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Randomized clinical trial on effectiveness of silver diamine fluoride and glass ionomer in arresting dentine caries in preschool children☆

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ABSTRACT

Objective: To compare the effectiveness of annual topical application of silver diamine fluoride (SDF) solution, semi-annual topical application of SDF solution, and annual application of a flowable high fluoride-releasing glass ionomer in arresting active dentine caries in primary teeth.

Methods: A total of 212 children, aged 3–4 years, were randomly allocated to one of three groups for treatment of carious dentine cavities in their primary teeth: Gp1-annual application of SDF, Gp2-semi-annual application of SDF, and Gp3-annual application of glass ionomer. Follow-up examinations were carried out every six months to assess whether the treated caries lesions had become arrested.

Results: After 24 months, 181 (85%) children remained in the study. The caries arrest rates were 79%, 91% and 82% for Gp1, Gp2 and Gp3, respectively ($p = 0.007$). In the logistic regression model using GEE to adjust for clustering effect, higher caries arrest rates were found in lesions treated in Gp2 (OR = 2.98, $p = 0.007$), those in anterior teeth (OR = 5.55, $p < 0.001$), and those in buccal/lingual smooth surfaces (OR = 15.6, $p = 0.004$).

Conclusion: Annual application of either SDF solution or high fluoride-releasing glass ionomer can arrest active dentine caries. Increasing the frequency of application to every 6 months can increase the caries arrest rate of SDF application.

Clinical significance: Arrest of active dentine caries in primary teeth by topical application of SDF solution can be enhanced by increasing the frequency of application from annually to every 6 months, whereas annual paint-on of a flowable glass ionomer can also arrest active dentine caries and may provide a more aesthetic outcome.

1. Introduction

Similar to many developing countries, in China, due to the under-developed oral health care system, most of the decayed teeth in children remain untreated, especially among those living in rural areas where the situation is more serious.[1,2] Untreated dental caries in children can lead to problems with food intake, sleep, daily activities, and self-esteem.[3] Thus, simple clinical methods that are effective in treating decayed

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teeth under field condition are needed for the mass child population.

Traditionally, dental caries is treated by a surgical restorative approach. This requires sophisticated dental equipment and well-trained operators, and is relatively expensive. In recent years, remineralization of caries lesions has gained acceptance in the practice of minimally invasive dentistry and caries arrest treatment is being promoted as part of the basic package of oral care.[4,5] Among the available methods, topical application of silver diamine fluoride (SDF) solution has been shown to be effective in arresting active caries in primary teeth.[6–8] In a clinical trial among Chinese preschool children, a 38% SDF solution was applied once a year onto the caries lesions in primary anterior teeth.[6] The success rate of SDF in arresting caries after 30 months was around 70%. In a clinical trial in Cuba, SDF solution was applied onto primary canines and molars, and first permanent molars of school children every 6 months for 36 months.[7] Most (77%) of the treated caries lesions that were active at baseline became arrested. Another clinical trial in Nepal found that approximately 35% of the active carious cavities in primary teeth became arrested at the 24-month follow-up after a single application of 38% SDF solution.[8] Whether a higher caries arrest rate can be achieved through more frequent applications is unknown. One of the outcomes of SDF applications is that the arrested caries lesion will turn black in colour which may not be pleasing. There is a need to look for another effective treatment that can produce a better aesthetic.

Glass ionomer has been used as a material for placement of dental restorations and is known to release fluoride which can help to remineralize carious lesion.[9] Recently, a flowable high fluoride-releasing glass ionomer material is introduced. A laboratory study found that it could release 213 $\mu g/mm^2$ of fluoride in the first day after setting which was double the amount released by a resin-modified glass ionomer.[10] The high concentration of fluoride ion released may help to arrest active caries and to prevent new dental caries development. Furthermore, its white colour makes it a good choice for use in anterior teeth. However, clinical evidence on its effectiveness in arresting dental caries is lacking.

The objective of this clinical trial was to compare the effectiveness of annual topical application of silver diamine fluoride (SDF) solution, semi-annual topical application of SDF solution, and annual application of a flowable high fluoride-releasing glass ionomer in arresting active dentine caries in primary teeth. The null hypothesis to be tested in this clinical trial was that there was no difference in the effectiveness of the three treatments in arresting active caries.

2. Materials and methods

The study site was conducted in 2007–2009 in a suburb of Guangzhou, Guangdong Province in southern China. Approval from the Independent Review Board of the University of Hong Kong (HK Clinical Trial Register UW07-083) was obtained. The study sample was recruited from the generally healthy children attending six kindergartens. Baseline examinations were conducted by two calibrated examiners in the kindergartens using an intra-oral LED light and disposable mouth-mirrors. After the examination, children who had teeth with active dentine caries not involving the pulp were invited to participate in the trial. Only children with written consent from their parents were accepted. Children who refused dental treatment and teeth that were grossly broken down, more than one third of the crown missing, or pulpally involved were excluded. Tooth with pulp exposure, presence of an abscess or a sinus, obvious discoloration, and premature hypermobility were regarded as pulpally involved tooth.

Status of the dentine caries lesions was assessed by visual inspection and aided by tactile detection using a sharp probe. Cavities with yellowish/brown rough wall/floor which could be easily penetrated by the probe using a light force were diagnosed as active. Those with smooth hard surfaces which could not be penetrated were classified as arrested. Great care was exercised not to damage the teeth when probing was used. Five surfaces in each posterior tooth (occlusal, buccal, lingual, mesial and distal) and four surfaces in each anterior tooth were assessed.

After the examination, children fulfilling the inclusion criteria were allocated individually to one of three treatment groups based on computer-generated random numbers by an assistant. To avoid over clustering, up to 3 decayed teeth in one child, selected using computer-generated random numbers, were included in this study. The parents were advised to bring their children to a dentist for treatment of decayed teeth not included in this study.

When providing treatment, the superficial soft decayed tissues of the selected decayed primary tooth were removed by hand instruments. Then, depending on the child's group allocation, either a 38% SDF solution (Saforide, Seiyaku Kasei Co. Ltd., Osaka, Japan) or a low viscosity, high fluoride-releasing glass ionomer material (Fuji VII, GC Corporation, Tokyo, Japan) was painted onto the cavity with a small disposable brush. Before application of glass ionomer, the cavity surfaces were conditioned with the conditioner supplied by the manufacturer, washed with a wet cotton pellet, and dried. Children in Group 1 received SDF solution application every 12 months; children in Group 2 received SDF solution application every 6 months; and children in Group 3 received glass ionomer application every 12 months. The children were instructed not to eat or drink for at least 30 min after the application.

Follow-up examinations at 6-month intervals were carried out by a single examiner who was not involved in the provision of treatments and did not know the children's group assignment. The treated caries lesions were classified as either active or arrested according to the diagnostic criteria used at baseline. Lesions in Group 3 that were totally covered by the glass ionomer material were classified as arrested. A random 10% sample of the children was re-examined during each examination to monitor intra-examiner reproducibility.

Questionnaires were completed by the parents at baseline and after 24 months to collect information on the child's tooth brushing behaviour, use of fluoride toothpaste, frequency of candy or sweet snack intake between meals, and parent's satisfaction with the child's dental appearance.

In the calculation of sample size required, the anticipated 24-month caries arrest rate of annual application of SDF solution was 70%.[6] An absolute difference of 12% in rates

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between groups was regarded as clinically significant. Based on a 5% statistical significance level and an 80% power, 200 lesions in each group would be required. Assuming, on average, each child had 4 caries lesions, 50 children were needed in each group. Anticipating a 20% drop-out rate, 200 children for the three study groups were recruited.

Collected data were entered into computer and analyzed using the software SPSS 16.0 for Windows (SPSS Inc., Chicago, USA) and SAS 9.2 (SAS Institute Inc., Cary, USA). Chi-square test and ANOVA were used, when appropriate, to assess the differences between the three groups of children regarding their demographic background, baseline toothbrushing habit and dmft score, and caries arrest rates at the 24-month evaluation. Since more than one caries lesion were chosen from one child, GEE (Generalized Estimating Equation) approach was used to adjust for the clustering effect and a multi-level non-linear logistic regression model was built.[11] The dependent variable was whether the lesion was arrested or not at the 24-month examination, and the independent variables included the child's group assignment, gender, toothbrushing frequency, use of fluoride toothpaste, snacking habit, baseline dmft score, tooth type and tooth surface involved. Statistical significance level was set at 0.05 for all tests.

3. Results

At baseline, 481 children were screened and 212 children (114 boys, 98 girls) with a total of 719 active dentine caries lesions meeting the criteria were included and randomly allocated into three treatment groups (Fig. 1). There were 71, 69, and 72 children in Groups 1–3, respectively.

The mean age of the children was 3.8 ± 0.6 years. Most of them did not brush their teeth daily and around two-thirds of them used fluoridated toothpaste (Table 1). The mean dmft score of the children at baseline was 5.1 ± 4.0. Around half of the included teeth were upper anterior teeth, and the most commonly involved surfaces were mesial, occlusal and distal surfaces. No statistically significant differences were found among the three groups of children in any of the above parameters.

After 24 months, 181 (85%) children remained in the study, 60, 59 and 62 children in Groups 1–3, respectively. The drop-out rates among the three groups were similar (χ^2 test, $p > 0.05$). There were no statistically significant differences in the baseline toothbrushing habit and mean dmft scores between the children who remained and those who were lost to follow-up (5.0 vs. 5.3; $p > 0.05$).

