Comparison of 3 One–bottle Adhesives on Fissure Sealant Microleakage: An In Vitro Study

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ABSTRACT

Purpose: The purpose of this in vitro study was to evaluate the microleakage of 3 one-bottle adhesives with different solvents added under the fissure sealant on intact etched enamel.
Methods: A total of 100 sound mandibular third molars were randomly divided into 5 groups (N=20). Occlusal pits and fissures were sealed with an unfilled fissure sealant (FS) material. Study groups included: (1) phosphoric acid etching + FS (control); (2) acid etching + Adper Single Bond 2 + FS; (3) acid etching + OptiBond Solo Plus + FS; (4) acid etching + One-Step Plus + FS; and (5) no pretreatment (FS alone). After aging and thermocycling, specimens were placed in 0.5% fuchsin, sectioned, and evaluated by digital microscope. Data were analyzed with Kruskal-Wallis and Mann-Whitney tests at a significance of $P<.05$.
Results: Group 5 (FS alone) showed the greatest microleakage, which was significantly different from the other groups ($P<.05$). Group 4 showed the lowest microleakage, followed by groups 3 and 2. No significant differences existed among groups 1 to 4 ($P>.05$).
Conclusions: Conventional acid etching alone or with a one-bottle adhesive that contained different solvents of acetone, ethanol, or ethanol/water combination yielded similar sealing results in sealant therapy. (J Dent Child 2013;80(1):16-9)
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KEYWORDS: ADHESIVE SOLVENT, FISSURE SEALANT, ONE-BOTTLE ADHESIVE, MICROLEAKAGE

Deep pits and fissures in young permanent molars are susceptible areas for the development of dental caries. Placement of resin-based sealant materials is an acceptable method for caries reduction.[1,2] Adhesion to the enamel has become a routine and reliable aspect of sealant therapy.

The acid etch technique incorporates a separate rinsing step to remove dissolved mineral from enamel, thus creating a high energy, strongly reactive bond with enamel microporosities on the tooth surface.[2,3] It provides space for the penetration of a low viscosity resin sealant and forms micromechanical resin tags, therefore achieving durable retention of the sealant materials.[2,4]

Different types of dental adhesives have been used to enhance retention of sealant materials. Placement of hydrophilic adhesive resins under the fissure sealant enhances acid-etched tooth surface wetting, particularly if the enamel is unable to be kept dry during sealant therapy. Thereby, complete penetration and adaptation of the sealant into the etched enamel can be obtained. This decreases microleakage between sealant materials and enamel margins.[5-7]

For several years, the etch-and-rinse adhesives have been widely used in studies.[5-8] These adhesives are applied in 3 steps (fourth-generation) or 2 steps (fifth-generation or one-bottle adhesive). The one-bottle etch-and-rinse adhesive systems have become popular due to their simplicity and ease of use vs the three-step adhesives, as they provide adequate bonding to the tooth surface. In the one-bottle adhesive system, the phosphoric

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acid etch-and-primer adhesive resin is applied in 2 separate steps.[9,10] Most adhesive systems contain low viscosity hydrophilic monomers diluted in organic solvents such as ethanol, acetone, water, or a mixture of these solvents.[9,11] After applying the adhesive, the solvents (acetone or ethanol) volatilize to displace the moisture in the deep etched parts of the pit and fissure, thus increasing resin penetration and adaptation.[3,7,11] The primer components in the adhesives consist of 2 functional groups:

1. A hydrophilic end that has the ability to bond to the tooth surface, even under moist conditions; and
2. A hydrophobic end, which bonds to the methacrylate in sealant resin matrix.[3]

Most studies have compared the associations of etch-and-rinse adhesives with sealants in terms of sealing ability and sealant bond strengths.[5-8,12,13] No data is available, however, for dentists to choose the appropriate one-bottle adhesive (with different solvents) for sealant therapy.

The purpose of this in vitro study was to assess the effect of enamel pretreatment with one-bottle adhesives on microleakage around fissure sealant margins in dry enamel of permanent molar teeth. The tested null hypothesis was that different adhesives did not affect microleakage of the resin sealant.

METHODS

Following approval of the research protocol by the Human Ethics Review Committee of the School of Dentistry, Shiraz University of Medical Sciences, 100 sound mandibular third molars were selected. The teeth were scaled, cleaned with fluoride-free pumice and a prophylaxis brush, and immersed in 0.1% chloramine T solution for 2 weeks for disinfection. Next, the samples were stored in distilled water at 37°C. The occlusal surfaces were examined to discard any teeth with enamel defects, cracks, or caries.

