Effect of Glass Ionomer Cement and Fluoride Varnish on the Remineralization of Artificial Proximal Caries in Situ.

C Trairatvorakul * / P Techalertpaisarn ** / S Siwawut *** / A Ingprapankorn ****

Objective: *To compare the effect of glass ionomer cement (GIC) and fluoride varnish (F-varnish) on artificial proximal caries in situ.* ***Study design:*** *Two 1x3 mm² enamel slabs, divided into three 1x1 mm² windows, were prepared from each proximal surface of 18 premolars. Each slab was distributed into a control area, an intact enamel area and a test area. Artificial lesions were created on the control and test areas by immersing in demineralizing solution for 24 hours. The test windows were either applied with GIC or F-varnish and the full slabs inserted into orthodontic brackets as carriers, which were then bonded to the buccal surfaces of the 6 upper posterior teeth of 6 volunteers using non-fluoride dentifrice for 30 days. There was a 1-week washout period in this crossover study. The middle specimens of the three windows were cross-sectioned to analyze the carious lesion area by a polarized light microscope and calculated with Image-Pro plus® software.* ***Results:*** *The average carious lesion area under GIC was significantly less than that under F-varnish ($p<0.05$).* ***Conclusion:*** *GIC promotes more remineralization of artificial carious lesions on proximal surfaces than F-varnish.*

Keywords: *Glass ionomer, Fluoride varnish, Artificial caries, Remineralization*
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INTRODUCTION

Approximately 60 percent of teeth with proximal radiolucencies in the outer half of dentin are likely to be non-cavitated and they should be remineralized to stop progression of caries.[1] Early carious lesions are first seen as white spots in caries susceptible locations especially proximal surfaces. This site is particularly vulnerable to progress from a non cavitated to cavitated lesion because of poor chemical and physical structure and more porosity at the enamel surface.[2-3] Fluoride presence at the site of caries attack can shift the equilibrium towards remineralization.[4–5] Using different topical fluorides can enhance the remineralization and reverse early carious lesions.[6]

F-varnish has commonly been used for caries prevention during the last three decades. The advantage of F-varnish is the relatively long contact time between the applied varnish and the tooth surface. F-varnish seems to be very hard to remove from enamel. This results in a prolonged fluoride release to the oral environment.[7-8] Findings from a clinical study reported that F-varnish (Duraphat®) had decreased the caries increment (DMFS) by 77%.[9]

GIC is now widely used in dentistry as a restoration, sealant or base because of its physicochemical bonding to tooth structures,[10] its long term fluoride release,[11] and its ability to serve as a rechargeable fluoride reservoir.[12] GIC contributes substantially to reduce demineralization.[13]

At present, there is no definitive method for initial proximal carious lesions management. The purpose of this study was to compare the effect of GIC and F-varnish application on artificial carious areas of proximal surfaces in situ and it is hoped the result might support a method of management.

MATERIALS AND METHODS

Preparation of enamel

Eighteen sound, extracted premolars were cleaned of soft tissue debris and were inspected for the absence of cracks, hypoplasia and white spot lesions. The enamel surface was polished with an automatic polishing machine (DPS 3200, IMPETECH, South Africa) using 100 rpm for 45 seconds to remove the surface layer with its fluoride rich zone. Two, one mm thick sections were cut from the middle third of the distal or mesial surface of each premolar using a hard tissue

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disc (273D, Intensiv, Grancia, Switzerland). Then each section was divided into two halves of 1×1×3 mm^3 slabs. Each half was divided into 3 windows of 1 mm^2 each and randomly distributed into a control area, an intact enamel area and a test area (Figure 1). Each slab was randomly assigned to either F-varnish or GIC groups.