Intra-examiner reproducibility was good, with Cohen's Kappa statistic values greater than 0.9 in the baseline and follow-up examinations. As shown in Table 2, the caries arrest rates of the treatments found at the 24-month examination were 79%, 91% and 82% for Group 1 (SDF 12-month), Group 2 (SDF 6-month), and Group 3 (GI 12-month), respectively (χ^2 test, $p = 0.007$). Presence of glass ionomer material was found in only 3.5% (8 out of 229) of the treated lesions in Group 3. Most of the successful cases (172 out of 180) in Group 3 were arrested lesions. No adverse side effects on the treated teeth and soft tissues were found.

Three variables remained in the final multi-level logistic regression model, namely group assignment, tooth type, and tooth surfaces (Table 3). The variables that were not statistically significant were gender (boy vs. girl), toothbrushing frequency (twice daily vs. once daily or less often), frequency of sweet snack intake (twice or more daily vs. once daily or less often), and baseline dmft score. Lesions treated by semi-annual topical application of SDF (Group 2), those in anterior teeth, and those in the buccal or lingual tooth surfaces had a higher chance to become arrested. Compared to those in Group 1, caries lesions in Group 2 had 2.98 times chance to become arrested ($p = 0.007$) while lesions in Group 3 had a similar chance ($p > 0.05$). Treatments for caries lesions in anterior teeth had 5.55 times chance compared to posterior teeth to arrest the caries ($p < 0.001$). Caries lesions in buccal or lingual tooth surfaces had 15.6 times chance compared to those on occlusal or approximal surfaces to become arrested ($p = 0.004$).

Regarding the colour of the arrested caries lesions at the 24-month examination, all except one lesion treated with SDF were black while 82% of those treated by glass ionomer were yellow/brown (χ^2 test, $p < 0.001$). Despite this, around 45% of the parents were satisfied with the appearance of their child's teeth at the 24-month evaluation, and the differences between the three groups were not statistically significant (χ^2 test, $p > 0.05$).

4. Discussion

This study was a randomized clinical trial using a parallel group design. For ethical reasons, all children in this study received treatment for their decayed teeth. It has been reported that annual application of SDF is an effective treatment to arrest active dentine caries but blackening of the lesions may not be pleasing.[12,13] The caries arrest rate of annual application of SDF after 24 months in this study is similar to that found in an earlier study on Chinese preschool children.[6] In this study, when the frequency of SDF application was increased to every 6 months, the proportion of active dentine that had became arrested increased. This is in line with the general recommendation that high risk children should receive more frequent topical fluoride applications.[14,15] Application of SDF solution every 6 months coincides with the commonly recommended frequency of recall visits for high risk patients.[16,17] Better results in managing dental caries in young children can be expected if SDF solution is applied onto the carious lesions every time a child visits a dentist at this recall frequency. This would be an appropriate alternative treatment to the conventional restorative approach in young children who are uncooperative and in places where the supply of dentist is scarce.

This study is probably the first one to investigate the effectiveness of annual paint-on of a flowable glass ionomer to arrest active dentine caries in primary teeth and found that it could be as effective as annual application of SDF solution. Although more time and manipulation in the process of application is needed, application of a flowable glass ionomer provides an alternative treatment when application of SDF solution is not accepted due to its taste or blackening of the

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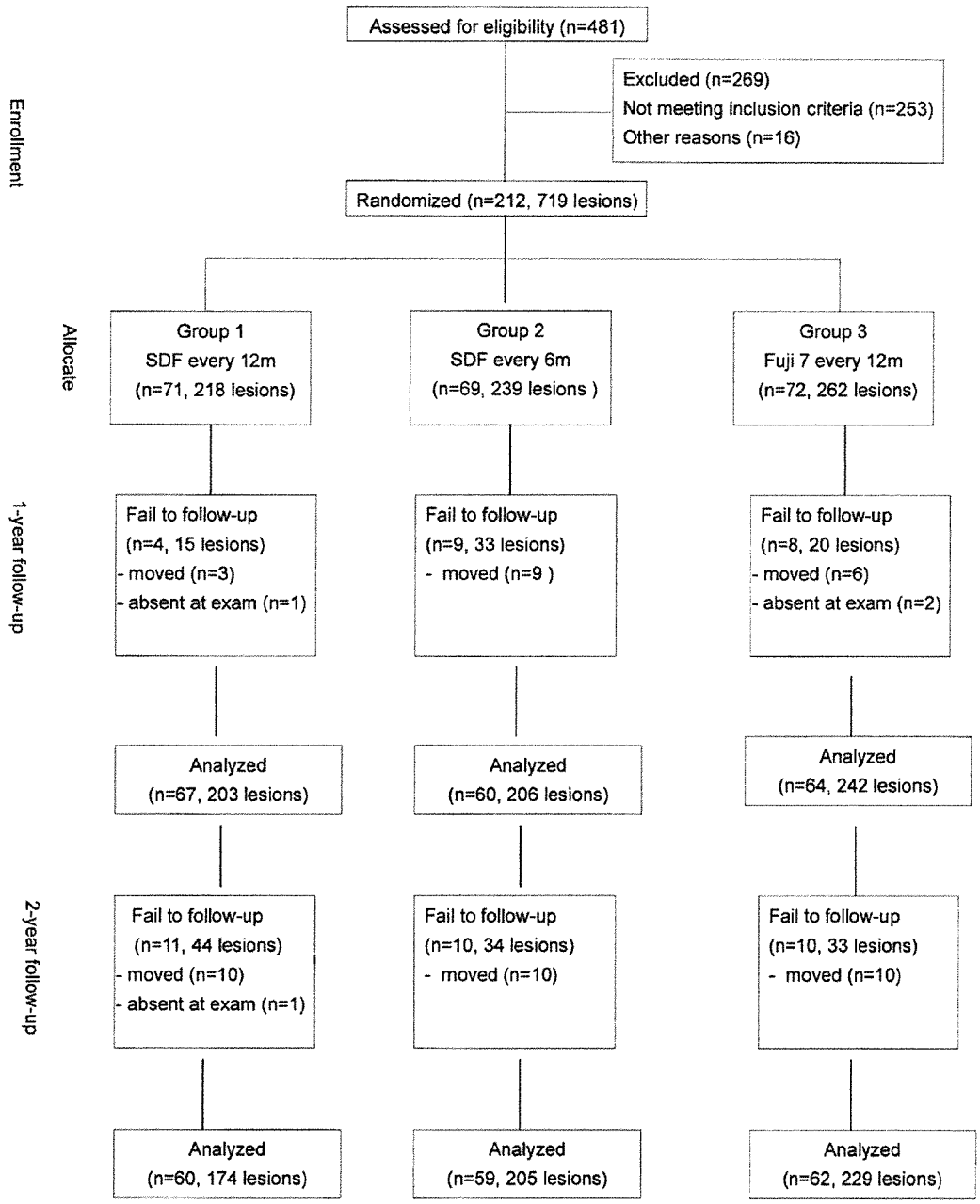

Fig. 1 – Flow of subjects over the 24-month study period.

arrested lesion. Lighter colour of the arrested caries lesion makes application of glass ionomer instead of SDF solution an intriguing method, especially for anterior teeth. Despite this, in this study parental satisfaction with their child's dental appearance was similar among the three treatment groups. This may be because the parents were not too concerned about the colour of the arrested lesions or that presence of decayed teeth was a greater problem. Since higher cost, more skilful operator and longer treatment time are needed for application of flowable glass ionomer compared to SDF solution, it is more practical to apply glass ionomer in dental clinics or where appearance is of great concern.

Safety of using silver fluoride solution in preschool children had once been doubted and the high fluoride concentration was the main concern.[18] So far, no severe side effect has been reported.[12] It has been estimated that each application of 38% SDF solution only contains 0.2 mg fluoride,[19] which is far below the probably toxic dosage of 5 mg/kg.[20] The amount of fluoride released from the glass ionomer material used in this study is around 0.2 mg/mm^2 in one day after initial setting.[10] These low dosages of fluoride are unlikely to have any systemic health effects and the study treatment methods should be very safe for use in preschool children.

Glass ionomer at a high viscosity has been used for placement of restorations in carious cavities in primary teeth in field setting, especially in the atraumatic restorative treatment (ART) approach.[21] However, the relatively low retention rate of these ART restorations is a problem.[22,23]

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Table 1 – Background information of the 212 children in the three study groups at baseline.

	Group			
	(1) SDF-12m ($n = 71$)	(2) SDF-6m ($n = 69$)	(3) GI-12m ($n = 72$)	p-Value
Age (years)	3.8 ± 0.6	3.8 ± 0.6	3.8 ± 0.6	0.669
Mean dmft score	4.8 ± 4.0	4.9 ± 3.8	5.5 ± 4.1	0.475
Gender				
Male	51%	63%	54%	
Female	49%	38%	46%	0.366
Toothbrushing				
Once a day	26%	30%	31%	
Twice or more	16%	15%	13%	
Occasionally	49%	49%	44%	
Never	10%	6%	13%	0.848
Fluoride toothpaste				
Yes	74%	65%	66%	
No	26%	35%	34%	0.842
Tooth included ($n = 599$)				
Upper anterior	51%	54%	56%	
Lower anterior	10%	12%	10%	
Upper posterior	7%	8%	13%	
Lower posterior	32%	26%	20%	0.076
Tooth surface included ($n = 719$)				
Occlusal	19%	24%	30%	
Occlusal	49%	44%	42%	
Distal	16%	21%	14%	
Buccal	12%	9%	11%	
Lingual	5%	3%	3%	0.080

Painting on a layer of flowable glass ionomer to cover the carious cavity and allowing the high release of fluoride to arrest the lesion may be a more practical treatment when full restoration of original tooth morphology is not needed. In this study, full retention of the applied glass ionomer material was found in only 3.5% of the treated lesions after 24 months. Many factors can contribute to this low retention rate, such as the low strength of the flowable glass ionomer which was produced primarily for use as a fissure sealant rather than as a restorative material, the lack of retentive cavity form in the carious cavities in primary teeth, and that only the superficial soft carious dental tissues were removed before application of the glass ionomer.

