# Potential inhibition of demineralization in vitro by fluoride–releasing sealants

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## ABSTRACT

**Background.** The incorporation of fluoride into sealants has been viewed as a viable way to prevent pit-and-fissure caries by potential inhibition of demineralization through the release of fluoride to enamel. The authors conducted a study to examine the effect of a recently introduced fluoride-releasing sealant (ProSeal, Reliance Orthodontic Products, Itasca, Ill.) on enamel demineralization in an in vitro artificial caries system.

**Methods.** The authors randomly assigned 45 extracted human third molars to three treatment groups receiving either conventional sealant without fluoride (Group 1), fluoride-releasing sealant (Group 2) or glass ionomer sealant with high fluoride release (Group 3). They placed cavity preparations on the buccal surfaces of the molars and filled them with the assigned material. They placed acid-resistant varnish on the specimens' enamel surfaces to within 1 millimeter of the sealant, leaving a 1-mm rim of sound enamel available for in vitro enamel caries formation. They thermocycled the teeth (500 cycles) in artificial saliva. They subjected the teeth to an in vitro artificial caries challenge for six weeks to produce carieslike lesions in enamel adjacent to the sealant materials. The authors took longitudinal sections from each tooth, immersed them in water and examined them via polarized light microscopy to determine wall lesion frequencies.

**Results.** The mean (± standard deviation) lesion depths were 232 ± 17 micrometers for Group 1, 144 ± 21 µm for Group 2 and 128 ± 15 µm for Group 3. The wall lesion frequency was 12 percent for Group 1 and 7 percent for both Groups 2 and 3. There was a significant difference ($P < .05$) among the fluoride-releasing materials versus the nonfluoride-releasing material. This study indicates that the new fluoride-releasing sealant substantially reduces the amount of enamel demineralization adjacent to the material.

**Conclusion.** ProSeal provided increased demineralization inhibition compared with a conventional sealant containing no fluoride, but less than that shown by a glass ionomer sealant.

**Clinical Implications.** ProSeal's physical properties and cariostatic effects may allow for applications beyond traditional sealant use.


**Key Words.** Fluoride; sealants; enamel; demineralization; caries; artificial caries.

*JADA 2007;138(4):502-6.*

Fluoride use has been credited with playing a major role in the reduction of caries in the pediatric population. In fact, the proportion of people entering adulthood without caries has increased dramatically.[1-3] The widespread use of fluoride in dentifrices, mouthrinses, fluoridated varnishes and gels all have helped to reduce the prevalence of dental caries. In the past few decades, owing to the introduction of bisphenol A glycidyl dimethacrylate (bis-GMA) resins, researchers have viewed fluoride incorporation into sealants as a viable way to prevent pit-and-fissure caries by means of potential demineralization inhibition through release of fluoride to tooth enamel.[4-22]

With recent advances in bonding technology, fluoride-releasing resins have potential applications beyond those of traditional pit-and-fissure sealants without fluoride, including protection of smooth surfaces, hypoplastic enamel and the area around orthodontic brackets.

The manufacturer of a rela-

**DISCLOSURE:** Reliance Orthodontic Products, Itasca, Ill., manufacturer of ProSeal, supplied the investigators with its product for this study.

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tively new fluoride-releasing resin-modified glass ionomer (ProSeal, Reliance Orthodontic Products, Itasca, Ill.) claims that the resin has 100 percent polymerization and reduces leakage because it has no oxygen-inhibited layer. In addition, it is highly filled to increase abrasion resistance, and it has fluoride-release properties to reduce the prevalence of decalcification and white-spot lesions.

We conducted an in vitro study to evaluate this new sealant in comparison with both a conventional nonfluoride-releasing resin sealant (Delton, Dentsply, York, Pa.) and a high fluoride–releasing glass ionomer sealant (GC Fuji Triage, GC America, Alsip, Ill.) with respect to in vitro inhibition of demineralization. Our hypothesis was that the use of ProSeal reduces enamel demineralization.

## MATERIALS AND METHODS

We selected 45 human extracted third molars for this in vitro study. We examined the buccal surfaces of the teeth with a dissecting microscope at ×16 magnification to ensure that they were free of any detectable white-spot lesions or other surface enamel defects. We performed soft-tissue débridement and a fluoride-free prophylaxis. We then randomly assigned 15 teeth to each of three groups receiving the following treatment:

- Group 1: conventional resin sealant without fluoride (Delton);
- Group 2: fluoride-releasing resin sealant (ProSeal);
- Group 3: glass ionomer sealant (GC Fuji Triage).

