

## Evaluation of a fluoride-containing sealant by SEM, microleakage, and fluoride release

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### Abstract

*A fluoride-containing sealant (FluroShield) was evaluated in vitro and compared to a sealant without fluoride (HelioSeal). Both materials were applied to the occlusal surface of extracted teeth and microscopically evaluated for their ability to penetrate pits and fissures. Additional specimens were subjected to dye immersion and evaluated for resistance to microleakage. Disc-shaped samples of the fluoride-containing sealant were immersed in distilled water and analyzed daily for seven days for fluoride release. All specimens of FluroShield released fluoride during the evaluation period, but there were differences between the materials in resistance to microleakage.*

### Introduction

Sealants have been used for the past 18 years (Cueto and Buonocore 1967) in pediatric dentistry. Since the efficacy of sealants has been questioned by some (Eames 1988) and recommended enthusiastically by the American Dental Association (Council on Dental Materials, Instruments, and Equipment 1981), the American Academy of Pediatric Dentistry, and the American Society of Dentistry for Children (Harrison 1983), the subject of preventive occlusal resins is controversial. To this date, sealants have had a poor acceptance by the profession. In the 1986-87 survey by the National Institute of Dental Research (Jakush 1989) which was reported at the 1989 meeting of the American Association for Dental Research, 8% of urban and suburban children and 6.3% of rural children had sealants. In the surveyed population of 40,000 children between the ages of 5 and 17 years, those with sealants had an average of 4.2 sealants per child.

Pits and fissures are recognized as highly susceptible to caries and least benefited by systemic or topical fluoride (Backer Dirks 1974). Sealants do prevent caries (Mertz-Fairhurst 1984) and are cost effective (Simonsen

1989). Mertz-Fairhurst (1984) reported that at the end of 10 years 78.3% of those first permanent molars with a single application of sealant placed in pits and fissures were caries free, compared to the unsealed matched pairs which had a caries-free rate of 31.3%. In that study, in which a white sealant (Concise, 3M Dental Products) was photographed, the sealants were considerably worn, yet continued to prevent caries (in contrast to the unsealed contra-lateral molars).

More recently, a commercially available sealant with fluoride has been marketed that purportedly releases fluoride. This product (FluroShield<sup>®</sup>, Caulk/Dentsply, Milford, DE 19963) is a visible light cure resin containing sodium fluoride and 50% (by weight) inorganic filler. Small quantities of fluoride have been shown to be of value in preventing demineralization. Fluoride also participates in remineralization of enamel (Norman 1960 and Triolo 1989). The adhesive properties of fluoride-releasing resins are affected by the delicate balance maintained between the structural properties of the material and the significant release of fluoride over time (Rawls 1988).

It is appropriate to assume that pediatric dentists would be most affected by the success or failure of a commercial fissure sealant which contains 50% by weight of inorganic filler having releasable fluoride. The purpose of this investigation was to evaluate a recently marketed commercially available fluoride-containing sealant.

### Materials and Methods

A pit and fissure sealant containing fluoride (FluroShield) was evaluated for its ability to penetrate fissures, resist microleakage, and release fluoride. It was compared to a pit and fissure sealant that did not contain fluoride (HelioSeal, Vivadent Inc., Tonawanda, NY

14151). HeliSeal was selected because it does not contain fluoride and is a visible light cure sealant. One investigator prepared all the specimens for this study.

### Fissure Penetration

Ten extracted human molar teeth that had been stored in 10% formalin were used as test specimens for each sealant. The occlusal surface of each of the teeth was etched for 60 sec with the etchant supplied with the sealant kit. The etched surface was washed for 30 sec and then air dried. Each sealant was applied to 10 teeth and cured for 20 sec with a visible light curing unit (Coe-Lite, Coe Laboratories, Chicago, IL 60658). Each tooth was sectioned from buccal to lingual with a diamond saw (Isomet, Buehler Inc., Evanston, IL 60204). Each specimen was examined for fissure penetration under a stereobinocular microscope by one examiner who was "blind" to the groups, and confirmed by two investigators. One of three ratings was assigned to each sample: Good (complete adaptation and penetration into all fissures), Fair (one minor failure of adaptation or penetration), or Poor (major failure of adaptation or penetration). Also, two teeth from each group were vacuum desiccated, gold coated, and examined for adaptation with a scanning electron microscope (JOEL, Model JSM-35, Peabody, MA 01960).

