

Original Article

Use of Fluoride-containing Sealant on Proximal Surfaces

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A visible light curing sealant was developed for the prevention of caries on the smooth surfaces especially on the proximal surfaces. The sealant is mainly composed of dimethacrylate monomers. It contains a total amount of 2.28 mass% fluoride as poly(methyl methacrylate-co-methacryloyl fluoride) and sodium fluoride. The fluoride-containing sealant could be successfully applied to the proximal surfaces between the first and second primary molars by making access to the interproximal space with an orthodontic separating module. Availability of fluoride was assessed by the concentration of fluoride released into 1 ml of distilled water as a function of time from disks 5 mm in diameter and 0.2 mm in thickness. Ten μg of fluoride was measured on the first day; after 3 days the rate remained fairly constant at about 1 $\mu\text{g}/\text{day}$ for a period of 28 days. The fluoride uptake and the improved acid solubility were investigated in vitro using bovine incisors. The fluoride of the control, that is enamel without sealant treatment, was not detectable. The fluoride incorporated into enamel after 37 hours application was 2100 ppm at 2 μm from the enamel surface. The enamel solubility to acids decreased by the fluoride incorporation.

Key words: proximal surfaces; fluoride; coating;

sealant; visible light curing

Introduction

The incidence of dental caries in deciduous dentition is most prominent on the occlusal surfaces of molars, on the proximal surfaces between the first and the second molars and also the mesial surfaces of the upper central incisors. Pit and fissure sealant has been used effectively for the prevention of occlusal caries^{1,2,3}. Dentists do not have, however, a very effective preventive method for proximal caries other than the instruction of tooth brushing and flossing at present.

A method of tooth separation in clinical pediatric dentistry using elastic bands was introduced by Seow⁴. He suggested that the application of the elastic bands created enough interproximal space to diagnose proximal lesions and to protect proximal surfaces in restorative preparations. In principle, this method could also be used to apply caries preventive agents to the proximal surfaces, as well as occlusal surfaces as indicated by Pitts et al⁵. Adherence of the sealant to the tooth surface is extremely important for its successive prognosis. Mertz-Fairhurst et al⁶ reported, for example, that the total or partial loss of sealant on occlusal surfaces led to the same caries incidence as that of untreated control surfaces. The use of fluoridated sealant is also desirable because of its greater chemical stability of enamel acquired by the uptake of fluoride originally in the sealant⁷. Both adherence and fluoride availability of sealant seem to be anticipated for the protection in the proximal surfaces against dental caries.

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The purposes of the present study were to investigate the following points. 1) clinical procedures to coat properly proximal surfaces with a protective sealant, 2) incorporation of fluoride originally present in sealant by enamel, and 3) reduction on acid solubility of enamel by the incorporated fluoride.

Materials and Methods

The visible light curing sealant was composed mainly of dimethacrylate monomers which were used in ordinary pit and fissure sealants. The viscosity was adjusted suitable for applying to the proximal surfaces using a small brush. It contained a total amount of 2.28 mass% fluoride as poly(methyl methacrylate-co-methacryloyl fluoride) and sodium fluoride. The structure of copolymer is shown in Fig 1. The fluoride in the copolymer is released slowly by hydrolysis and replaced by a hydroxy group followed by the anhydride formation⁸. The mechanical property of the sealant was reported not to be affected by its fluoride release⁹. The simultaneously released hydrogen ions will do no harm as it will be neutralized immediately in the oral circumstances.

The most suitable procedure of applying the sealant to the proximal surfaces was studied by changing separation methods and by considering brush technique from clinical view points.