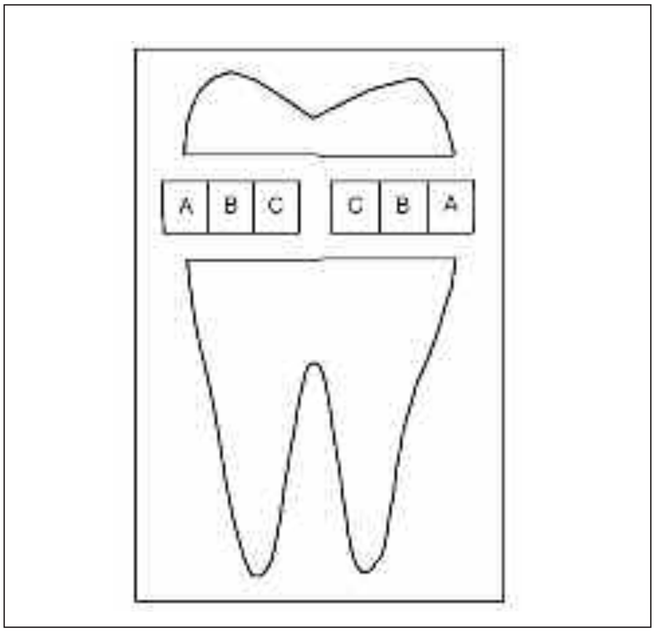

Figure 1. View of distal or mesial surface section of premolar crown depicting (A) an area with an artificial carious lesion to be covered with an application of GIC or F varnish, (B) an area of intact enamel and (C) a control window

Lesion Formation

All surfaces of the specimen were coated with nail varnish except the control area and the test area on the polished enamel surface. Each specimen was then demineralized by immersion in 2 ml of 85% lactic acid-sodium hydroxide buffer at a constant temperature of 37ºc for 24 H to produce an artificial carious lesion. The lactate buffer contained 8 ml of 0.2% polyacrylic acid or Goodrite® (B.F.Goodrich Co., Cleveland, OH, US) with 0.88 ml 85% of lactic acid, 50 mg hydroxyapatite and 92 ml of deionized water then was adjusted with NaOH to the pH of 4.8. The depth of the lesion was approximately 100 µm.

The specimens were washed in deionized water. Nail varnish covering the intact enamel window was removed and then the control window was painted with nail varnish. All sections were sterilized for 12 hours in ethylene dioxide.

Subjects

Six volunteers aged 18-20 years old who were orthodontic patients served as subjects in this study. After they had been given verbal and written explanations of the experimental protocol, informed consent was obtained. The design of the study was approved by the Ethics Committee, Faculty of Dentistry, Chulalongkorn University, Thailand.

Experimental Protocol

Two pairs of slabs (each from mesial and distal surface) were obtained from the 18 teeth, therefore 36 pairs (72 slabs) were available for the experiment. The test area of each paired specimen was randomly applied with either F-varnish (Duraphat®, Colgate, Canton, MA) or GIC (Fuji VII®, GC Corporation, Tokyo, Japan), in this crossover study. Application of each material was carried out according to the respective manufacturer's instructions. The specimens were inserted laterally against the mesial wall of each bracket to mimic proximal contact (Figure 2). The surface opposite the windowed surface was bonded to the bracket with flowable composite (Filtek Flow®, 3M-ESPE, St. Paul, MN, USA). Each of 6 volunteers wore 6 brackets carrying 6 slabs from 6 pairs of slabs in each of the 2 experimental sessions. The brackets were bonded to the buccal surface of the six upper posterior teeth with a bonding agent (Transbond XT®, 3M Unitek, Monrovia, CA). Half of the subjects were randomly assigned for each material in each session, and then they were alternated to the other material in the next session. The subjects were given a non-fluoride-containing dentifrice (Sensodyne® Original, GlaxoSmithKline, USA) to use for 7 days before the study began and during the test period. Soft-bristled toothbrushes were given to all subjects. They were instructed to keep to their regular diet and any changes would be grounds for exclusion from the study.

Following the 30-day test period, the enamel specimens were removed from the brackets. There was a 5-day wash-out period with no testing, and then the subjects' teeth were bonded again with specimens that were treated with the alternate material.

