Flowable resin used as a sealant in molars affected by dental fluorosis: a comparative study

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The decline in prevalence and incidence of dental caries in developed countries over the last two decades is considered to be due mainly to the widespread use of fluoride in different forms, but simultaneously with decline in caries, an increase in dental fluorosis has been reported. The aim of this study was to compare the Conventional Sealant Technique (CST) and Enameloplasty Sealant Technique (EST) using a flowable resin as sealant in molars affected by dental fluorosis. A total of 40 extracted third molars affected by dental fluorosis were divided at random into two groups of 20 teeth each, and Tetric Flow resin was used as sealant. All teeth were studied for lateral adaptation and resin penetration by direct and indirect techniques; all samples were replicated in epoxy resin and were evaluated with Scanning Electron Microscopy (SEM). The results demonstrated that EST allowed a deeper sealant penetration and a superior sealant adaptation than CST, both in direct and indirect evaluations by SEM. The most important variables being penetration-interface and penetration depth both being statistically significant ($p<0.05$). The CST did not flow into the bottom of the fissures, leaving spaces that can favor the fracture of the material and initiate the process of dental caries. We conclude that a flowable ceromer is an excellent material alternative to be used as sealant and that EST is quite necessary in molars affected by dental fluorosis, the combination of both being a reliable method to be used as primary prevention approach of dental caries in endemic areas of dental fluorosis.

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INTRODUCTION

The decline in prevalence and incidence of dental caries in developed countries over the last two decades is considered to be largely due to the widespread use of fluoride in different forms, but simultaneously with decline in caries, an increase in dental fluorosis has been reported.[1] An endemic dental health problem in several countries around the world, dental fluorosis, has dramatically increased in frequency in developing countries, especially in Latin America, in recent years.[2-8] Since Mexico is one of the major producers of fluorspar in the world, the two states associated with this productivity, San Luis Potosi and Coahuila, have great amounts of fluoride in their sources of drinking water and their populations have a high incidence and prevalence of dental fluorosis.[9] Recently, there have been several reports showing that a wide area in central and northern states of Mexico is affected by an endemic dental fluorosis that affects both primary and permanent dentitions. [6,10]

Clinicians in endemic fluorosis areas seem to be unsure whether to seal permanent molars affected by dental fluorosis or not, and whether to use Enameloplasty Sealant Technique (EST) or not prior to sealant application. Three main problems have been reported, which should be considered to avoid microleakage when sealants are applied on healthy enamel structure: 1) Proper cleaning and increase of retention surface to enhance sealant retention; 2) sealant penetration into deep pits and fissures; and 3) a proper etching time on enamel. These criteria are also applicable to fluorotic enamel structure, playing an important role in the

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clinical retention success.[11] Also well-known facts are that dental fluorosis affects enamel structure, producing several porosities on its surface affecting, pit and fissures of teeth.[12,13] Therefore, it is important to consider treatment alternatives to prevent dental caries in endemic areas affected by dental fluorosis with protocols without fluoride therapy, such as topical fluoride applications and use of beverages containing fluoride. The aim of this study was to compare a Conventional Sealant Technique (CST) and Enameloplasty Sealant Technique (EST) by using a flowable resin as a sealant in pit and fissures in molars affected by dental fluorosis.

MATERIAL AND METHODS

A total of 40 extracted permanent molars were used in this study, the selection criteria being as follows, inclusion criteria: dental fluorosis in degrees 1-4 in accordance with Tooth Surface Index of Fluorosis (TSIF),[14] exclusion criteria: molars with occlusal restorations, dental caries, and presence of enamel hypoplasia. After dental extraction, teeth were cleaned and stored in distilled water until experiment time.

The teeth were distributed at random into two groups of 20 teeth each: Group 1: Pumice prophylaxis, rinse, dry, acid etching for 40 seconds, rinse, dry, bonding agent, and flowable sealant placement were carried out. Group 2: Enameloplasty, rinse, dry, acid etching, rinse, dry, bonding agent, and flowable sealant placement were carried out.[15,16] To select the best bur for this study, a pilot study was carried out, using a diamond bur specially designed for pit and fissure sealants UP 791 (Ultradent, Utah, USA) and a carbide bur 329 (SS White, USA); the bur UP 791 was selected because it kept a cleaner and smoother occlusal surface when observed under Scanning Electron Microscope (SEM). The pit and fissure sealant and bonding agent used in this study were Tetric Flow Cavifill and Exite Universal Dental Adhesive (Vivadent, Lichtenstein).

Occlusal surface of molars of both groups were acid conditioned with 37% phosphoric acid gel (Bisco, USA) applied for 40 seconds; sealants were then applied to molars and were light-cured (QHL75™, Dentsply, USA) for 40 seconds. In group B molars, pit and fissures were enlarged prior to sealant application, always maintaining the preparation in enamel structure, the invasive technique being carried out in accordance with the method described by do Rego et al.[15] After sealants were placed, impression of each restoration, using individual impression trays and polyvinyl siloxane (FlexiTime, Heraeuz Kulzer, Germany), were made; then a transparent epoxy resin was poured in (Araldit M, USA) and maintained for 24 hours at room temperature to get a complete polymerization.[17] After removal of epoxy resin material, excess of the impression material was cut off to get a good view of occlusal surface, and these duplicates were used to study marginal adaptation by using SEM (Phillips XL30, USA).