The availability of fluoride was assessed by the rate of fluoride released into distilled water during a period of 28 days. Disks, 5 mm in diameter and 0.2 mm thick, were prepared by the resin. Layered both sided adhesive tape with a hole was stuck on a glass plate and used as a well for the disk preparation. The well was filled with the sealant and polymerized with visible light for 40 seconds. The surface was wiped with laboratory tissue paper. Each disk was immersed into 1 mL of dis-

tilled water at 37 °C for 28 days. The distilled water was changed on the 1st, 3rd, 7th, 10th, 14th, 21st and 28th days and the fluoride concentration was analyzed by a specific fluoride ion electrode (Orion Research, Inc., USA). The fluoride uptake and the improved acid solubility were investigated in vitro using bovine incisors. The teeth were cut longitudinally into two pieces and the labial surface layers were removed with a dental cutter (Silverstone-Taylor, USA). The surfaces were ground with 600 grit sandpaper. After washing the teeth with distilled water in an ultrasonic bath, a circular window of 5 mm in diameter cut from adhesive tape was placed on the enamel surface. The sealant was applied to the window with a thickness of approximately 200 µm and it was cured with visible light for 40 seconds. In order to remove afterward the sealant from the enamel for the analysis of incorporated fluoride, the enamel surface was not etched. The enamel pieces were maintained in 0.1 mol/l phosphate buffer at pH 7.0 for 37 hours, 1, 2, 3 and 4 weeks. Then the resin was removed and a new window of 3 mm in diameter was cut using adhesive tape. The enamel was etched off with 10 µl of a hydrochloric acid-sodium acetate buffer at pH 1.0 for 2 minutes. Four consecutive etchings were performed and fluoride and calcium amounts were measured in each of the four acid aliquots using a total of 5 teeth. The fluoride and calcium concentrations were measured with the fluoride electrode (Orion Research, Inc.), and the atomic absorption spectrophotometer (Perkin-Elmer, USA), respectively. The depth of etching was calculated using an enamel calcium content of 37.9 % and an enamel density of 2.57 g/ml.

Results

The finally achieved clinical procedure was as follows and the color photos were shown in Fig 2. The sealant was applied to the proximal surfaces of the first and second primary molars. One week after a separator was inserted between these teeth, about 0.5 mm of separation was obtained. After the rubber dam application the proximal surfaces were etched with a phosphate gel, rinsed with water and dried. One drop of the sealant was applied to the proximal surface with a small brush and cured with light for 40 s. One week after this treatment, the separation closed by itself.

Fig 3 shows the amounts of fluoride released from the resin disk into water. The left vertical axis indicates the weight of fluoride released per day. The right verti-

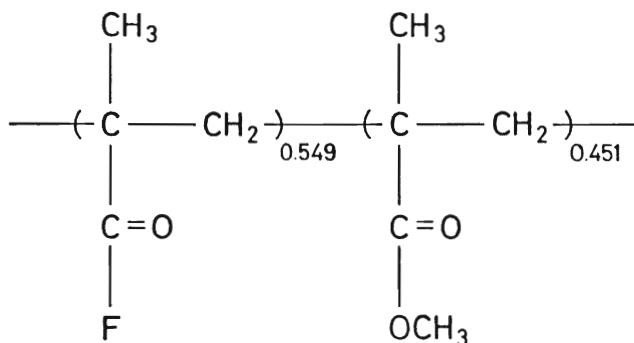


Figure 1. The fluoride releasing copolymer used for the sealant

cal axis indicates the cumulative percentage of released fluoride with reference to the total fluoride content of the resin disk. Ten μg of fluoride per day was released in the first day. After 3 days immersion, the releasing rate remained fairly constant at about 1 μg

per day for a period of 28 days and this rate was expected to continue for some time afterwards. The cumulative mass of fluoride released by the 28th day amounted to about 32 percent of the total fluoride present initially in the disk.

An example of the fluoride uptake obtained is shown in Fig 4. This is the fluoride profile in bovine enamel after 1 week of sealant application. The depth from the surface is plotted on the abscissa and the fluoride concentration in enamel is plotted on the ordinate. Points with the same symbol indicate the fluoride data obtained by four consecutive etching procedures on one bovine tooth sample. Even though there are large standard deviations in the concentrations, clearly the fluoride is incorporated into the enamel to a depth greater than 10 μm .