Table 2 – Caries arrest rates at the follow-up examinations in the three study groups.

Group	Caries arrest rate (%)			
	6m	12m	18m	24m
(1) SDF-12m	31.5	37.0	77.2	79.2
(2) SDF-6m	43.3	53.0	82.9	90.7
(3) GI-12m	31.3	28.6	73.1	81.8
	$p = 0.012$	$p < 0.001$	$p > 0.05$	$p = 0.007$

Table 3 – Logistic regression model of the caries arrest rate at 24-month examination with clustering effect adjustment by GEE.

Explanatory variables	Odds ratio	95%CI	p-Value
Group			
(1) SDF-12m[a]			
(2) SDF-6m	2.98	1.35–6.69	0.007
(3) GI-12m	1.13	0.52–2.45	>0.05
Tooth type			
Posterior[a]			
Anterior	5.55	3.09–9.98	<0.001
Surface			
Occlusal or approximal[a]			
Buccal or lingual	15.6	2.35–103.0	0.004

[a] Reference category.

In this study, information on selected possible confounding factors was collected. Clustering effect of having more than one lesion in a child was adjusted.[24] In the final multi-level logistic regression model, it was found that the child's demographic background, oral health habits, and baseline caries experience did not significantly influence the outcome, i.e. caries arrest. The effect of having more frequent application of SDF was confirmed. It was also found that lesions in the anterior teeth and buccal/lingual surfaces had a higher chance to become arrested. This is probably because these teeth and surfaces are easier to be cleaned by young children. It is also important to find that upper anterior teeth, being commonly involved in early childhood caries, respond well to caries arrest treatment.

This study shows that regular applications of topical fluoride agents can stop the dental caries process even when the lesion has progressed into dentine. Use of simple caries arrest treatment in outreach community health services will be of great significance in the control of the prevalent dental caries problem in many child populations.[25] This is especially so in places where accessibility to proper dental care is limited.

5. Conclusions

Based on the results of this study, the null hypothesis is rejected. It is concluded that while the effectiveness of annual

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application of SDF solution and that of annual application of a flowable high fluoride-releasing glass ionomer in arresting active dentine caries in primary teeth does not differ significantly, increasing the frequency of application of SDF solution to every 6 months can increase the caries arrest rate.

Conflict of interest statement

The authors had no conflict of interests.

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REFERENCES

1. Qi XQ. Report of the third national oral health survey in China. Beijing: Publishing House of People's Health; 2008.
2. Wong MC, Lo ECM, Schwarz E, Zhang HG. Oral health status and oral health behaviors in Chinese children. *Journal of Dental Research* 2001;**80**:1459–65.
3. Kagihara LE, Niederhauser VP, Stark M. Assessment, management, and prevention of early childhood caries. *Journal of the American Academy of Nurse Practitioners* 2009;**21**:1–10.
4. Murdoch-Kinch CA, McLean ME. Minimally invasive dentistry. *Journal of the American Dental Association* 2003;**134**:87–95.
5. Frencken JE, Holmgren CJ, van Palenstein Helderman WH. Basic package of oral care. Nijmegen: College of Dental Sciences, University of Nijmegen; 2008.
6. Chu CH, Lo ECM, Lin HC. Effectiveness of silver diamine fluoride and sodium fluoride varnish in arresting dentin caries in Chinese pre-school children. *Journal of Dental Research* 2002;**81**:767–70.
7. Llodra JC, Rodriguez A, Ferrer B, Menardia V, Ramos T, Morato M. Efficacy of silver diamine fluoride for caries reduction in primary teeth and first permanent molars of schoolchildren: 36-month clinical trial. *Journal of Dental Research* 2005;**84**:721–4.
8. Yee R, Holmgren C, Mulder J, Lama D, Walker D, van Palenstein Helderman W. Efficacy of silver diamine fluoride for arresting caries treatment. *Journal of Dental Research* 2009;**88**:644–7.
9. Hatibovic-Kofman S, Suljak JP, Koch G. Remineralization of natural carious lesions with a glass ionomer cement. *Swedish Dental Journal* 1997;**21**:11–7.
10. Bayrak S, Tunc ES, Aksoy A, Ertas E, Guvenc D, Ozer S. Fluoride release and recharge from different materials used as fissure sealants. *European Journal of Dentistry* 2010;**4**:245–50.
11. Hardin WJ, Hilbe MJ. Generalized estimating equations. London: Chapman & Hall; 2003.
12. Chu CH, Lo EC. Promoting caries arrest in children with silver diamine fluoride: a review. *Oral Health Preventive Dentistry* 2008;**6**:315–21.
13. Rosenblatt A, Stamford TC, Niederman R. Silver diamine fluoride: a caries "silver-fluoride bullet". *Journal of Dental Research* 2009;**88**:116–25.
14. Azarpazhooh A, Main PA. Fluoride varnish in the prevention of dental caries in children and adolescents: a systematic review. *Canadian Dental Association Journal* 2008;**74**:73–9.
15. Professionally applied topical fluoride: evidence-based clinical recommendations. *Journal of the American Dental Association* 2006;**137**:1151–9.
16. Evans RW, Pakdaman A, Dennison PJ, Howe EL. The Caries Management System: an evidence-based preventive strategy for dental practitioners. *Application for adults Australia Dental Journal* 2008;**53**:83–92.
17. Beirne P, Clarkson JE, Worthington HV. Recall intervals for oral health in primary care patients. *Cochrane Database Systematic Review* 2007:CD004346.
18. Gotjamanos T. Safety issues related to the use of silver fluoride in paediatric dentistry. *Australia Dental Journal* 1997;**42**:166–8.
19. Chu CH. Effectiveness of silver diamine fluoride and sodium fluoride varnish in arresting dentine caries. PhD thesis. University of Hong Kong, Hong Kong; 2004.
20. Whitford GM. Fluoride in dental products: safety considerations. *Journal of Dental Research* 1987;**66**:1056–60.
21. van't Hof MA, Frencken JE, van Palenstein Helderman WH, Holmgren CJ. The atraumatic restorative treatment (ART) approach for managing dental caries: a meta-analysis. *International Dental Journal* 2006;**56**:345–51.
22. Yu C, Gao XJ, Deng DM, Yip HK, Smales RJ. Survival of glass ionomer restorations placed in primary molars using atraumatic restorative treatment (ART) and conventional cavity preparations: 2-year results. *International Dental Journal* 2004;**54**:42–6.
23. Lo ECM, Luo Y, Fan MW, Wei SH. Clinical investigation of two glass-ionomer restoratives used with the atraumatic restorative treatment approach in China: two-years results. *Caries Research* 2001;**35**:458–63.
24. Wong MC, Lam KF, Lo ECM. Bayesian analysis of clustered interval-censored data. *Journal of Dental Research* 2005;**84**:817–21.
25. Petersen PE. The World Oral Health Report 2003: continuous improvement of oral health in the 21st century – the approach of the WHO Global Oral Health Programme. *Community Dentistry and Oral Epidemiology* 2003;**31** (Suppl. 1):3–23.

A Method of Sterilizing, and at the Same Time Impregnating with a Metal, Affected Dentinal Tissue.*

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(Research Laboratory of the Forsyth Dental Infirmary for Children.)

WE have found the treatment about to be described effective and of broad application, as follows:

I. It is effective in the sterilization of the disintegrated dentin overlying pulps, as in the large cavities of carious first molars.

II. By this method it is possible to completely sterilize not only a putrescent pulp without removing it, but also the dentinal structure of the root as well.

III. In acute pericementitis following the death of the pulp it is only necessary to pump this material into the pulp chamber and into the canals as well as possible and close the tooth. The pericementitis in such cases as we have treated has been quickly allayed, and a subsequent and more thorough application has apparently ended the trouble.

IV. We have found it effective in the treatment of chronic abscesses; indeed this treatment was developed largely for these special cases. The loss of the first or second molar means so much to a child that we attempted to find a simple, rapid, and effective method of treating these teeth in a large clinic.

V. We believe this to be a most admirable means of taking care of apical foramina in all cases if properly used. It is also applicable in cases where a slight apical sensitiveness exists, due to a small piece of pulp tissue left after removal of that organ during infiltrative or conductive anesthesia.

VI. It is an excellent means for almost painlessly disposing of the remaining part of a pulp after the death or removal of a portion of it. For example, it frequently happens that one root in a molar retains some degree of vitality, while the rest of the pulp is dead. This method effectually disposes of the remaining nerve shred.

VII. Applied to the root-end after apicoectomy it lessens the probability of subsequent trouble.

In all these cases this method does more than sterilize the tissue. It fills it at the same time. It permeates any affected dentin, and fills it with metallic silver in a wonderfully perfect manner.