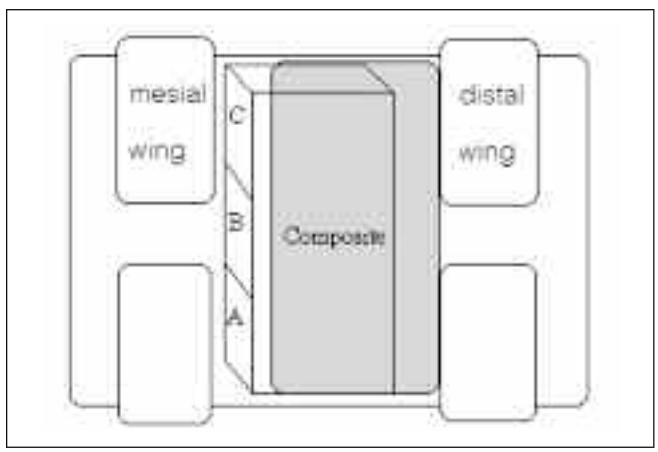

Figure 2. Bracket from buccal surface shows experimental surface of the specimen facing the mesial wing

Evaluation of lesion area

The enamel blocks were embedded in epoxy resin and thin sections (100 µm) at the middle of the three windows were cut with a saw microtome (SP 1600, Leica Co., Ltd., Germany). They were examined by a polarized light microscope (9300 MEIJI, Seitama, Japan). Each lesion was transferred to a digital image (CoolpixS3, Nikon, Japan) (Figure 3) and 100% contrast was used with Adobe Photoshop pro-

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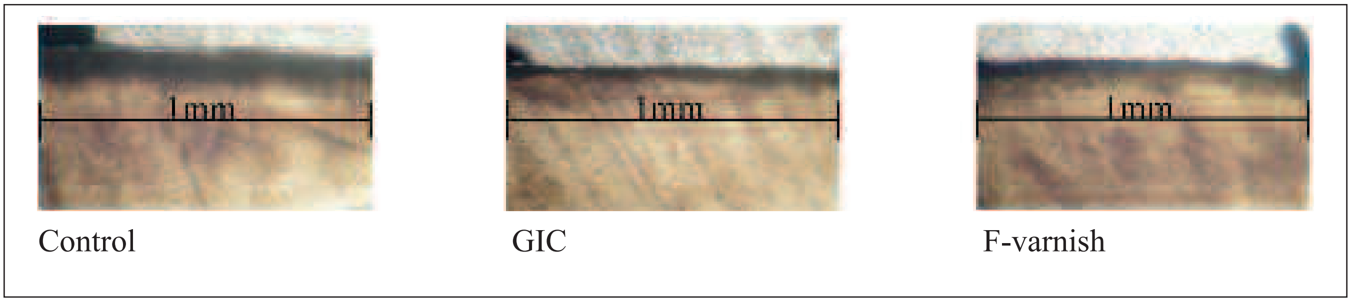

Figure 3. Carious lesion area under polarized light microscope x40

gram (version 7.0) to localize the carious area. The images of the carious lesion area were then analyzed and measured using Image Pro-Plus® software (Media Cybernetics, Inc., MD, USA).

Statistical analysis

SPSS (version 11.0) was used to analyze the data at a standard of 0.05.Normality of the data was confirmed using normal probability plots and the SW test. Homogeneity of variance was confirmed using Levene's test. The difference between the lesion area under F-varnish and GIC materials was analyzed statistically by paired t test.

RESULTS

Compliance

No subject reported any diet change and none withdrew during the test period. Some of the specimens were broken during the experimental procedures and their pairs were excluded. At the end of the experiment, there were 31 pairs of slabs in each of the control, intact enamel and test group.

Lesion area

The mean values of the size of the carious lesion area under GIC was significantly less than under F-varnish ($p<0.05$). There was no statistically significant difference between control groups of F-varnish and GIC ($p>0.05$). There was also no statistically significant difference between the demineralized, originally intact areas of both groups ($p>0.05$) (Table 1).