Roots of molar specimens of both groups were cut from crowns using a high-speed water-cooled diamond blade, teeth of both groups were subjected to thermocycling at 5ºC, 37ºC and 55ºC for 250 cycles with a dwell time of 30 seconds, before being tested to study marginal integrity.[18] These specimens were dried by soaking at 30%, 50%, 70% and 96% alcohol for 4 hours in each step and then allowed to dry at 37ºC for 8 hours before being subjected to gold sputting (Fine Coat Ion Sputter JFC-1100, JEOL, USA) for SEM studies. To evaluate sealant penetration each crown was slit bucco-lingually with a water-cooled diamond blade (7010KG, Sorensen, Finland) to allow observation of deeper recesses of fissures. Samples were then remounted and conductively coated for re-examination by SEM and observations were recorded. To study sealant penetration and interface resin-enamel walls magnifications of 15X, 30X, 60X, 120X, 480X, and 960X were tested. The best views were at 30X, all results being reported at this magnification.

The statistical analysis of the results was based on the Mann-Whitney U test for the comparison of independent data samples; statistical significance was considered for $p<0.05$. JMP version 4.0 statistical program was used to do statistical analysis of data.

RESULTS

Table 1 depicts results regarding the different variables used to study bucco-lingual cut samples related to the flowable resin penetration into pit and fissure of molars affected by dental fluorosis by CST and EST. Results regarding marginal gap showed an excellent adaptation in both groups, no statistical difference existed between groups ($p>0.05$). The lateral interface of flowable resin into fissure was more efficient when using EST, being statistically significant ($p<0.05$). However, the main dif-

Table 1. Marginal gap and penetration of flowable resin into pit and fissures of fluorotic molars, using CST and EST by SEM.

	CST		EST	
Marginal gap				
	Epoxy resin duplicate (µm)	**DM (µm)**	**Epoxy resin duplicate (µm)**	**DM (µm)**
Mean±SD	14.5±26.4*	45.3±30.5*	17.6±37.1*	58.7±38.2*
Range	0 – 97.9	10.7 – 124.5	0 – 124.8	12.8 – 146.7
Penetration				
	Penetration depth (mm)	**Lateral interface (µm)**	**Penetration depth (mm)**	**Lateral interface (µm)**
Mean±SD	0.51±0.26**	10.1±14.5**	1.12±0.2**	5.42±14.1**
Range	0.06 – 1.13	0 – 45.3	0.78 – 1.79	0 – 57.3

DM (Direct Method); ± (Standard Desviation); CST (Conventional Sealant Technique); EST (Enameloplasty Sealant Technique); SEM (Scanning Electron Microscope); (*) there was no statistical difference; (**) there was a statistical difference. Data were analyzed by Mann-Whitney U test.

Figure 1. Cross-section of an occlusal fissure treated with CST at magnification of 60X.

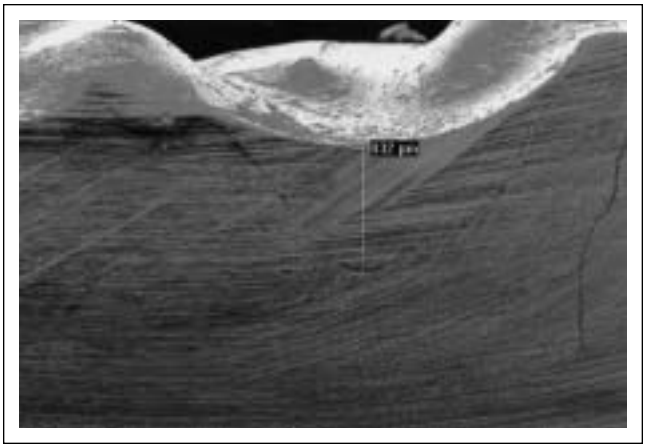

Figure 2. Cross-section of an occlusal fissure treated with EST at magnification of 30X.

ference was found in penetration depth, with the flowable resin running deeper into the fissure ($p<0.05$).

Figure 1 shows a cross-section of untreated fissure (CST); the flowable resin did not run into the fissure, showing a poor penetration and leaving a narrow gap without sealant. Figure 2 depicts a cross-section of a mechanically-treated fissure by enameloplasty technique (EST), showing a broader base, especially at the bottom of the preparation. The flowable resin completely sealed the fissure.

Table 2, displays a summary of the different variables used in this study; the major results are as follows: marginal gap showed an excellent result in both groups and there was no significant statistical difference in all variables ($p>0.05$). On the other hand, it is important to note that the lateral-interface and penetration depth showed differences when comparing both groups; sealant penetration was significantly improved by mechanical preparation when compared with non-prepared fissures, with a significant statistical difference in all variables of ($p<0.05$).

