

Light microscopy and SEM evaluation of three different fissure sealants

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Summary

The aim of this study was to determine the stereo-light microscope and SEM evaluations of three sealant agents which have different chemical structures and filler contents: a compomer based pit & fissure sealant (Dyract® Seal), a sealant with high filler (Ultraseal XT), flowable pit & fissure sealant (Delton® FS).

45 extracted human molars were randomly assigned to 3 groups. Then each tooth was sectioned into two portions bucco-lingually, resulting in mesial and distal tooth halves, using an Isomet cutter. The penetration in depth and adaptation of these three materials were evaluated. The results were statistically analyzed with one-way analysis of variance (ANOVA) at a confidence level of 95% ($p = 0.05$). A post-hoc Tukey HSD-test was used for comparisons between groups. 46.7% of the teeth with Delton agents, 40% of Ultra-seal XT and 20% of Dyract-seal were sealed the whole depth of the fissure. While the sealant with less filler content penetrated better the whole fissure, the one with alcohol conditioner adapted best to the enamel walls.

It was concluded that fissure shapes were as important as the sealant material content as regards the penetration. In U-shaped and medium depth fissures there was a better adaptation to enamel.

Keywords: fissure sealant, penetration, adaptation, light microscope, SEM.

Introduction

Fissures are susceptible to caries because of their anatomy, favoring plaque retention and maturation [1,2]. This could imply that fissures should be sealed as early as possible during the stage of eruption to prevent any lesion development. Sealed lesions, which are radiographically evident, have been shown not to progress over a 10-year period [3,4]. Robertson reported in 1835 that the caries potential was directly related to the shape and depth of the pits and fissures, and caries seldom began on smooth, easily cleaned surfaces [5,6]. In 1923, Hyatt described a technique called *prophylactic odontology* [7]. Widening the fissures mechanically was suggested so that they

would be less retentive to food particles. This was called "*fissure eradication*" [8]. In 1942, Klein and Knutson reported clinical studies on ammonia silver nitrate, which was described by W.G. Miller in 1905 [9]. Ast et al. used zinc chloride and potassium ferricyanide in 1950 [10]. In 1951, J. Miller tried copper cement as material of choice [11]. In 1955, Buonocore reported that auto curing acrylic resin adhered to enamel surfaces that were etched with phosphoric acid [12]. Bis-GMA resin that was developed by Bowen was the base resin to most of the current commercial sealants. Urethane dimethacrylate and other dimethacrylates are alternative resins used in sealant materials [13]. Since the development of several functional monomers, resins, which possess

both low viscosity and excellent wetting properties, have been recommended for dental use. Dogon (1975) and then Cate et al. (1975) found that tag distribution and length increased as the viscosity of the resin decreased [14,15]. The penetration of a sealant depends on the configuration of the pit or fissure, the presence of deposits and debris within the pit or fissure and the properties of the sealant itself. Anatomy of pits and fissures may be helpful in understanding the effects of sealants in the prevention of dental caries. The shape and depth of pits and fissures vary considerably even within one tooth. Adhesion of sealants to etched enamel has been improved last decade [16]. However, over time, sealants undergo abrasive wear. Some manufacturers have added filler particles to their sealants to increase wear and abrasion resistance. An increase on the viscosity of sealant lowers its penetration coefficient. This is an important property of a sealant as well as its ability to penetrate through porous enamel via capillary forces, surface energy and surface tension [17].

One of the major problems when considering the success rates of sealant restorations is the variation in techniques and materials used. Short-term studies indicated a high degree of success for sealant restorations [18-20]. However, long-term studies

appear to indicate that success is less predictable [21-23].

The aim of this paper was to evaluate the penetration and adaptation related to the shape and depth of fissures, and also the bonding quality between tooth-hybrid layer and between hybrid layer-seal of sealant resin on the occlusal surfaces of posterior teeth, using light and scanning electron microscopy *in vitro*.

Material and Methods

Forty-five intact, non-carious human molars were randomly chosen in this study. The teeth had been stored in 0.1% thymol solution for the time between extractions and the moment when used in the *in vitro* study. The absence of caries was determined according to clinical parameters, using visual inspection. The occlusal surfaces were cleaned with polishing brush and rinsed vigorously at least 20 seconds. Following cleaning, the teeth were mounted onto blocks of pink wax. Three types of sealant materials: a compomer pit & fissure sealant (Dyract[®] Seal by Dentsply De Trey, Germany), a sealant with high filler (Ultraseal XT by Ultradent, USA), flowable pit & fissure sealant (Delton[®] FS by Dentsply De Trey, Germany) (*Table 1*) were used.