PREPARATION OF THE MATERIAL AND METHOD OF USING IT.

Two solutions are required:

Solution 1. This consists of a saturated solution of silver nitrate in water to which is added little by little strong ammonia. As the ammonia is added a dark precipitate of silver oxid is thrown down. This is soluble in excess of ammonia, therefore continue adding the ammonia until the solution becomes clear.

Solution 2. This consists of a twenty-five per cent. solution of formalin in water.

These two solutions must be kept in separate dark-colored glass bottles, with glass stoppers, and should be away from

* The substance of this paper was presented in the form of a lecture before the Pennsylvania State Dental Society, Philadelphia, June 26, 1917.

the light as much as possible. They work better if they are freshly prepared, but are still good after a considerable time if kept as recommended.

The principle is that of silver reduction. Metallic silver is thrown down in a very finely divided state. It is deposited upon the sides of a clean test tube as a mirror. The principle is used in photography and in staining methods in histology. The action in the tooth is the same. A finely divided deposit of silver in its metallic form occurs wherever the liquid penetrates. By successive applications a very appreciable thickness of deposit occurs. This may be burnished and made to take on the luster of the metal.

The reaction in this method is as follows:

$$2AgNO_3 + 2NH_4OH = Ag_2O + 2NH_4NO_3 + H_2O$$
$$Ag_2O + CH_2O = 2Ag + HCOOH$$

Formic acid acts readily as a reducing agent, taking away O, and forming carbonic acid H_2CO_3, which decomposes easily into CO_2 and H_2O. We have then practically metallic silver and nothing else. The reaction sterilizes, as we have ascertained by repeated examinations, and at the same time leaves this heavy deposit of metallic silver in a fine state of subdivision, which penetrates all affected dentin but does not penetrate the sound tissue of the teeth.

The method of procedure is very simple. Such slight changes as are needed to make it adaptable to different localities in the mouth can readily be solved by the ingenuity of the operator. We shall describe some of these in our discussion of specific cases.

It is better to apply the rubber dam or to protect the tissues in some way. Any applicator will answer the purpose for conveying the liquids to the cavity. Broaches wrapped with cotton will serve the purpose. In the clinic here we use two pieces of glass tubing; these we prepare by heating a piece of small-bore glass tubing in the middle, and by drawing it out to a capillary. With a file this is then broken in the center. One tube we keep for the ammoniacal silver solution and the other for the formalin. If the solutions are of sufficient depth in the stock bottles, the liquid will collect in the capillary end of the tubes, or it can be drawn up into the tubes by suction. The fluid can be retained and controlled by placing the finger over the large end of the tube. Tubes with curved ends are used for the upper teeth.

A tube of solution 1 is taken, the capillary portion filled, the finger placed over the end, and this is conveyed to the cavity. By momentarily raising the finger a small drop of the silver solution is allowed to flow into the tooth. A small drop of solution 2 is now flowed in, the solution darkens, silver is reduced and is deposited upon the surface. After a few moments absorb this solution and repeat the process, in order that more silver may be reduced and deposited.

It is well to protect the hands with rubber gloves or to wear finger-cots. Throughout the treatment the silver that is deposited in the dentin is black. It is no longer silver nitrate; it is no longer formaldehyd; it is simply metallic silver that is deposited, with the formation of weak formic acid, which latter is readily converted into CO_2 and water. Sound dentinal tissue does not discolor, but any defective tissue appears jet black. Any tooth, even an anterior one, can be protected from the discoloring effects of these solutions by a coating of adhesive wax. By neatly cutting away the wax the treatment can then be applied at the point where it is indicated.

So much for general rules in the use of this treatment. More specific details will be given in the discussion of the various headings that I have given.

METHOD OF CONDUCTING BACTERIAL EXAMINATIONS.

In all cases we use the following media: Agar, glucose-agar, blood serum,

and bouillon; the cultures are made aerobically and anaerobically.

In the case of dentin small bits are smeared over the solid media, and dropped into the liquid media.

In root-canals the dentinal structure is removed by a sterile bur, and the shavings dropped upon or into the media. We begin with a No. 3 bur, then use a No. 4, and so on up to No. 6. After we use a No. 6 bur the sides of the canals are lightly burred with a lower number, as No. 1. Of course in some cases the use of so large a bur as No. 6 is precluded, but the same principle is observed.

The bacterial examination of root-canal contents is made by scraping out the material with a sterile broach, excising the broach with sterile cutting-pliers, and dropping it upon the media. Sterile cotton points are introduced into the canals and then cultured.

STERILIZING DISINTEGRATED DENTIN.

(I) *It is effective in sterilizing disintegrated dentin overlying pulps.* In the course of our studies upon the bacteriology of dental caries at this institution we have found that cavities as they are ordinarily prepared for filling are not sterile. If cuts are made into the deep dentinal structure, and the material cultured, a good growth of the Moro-Tissier micro-organisms, which we have elsewhere shown to be the constant flora of caries,* is obtained. In the account of our work we have shown that this type of bacteria, and this alone, remains alive under fillings for at least six months. They are not only alive, but grow vigorously when cultivated upon laboratory media. With the dentinal tissue, then, containing bacteria, and with the bacteria capable of living under fillings, according to modern surgical principles this tissue should be sterilized even in simple cavities, while in deep cavities it is more imperative.

The study of carious tooth sections shows that the carious process penetrates much deeper than is ordinarily supposed. Particularly is this so in the molars of children. It is not practical to sterilize by means of the bur cavities that approach closely to the pulp. Is it not infinitely better not to disturb decalcified dentin, with its perfect and individual adaptation to the pulp, than it is to remove it and to attempt its substitution by a foreign material? Such a substitution can at best be only a crude and rough affair. Is not the sterilization of this tissue and its simultaneous impregnation with a metal an infinitely more therapeutic measure?

DESIRABILITY OF SAVING THE PULP WHERE POSSIBLE.

One cannot examine carious tooth sections for long without being convinced that the pulp comes early into contact with the bacteria of caries. Cavities in the molars particularly penetrate quickly to the pulp; *to* but not *into* it. The pulp has the ability to protect itself against bacteria as does other tissue, but the pulp has the further ability of recalcifying dentinal tissue. This has been practically shown, but is not yet fully understood, so that unless bacterial contact becomes an invasion, or the vitality of the pulp has become impaired, it seems reasonable to believe that the treatment we are presenting for your trial and study can act only beneficially.

Is it not better in the most extensive decay of molars to apply this treatment and to give the pulp a restorative chance than it is to immediately destroy it? I shall show farther on that the pulp is an important organ until late in life, and every effort should be made to preserve it. This is particularly so in the case of the growing child.

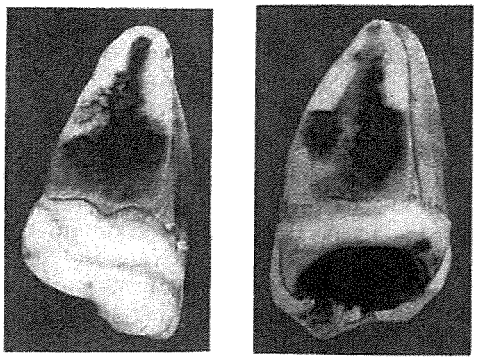
In the case of infection of the pulp, as in the case of many oral infections, the actual bacterial invasion must be preceded by chemical or mechanical trauma, by circulatory disturbance, by the irritations due to thermal changes, or to the conductivity of metallic fillings, by discase, by nervous disturbances, and other

* *Journ. Med. Research*, N.S. xxxi, No. 3, pp. 481-91.

similar agencies. The pulp has its full share of resistance, and will respond to therapeutic measures. Wash out the cavity with Dakin's solution, then treat by the method that I am giving here, and I think that the pulp will have a fighting chance, and recover its normality if it has not been too severely injured.

If the agitation over the blind abscess amounts to nothing more, it at least demonstrates to us that to save teeth we must begin at the beginning, and conserve dentinal tissue. It is possible to

FIG. 1. FIG. 2.



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.

destroy a tooth mechanically as well as pathologically. It requires some skill to cut out or off any part of the anatomy. But surgery should be the last resort; it should follow only after all restorative attempts have failed. We should rely more upon therapy and less upon mechanics in all dental treatment. Cavities are rarely sterilized by the bur, as we have ascertained by careful clinical and laboratory examination, and our sections show why. It is on account of the depth of the bacterial penetration. This is particularly the case in posterior teeth. Is it not better, then, to remove as little as possible of dentin consistent with the stability of our mechanical substitutes, and sterilize this disintegrated tissue and simultaneously impregnate it with a metal like silver?

IMPORTANCE OF PRESERVING THE FIRST MOLARS.

The removal of the four first molars from the children in a clinic of the size of this is a matter that deserves more than passing attention. A good inch taken from each arch and to the depth of half an inch in the grinding region of a child's mouth, directly under and affecting the maxillary sinuses during a growing and formative period, is a serious matter. It is serious directly to the individual, indirectly to posterity. Every dentist recommends coarse foods and mastication for tooth and jaw development and protection; so does the physician for a more extended bodily effect. Shall we reduce the masticatory surface by one-third, and at the beginning of life? We are continually dealing with cramped arches and nasal constrictions. Shall we at one operation reduce the size of the arch in a large measure?

