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Evaluation of an autopolymerizing fissure sealant as a vehicle for slow release of fluoride

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Abstract

The purpose of this study was to investigate the rate of fluoride release from an autopolymerizing fissure sealant containing various proportions of sodium fluoride. In the first phase, cured resin discs containing 0.00%, 0.1%, 0.25%, 1.0%, and 2.5% sodium fluoride were evaluated over a 180-day period. The second phase studied the release from the fissure sealant containing 2.5% sodium fluoride when bonded to the occlusal surfaces of noncarious premolars and molars. Determinations were made at the end of 7 and 30 days. The pattern of fluoride release was similar for all experimental groups with considerable fluoride being leached during the first day but decreasing rapidly thereafter. The surge of fluoride released after one day apparently was due to sodium fluoride on the surface of the cured sealant resin which quickly went into solution. The fluoride released from samples containing 2.5% sodium fluoride was significantly greater than that released from the other test specimens from days 31 to 90. However, there was no significant difference in fluoride release from the resins containing 1.0% and 2.5% sodium fluoride during the 91 to 180-day test period. Over 96% of the total incorporated fluoride remained bound at the end of the test period. In conclusion, a bis-GMA fissure sealant would not appear to be an appropriate vehicle for delivering fluoride to the oral cavity.

The cariostatic effects of fluoride are well known. However, these benefits are limited primarily to the smooth surfaces of teeth. Approximately 80% of the dental caries experienced by children are of the pit and fissure variety.[1] Several methods have been proposed to provide protection to these areas by using sealants. Investigations by Buonocore and others led to the development of the first effective and clinically practical occlusal fissure sealant which was an ultraviolet light-cured reaction product of bisphenol A and glycidyl methacrylate (bis-GMA).[2,3]

The protective effects of fluoride are enhanced if its clearance from the oral cavity is prolonged. Systems have been developed for providing ambient fluoride, e.g., varnishes containing—or used with—fluoride compounds, fissure sealants containing fluoride, or fluoride-releasing devices. Varnishes containing fluoride have provided marked protection to the tooth even though the varnish layer lasts only a few days.[4-6] A device that would provide a slow, continual release of fluoride should provide even greater benefit.[7] However, they are not yet available for general use.

It would be useful if an existing sealant could be modified in order to provide protracted low levels of fluoride. Attempts to combine the benefits of extended topical fluoride application with occlusion of caries-susceptible fissures have been made in the past.[8,9] Recently, El-Mehdawi et al. presented data which suggested that a hard, nonflexible, ultraviolet light-cured, bis-GMA fissure sealant[a] could be used as a vehicle for extended fluoride release. They reported that fluoride ion release increased over the duration of the in vitro study and with the level of sodium fluoride in the resin.[10]

The present study investigated the rate of fluoride release from mixtures containing various proportions of sodium fluoride in an autopolymerizing fissure sealant.[b]

Methods and Materials

The stock for these mixtures was formed by adding sodium fluoride powder to bottles of universal sealant resin.[b] These mixtures when added to a catalyst[b] (1:1) formed a plastic containing various concentrations of fluoride. Five experimental groups were prepared:

[a] Nuva Seal; L.D. Caulk Co., Milford, DE.
[b] Delton Pit and Fissure Sealant (Batch #2M402); Johnson & Johnson Products, Inc., East Windsor, NJ.

Group A (control)	—0.00% sodium fluoride
Group B	—0.1% sodium fluoride
Group C	—0.25% sodium fluoride
Group D	—1.0% sodium fluoride
Group E	—2.5% sodium fluoride

The study was divided into two phases. In the first phase, six resin discs, or specimens, were made for each of the five groups. Each specimen was transferred to a plastic tube containing 5 ml of distilled water which was replaced after each extraction period. The extraction periods were 0-1, 2-7, 8-30, 31-90, and 91-180 days. A 1 ml aliquot of each extract was mixed with an equal volume of total ionic strength adjustor (TISAB II[c]). Fluoride levels of the resultant mixtures were measured using a fluoride-specific ion electrode and meter.[c] The electrode was allowed to equilibrate for one minute in each sample before recording the results. Data from each time period were analyzed with a one-way ANOVA. Mean differences were tested using Tukey's method.[11]

In the second phase of the study four extracted noncarious mandibular permanent molars and four maxillary premolars were selected and washed with a toothbrush and distilled water. The autopolymerizing fissure sealant containing 2.5% sodium fluoride was placed on the occlusal surface of the teeth according to the manufacturer's instructions. Each tooth was placed in an individual plastic test tube along with 5 ml of distilled water. Fluoride release was determined at the end of days 7 and 30 using the same methods described earlier.

Results

The mean weight of the sealant samples was similar for each of the five groups in phase one (204.72 ± 3.53 mg) and the coefficient of variation for the groups was low (0.09 ± 0.03). The pattern of fluoride release was similar for all experimental groups with considerable fluoride being leached during the first day but decreasing rapidly thereafter. However, fluoride release remained relatively stable from the specimens containing 2.5% sodium fluoride through the 8 to 30- and 31 to 90-day test periods. The released rate of specimens from three of the groups (containing 0.00%, 0.1%, and 0.25% sodium fluoride) was statistically equivalent during each test period. Only the fluoride released from the samples contaning 2.5% sodium fluoride was significantly different from the other groups from 31 to 90 days. However, the total fluoride leached from 91 to 180 days from the specimens containing 1.0% and 2.5% sodium fluoride was not significantly different (Tables 1 & 2). Despite the protracted period of release, more than 96% of the total incorporated fluoride remained bound in all the resin discs at the end of the test period.