We prepared cavities without feathered edges or bevels within the middle one-third of the buccal enamel surface of the teeth using fissurotomy burs (SS White Burs, Lakewood, N.J.) and a high-speed handpiece. The depth of the cavity preparations was approximately 1.5 millimeters. We then placed the sealant materials in the cavity preparations according to the manufacturers' recommendations as follows:

- Group 1: we acid-etched the entire cavity with 37 percent phosphoric acid gel for 30 seconds, rinsed it with distilled water for 10 seconds and dried it with oil-free compressed air for 10 seconds, then placed the material in the cavity with the manufacturer's direct delivery system up to the cavosurface margin and light cured it for 40 seconds with a light-curing unit (Optilux 501, Demetron, Danbury, Conn.).
- Group 2: we filled the entire cavity preparation with ProSeal using a disposable brush, then light cured the material for 40 seconds.
- Group 3: we cleaned the entire cavity preparation for 15 seconds with Cavity Conditioner (GC America), rinsed it for 10 seconds with distilled water and dried it with compressed air. We triturated the GC Fuji Triage capsule for 10 seconds and injected the material into the cavities. After removing the excess with a plastic instrument, we light cured the material for 40 seconds with a curing lamp (Optilux 501, Demetron).

We applied an acid-resistant varnish to the surface of the molars, leaving a 1-mm rim of exposed sound enamel surrounding the sealant-filled cavities. This procedure allowed for the in vitro formation of white-spot lesions adjacent to the sealants using an artificial caries medium. We then thermocycled the teeth (5 C to 55 C for 500 cycles, with a dwell time of 30 seconds) in artificial saliva (20 millimoles bicarbonate of soda, 3 mmol sodium dihydrogen phosphate, 1 mmol calcium chloride, pH 7.00).[23,24] After thermocycling, we inspected the teeth to determine whether the acid-resistant varnish was intact and reapplied it as necessary.

We then exposed the specimens to an acidified gelatin gel (dialyzed gel, pH 4.25, 1 mmol calcium, 0.6 mmol phosphate, < 0.05 mmol fluoride) for six weeks to produce carieslike lesions in enamel adjacent to the sealant materials.

We took two longitudinal sections from each tooth, immersed them in water, examined them with polarized light microscopy, and took photomicrographs of them.[11,19,22] We determined mean lesion depths of the carieslike lesions in a blinded fashion by projecting the photomicrographs onto a computer-interfaced digitized tablet and measuring 10 points along the advancing front of the lesions.[11,19,22] Using the same protocol, we also determined the presence or absence of wall lesions for each specimen. We measured the advancing front along the body of the outer surface lesion, with the first measurement located 100 micrometers from the cavity preparation. In terms of our statistical analyses, we used analysis of variance (ANOVA), Duncan multiple range test and *t* test, where appropriate, to demonstrate differences among the three treatment groups.

**ABBREVIATION KEY. ANOVA:** Analysis of variance. **Bis-GMA:** Bisphenol A glycidyl dimethacrylate.

**TABLE**

**Effect of fluoride release from sealant material on enamel demineralization.**

| SEALANT* | MEAN OUTER LESION DEPTH† (MICROMETERS) ± STANDARD DEVIATION | WALL LESION FREQUENCY (%) | REDUCTION IN OUTER LESION DEPTH (%)‡ |
|---|---|---|---|
| **Group 1: Delton** | 232 ± 17[a,b] | 12[d,e] | Versus ProSeal: 38<br>Versus GC Fuji Triage: 45 |
| **Group 2: ProSeal** | 144 ± 21[a,c] | 7[d] | Versus GC Fuji Triage: 14 |
| **Group 3: GC Fuji Triage** | 128 ± 15[b,c] | 7[e] | — |

* Delton is manufactured by Dentsply, York, Pa. ProSeal is manufactured by Reliance Orthodontic Products, Itasca, Ill. GC Fuji Triage is manufactured by GC America, Alsip, Ill.
† Mean lesion depths and wall lesion frequencies with same letters are significantly different (analysis of variance, Duncan multiple range test, $P < .05$).
‡ Significant difference among all groups ($t$ test, $P < .05$).