### Microleakage

Thirty extracted human molar teeth were used as specimens for each sealant. The sealants were applied to the teeth as described in the previous section. The specimens were thermocycled for 800 cycles at 6°C and 60°C with an immersion time of 30 sec. Except for the area covered with sealant and 1 mm of the surrounding enamel, the teeth were completely coated with nail polish and then placed in 5% methylene blue for 4 hr. The teeth were sectioned with a diamond saw, and both halves examined with a stereobinocular microscope (IOX) for microleakage between the sealant and the enamel. Each specimen was examined by one examiner who was "blind" to the groups. Results were confirmed by two investigators. The following scores were used: 0—No microleakage, 1—Microleakage along the enamel-sealant interface, 2—Microleakage penetrating to depth of fissure.

### Fluoride Release

Five disc-shaped specimens (15 mm x 1 mm) were made from the FluroShield sealant by using a Teflon™ matrix of the same size. The sealant was step polymerized for 20 sec in each quadrant using a visible light curing unit (Coe-Lite, Coe Laboratories, Chicago, IL 60658). One specimen of HeliSeal was prepared in the same manner.

After polymerization, each disc was placed in 10 ml of distilled water in a plastic specimen bottle. A blank

(with no specimen) also was prepared using 10 ml of distilled water. The samples and containers were maintained at 37°C throughout the duration of the study.

Fluoride release was determined with the Orion Research Combination Fluoride Electrode and an Orion Digital Ionalizer (model 601A, Orion Research Inc., Cambridge, MA 02139). The fluoride electrode was standardized before each test according to the manufacturer's instructions.

The fluoride electrode gave readings which were in millivolts (mv) and were converted to parts per million (ppm) of fluoride. This was accomplished by entering the millivolt readings of the fluoride standards (1, 10, 100 ppm) into a computer program (Curve Fit, Public Brand Software, Indianapolis, IN 46251) that mathematically established the fluoride level for each mv unit. The mv readings from each test specimen were recorded, then compared to the computer-generated listing for conversion to ppm of fluoride.

Fluoride measurements were made daily for seven days. During the fluoride measurements, the specimen discs were removed from their containers, and the solution analyzed for fluoride. TISAB (total ionic strength adjustment buffer) was added to each sample to provide a constant background ionic strength, decomplex fluoride, and adjust solution pH. After the measurements, the solution was discarded. To each specimen was added 10 ml of distilled water in preparation for the next 24 hr analysis.

## Results

The results are divided into three separate phases as in the test procedure:

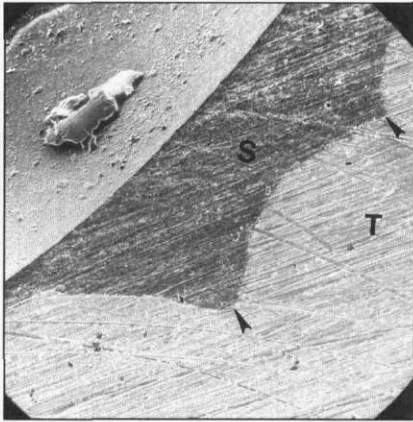
### Fissure Penetration

The 10 samples of each product were rated good, fair, or poor for fissure penetration and adaptation to the enamel as follows:

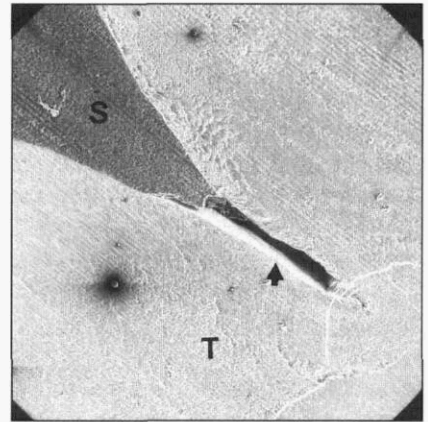
HeliSeal			FluroShield		
<u>Good</u>	<u>Fair</u>	<u>Poor</u>	<u>Good</u>	<u>Fair</u>	<u>Poor</u>
3	1	6	3	3	4

Both materials had three specimens that were rated as good, but the HeliSeal had six specimens rated as poor, while the FluroShield had four. When this data was subjected to a Chi-Square test, no significant differences were found between the two groups ( $P > .05$ ).