The relationship between fluoride uptake and acid solubility is illustrated in Fig 5. The horizontal axis indi-

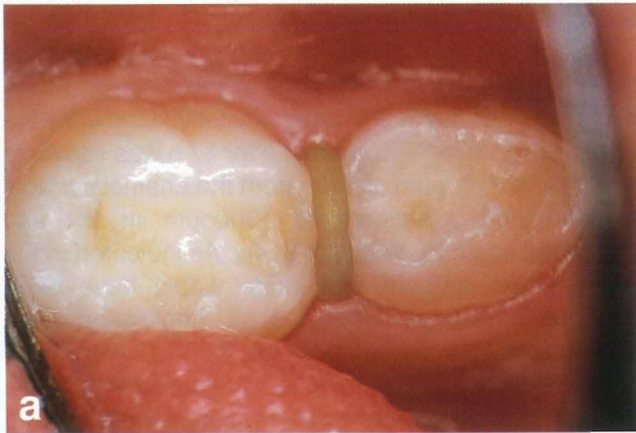


Figure 2. The clinical procedures
 a: The separation module was inserted between the first and second primary molars.
 b: After one week, about 0.5 mm of separation was obtained.
 c: The fluoride releasing sealant was applied to the proximal surfaces.

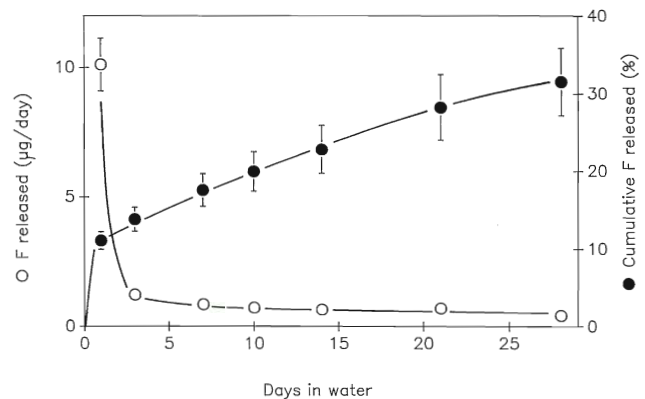


Figure 3. The amounts of fluoride released from the resin disk into water

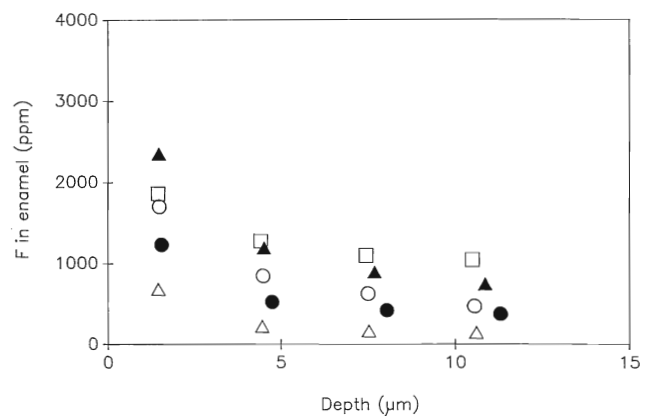


Figure 4. Fluoride profile in bovine enamel after 1 week of sealant application. Points with the same symbol indicate the fluoride data obtained by four consecutive etching procedures on one bovine tooth sample.