## RESULTS

The table shows the mean depths of the outer lesions from the three treatment groups. We compared the mean depth of outer lesions using ANOVA and Duncan multiple range test (significance level of $P < .05$). A total of 90 caries-risk sites were available for analysis.

The mean outer lesion depth was greatest for Group 1 (conventional sealant group without fluoride) and least for Group 3 (glass ionomer sealant). Mean reductions in outer lesion depth for the glass ionomer sealant (Group 3) and fluoride-releasing sealant (Group 2) were 55 percent and 62 percent, respectively, when compared with that for the conventional sealant group (Group 1). We observed a significant difference among the three treatment groups ($P < .05$), with the glass ionomer sealant group demonstrating the smallest lesion depth. The outer lesions adjacent to cavities filled with fluoride-releasing sealant had a reduction of 38 percent in depth when compared with those filled with the conventional nonfluoride-containing sealant. The outer lesions adjacent to the cavities filled with glass ionomer sealant had a reduction of 45 percent in depth when compared with the conventional nonfluoride-containing sealant. The glass ionomer sealant group also had a 15 percent reduction in outer lesion depth when compared with the fluoride-releasing sealant group. We calculated the percentage of reduction by dividing the mean lesion depth for the treatment group by the mean lesion depth for the control group and multiplying the result by 100 percent.

Wall lesion frequency was identical for the glass ionomer sealant and fluoride-releasing sealant groups. The group that received the conventional nonfluoride-containing sealant had a wall frequency of 12 percent, while the other two treatment groups had a wall lesion frequency of 7 percent (Table). Both fluoride-releasing sealants had a reduction of 58 percent in wall lesion frequency when compared with the conventional sealant, which we found to be statistically significant ($P < .05$, $t$ test). Wall lesions were confined to the superficial part of the cavity preparation and typically were wedge-shaped with the broad base facing toward the outer enamel surface. The figure shows the results for the different groups.

## DISCUSSION

The role of fluoride released from dental materials in the prevention of caries initiation and progression has been well-established in the dental literature.[5-10] Although researchers have shown that other agents such as fluoridated varnishes, dentifrices, mouthrinses and gels can reduce the prevalence of caries, the fluoride released from dental materials also plays a promising role in caries prevention.[5-9,11-22] The ability of a dental material to act as a fluoride reservoir is a distinct advantage in caries resistance, both at the enamel-restorative interface and adjacent to the outer enamel surface near the fluoride-releasing dental material.[11-15]

The results of our study show a significant reduction in the frequency of wall lesions in the groups that received fluoride-releasing sealant when compared with the group that received the conventional nonfluoride-containing sealant. The presence of fluoride at the enamel-restorative interface plays a role in reducing the incidence of caries initiation and progression at this interface, as found in our study. The similarity between the wall lesion presence for ProSeal and GC Fuji Triage may be caused by the limited access to the interface by fluoride ions. ProSeal and GC Fuji Triage have similar adherence to enamel-resin interfaces owing to both physical and chemical bonding to the tooth's mineral elements. Both