Recall the animal experiments that demonstrate the effect of the use or lack of use of the molars upon the dental arch and the adjacent structures. The deciduous teeth upon one side of the animal's head were removed or treated so that they were not usable, while upon the other side they were not disturbed. After a few weeks the skulls of these dogs showed a striking cessation of development upon the unused side, not only of the teeth, but of the nasal passages and of the sinuses, while upon the other side a full and natural growth took place. Nasal constriction, then, follows removal of these teeth in children, and we know that full nasal breathing is of importance in general health. Statistics show that by far the most frequent tooth to decay is the first molar. For these reasons a more than ordinary attempt should be made to save these teeth, and I feel that the treatment which we have under consideration has possibilities in this direction that are superior to a mere mechanical procedure, whether the caries comes

to us at its commencement or in a more advanced state. The clinical results are certainly very encouraging.

STERILIZING PUTRESCENT PULPS.

(II) *It is possible to completely sterilize a putrescent pulp without removing it.* We do not recommend this procedure, but by it it is entirely possible to leave a silver deposit in the tissue of the pulp, perhaps in the form of silver albuminate. At any rate, the pulp is sterile if the procedure is properly carried out, as we have demonstrated by repeated tests.

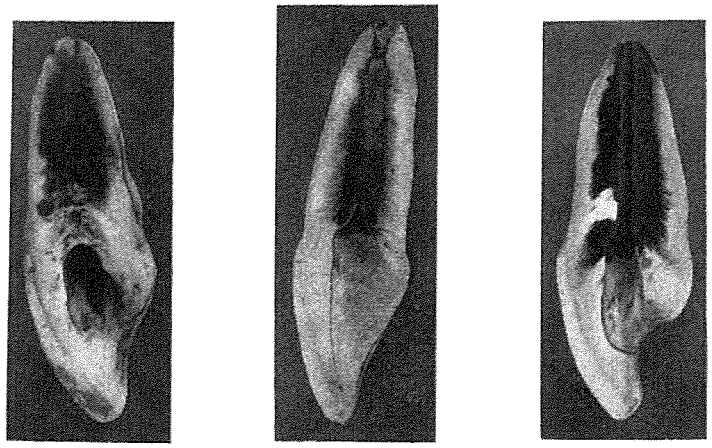
This is a safety measure, for it not infrequently happens in root-canal work that, although the instruments are sterile, the septic pulp tissue is pricked through the apices, or that the broach goes through after passing through septic root matter, thus inoculating the tissues beyond.

If upon opening a tooth that is pulpless the first procedure is to apply this method, the canal may be cleaned in safety. Indeed, it is surgically clean and more. The dentinal tissue of the root itself, of equal importance in the preservation and retention of the tooth, is not only rendered sterile, but is impregnated with metallic silver. If this treatment is thoroughly applied no further treatment is necessary, and the tooth may be immediately filled.

TREATING ACUTE PERICEMENTITIS FOLLOWING DEATH OF THE PULP.

(III) *When the death of the pulp is followed by acute pericementitis, it is only necessary to apply the treatment and close the tooth, when the inflammation will be promptly allayed.* It is better to see such a case a second time, for in any inflammation serous exudates occur, and they might find their way into the canal. These should be absorbed with sterile cotton points in the usual way, and the sterilization done a second time, depositing a good body of the silver in order to close the foramina. In such cases as we have had under observation this treatment has apparently ended the trouble. We have found that canals which have been treated by other methods, when treated by the method we are describing are dry, and that the small canals have been closed with the silver.

FIG. 3. FIG. 4. FIG. 5.

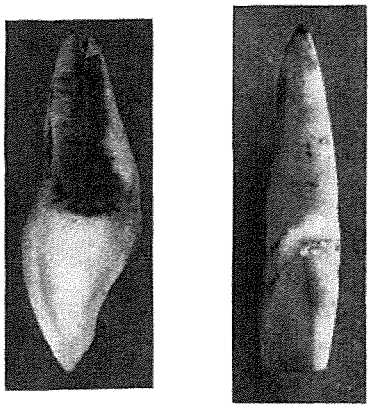


These are laboratory teeth. The tooth in Fig. 3 had five foramina; that in Fig. 4 had two foramina. All foramina are filled. Note the healthy structure in the root of the tooth in Fig. 5, just above the gum margin.

TREATING CHRONIC ABSCESS.

(IV) *We have found this treatment effective in chronic abscesses.* In the treatment of these cases we do not hesitate to work the material into the abscess itself by way of the root-canal. At no time have I seen any indication of disturbance following such a procedure, but in all cases the treatment has been markedly effective. As yet we have not had to remove any of the teeth so treated, and they have been the discards of a large clinic. Some of our efforts have not been wholly successful, but a radio-

FIG. 6. FIG. 7.



Showing it to be possible to use this method in anterior teeth. No discoloration of crowns.

graph has usually disclosed the cause, showing that we were not able to reach the abscess; but in all cases it is safe to say that there has been great improvement. This may be seen from the description of the cases that Dr. Burke has treated, which is included in this report.

In the use of this treatment in chronic abscesses it may be well to use as an adjunct to it some more continuous mode of sterilization. The action under this method is immediate and complete. An abscess, or an inclosed or encysted area responds curatively to ionization. Those preparations that give off formaldehyd or induce some more penetrating or continuous method of sterilization are valuable aids in such cases.

Before this is discussed further, notice from an examination of our slides what occurs in a vital tooth in an inflammatory condition of the pulp or of the pericementum, more frequently in chronic than in acute cases. Usually a so-called acute crisis is the result of a chronic condition. Long-continued irritation of the pulp, even if in a mild form, eventually results in the death of the pulp, and then comes the acute abscess, which when neglected relapses into a chronic abscess. Ground sections of teeth so affected, abscessed or pyorrhetic teeth, show distinct hyaline areas throughout the dentinal structures. This is indicative of degenerative action. In these hyaline areas the dentinal fibrils are few and far between, as shown in the illustrations. This fact, if ever noticed before, has never been enlarged upon. So, too, where pulp irritation has been of long standing the dentin is affected. While this hyaline condition of the dentin is undoubtedly a degenerative process, it is at the same time a protective one, for it stains only where the fibrils exist. Just previous to the actual hyaline state the dentin undergoes an alteration under which it stains deeply. We are extending our studies upon these internal tooth changes, and in another paper shall give a fuller account of them.

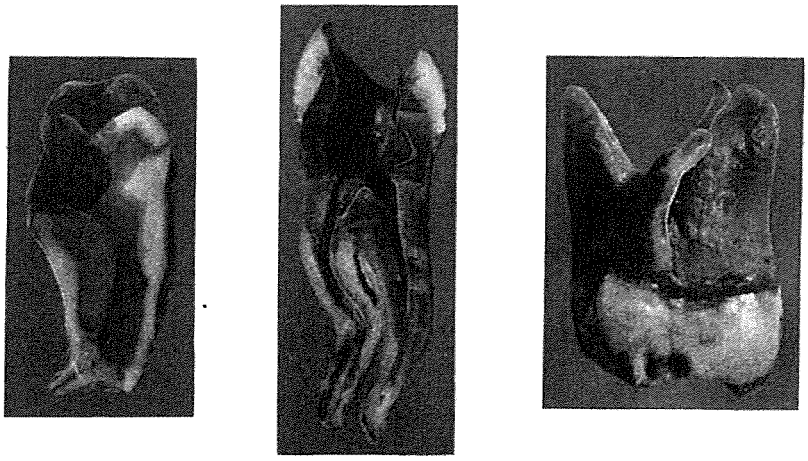
If you will examine the teeth that we have treated by this method you will see that the sound tissue is not affected, while the unsound is black with the silver impregnation. Some of these teeth were treated in the mouth and then extracted. The sound tissue seems to be unaffected. (See Figs. 1, 2, and 3.)

In practice we attempt to fill the canals of pulpless teeth—although the X-ray shows that in a large majority of cases we do not—but no or but comparatively little attention is paid to the dentinal structure. These sections show that the alteration is extensive; that the silver fills this affected dentinal structure. Our bacterial examinations show that the tissue is sterile when thus treated. Hyaline areas are sealed by nature, so that we feel we are demonstrating important facts in tooth treatment.

In the ground sections of teeth that we present here deep penetration of the tubuli is seen. A distinction must be made between the laboratory tooth and the living tooth, for the one is not vital, while the other is, and contains normal serum and moisture. It is at times possible to stain a laboratory tooth that apparently is sound, while in all the teeth we have treated and then extracted, the healthy dentin has not been stained.

From what has been said it is evident that in chronic abscesses, so far as the root-canal and dentinal tissue are concerned, this treatment is immediate and effective. When worked directly into the abscess nothing but good results have been observed so far as our studies show; but if there is a sac of serous matter it should be drained, washed with Dakin's solution, and resolution awaited before it is finally filled. Some of our investigators have endeavored to show that they cannot get an abscess sac sterile. We should hardly expect to do this clinically at one operation. We have to remember that anything that destroys the bacteria destroys the living tissue. We may wash a wound free from detritus of many kinds, we may reduce the number of bacteria by various solutions, and we may incite a healthy healing process so that shortly the wound becomes bacteria-free. This is about what we are to expect in dental abscess treatment. The forces of immunity and of resistance are fully as much to be considered as the mere presence of the bacteria. I believe that ionization is frequently an excellent accompaniment of this method that I am recommending, for it induces a healthy action in tissue, and reaches farther than we are always able to do with this treatment.

FIG. 8. FIG. 9. FIG. 10.