DISCUSSION

Dental caries has been decreasing around the world over the last two decades, this having been associated largely to use of fluorides in different forms, because of its protective effect mainly on smooth surfaces, but dental caries associated with occlusal surfaces still persists.[1] Besides, in some developing countries with endemic dental fluorosis, topical application of fluoride and other supplements that contain fluoride, such as toothpaste, drinking water, and soft drinks should be avoided.[19] Therefore, the best candidate to prevent dental caries in people affected by dental fluorosis is the application of pit and fissure sealants.

Table 2. Comparison between CST and EST on adaptation gap and penetration depth of sealant on pit and fissures of fluorotic molars by SEM.

	CST	EST	p value
Marginal gap Epoxy resin duplicate	2.10 µm	2.10 µm	> 0.05
Occlusal marginal Adaptation	44.5 µm	45.7 µm	> 0.05
Penetration depth	1.1 mm	0.44 mm	< 0.05
Depth interface	0 mm	0.03 mm	< 0.05

CST (Conventional Sealant Technique); EST (Enameloplasty Sealant Technique); SEM (Scanning Electron Microscope). Data were analyzed by Mann-Whitney U test.

The results of this study demonstrated that occlusal marginal adaptation of sealants on both occlusal surfaces of extracted teeth and occlusal surfaces of epoxy resin duplicate samples, in both CST and EST, showed similar adaptation to enamel structure at SEM. This suggests that epoxy resin duplicates are useful to do follow-up studies in clinical trials because this method copies the occlusal surfaces treated with sealants or any other adhesive restorative materials used.

To study flowable resin penetration into pit and fissures of molars affected by dental fluorosis, bucco-lingual sections are important. Our results demonstrate that EST is necessary to provide a way for resin to flow into fissure, penetration being statitically significant. These results agree with several reports that suggest that EST is a key to successful bonding of the sealant, mainly because etching and sealant materials do not penetrate beyond the region of fissural constriction when non invasive technique is used.[11,20] In this study EST allowed a deeper sealant penetration and a better sealant adaptation than conventional sealant treatment without any mechanical enlargement of occlusal fissures.

Several reports have shown that rubber cup or bristle brush pumice prophylaxis does not completely remove material deposits and there is the possibility of air entrapment in the pit and fissure. These factors become even more important for fluorotic enamel which in its structure contains several porosities that enhance the penetration of food debris and cariogenic

bacteria such as *Streptococcus mutans* and *Streptococcus sobrinus*.[21,22]

The main difference found in this study was associated with penetration depth. Results clearly show that in order to promote penetration of the flowable resin into the fissures, EST should be considered. When comparisons were done between groups there was a significant correlation between a better penetration depth and invasive technique. In this regard, several researchers agree that preventive properties of sealants are mainly due to their maintenance in occlusal surfaces as long as possible, these findings based on studies that provided information about retention rates of sealants.[23] In this process, a vital role is played by enamel surface available for sealants, EST being the best approach for mechanical preparation of fissured surfaces to be beneficial as to retention and microleakage.[24,25]

An important concern is that 80% of dental caries are found in children and teenagers. These lesions in enamel and dentin surfaces being associated to a bacteria, *S. mutans*. Sealant protocols have an additional advantage: etching by itself has an antibacterial effect on this specific microorganism in *in vitro* studies.[26] We agree with authors that have considered that etching process should be increased in time to at least 60 seconds for teeth affected by dental fluorosis, to enhance adhesion of sealants or other dental material which include etching and bonding.[27] Additionally, it has been suggested that sealants decrease cariogenic bacteria *in situ* due to a mechanical seal of fissures; it has been recognized that antibacterial properties such as fluoride release by sealants inhibit *S. mutans* growth. Also, comparative studies reported that fluoride-containing sealants significantly improve caries resistance of enamel in close proximity to the sealant.[26,28]

It has been demonstrated that for an adequate sealant adhesion, enough tooth surface should be provided, especially in irregular surfaces such as pit and fissures; also, a clean surface free of food debris and cariogenic bacteria before sealant placement is needed.[11] However, the main disadvantage of *in vitro* studies is that they do not provide information about long term microleakage which could lead to sealant deterioration and increase the possibility of dental caries. Besides, there is little information available about how etching time affects the process of sealant retention to fluorotic enamel. We agree that it is necessary to increase etching time to at least 40-60 seconds with 37% phosphoric acid to obtain a better shear bond strength of sealants in fluorotic human enamel.[27] Recent studies reported that the application of an adhesive layer beneath the sealant is necessary to avoid microleakage and to improve retention in premolars and molars.[29,30] Because of the masticatory status of molars, a more wear-resistant material such as the flowable resin Tetric-Flow is necessary. Also, it has been reported that penetration ability of sealants was higher in shallow-wide than in narrow-deep fissures and that a flowable ceromer provided higher penetration than unfilled resin sealant in wide fissures.[20]

It is important to notice that *in vitro* studies provide useful information for the dentist, but longitudinal clinical studies are the best design to demonstrate the effectiveness of sealants or any other dental material in molars affected by dental fluorosis. Due to all of the above, we conclude that a flowable ceromer is an excellent material alternative to be used as sealant and that EST is quite necessary in molars affected by dental fluorosis.

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