruments, since we cannot afford to spend an hour's time after every operation in sterilizing.

Lysol gave results nearly identical with those of trichlorphenol, and consequently need not receive especial consideration.

Bichloride of Mercury

in a five per cent. aqueous solution was found to be by far the most prompt in its action of all the substances tested, as will be seen by the accompanying table of results :

Body experimented upon.	Time of exposure.	Number of tests.	Sterile.	Not sterile.
Glass cylinders ...	5 minutes.	6	5	1
" "	8 "	17	15	2
" " ...	9 "	8	7	1
" "	12 "	4	4	0
Peas	2 "	1	0	1
"	4 "	1	1	0
"	2, 4, and 6 minutes.	3	0	3

Unless for particularly exceptional cases, an action of fifteen to twenty minutes could be relied upon to produce a thorough sterilization of instruments ; but the time required is, as seen, still so long as to render the bichloride of mercury in five per cent. aqueous solutions unsuitable for the purpose. More than this, the powerful action of bichloride upon the steel or iron very seriously interferes with its constant use for sterilizing instruments made of these materials.

It will not be at all necessary to refer to the results obtained by the various other substances tested. Suffice it to say that they all fell far short of those already mentioned. The ten per cent. solution of the *peroxide of hydrogen* came next to carbolic acid, but is considerably inferior to it. *The essential oils* in emulsions, as well as in pure form, utterly failed to produce the desired action.

Mixed Antiseptics.

The idea that by application of a mixture of two or more antiseptics a more rapid or powerful action may be obtained has found its expression in the various mixtures which have been recommended as mouth-washes. In the present case the thought occurred to me that by a combination of peroxide of hydrogen with some active antiseptic the former would tend to dissolve or break up the small particles of matter in which bacteria are usually inclosed, and thus render them more easily accessible to the other component of the mixture.

I accordingly applied tests to a five per cent. solution of trichlorphenol in peroxide of hydrogen, and invariably found that this solution acted slightly more rapidly than the simple five per cent. aqueous solution of trichlorphenol alone, or the peroxide of hydrogen alone. The improvement was, however, not so great as to encourage further experimentation in that direction.

Boiling Water.

After I had satisfied myself by about a thousand tests that none of the chemical antiseptics at present at our disposal meet the requirements of a rapid, convenient, and absolutely sure mode of sterilization for dental instruments, I turned my attention to boiling water, and very soon became convinced that this is so far superior to all other means for sterilizing, so easy of application, and so rapid in its action, that it must recommend itself to every practicing dentist and physician at once.

I have found boiling water to accomplish in two minutes as much as the chemical agents ordinarily used in half an hour, as will be seen by the following table of results :

Body experimented upon.	Time of exposure.	Number of tests.	Sterile.	Not sterile.
Glass cylinders....	½ minute.	5	4	1
" "	1 "	10	9	1
" "	1½ minutes.	4	4	0
" "	2 to 3 "	15	14	1
" "	5 "	5	5	0

Experiments on other objects (peas, bullets, shot, etc.) gave corresponding results, so that I regard an exposure of three minutes to boiling water sufficient for sterilizing smaller dental instruments, *i.e.*, excavators, etc., unless they are particularly dirty ; whereas for forceps it would be better to continue the action for five minutes.

Boiling Antiseptic Solutions,

such as five per cent. carbolic acid solution, act still more rapidly than simple boiling water. The disadvantages of such solutions will, however, be found to more than overbalance their greater rapidity of action.

Boiling Solution of Carbonate of Sodium.

I have found, in agreement with the results obtained by Schimmelbusch* and Behring,† that a one to two per cent. boiling solution of soda has a slightly stronger action than water alone. Its chief advantage, as pointed out by the first-named author, lies in the fact that the rusting which is liable to occur when the instruments are boiled in water is avoided by the addition of soda.

An exposure of three to five minutes to a boiling one to two per cent. solution of soda is consequently the means I wish to recommend for sterilizing dental as well as surgical instruments. It is to be emphasized that the solution must not be simply hot, but boiling, since the motion of the boiling water materially assists in rapidly raising the temperature of the instrument to 100° C., and at the same time loosens up any matter that may be clinging to the instrument.

To many the results of my experiments may appear incredible. To those, however, who have had access to the literature of the subject, and in particular have followed the more recent communications, they will cause no surprise.

The view to which we are forced by the results obtained by nearly all who have worked at this subject is well summed up by Schimmelbusch,‡ who says, "Anyone who is obliged to perform a number of operations in succession upon aseptic and infected objects with an instrumentarium kept in carbolic acid will soon become convinced, by failure in respect to the healing of the wounds, of the inadequate disinfecting power of carbolic acid. Its disinfecting value in such cases may be placed at about zero."

In the foregoing communication no reference has been made to the mechanical means of cleansing instruments. Naturally a thorough brushing of the instrument and rinsing in pure water goes a great

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* Arbeiten aus der chirurgischen Klinik V. Berlin, 1890.

† "Desinfection, Desinfectionsmittel and Desinfectionsmethoden." *Zeitschrift für Hygiene*, 1890. Bd. 9.

‡ *Loc. cit.*

way toward freeing it from germs, but it can never completely disinfect it; and whatever method of disinfecting we may use, the instruments should be first cleansed mechanically, though where boiling water is used for disinfecting, the mechanical cleansing beforehand may be virtually dispensed with. Furthermore, I wish to testify to the fact that although weak solutions of carbolic acid are very often illusory in their action, they are still better than nothing, and undoubtedly much good has resulted from their use; but we have no right to subject our patients to even a slight risk of infection by a partially disinfected instrument, when a complete disinfection may be accomplished so readily.

The dentist or surgeon who communicates a disease, perchance syphilis, to his patient by the use of an impure instrument, has a burden of sin upon him greater than which there are but few. Besides, exquisite cleanliness and absolute freedom from germs constitute half the battle in many operations in dentistry as well as in surgery.

Sterilization of Teeth for Transplantation and Implantation.

The possibility of transmitting infectious diseases by the operation of transplanting or implanting teeth renders it imperatively necessary that the teeth used for such purposes be absolutely free from living germs. It is generally accepted that the operator takes every possible precaution when he allows the tooth to lie for one-half to one hour in a one per cent. solution of carbolic acid, or in a 1 to 1000 solution of bichloride of mercury. The following experiment will, I think, convince every one that this treatment cannot be relied upon to bring about the desired result:

Two roots whose canals were thoroughly cleansed and filled with cement were placed for a short time in a culture of a pathogenic mouth-bacterium to be described in a later article. They were then dried and subjected, the one to the action of one per cent. carbolic acid, the other to a one-tenth per cent. solution of bichloride of mercury, sixty and sixty-five minutes respectively. Thereupon they were rinsed in sterilized water and placed in tubes containing bouillon. Not only was the bouillon in both tubes densely clouded in twenty-four hours, but a drop of it injected into the skin of a mouse sufficed to kill it in fifteen hours.

Particularly in order to reach such bacteria as may have penetrated into the lacunæ or chance vascular canals, a much longer action of the antiseptic is necessary, and to be perfectly certain that we have accomplished our object, we should have recourse to boiling water.