Table 1. Mean values of three carious lesion areas (mm2) treated with fluoride varnish or glass ionomer cement

Group	Mean values (±SD)	
	fluoride varnish	glass ionomer cement
Control area	0.075 ± 0.015	0.077 ± 0.012^{NS}
Intact enamel area	0.029 ± 0.011	0.027 ± 0.011^{NS}
Area under test material	0.050 ± 0.016	0.037 ± 0.009*
% reduction	33.33	51.95

NS = Non-significant difference
*$p<0.05$ for comparison of fluoride varnish and glass ionomer cement (paired t test)

DISCUSSION

Previous studies have shown caries-preventive effect of both materials in comparisons with resin sealant.[14-15] This is the first study to compare the two materials by treating incipient lesions *in situ*.

We chose Duraphat® for the F-varnish because it was found to elevate fluoride levels in whole saliva more than other F-varnishes at baseline.[16] Moreover, its anticariogenic property was shown to be more effective than Fluor Protector.[17] Fuji VII® was chosen as the GIC because it is a duo-cured GIC which is accelerated by light application and it is clearly visible due to its pink color. Its fluoride release is 6 times higher than Fuji III® and Fuji IX GP® within 30 days according to the manufacturer's product information.[18]

This experiment had a randomized crossover design to diminish the influence of oral environmental differences between the test subjects.

The present study shows that GIC was more effective than F-varnish in the remineralization of artificial carious lesions underneath the materials, but they caused no difference in intact enamel areas adjacent to the materials. And, both of the materials caused reduction in the carious areas when compared to controls.

Many studies have supported the effectiveness of GIC. Artificial initial carious lesions at proximal surfaces adjacent to cavities restored with GIC can be remineralized.[19-20] F-varnish had the same positive effect of decreasing the progression rate of proximal caries lesions because of its prolonged retention to enamel surface.[7] Previous studies have also shown that F-varnish promoted the remineralization over or around the lesion and they suggested that dissolution of varnish by a moist environment could expose the carious lesions to saliva supersaturated with calcium phosphate and fluoride from the remaining varnish.[21]

A plausible explanation for this main finding derives from differences in the mechanism of fluoride-releasing materials to create fluorapatite. F-varnish has been reported to deposit large amounts of fluoride in the enamel through the formation of CaF_2- like material, surrounded by pellicle protein and phosphate at neutral pH to prolong its retention on the enamel surface.[22] F-varnish seems to be very difficult to remove from the enamel.[8] This creates a fluoride reservoir that is slowly dissolved to promote remineralization for an extended period of time. At lower pH F-varnish allows increased fluoride release into the oral environment and it

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may then adsorb onto the enamel surface in order to contribute to the remineralization process.[23]

This mechanism seems to be different in GIC where polyalkenoic acid from the cement is buffered by phosphate ion within the tooth in the aqueous environment. Calcium and phosphate ions are dispersed from the hydroxyapatite into the unset cement.[24] Fluoride is released from GIC as ionic F, ionic AlF_6 and fluorophosphate compounds.[25] Moreover, the exposed surface of GIC can also release fluoride ion during periods of low pH in the oral cavity which then forms fluorapatite. Besides the difference in fluoride-releasing mechanisms, GIC has higher fluoride content (10-30%)[26] than F-varnish (2.26%).[27]

The lack of difference in the demineralized, originally intact area was affected by the pH cycling in the oral cavity. However, the effect that the two test materials could have had on this adjacent area cannot be totally excluded. Due to the randomized nature of this study, half of the subjects were exposed to each material in each session and all the subjects were reported to have kept to their normal diets in the two experimental sessions. Therefore, one could assume that the effect of the two materials is unlikely to be different on the adjacent intact enamel. This additional positive effect of the materials should be explored in a future study.

CONCLUSIONS

The results of our study showed that the application of GIC or F-varnish over the incipient proximal carious surface can help reduce the carious area by 33% and 52%, respectively. Further clinical study should be confirmed so that when the incipient carious lesion is detected at the proximal surface, the dentist may have the choice of separating the teeth with an elastic band and applying these materials instead of prescribing the home use of fluoride products that depend on the uncertain co-operation of the patient.

This study's results show that after treatment the average carious lesion area under GIC was significantly less than that under F-varnish.

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