Table 1. The sealant materials used in the study and manufacturers' names

Materials	Manufacturer
Delton	Dentsply De Trey GmbH Konstanz/Germany
Ultraseal-xt	Ultradent products Inc South Jordan, Utah/AB
Dyract [®] Seal	Dentsply De Trey GmbH Konstanz/Germany

Three groups, each of 15 teeth were planned. In Delton group, the teeth were etched with 35% phosphoric acid gel for 60s, rinsed and dried. Delton sealant materi-

al was applied with the special tips onto surfaces for 15s. It was light cured with a halogen light source (Chromalux 75, Mega-Physics Dental, Germany) for 20s. In

Ultraseal-xt group the surfaces were etched with 35% phosphoric acid gel for 15s, rinsed and dried. Primadry was applied with its specific brush tip to the etched surfaces. Then it was air dried for 20s. Ultraseal-xt was applied with its brush tips onto surfaces for 15s. It was light cured for 20s. In Dyract Seal group the occlusal surfaces were rinsed, dried, and then no-rinse conditioner was applied as one drop with an applicator tip for 20s. Excess parts were removed. Prime and bond NT was applied as one drop to the fissures and left undisturbed for 20s. The solvent was blown at least 5s and Dyract Seal placed immediately. The sealant was light cured for 20s with halogen light.

Care was taken not to include any air bubbles. If air bubbles were seen they were removed away by the gentle use of an explorer. After the sealant was light cured for 20 s, the surfaces were wiped with a cotton roll to remove the superficial layer that was not polymerized owing to the inhibiting effect of oxygen in the atmosphere. The following step was to check if all fissures were covered and the sealant adhered to enamel. Then each tooth was sectioned into two portions bucco-lingually, producing mesial and distal tooth halves, using an Isomet cutter (Isomet® 1000 Precision Sow, IL USA). Samples were evaluated in a stereo-light microscope (Leica 7.5 Mz, Microsystems Ltd. Business Unit SM, Heerbrugg, Switzerland) at x 30 magnification and adaptation of these samples was evaluated under scanning electron microscopy (SEM) (JSM-5910LV, Tokyo, Japan).

The following criteria were evaluated *for penetration*, as percent values (%):

- 1 = sealed only top of fissure
- 2 = sealed top and half way of the fissure
- 3 = sealed 2/3 fissure
- 4 = sealed whole fissure

The following criteria *for adaptation* were:

- 1 = complete disconnection from enamel surface
- 2 = disconnection at some interfaces
- 3 = flash contact between sealant and enamel surface

The success of penetration and adaptation related to the depth and shape (U, V, I) of fissures was assessed as well.

The results were statistically analyzed with one-way analysis of variance (ANOVA) at a confidence level of 95% ($p = 0.05$). A post-hoc Tukey HSD-test was used for comparisons between groups.

Results

There were 7 teeth (46.7%) in Delton group, 6 (40%) in Ultraseal-xt group and 3 (20%) in Dyract Seal group in which the whole fissure was penetrated (*Table 2*). In *Figure 1* penetration of the whole fissure in Delton group is shown. Two I-shaped fissures, 8 U-shaped fissures and 6 V-shaped fissures were completely penetrated (*Table 3*).

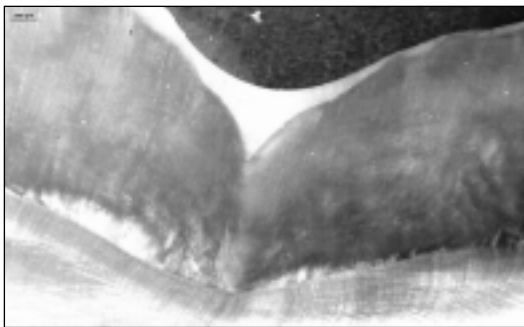
Table 2. Materials and penetration (%)

Materials	Sealed top of fissure	Sealed 1/2 of the fissure	Sealed 2/3 of the fissure	Sealed whole fissure	Total
Delton (n =15)	1 6.7%	5 33.3%	2 13.3%	7 46.7%	15 100%
Ultra Seal xt (n =15)	1 6.7%	1 6.7%	7 46.7%	6 40%	15 100%
Dyract-Seal (n = 15)	1 6.7%	2 13.3%	9 60%	3 20%	15 100%
Total (n = 45)	3 6.7%	8 17.8%	18 40%	16 35.6%	45 100%

Table 3. Penetration of three sealant materials and fissure depth – fissure shape (number)

(n = 45)	Shallow	Medium	Deep	I	U	V
Sealed top of fissure	0	0	3	3	0	0
Sealed 1/2 fissure	0	4	4	7	1	0
Sealed 2/3 fissure	6	9	3	0	11	7
Sealed whole fissure	2	11	3	2	8	6

Figure 1. Penetration of whole fissure in Delton group on light microscope (x 30)



Group Delton had 2, group Ultraseal-xt had 9 and group Dyract Seal had one tooth with high adaptation of sealant materials to enamel (Table 4).