The teeth were randomly divided into 5 groups containing 20 teeth each, in which pretreatment steps were performed on occlusal surfaces before fissure sealant (**FS**) application as follows:

1. group 1—phosphoric acid etch + FS (control group);
2. group 2—phosphoric acid etch + Adper Single Bond 2 (3M ESPE, St. Paul, Minn.) + FS;
3. group 3—phosphoric acid etch + OptiBond Solo Plus (Kerr Corp, Orange, Calif.) + FS;
4. group 4—phosphoric acid etch + One-Step Plus (Bisco Inc, Schaumburg, Ill.) + FS; and
5. group 5—fissure sealant without using acid etch and adhesive resin.

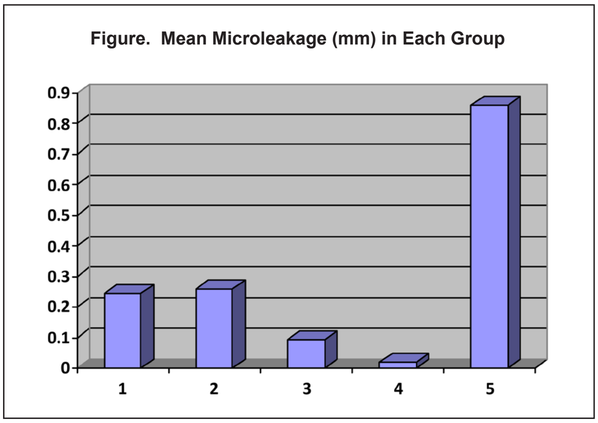
All materials were applied according to the manufacturer's instructions. Next, the occlusal surfaces were sealed with unfilled fissure sealant (Clinpro, 3M ESPE, St. Paul, Minn.) and light-cured for 20 seconds using a halogen light curing unit (Coltolux, Coltene, Whaledent, Altstaetten, Switzerland) with a power density of 500 mW/cm2. The tip of the light cure was placed close to tooth surfaces to increase the curing depth of the sealant. The specimens were then stored for 6 months in distilled water at 37°C (the water was changed every week) before being subjected to 1,000 thermal cycles in 5°C and 55°C water baths, with a dwell time of 30 seconds and a 20-second transit time between the baths.

The root apices were sealed with sticky wax, and all tooth surfaces, except for a 1-mm-wide zone around the margins of each fissure sealant, were sealed with 2 coats of nail polish. Microleakage was assessed via a dye penetration method that required all specimens to be immersed in 0.5% basic fuchsin (Merck, Germany) dye solution for 24 hours. The samples were rinsed to remove excess dye and each tooth was sectioned faciolingually across the center of the sealant using a diamond saw (Letiz, 1600, Leica, Wetzlar, Germany) with continuous water irrigation.

Two independent examiners observed the sectioned teeth under a digital microscope (Dino Lite, Taipei, Taiwan) at 50× magnification and scored linear dye penetration in millimeters from the margin of the fissure sealant through the interfaces between the tooth and the sealant. The microscope and operators were calibrated before evaluations. The examiners were calibrated on 10 sectioned teeth before evaluation began. Mean dye penetration was recorded, and statistical analyses were conducted via the Kruskal-Wallis test to compare all groups together. Two-paired comparisons were made with the Mann-Whitney test ($P<.05$).

RESULTS

The Figure shows the average microleakage in the experimental groups. Group 4 (acid etching + One-Step Plus+ FS) had the least mean microleakage followed by group 3(acid etching + OptiBond Solo Plus + FS). Groups 1 (control) and 2 (acid etching + Adper Single Bond 2 + FS) had similar microleakage, both of which were higher than groups 3 and 4. Group 5 (FS alone) had more microleakage than groups 1 to 4. Statistical analysis showed



(1) Phosphoric acid etch + fissure sealant (FS, control group). (2) Phosphoric acid etch + Adper Single Bond 2 + FS. (3) Phosphoric acid etch + OptiBond Solo Plus + FS. (4) Phosphoric acid etch + One-Step Plus + FS. (5) FS (without etching and adhesive).

significant differences among all groups (P=.000). There was no significant difference among groups 1 to 4 when compared with one another (P>.05). Two-paired comparisons between all groups revealed that only group 5 was significantly different from the other groups (Table).

DISCUSSION

The effectiveness of sealants is dependent upon their retention and sealing ability. Laboratory tests such as microleakage evaluation remain useful ways to assess their sealing abilities.[14,15] Microleakage due to marginal gaps between tooth structure and restorative materials may lead to recurrent caries.[16] Regarding composite resin-based restorations, it is assumed that microleakage may occur along the interface of enamel and sealant material.