In those samples prepared for SEM observation, the HeliSeal developed a close adaptation to the enamel surface as can be seen in Figs 1 & 2 (see next page). However, Fig 2 shows that the HeliSeal did not penetrate to the depth of a deep, narrow fissure. Both materials experienced this lack of penetration on several samples.



**Fig 1.** (left) HelioSeal (S) demonstrating complete penetration into the depths of two fissures (arrows). The sealant is identified by an "S" and the tooth by a "T". 55X



**Fig 2.** (right) HelioSeal. A deep fissure (arrow) which the sealant (S) did not completely penetrate (T-tooth). The deepest area of the fissure may have contained plaque, debris, or air that prevented the sealant from flowing into the area. 55X

The FluroShield varied in its adaptation to the enamel as illustrated in Figs 3 through 5 (see bottom, this page), yet it did penetrate to the depth of the fissures on the SEM specimens as depicted by the photographs. On the surface and in crosssection, the FluroShield appeared more coarse than the HelioSeal.

### Microleakage

The microleakage scores are listed in Table 1 (upper right, next page). HelioSeal did not allow any microleakage with any of the specimens. FluroShield had microleakage on seven of the specimens which penetrated to the depth of the fissure in three cases. When this data was subjected to a Chi-Square test, FluroShield was found to have significantly more leakage ( $P < .05$ ).

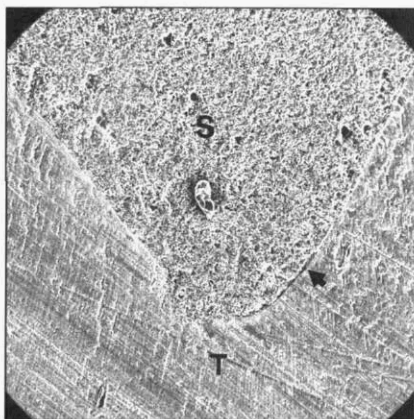
### Fluoride Release

All FluroShield specimens released fluoride over the seven-day test period (Fig 6, next page). The mean fluoride release decreased by one-half for each of the first three days and stabilized at approximately  $1 \mu\text{g}/\text{cm}^2$

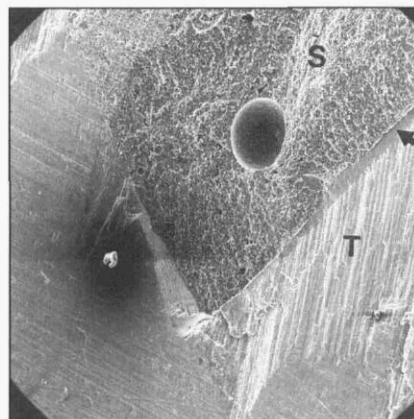
(.41 ppm) the final two days. The blank and HelioSeal did not have any detectable fluoride at any of the test periods. When this data was subjected to a *t*-test (one tail), there was a significant decrease in fluoride release from FluroShield for each day except day seven ( $P < .05$ ).

### Discussion

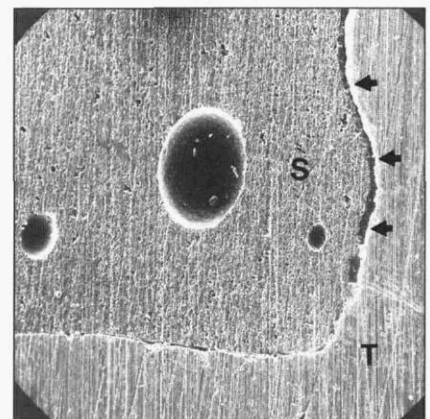
When examined for fissure penetration and adaptation to the enamel, there was no statistical difference between the two products. On examination with the SEM, the fluoride-containing sealant (FluroShield) did not appear to adapt as well to the enamel surfaces as did the nonfluoride sealant (HelioSeal). This also was reflected in the microleakage phase of the study in which seven of the FluroShield specimens exhibited microleakage, and the dye penetrated to the depth of the fissure in three specimens. Both of these problems may be related to viscosity. It was noted that the FluroShield was more viscous than the HelioSeal and did not appear to flow as well into the fissures. However, adaptation as