One I-shaped, 6 U-shaped and 5 V-shaped fissured teeth were determined with the best adaptation to enamel walls (Table 5). As shown in Figure 2 there was a high adaptation of Ultraseal-xt material. There was no statistically significant difference between the three sealant groups that were tested in this study. On the other hand, it was determined that medium depth of fissures was the most appropriate in order to obtain tight connection to enamel. Deep and shallow fissures did not allow a good adaptation to enamel walls as observed with medium depth (Table 5). Sealant material showed a poor adaptation in Figure 3.

Table 4. Materials and adaptation (%)

Materials	No connection to enamel	Half connection to enamel	Tight connection to enamel
Delton (n = 15)	0 0%	13 86.7%	2 13.3%
Ultra-Seal xt (n = 15)	0 0%	6 40%	9 60%
Dyract-Seal (n = 15)	2 13.3%	12 80%	1 6.7%
Total (n = 45)	2 4.4%	31 68.9%	12 26.7%

Table 5. Adaptation of three sealant materials and fissure depth – fissure shape (number)

(n = 45)	Shallow	Medium	Deep	I	U	V
No connection to enamel	0	1	1	1	1	0
Half connection to enamel	5	16	10	10	13	8
Tight connection to enamel	3	7	2	1	6	5

Figure 2. High adaptation of Ultraseal-xt material to enamel on SEM (x 400)

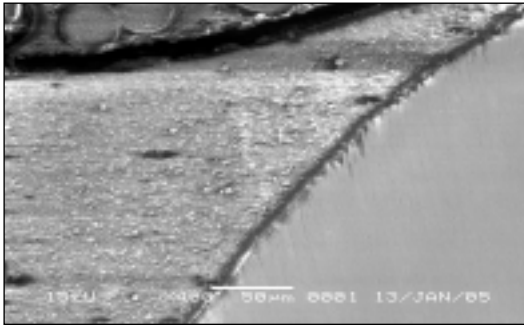
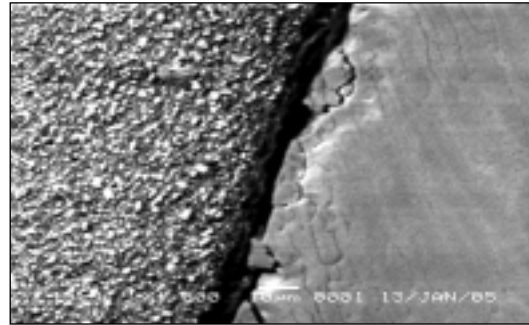


Figure 3. Poor adaptation of Dyract-seal material to enamel walls on SEM (x 1000)



Discussion

Wide V-shaped and shallow fissures are known as better filled by sealant [24]. The significant impacts on penetration ability are the fissure type, the material and way of application [25]. Ideally, the sealant should penetrate to bottom of a pit or fissure; such penetration is frequently impossible because any residual debris, cleaning agents and trapped air prevent passage of the material. The non-invasive cleaning method with an air polishing system and the use of drying agent improved the quality of sealants. The fissure type has the greatest influence on penetration ability [25]. In *Figure 4*, I-shaped medium fissure had two air-trapped areas in Delton group. Besides clinical obstruction such as described in the previous sentence, materials ability of penetration and adaptation may be determined *in vitro*. The low viscosity sealant material

exhibited better marginal adaptation than its high viscosity counterpart [26]. Among sealant materials tested in this study, Delton showed a better penetration in the whole fissure in more samples. On the other hand, Ultraseal xt showed comparably tight adaptation to enamel walls. This high score might be due to use of primadry agent, which evaporates any remnants of water, and removes air bubbles with its alcohol content.

Sealants adapted well to the vertical walls at the orifice of deep fissures but generally failed to penetrate into the deeper parts. Reducing the etching period with 37% phosphoric acid resulted in increased voids between the sealant and enamel surface and poorer adaptation to the vertical walls [27]. Application of primadry before Ultraseal xt may increase the adaptation area on enamel walls of fissures. These aspects are shown by *Figure 5* in light microscopy and by *Figure 6* in SEM.