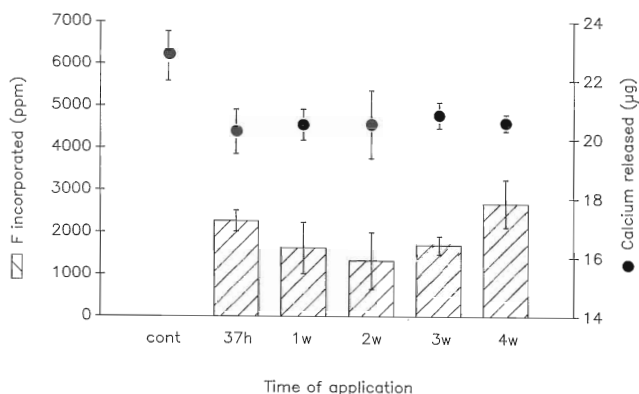


Figure 5. The relationship between fluoride uptake and acid solubility

cates the time of contact between sealant and enamel. On the left vertical axis is plotted the enamel fluoride concentration at 2 µm from the surface. The amount of calcium dissolved by 2 min of acid treatment is plotted on the right vertical axis. This calcium amount can be taken as an index of enamel solubility by acid. The fluoride content of the control, that is enamel without sealant treatment, was not detectable. The fluoride incorporation into enamel after 37 h increased to 2100ppm at 2 µm from the enamel surface. It decreased afterwards to 1300ppm at 2w and increased again to 2600ppm at 4w.

Discussion

The coating of proximal surfaces of primary molars is a good method to protect them from caries attack. It can be applied even to the proximal surfaces of permanent incisors as well. Separation of about 0.5 mm could be achieved by a one week application of the separating module which is often used for orthodontic purposes. Although it is rather troublesome for the patient as this requires an additional dental visit for the separation, this method is very simple and can gently create space between the deciduous molars. It also makes it easy for a dentist to find small caries on the proximal surfaces, and if caries is found there, the interproximal space is an advantage for the access of restorative equipment. An alternative method of separation would be the use of the Eliot's separator. About 0.3 mm of separation can be achieved even though it gives minor discomfort to patients. It may be desirable if the proximal sealant can be applied along with an occlusal restoration under local anesthesia. Ohmori *et al.*¹⁰ reported another separating method using the

"Wedge matrix" which they specially developed. This creates interproximal space with the wedge part and its celluloid strip part can isolate the two adjacent teeth by separating the applied sealant. The final evaluation of the present method has to be made by overall observation of retention rate, long term prognosis and reduction rate of proximal caries.

Idaira *et al.*¹¹ showed qualitatively the incorporation of fluoride into bovine enamel using the electron probe microanalysis. In the present quantitative study, the fluoride incorporation into enamel after 37 h was shown to increase to 2100ppm at 2 µm from the enamel surface. It decreased afterwards to 1300ppm at 2w and increased again to 2600ppm at 4w. As indicated in Fig 3, the large amount of fluoride would have been released right after the sealant application. The decrease of fluoride incorporation found at 1w and 2w in Fig 5 was speculated to reflect the movement of this front line of high fluoride concentration, penetrated into enamel by diffusion. In enamel containing 2000 ppm fluoride at 0.5 µm from the surface, 50 % of reduction in demineralization was observed in our previous study⁷. The fluoride concentration obtained in the present experiment was equivalent to this. However, it is not possible to determine a standard value of fluoride concentration in enamel that is sufficient for the caries prevention, because the driving force of enamel demineralization varies person to person and occasion to occasion.

The acid etching of intact enamel surfaces, as a pre-treatment for sealant application, will remove the fluoride rich layer of surface enamel. The possible risk of iatrogenic caries may be prevented by the fluoride incorporated to the enamel from the coating material even in the case it is detached. According to the calculation¹² using the data of human plaque fluid sample from white-spot surface at 7 minutes following a one-minute sucrose rinse¹³, the fluoride concentration required to make the plaque fluid supersaturated with respect to fluoroapatite was approximately 10^{-10} M when the pH was 5.42. So theoretically very small amounts of fluoride released from the sealant may exert some effect in increasing the degree of saturation with respect to fluoroapatite¹⁴, which may lead to the protection of enamel surface. However, as this concentration of fluoride is not analytically detectable, incorporation of fluoride into plaque released from the sealant can not be traced by equipment presently available.

Compared with the occlusal surfaces of deciduous and permanent molars which can be protected by fis-

sure sealant, the proximal surfaces are difficult to protect from carious challenge. The material and method used in this experiment is promising from the viewpoint that the demand for the protection of proximal surfaces is increasing not only in deciduous dentition but also in permanent dentition.

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