Illustrating the manner in which the solution finds its way to the very end of the root, even when the broach is unable to reach it.

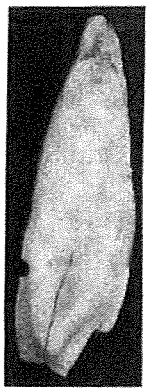
These cases should be kept under observation, and the permanent filling not too hurriedly inserted, not because of the tooth itself, for the affected tooth structure is sterile and impregnated with the silver, but on account of the abscess sac and the peridental membrane, which require a little time for return to normality.

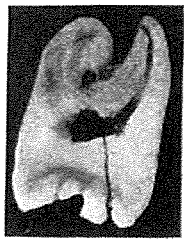
TREATING APICAL AREAS.

(V) *Application of this treatment to the region of the apices of tooth roots.* When a pulp is removed under conductive or infiltrative anesthesia no one can say at what point it will be torn off. The

elastic pulp tissue may break short of the apical foramen. There may be several foramina, and several shreds may be left. The break may occur and the elasticity of

FIG. 11. FIG. 12.





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.

the tissue draw the point of breakage outside of and beyond the apical foramen. Any of these are annoying conditions, and a source of discomfort to the patient, frequently of long duration. The application of this treatment disposes of the first condition, and is an aid in the second.

From what we may see from the ground sections in the laboratory and from the clinical evidence that we have, the treatment is ideal in any apical work. In the case of the many foramina, they are rendered sterile and are filled. One tooth with five foramina shows the silver in every one. In the case of crooked and of very fine roots the silver goes to the very end, as may be seen in the illustrations. The silver has gone through in some cases, but nothing but good effects have been observed. When penetration does occur it is not similar to the penetration of gutta-percha.

The treatment of root apices is a delicate matter, in my opinion. Examination of the tooth sections that we have prepared will show that in the teeth of the adult a limited hyaline condition very frequently exists in this region. This may be more or less extended without any noticeable pathological features. In the case of the chronic root abscesses there is an extended hyaline area, occurring not alone at the apex of the root but here and there throughout the tooth, although more especially toward the end of the root.

What the X-ray may disclose we are not prepared to say—we have not sufficiently studied this histological change; but the fact that such a change does occur should be borne in mind in interpreting the radiograph. We have seen revealed by radiography failures in attempts to fill root-canals. That these were not filled was not known by the patient or by the operator. In many

FIG. 13.

Showing a small cervical cavity. By transmitted light the disintegrating effect may be seen reaching to the pulp. A close examination shows a dentinal alteration. The posterior portion of the tooth is affected more or less throughout its length. This may be seen along the upper part of the root. At the apex a distinct hyaline area exists, as with the sound teeth in the previous figures.

such cases the tooth has been useful, comfortable, and physiologically tolerated. On the other hand we have taken out with the fingers loose teeth from about which pus was discharging, and from which an eighth of an inch of

gutta-percha was protruding through the apical end of the root. We have also removed from a fistula a pellet of gutta-percha that had been forced through the root-end. Nature is wonderfully tolerant, but we can see no reason for forcing gutta-percha into tissue beyond the root-end. Such a foreign mass is only an irritant, and disturbs the natural arrangement of vessels, nerves, and tissues; it interferes with the natural circulation. The tooth at its apex is tapered, often translucent, as I have shown by sections, and the adjustment between this and the alveolus is delicate.

When there are several foramina, why should a gutta-percha point forced into the adjacent tissues an eighth of an inch, passing between all these natural connective openings, be considered a therapeutic measure? It is well to keep away from the apical region with mechanics. The treatment that we are advocating has at least some elements that are in harmony with modern biological principles. The enlarged apical ends of the developing molars of the child present no difficulties that cannot be safely remedied by this treatment, if we are to judge from the subsidence of inflammation and the return to apparently normal state that follows its use.

FIG. 14. FIG. 15. FIG. 16.

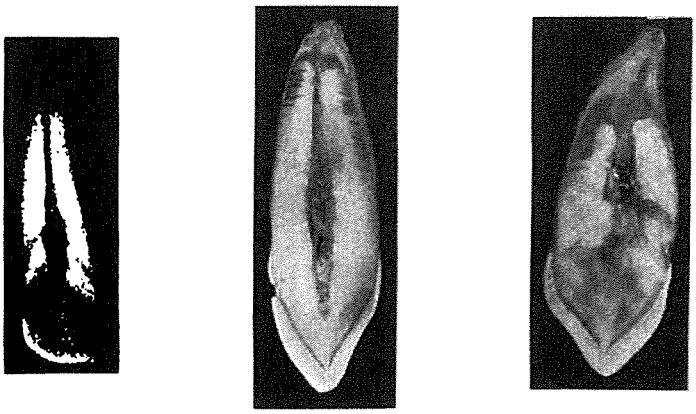


FIG. 14. Note the cavity extending to the pulp. Note dentinal alteration, also the hyaline condition at the apex. This tooth had abscessed.
FIGS. 15, 16. These show a similar dentinal alteration. The teeth were firm in the jaw, but were removed with others.

DESENSITIZING REMAINING PULP SHREDS.

(VI) *Disposes almost painlessly of the remaining part of a pulp after the death or removal of a portion of it.* Another place where this method is serviceable is in the case of a vital pulp shred that remains in one root-canal, while in the others the pulp is dead. These living shreds are difficult to get rid of. By this method one is able to almost painlessly dispose of this sensitive pulp tissue. If slight pain is felt when the ammoniacal silver nitrate is applied, follow it immediately with formalin, working it down the root-canal, when the pain will cease. Pressure with a rubber pellet is sometimes a very good way to force the liquid down the canal; the pulp will be sterile and stiff with the impregnation of the silver.

USE OF SILVER NITRATE SOLUTION FOLLOWING APICOECTOMY.

(VII) *A still further application of the principle of dentinal tissue impreg-*

nation in the treatment of the tooth stub after apicoectomy. Dr. Shuman, after examining the tooth sections and the effect of this method in other cases, applied it following apicoectomy for the purpose of sterilizing the remaining dentin and sealing it against serous exudates following the operation, and reports that he has had no trouble since its use. Previous to its use an occasional swelling would occur some time after the operation.

There are questions that naturally arise in the consideration of this method, some of which we shall attempt to answer here. One of the first that occurs is, Does this treatment discolor the teeth? It renders them jet black wherever the

FIG. 17. FIG. 18. FIG. 19.

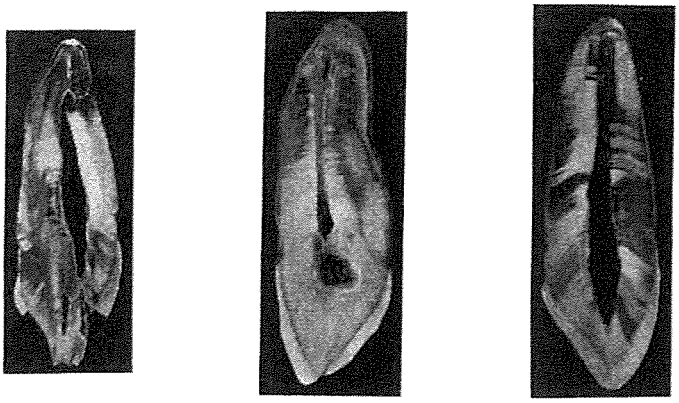


Fig. 17 shows abscessed tooth in which the crown was broken in grinding. Figs. 18 and 19 show pyorrhetic teeth. Note in Fig. 19 that both the pulp and the pericementum have taken part in this dentinal change.

FIG. 20. FIG. 21. FIG. 22.

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.

silver deposition takes place. This is certainly an objection to its use, and limits its employment. It will enter any defective tooth structure, but does not seem to penetrate sound tissue, as we have said.

The method was evolved particularly to save posterior teeth, the first molars especially, nearly all of which are affected in a large clinic like the one at this institution. The treatment had to be prompt, simple, and efficacious—and so far it seems very successful. Here the color did not matter so much, but breadth of application was needed, and we have therefore worked out the following method for treatment of anterior teeth. The root-canal is enlarged to well below the gum margin. The entire tooth is coated with adhesive wax, and the enlarged part of the canal is filled with it. With a cold wet instrument the wax is punctured in a line with the apical end of the root-canal. The canal is cleaned with a barbed broach and the silver solutions applied. After treatment the apical portion of the root is filled by any method chosen, any remaining silver being wiped out, and the wax removed. This prevents discoloration of the lower part of the canal or the crown. It is best to practice this procedure in the laboratory before trying it on the patient.

TOLERANCE OF THE TISSUES FOR THE SILVER SOLUTION.

Another question that arises is that of tissue tolerance. It is a well-known fact that silver in its metallic form has been used in different parts of the body, and that it is tolerated by the tissues. We have shown that when it is passed outside of the apical foramen it has not increased inflammation, but allayed it.

FIG. 23.

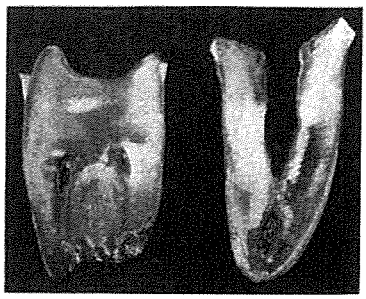
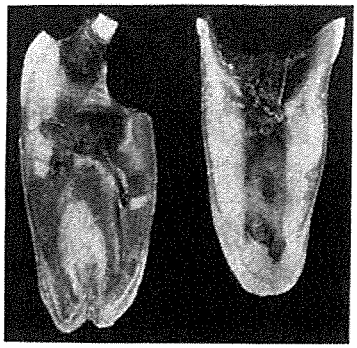


FIG. 24.