Figure 4. Delton group had two air-trapped areas at I-shaped medium fissure – light microscope (x 30)

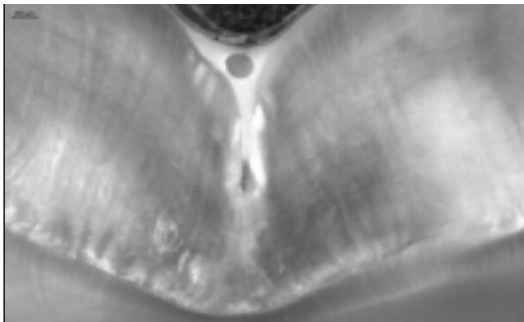


Figure 5. High adaptation of Ultraseal-xt on enamel walls of fissures on light microscope (x 30)

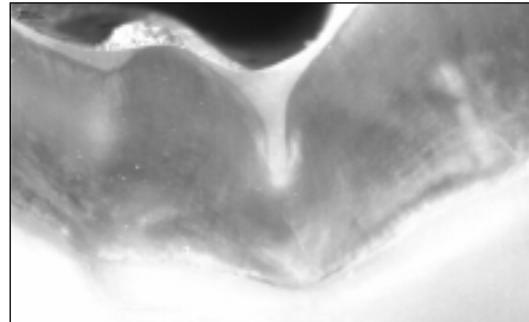
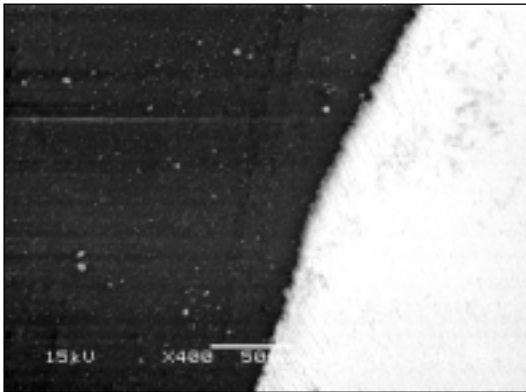


Figure 6. High adaptation of Ultraseal-xt on enamel walls of fissures on SEM (x 400)



While Delton showed better penetration with 7 samples, Ultraseal xt showed in 6 samples. This slight difference might be due to the higher filler content of Ultraseal xt (67-80%) compared to Delton's. Although higher filler content increases resistance to wear, more viscous sealant with more filler may not penetrate deeper through fissures. The difference in acid application time might play a role on material adaptation to enamel walls.

On the other hand, the shape and depth of fissures play an important role in penetration and adaptation, as shown in this study. If the depth of fissures is shallow, 2/3 is expected to be sealed at most. If the fissure is deep, 1/2 would be sealed at most. The interesting result was that medium depth fissures were the most frequently completely sealed (*Table 3*). The reason why shallow depth was sealed completely only in two samples might be due to some air trapped at the bottom of fissures (*Figure 7*). Also in shallow fissures only three samples had tight connection and this might be another result of the air voids (*Table 5*).

Deep fissures were not completely sealed as much as medium fissures (only three samples). The bottom of deep fissures might contain some remnants and air bubbles; therefore they are not sealed completely (*Table 3, Figure 8*). Although penetration

has been demanded from a sealant material, better adaptation might be a good solution to long-term retention and caries resistance of sealants. The presence of unetched areas after routine cleaning and acid etching, especially in and around pits and fissures could be a major cause of early sealant loss [28].

Under the conditions of this study, resin sealants with less filler content seem to penetrate almost the whole fissure, while resin sealant with an alcohol conditioner applied before adapted best to enamel walls. U-shaped and medium deep fissures showed better adaptation to enamel.

Acknowledgements

The authors thank biologist Nurhan Yaşlıoğlu for the help of using stereo-light microscope.

Figure 7. An air-trapped area at the bottom of fissure sealant on light microscope (x 30)

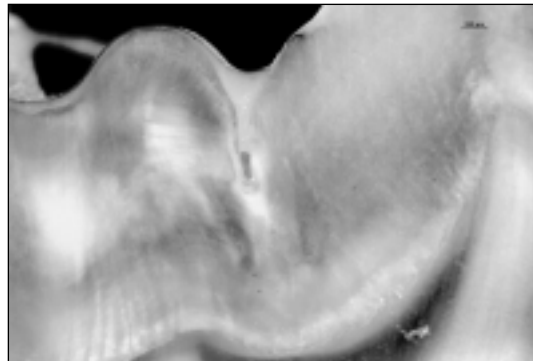
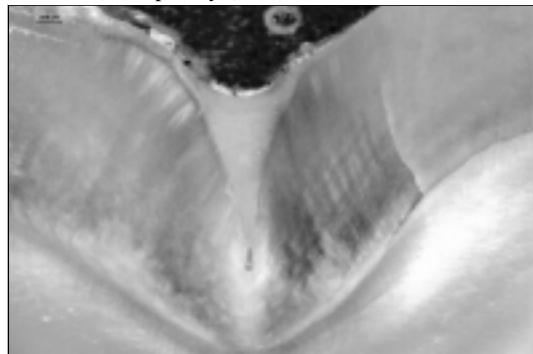


Figure 8. There might be some remnants and air bubbles at the bottom of deep fissures, therefore they are not sealed completely (x 30)



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