This phenomenon is noticeable in the resin sealant because unfilled resin has more polymerization shrinkage than filled composite resin with high inorganic filler content, particularly in the deep and narrow parts of fissures.[17] Furthermore, an unfilled resin sealant tends to have more water absorption than filled composite resin.[16]

Following thermal changes during thermocycling and water absorption in long-term aging, this difference might lead to degradation of enamel-resin bonds and hydrolysis of interface components, resulting in microleakage along the resin sealant and the tooth structure.[16,18,19]

In the present study, all experimental groups showed different degrees of microleakage, which confirmed the results of other studies.[10,14] Pérez-Lajarín et al.[14] have noted that no sealant materials are able to completely eliminate microleakage between the sealant and enamel margins. There was no difference in terms of microleakage between the use of adhesive systems under the sealant resin and the control group (acid etching + FS), which used no adhesive system. This finding is in agreement with previous studies, which demonstrated no beneficial effect in adding an adhesive system between the etched enamel and sealant when compared to the acid etching technique.[20-23] Therefore, the use of a bonding agent may increase the time and cost of sealant therapy, and these considerations should be taken into account before deciding to use this method.[2] Among the 3 adhesives tested in this study, Adper Single Bond 2 (ethanol based) had the highest degree of microleakage, whereas One-Step Plus (acetone based) showed the lowest degree of microleakage. The differences between these 2 groups, however, were not statistically significant. The main difference among the adhesives was the solvent.

In agreement with our results, Lopes et al.[21] have shown no significant difference between acetone and ethanol-based one-bottle adhesives in terms of enamel bond strength. Torres et al.[13] reported that the use of an intermediate layer acetone-based one-bottle adhesive (Prime & Bond, Dentsply, York, Pa.) leads to increased bond strength of the sealant to etched enamel. Kersten et al.[12] have shown that the use of an acetone-based adhesive on etched enamel leads to a considerable increase in surface energy, with enhanced sealant penetration. They attributed this to the drying effect of acetone on the etched enamel, thereby improving surface wetting by a hydrophobic sealant. This improved effect was reported when using acetone-containing adhesives to etched enamel, whereas water-based adhesives may have a less positive effect on bonding to etched and dry enamel.[14]

Table. Two-paired Comparison of Groups

Adhesive/technique	P-value
Groups 1 and 2: Etch + fissure sealant (FS)/etch+ Single Bond (SB)+ FS	>.96
Groups 1 and 3: Etch+ FS/etch+ OptiBond Solo Plus (OB Plus) + FS	<.31
Groups 1 and 4: Etch + FS/etch + One-Step Plus (OS Plus) + FS	>.09
Groups 1 and 5: Etch + FS/FS	.00*
Groups 2 and 3: Etch + SB + FS/etch + OB Plus + FS	>.46
Groups 2 and 4: Etch + SB + FS/etch + OS Plus + FS	>.13
Groups 2 and 5: Etch + SB + FS/FS	.00*
Groups 3 and 4: Etch + OB Plus + FS/etch + OS Plus + FS	<.26
Groups 3 and 5: Etch + CH + FS/FS	.00*
Groups 4 and 5: Etch + OS Plus + FS/FS	.00*

* P<.05.

Adper Single Bond 2, used in the present study, contains ethanol and water as co-solvents, which results in a lower volatility of this adhesive compared to adhesives that contain only acetone.[24] Gomez-Silva et al.[24] have shown lower sealant bond strength to etched enamel associated with Single Bond than with the sealants without adhesive. This may be related to the water content of the adhesive, which may compromise the penetration of the hydrophobic sealant and interfere with sealant adhesion.[24]

The wettability of the adhesives depends on their viscosity. Some studies have shown that filled adhesive systems with high viscosity have difficulty in penetrating interprismatic areas as deeply as unfilled or nanofilled adhesives.[3] Single Bond is a nanofilled adhesive (5 nm filler size) with low viscosity and high wettability. One-Step Plus (1 µ filler size) and OptiBond Solo Plus (0.4 µ filler size) contain larger filler particles and have higher viscosity.[11] The differences between microleakage of the adhesives, however, may be related to the presence of water in Single Bond. In addition to that, it is possible that the filler sizes have a minor effect on adhesive adaptation to the etched enamel surface.

It is important to consider that this in vitro study did not completely simulate in vivo conditions. We used 6-month water storage and thermocycling to accelerate aging. Functional loading and pH cycling might influence the marginal quality of the fissure sealants.[16,18,19] Further studies require a comparison of the different solvent-type adhesives in moisture-contaminated enamel in fissure sealant therapy.

CONCLUSIONS

Based on this study's results, the following conclusions can be made:

1. The use of different one-bottle adhesives as an intermediated layer significantly reduces microleakage on dry etched enamel.
2. Conventional phosphoric acid etching alone or with different solvent type adhesives is an effective sealing method in sealant therapy.

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