**Fig 3.** FluroShield. This fissure was completely filled with the sealant (S) and had close adaptation to the tooth (T), except for one of the deeper areas (arrow). 120X



**Fig 4.** FluroShield. The sealant (S) penetrated to the depths of a "V"-shaped fissure (T-tooth). One area (arrow) did not have close adaptation to the enamel. A void or air bubble can be seen in the center of the sealant. 120X



**Fig 5.** FluroShield. The sealant (S) did not adapt well to the walls of this fissure (arrow) which may permit leakage (T-tooth). 120X

Fluoride Release from FluroShield

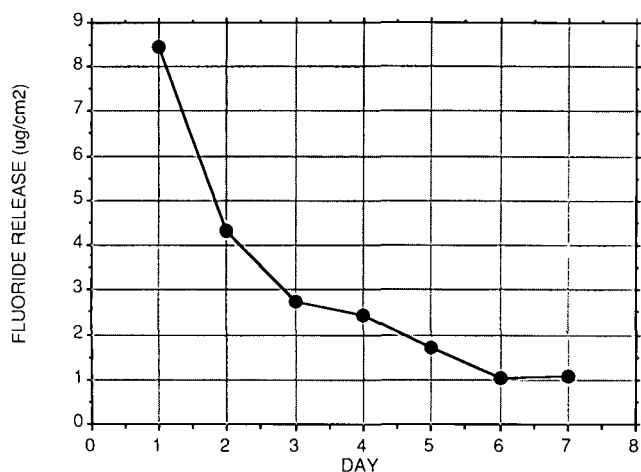


Fig 6. Mean Daily Fluoride Release from FluroShield.

visualized under the stereobinocular microscope, was not statistically different for FluroShield with 50% filler compared to HelioSeal, which is unfilled.

All the FluroShield specimens released fluoride for seven days. There was a "burst effect" in which larger amounts of fluoride were released on the first and second day, then the release tapered off. Fluoride release decreased by approximately one-half for each of the first three days. Statistical analysis found that there was a significant decrease in fluoride release for each day except the last one. A similar "burst effect" has been seen with fluoride-containing composites (Cooley et al. 1988), cavity liners/bases (McCourt et al. 1990), and orthodontic adhesives (Cooley et al. 1989). Previous studies have found that fluoride is released from ultraviolet light-cured sealants over a three-week period and that the quantity of fluoride ions released was related to the available fluoride in the sealant (El-Mehdawi et al. 1985). Tanaka et al. (1987) found that fluoride release from an experimental sealant in vivo deposited significant fluoride concentrations to a 60  $\mu$ m depth in the enamel. They concluded that a fluoride resin sealant could be expected to protect the enamel from caries even after sealant detachment.

Although dye immersion displayed leakage of the FluroShield which was statistically greater than HelioSeal, there may still be a caries-preventive effect since the residual tags within the enamel surface (10–20  $\mu$ m) contain fluoride. Fluoride uptake by the enamel from the sealant may inhibit caries formation (Rawls 1988).

## Conclusions

A fluoride-containing sealant (FluroShield) was evaluated for penetration into fissures, resistance to microleakage by dye immersion, and fluoride release.

TABLE 1. Individual Microleakage Scores

Leakage Scores	0	1	2
HelioSeal	30		
FluroShield	23	4	3

There was no difference, statistically, between the fluoride-containing sealant (FluroShield) and a non-fluoride sealant (HelioSeal) in ability to penetrate fissures. The FluroShield allowed microleakage in seven of the specimens tested. With consideration to it being 50% filled (by weight), FluroShield adapted and penetrated the fissures well, and its microleakage may not be clinically significant considering its ability to release fluoride. All specimens of the FluroShield released fluoride over the seven-day test period. There was a "burst effect" in which larger amounts of fluoride were released on the first and second day. On each of these days, the released concentrations of fluoride decreased by approximately one-half.

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