[c] TISAB II; Orion 94-09 Fluoride Electrode; Orion 901 Ionalyzer; Orion Research Inc., Cambridge, MA.

Table 1. Total Micrograms of Fluoride Released During Time Intervals

Group	*1 Day*	*2-7 Days*	*8-30 Days*	*31-90 Days*	*91-180 Days*
A (control)	0.60	0.50	0.20	0.55	0.55
B	4.75	0.90	0.55	1.30	0.80
C	13.05	2.40	1.25	2.10	1.40
D	61.35	6.90	3.10	4.95	3.20
E	95.55	11.45	5.70	19.95	3.65

Means connected by a solid line are *not* significantly different ($p < 0.05$). Tukey's "t". A break in the line denotes a significant difference. The mean coefficient of variance (cv) for each time period ranged from 0.24 to 0.31.

Table 2. Micrograms of Fluoride Released Per Day

Group	*1 Day*	*2-7 Days*	*8-30 Days*	*31-90 Days*	*91-180 Days*
A (control)	0.60	0.070	0.010	0.010	0.005
B	4.75	0.105	0.025	0.020	0.010
C	13.05	0.345	0.060	0.0035	0.015
D	61.35	0.985	0.150	0.085	0.035
E	95.55	1.635	0.270	0.330	0.040

Means connected by a solid line are *not* significantly different ($p < 0.05$). Tukey's "t". A break in the line denotes a significant difference.

The rate of fluoride release from the sealed surfaces of the premolars and molars was approximately 10% that of the unattached discs. The discharge of fluoride from the discs appears to simulate the fluoride release into the oral cavity if approximately 10 posterior teeth were sealed.

Discussion

The surge of fluoride release observed after one day in all experimental groups apparently was due to the sodium fluoride on the surface of the cured sealant resin which quickly went into solution. The resin containing 2.5% sodium fluoride released signficantly more fluoride per day than the other groups throughout all test periods except 91-180 days. Nevertheless, when the dilution factor of average daily saliva secretion (1,500-2,000 ml/day) is considered, the fluoride level which would be present drops below any known level of physiological significance.[12,13]

An autopolymerizing sealant was used in this study rather than an ultraviolent light-cured type as employed by El-Mahdawi et al.[10] However, the present investigation supports their findings that fluoride incorporated in a bis-GMA fissure sealant is released at a level directly related to the quantity of sodium fluoride added to the resin. However, observations by

the authors of this study indicate that the fluoride is released at very low levels and would not be clinically effective.

Theoretically, a fissure sealant that could store and release approximately 0.5 mg of fluoride per day for a protracted period of time would be an excellent caries prevention device. However, the bis-GMA resins are apparently too rigid and hydrophobic to provide this vehicle. One also could speculate that the protective effects of the sealant actually may be compromised by the addition of sodium fluoride. Inspection of the discs under a dissection microscope (15x) revealed that the specimens which contained fluoride exhibited greater surface roughness than did the unadulterated plastic. The rougher surface could provide a more secure attachment for microorganisms and a niche for harboring food residues. Furthermore, the sodium fluoride crystals may weaken the plastic and its attachment to the tooth.

Conclusions

Based on the results of this study and the foregoing speculations, the authors consider the bis-GMA fissure sealant as an inappropriate vehicle for delivering fluoride to the oral cavity.

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1. Jackson D: Caries experience in English children and young adults during the years 1947–1972. Br Dent J 137:91–98, 1974.
2. Buonocore MG: A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. J Dent Res 34:849–53, 1955.
3. Buonocore MG: Adhesive sealing of pits and fissures for caries prevention, with use of ultraviolet light. JADA 80:324–28, 1970.
4. Riethe P, Weinmann K: Caries inhibition with fluoride gel and fluoride varnish in rats. Caries Res 4:63–68, 1970.
5. Heuser H, Schmidt HFM: Deep impregnation of dental enamel with a fluorine lacquer for prophylaxis of dental caries. Stoma 21:91–100, 1968.
6. Heuser H, Schmidt HFM, Wienmann J: Inwieweit beeinflusst eine kurze Anätzung des Zahnschmelzes die Wirkung einer Touchierung der Zähne mit Fluorlack: II. Dtsch Zahn Mund Kerferheilkd 55:266–73, 1970.
7. Mirth DB, Shern RJ, Emilson CG, Adderly DD, Li SH, Gomez IM, Bowen WH: Clinical evaluation of an intraoral device for the controlled release of fluoride. JADA 105:791–97, 1982.
8. Lee H, Ocumpaugh DE, Swartz ML: Sealing of developmental pits and fissures. II. Fluoride release from flexible fissure sealants. J Dent Res 51:183–90, 1972.
9. Roydhouse RH: Prevention of occlusal fissure caries by use of a sealant: a pilot study. J Dent Child 35:253–62, 1968.
10. El-Mehdawi SM, Rapp R, Draus F, Zullo T: In vitro study of addition of sodium fluoride to ultraviolet-cured sealant as evaluated by fluoride ion release. J Dent Res (abstract) 62:204, 1983.
11. Winer BJ: Statistical Principles of Experimental Design. New York; McGraw Hill, 1962 pp 79.
12. Mandel ID: Sialochemistry in diseases and clinical situations affecting salivary glands. Critical Rev Clin Lab Sci 12:321–66, 1980.
13. Ingram G, Nash PF: A mechanism for the anticaries action of fluoride. Caries Res 14:298–303, 1980.