Showing abscessed roots of children's sixth-year molars. These teeth were firm, but had a history of swelling, and were inflamed at the time of extraction.

We have in our collection a molar that is dark with silver stain throughout its entire root substance! This tooth was firm in its socket, a piece of alveolus being removed with it in its extraction. The tissues around it were pink and healthy. The majority of the remaining teeth were loose and diseased, and for this reason were removed. One occasionally sees a tooth filled with coin amalgam that has outlasted modern work.

Silver nitrate has long been used in dentistry to allay sensitiveness and to arrest decay. It has been used electrolytically in abscess treatment. Dr. Prinz's book contains an excellent exposition of the subject. Silver tartrate and silver citrate have been recommended for

wound treatment. Dilute silver nitrate is used for an eyewash for infants. Argyrol is of wide use. It is reasonable to conclude that silver is not only tolerated by the tissues, but that it is a valuable therapeutic agent. In presenting this method of sterilizing and at the same time impregnating affected dentinal tissue, we wish to state that we still consider the work experimental. Whether it is original or not is a matter of no moment. So far as we know it is, and we believe it is founded on sound principles. If it is ever good practice to sterilize and fill tooth tissue it may be done in this manner simply, effectively, and perfectly.

We do not hesitate to recommend it for trial. It is natural to expect some failures, particularly until the technique is mastered. In the hands of the dental practitioner this will be readily accomplished, and undoubtedly many helpful suggestions will be made.

If there is anything to be added in the way of caution in the employment of this method, it is to remember the distinction between dentinal tissue and the cellular tissue beyond the root-end. While the silver does no harm in the diseased cellular tissue, and is indeed beneficial, it is at times slightly irritating for a short period. On the whole, we believe that it is the best practice to first use Dakin's solution in this tissue, and confine the action of the silver solution to the dentinal tissue as much as possible. Should this not prove effective, work the silver solution directly into the abscessed tissue. No serous discharge ever follows. The tooth is always dry, and it is sterile. A little experience and a little judgment is all that is necessary.

Preliminary Report of Cases.

The following is a preliminary report of cases by Dr. Burke. He has many other cases he has treated, which he will make the subject of a subsequent report. Many more are being daily treated in this manner by other operators in our clinic, an account of which will be given later.

Case 1. Lower right first molar. Pulp had died under an amalgam filling. There was considerable pain and some swelling, the X-ray showing an abscessed area at the apices of the roots. (See A.)

Ammoniacal silver nitrate and formalin was applied in the canals, and cultures taken from the canals, which showed no growth. The

A

B

Case 1.

tooth was then sealed up with cotton and gutta-percha. The X-ray showed a deposit of metallic silver along the walls of the canals and the pulp chamber. (See B.)

The treatment was repeated one week later; there had been no pain after the first sitting, and the swelling was reduced.

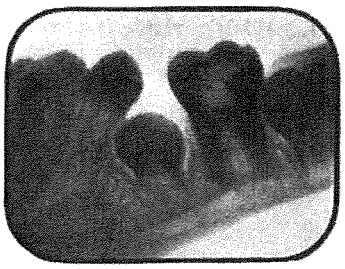
Case 2. Lower right first molar. Patient eleven years of age. X-ray taken before treatment, June 8, 1917. (See A.)

The mesial canals were putrescent; the pulp in the distal canal was vital, with a history of pain. Ammoniacal silver nitrate in solution was introduced into the canals, pumped

down with a smooth broach, and reduced with formalin. The tooth was sealed with gutta-percha.

On June 22d, patient returned for further treatment. There had been no pain or odor. The treatment was repeated.

On June 29th an X-ray (see B) was made before filling the canals, showing deposit of



A

B

C

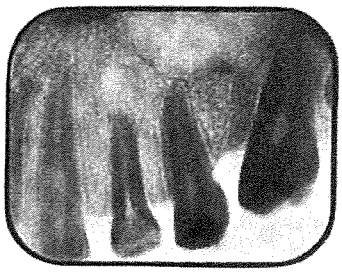
Case 2.

metallic silver along the walls of the canal and the pulp chamber. The canals were filled with zinc oxid, aristol, and eugenol solution, plus gutta-percha points.

On July 6th an X-ray (see C) showed the canals filled.

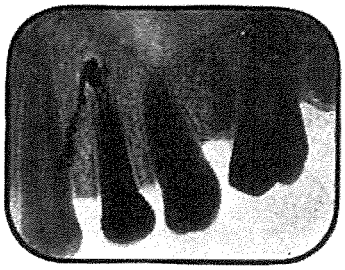
Case 3. Upper right first bicuspid—X-ray taken before treatment (see A)—containing a putrescent pulp, with a very foul odor.

One or two drops of the silver nitrate solution were applied in the pulp chamber of the



A

B



C

Case 3.

tooth, and gently worked into the canals with a smooth broach. One drop of a 25 per cent. solution of formalin was then added to reduce the silver nitrate.

A radiograph (B) shows the deposit of the metallic silver along the walls of the pulp chamber and root-canals.

Cultures taken from the dentin of the canals showed no growth.

A radiograph (C) shows the canals filled.

Case 4. Lower right first molar, in which an attempt had been made to remove the pulp with novocain at some previous time. I found the mesial canals putrescent and the pulp in the distal canal vital.

Silver nitrate was introduced into the canals by applying a drop or two in the pulp chamber and then working it into the canals with a smooth broach. This solution was reduced in the tooth by adding one drop of a 25 per cent. formalin solution.

The canals were then filled with a paste of zinc oxid, aristol, and eugenol, and gutta-percha points.

Case 5. A lower left second molar in which the pulp had died under an old copper amalgam filling. There was the usual foul odor accompanying such a condition.

The solution of silver nitrate was introduced into the canals, and reduced with the solution of formalin, and the tooth sealed with sterile cotton and gutta-percha.

Case 6. Lower left first molar of a patient twelve years of age. A radiograph (see A)

A

B

Case 6.

shows the case before treatment, June 2, 1917. There was present a putrescent pulp with a history of pain and swelling.

An ammoniacal solution of silver nitrate was introduced into the canal, pumped down with a smooth broach, and reduced with a 25 per cent. solution of formalin.

The tooth was sealed with cotton and gutta-percha. A radiograph taken June 9th (see B) shows the deposit of the metallic silver along the walls of the canals and pulp chamber. Cultures taken from the canals were negative.

The canals were filled with a paste of zinc oxid, eugenol, and aristol, plus gutta-percha points.

Case 7. A lower right first molar which had previously been treated with phenol and formocresol, etc., but finally presented with a slightly foul odor.

Silver nitrate and formalin were applied in the canals and cultures taken were negative. They were immediately filled with zinc oxid, aristol, and eugenol paste, plus gutta-percha points, with no subsequent trouble.

Case 8. Upper left first molar which had abscessed and was loose and aching, with considerable swelling.

Silver nitrate and formalin were applied. The tooth was so sore that it was impossible to apply the rubber dam. The patient returned the next day, when the swelling was still present, though no pain accompanied it.

The tooth was again treated with formalin and silver nitrate and sealed up with cotton and gutta-percha. The patient presented herself three days later, at which time the swelling was completely reduced and there was no pain; tooth firm.

The tooth was examined two months later. The gum about the tooth was pink and healthy, the tooth firm, and there had been no pain or discomfort since the treatment.

Case 9. A lower right first molar which had been long treated and was very uncomfortable to the patient. Examination showed hypertrophied pulp tissue filling all the canals. Ammoniacal silver nitrate solution was gently worked into the canals and reduced with formalin. As the hour was late, a filling of zinc oxid and eugenol was inserted, and patient seen on the following morning. No vital pulp in any of the canals; tooth dry and sterile. This tooth was then filled in the usual manner, with no subsequent trouble.

Case 10. A lower left first molar with vital pulp left in the root tips after attempted removal under conductive anesthesia. This tooth had been a source of discomfort to the patient for three months. The tooth was treated according to the method described and filled at once, with no further trouble.

10 EXETER ST.

to report to our headquarters all cases thus cared for, so that we may compile statistics to present to the Surgeon-general. The Government appreciates what we are doing, and we believe our efforts will not go unrewarded when future favorable legislation may be desired by us.

We hope to bring many new members into the National Dental Association through the League, and would call the attention of the officers of our units to this matter. We should bring many into the National before the annual meeting in October next.

The second annual meeting of the League will be held in conjunction with the National Dental Association on October 23, 1917, in Concert Hall, Hotel Astor, New York. We are planning a splendid program, and will be able to report wonderful results from the different units. Several dental ambulances for use in France are being supplied by our units, and other equally patriotic movements are under way.

We urge the formation of units more generally in order to promote the various objects of the League. Organization is essential, and we would point out that *now* is the time our best efforts are demanded, as the League is organized as a war measure; therefore we invite correspondence with this object in view. Headquarters are at 131 Allen st., Buffalo, N. Y.

INFORMATION RELATING TO APPOINTMENTS IN

THE DENTAL RESERVE CORPS OF THE ARMY.