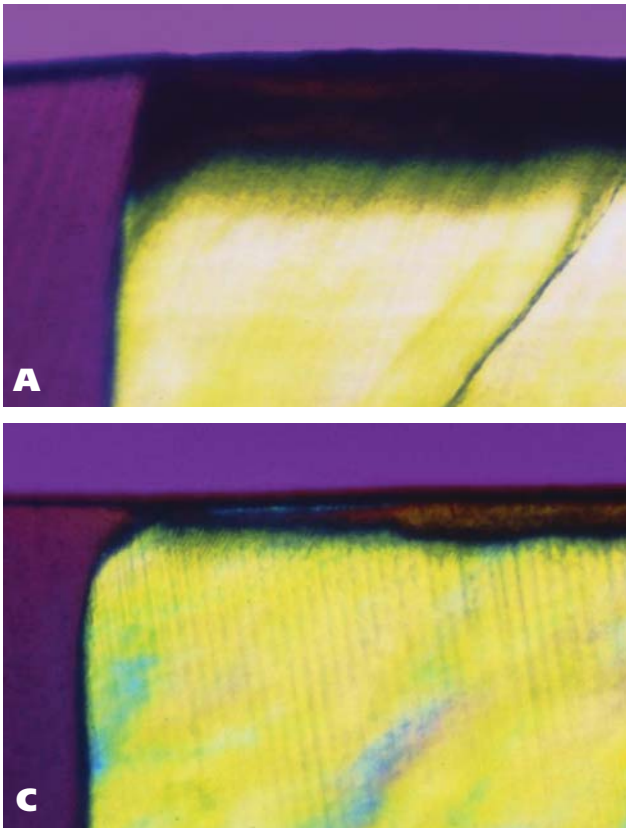


**Figure.** Artificial enamel caries formation adjacent to each of the sealants tested. Specimens were immersed in water and photographed using polarized light microscopy under ×200 magnification. **A.** Nonfluoride-releasing sealant (Delton, Dentsply, York, Pa.). **B.** Fluoride-releasing resin-modified glass ionomer sealant (ProSeal, Reliance Orthodontic Products, Itasca, Ill.). **C.** Glass ionomer sealant (GC Fuji Triage, GC America, Alsip, Ill.).

ProSeal (resin-modified glass ionomer) and GC Fuji Triage (glass ionomer) have a relatively high fluoride content, and both release enough fluoride to the local environment to inhibit caries significantly. The fluoride content and period during which fluoride is released are greater for GC Fuji Triage (glass ionomer) than they are for ProSeal (resin-modified glass ionomer). With diffusion of fluoride being greater and the period of fluoride release being longer for GC Fuji Triage, the outer surface lesion would be affected to a greater extent than the cavosurface lesion owing to unimpeded access to the fluoride released.

We noted a significant difference in the reduction of the mean outer lesion depth when we compared the groups that received the fluoride-releasing sealant with the group that received the conventional nonfluoride-containing sealant (Delton). There also was a significant difference in the reduction of the mean outer lesion depth between the fluoride-releasing sealant groups. The glass ionomer sealant group (GC Fuji Triage) exhibited a significant reduction in the mean outer lesion depth when compared with the resin fluoride-releasing sealant (ProSeal). This finding suggests that the increased resistance to caries in the enamel near the fluoride-releasing material may be related proportionately to the increased level of releasable fluoride from dental materials. The higher fluoride content of the glass ionomer sealant may explain the greater reduction it brought about in the mean outer lesion depth when compared with the resin fluoride-releasing sealant. This finding is not surprising, because other studies also have shown that the increased fluoride content of glass ionomer materials allows for a greater degree and more prolonged release of fluoride than those of other dental materials.[10,13-17]

Another factor that deserves consideration is that fluoride-releasing materials have the ability to be recharged with fluoride from daily use of readily available exogenous fluoride sources, such as over-the-counter fluoridated dentifrices, fluoride mouthrinses and fluoride gels.[15,18] The ability of fluoride-releasing materials to be recharged allows for extended fluoride release long after the exogenous source of fluoride has been cleared from the oral environment by salivary flow.[10-12] This extended release could further increase resistance of enamel near the fluoride-releasing material and also may offer some protection against active lesion progression by aiding in the remineralization process. Investigators who conducted a previous in vitro study found that surface enamel located up to 7.5 mm away from a fluoride-releasing material experienced significant increases in fluoride content (2,250 parts per million) over baseline fluoride levels.[5]

While the application of fluoride-releasing

sealants in susceptible pits and fissures has received considerable attention in the dental literature, other possible applications often have not been mentioned. The physical property of the transparent ProSeal allows it to be applied in a thin layer while maintaining a visible enamel surface. This allows the potential for application to the facial enamel surfaces of anterior teeth, where other sealants cannot be placed because of esthetic considerations. This may enable application of this material in situations in which hypoplastic enamel, hypomineralized smooth surface enamel and incipient white-spot lesions are present or have an increased potential for developing, such as around orthodontic appliances.[19,20] An in vitro study has shown that even unfilled resins without fluoride inhibited demineralization of enamel in both primary and permanent teeth.[21] The addition of fluoride may reduce enamel solubility, as well as aid in the remineralization of hypomineralized enamel, by increasing caries resistance in susceptible enamel surfaces.[22]

## CONCLUSIONS

We can draw the following conclusions from the results of our study:

- Fluoride-releasing sealants (ProSeal, GC Fuji Triage) showed a significant reduction in wall lesion frequency when compared with a nonfluoride-containing sealant (Delton).
- The mean outer lesion depths in enamel adjacent to fluoride-releasing sealants were significantly reduced when compared with those in enamel adjacent to a nonfluoride-containing sealant. ■

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