THE National Defence Act of June 3, 1916, and the tentative regulations thereunder, provide for a dental section or branch of the Officers' Reserve Corps. The officers of the Dental Reserve Corps have the rank of first lieutenant, and are appointed and commissioned by the President, after having been found, upon examination prescribed by him, physically, mentally, and morally qualified to hold such commissions. Commissions are issued for periods of five years, at the end of which time the officers may be recommissioned, subject to such further examinations and qualifications as the President may prescribe. They are subject to call for duty in time of actual or threatened hostilities only. While on active duty under such call they are entitled to the pay and allowances (including quarters, fuel, and light) of their grade. They are entitled also to pension for disability incurred in the line of duty and while in active service. They are not entitled to pay or allowances except when in active service, nor to retirement or retired pay.

Appointees must be citizens of the United States, between TWENTY-ONE and FIFTY-FIVE years of age, must be graduates of standard dental colleges, and must, at the time of appointment, be in the active practice of their profession in the states in which they reside.

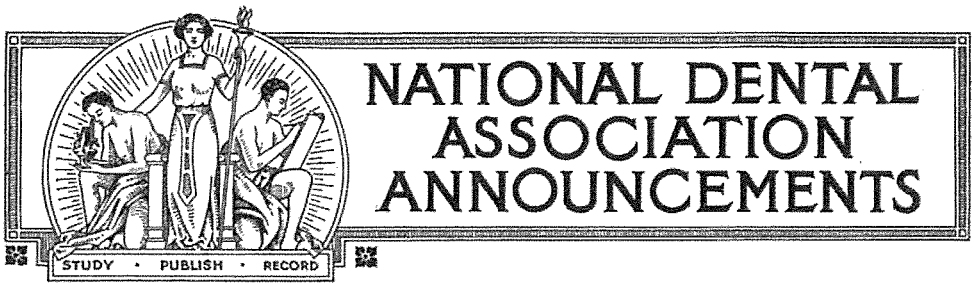
The examination is physical and professional. It is conducted by boards consisting in each case of one medical and two dental officers in the Army, designated by the War Department.

The examination as to physical qualifications conforms to the standard required of recruits for the United States Army. Defects of vision resulting from errors of refraction which are not excessive, and which may be entirely corrected by glasses, do not disqualify unless they are due to or are accompanied by organic disease. Minor physical deficiencies may be waived.

The professional examination will be oral. If the applicant fails therein, he may, if he desires, have a written examination. An average of 75 per cent. is required to qualify in the examination. The examination comprises the following subjects:

(1) Dental pathology and bacteriology.
(2) Chemistry, physics, and metallurgy.
(3) Recent advances in dental surgery and technique.

Applications for appointment in the Dental Reserve Corps must be made in writing, upon the prescribed blank form, to the Surgeon-general of the Army, Washington, D. C., who will supply the blank upon request. The correctness of the statements made in the application must be sworn to by the applicant before a notary public or other official authorized by law to administer oaths. It must be accompanied by testimonials based upon personal acquaintance from at least two reputable persons as to the applicant's citizenship, character, and habits, and by his personal history given in full upon the blank form furnished him for the purpose.



Twenty-first Annual Meeting, New York City, October 22-26, 1917.

To date the following reports have been received from the various section chairmen, committeemen, etc.

Partial Program.

SECTION I.

Chairman—Dr. E. D. Coolidge, 59 E. Madison st., Chicago, Ill.

"Some Neglected Operative Prerequisites." Dr. Fred E. Hart, San Francisco, Cal.

"Porcelain Inlays" (exact title not yet chosen). Dr. W. L. Fickes, Pittsburgh, Pa.

"Present Tendencies in Operative Dentistry." Dr. J. M. Walls, St. Paul, Minn.

Also an important paper dealing with the subject of Dental Education. (Essayist not selected as yet.)

SECTION II.

Chairman—Dr. F. B. Moorehead, People's Gas Bldg., Chicago, Ill.

Dr. Virgil Loeb of this committee reports that he has thus far accepted two essayists: Dr. Elmer S. Best, Minneapolis, Minn., on some phase of Root-canal Filling; and Dr. Howard R. Raper, Indianapolis, Ind., on "Misinterpretation of Radiographs."

SECTION III.

Chairman—Dr. L. E. Custer, 28 N. Ludlow st., Dayton, Ohio.

"Ionization, with Special Reference to Ionic Chemistry." Dr. Geo. T. Fette, Cincinnati, Ohio.

"The Chemical Action of Soil Bacteria on Calcium Phosphates, with the Chemical Analysis of the Human Teeth." Dr. J. E. Hinkins, Chicago, Ill.

"Why Measurements of the Mandible, Tracings of the Condyles, Construction of Hypothetical Triangles, and Use of the Face-bow, are All Non-essential to the Construction of Dentures Possessing the Highest Degree of Efficiency." Dr. D. D. Campbell, Kansas City, Mo.

(Subject to be announced later.) Dr. Calvin S. Case, Chicago, Ill.

Also two other papers, the titles of which will be announced later.

STATE SOCIETY OFFICERS' SECTION.

Chairman—Dr. John C. Forsyth, 430 E. State st., Trenton, N. J.

First session. "Some Phases of Postgraduate Work." Dr. B. L. Shobe, Tulsa, Okla.

"Securing Some Satisfactory Legislation." Dr. Alexander H. Reynolds, Philadelphia, Pa.

Second session. This will be devoted to six or seven short papers of five to ten minutes each by men of different state societies, telling of some outstanding feature of their own society's work that is thought to be of the greatest importance; or, if the essayist prefers, he may present the weak part of the work and ask for helpful suggestions. These papers are to be followed by a general discussion which it is hoped will bring out some very valuable points. (The essayists for this session have not as yet been secured.)

COMMITTEE ON ANESTHETICS.

The secretary of this committee, Dr. Chalmers J. Lyons, of Ann Arbor, Mich., reports as follows:

"The Teaching of Conductive Anesthesia." Dr. Theodor Blum, New York City.

"After-Pain in Local and General Anesthesia." Dr. A. E. Hertzler, Kansas City, Mo.

"The Toxicity of Local Anesthetics." Dr. Geo. B. Roth, Washington, D. C.

COMMITTEE ON ENTERTAINMENT.

At a recent meeting of this committee a Ladies' Auxiliary was organized, of which Mrs. Dr. M. L. Rhein was made chief officer, and Mrs. Dr. Henry W. Gillett, 140 W. 57th st., New York City, secretary. It would greatly facilitate the endeavors of the Ladies' Auxiliary to add as much as possible to the pleasures and comforts of the visiting ladies, if those who intend to come to New York would notify Mrs. Gillett stating, if possible, the hotel at which they will be registered.

Publicity Committee,

R. OTTOLENGUI, *Chairman.*

Railroad Rates.

THE Trunk lines and the New England and Central passenger associations have granted a rate of two cents per mile in each direction, going and returning via the same route only, limited to midnight of October 30th.

Going tickets in Trunk line territory will be on sale October 19th, 20th, 21st, at the one-way fares, on the certificate plan, these certificates to be indorsed by General Secretary Otto U. King, and to be validated by the special agent of the railroads, who will be in attendance on October 24th, 25th, 26th. Return tickets to be sold on presentation of validated certificates, October 24th to 29th, at the difference between the fares paid on the going trip and the fares for the round trip. Return limited to continuous passage to destination, and not later than October 30th. This applies on tickets with a minimum of $1.00 for round trip.

New England passenger association tickets to be sold or certificates issued and good going October 19th, 20th, and 21st and returning not later than October 30th. Two cents per mile each direction, shore line mileage, going and returning via the same route only.

Central passenger association territory round-trip tickets, requiring validation in New York City, will be sold on October 19th, 20th, and 21st, with a final return on October 30th. Two cents per mile in each direction.

There will be no fee for validation.

Committee on Transportation,

D. C. BACON, *Chairman.*

[NEW YORK CITY.]

National Association of Dental Faculties.

THE 1917 meeting of the National Association of Dental Facultes will be held at the Astor Hotel, New York City, Friday and Saturday, October 19 and 20, 1917.

The Executive Committee will meet at 9 A.M., and the general session will open at 10 o'clock as usual.

CHAS. CHANNING ALLEN, *Sec'y,*
N. W. cor. 10th and Troost, Kansas City, Mo.

[NEW YORK CITY.]

Xi Psi Phi Fraternity.

THE alumni of the Xi Psi Phi Fraternity will hold a dinner at the Waldorf-Astoria Hotel, New York City, on October 22, 1917.

All the alumni of the fraternity are most cordially invited to attend. For particulars write

J. NOHERT GELSON,
282 Park Place, Brooklyn, N. Y.

[NEW YORK CITY.]

Association of Military Dental Surgeons.

THE annual meeting of the Association of Military Dental Surgeons of the United States will be held at Hotel Astor, New York City, October 23 to 26, 1917.

J. D. MILLIKIN, *President,*
S. W. HUSSEY, *Sec'y.*

American Society of Orthodontists.

THE annual meeting of the American Society of Orthodontists will be held at Excelsior Springs Mo.—thirty minutes' ride from Kansas City—September 5, 6, 7, and 8, 1917.

The program will be one of the best ever presented by the society. All those interested in orthodontia are invited to attend.

F. M. CASTO, *Sec'y,*
Cleveland, Ohio.

Northeastern Dental Association.

THE twenty-third annual meeting of the Northeastern Dental Association will be held at the Bancroft Hotel, Worcester, Mass., on September 26, 27, and 28, 1917.

ALVIN A. HUNT, *Sec'y,*
Hartford, Conn.