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Evaluating micro shear bond strength of two different materials in permanent teeth

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ABSTRACT

Aim: Caries on the grooved surfaces of posterior teeth is the most common type of caries in children and adolescents; a prerequisite for achieving a successful fissure sealant is proper isolation of etched enamel against saliva contamination. Recently, self-adhering flowable composites have received more attention due to simple application of this type of material, which allows proper insulation. Therefore, this study tends to compare microshear bond strength of fissure sealant and self-adhering flowable composite in permanent teeth. Methods: This experiment was performed on 30 dental samples in vitro in 2019-2020. After initial preparation, the teeth were randomly divided into 3 groups; the first group: acid etch (Den fil Etchant-37 / USA) + bonding (Tetric N-Bond / USA) + fissure sealant (Clinpro, ESPE 3M); the second group: acid etch + Vertise Flow; the third group: Vertise Flow. After thermocycling (500 cycles, 5-55ºC), shear bond strength was tested using Universal testing machine at 0.5 mm/min. Finally, the obtained data were evaluated using SPSS 21 statistical software and Independent T-test. Results: Composite of the third group was isolated from the tooth surface after thermocycling. Shear bond strength of the first group is 12.3±44.97 MPa and shear bond strength of the second group is 11.184±47 MPa. According to Independent T-test analysis, there is no statistically significant difference between group 1 and group 2. Conclusion: Self-adhering composite without acid etching has very low bond strength, so the use of this composite without acid etching is not recommended.

Keywords: Self-adhering flowable composite, Fissure sealant, Micro-shear bond strength.

1. INTRODUCTION

Currently, grooved surface caries account for 80 to 90 percent of all caries in children and adolescents. With introduction of sealants, a clinical method in caries prevention became available (Pinkham et al., 2005; Mertz-Fairhurst et al., 1984; Simonsen, 1991). Pit and fissure sealant is considered as one of the safest and most effective ways to prevent tooth decay, particularly occlusal surfaces of posterior teeth (McJare et al., 2003). Complete isolation of the tooth during treatment is a necessary condition for fissure sealant. The most

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common reason for fissure sealant failure is insufficient accuracy in proper insulation of etched enamel against saliva contamination (Pinkham et al., 2005; Perdigão et al., 2005). Studies show that a high degree of decay and loss of sealant occurs due to contamination of etched enamel with saliva and prevention of resin penetration into pores of the etched enamel (Roberson et al., 2006).

Contamination of the etched enamel with saliva prevents the binding of fissure sealant polymers to the enamel. Drying the surface is not effective, even if the surface still looks etched. The optimal time for dental fissure sealant is as soon as the occlusal surface grows in the oral environment. At this time, only a small amount of tooth has grown and it is difficult or impossible to use rubber dam to control moisture, and this is especially important for permanent first molar teeth (Mertz-Fairhurst et al., 1984). Since this tooth grows around the age of six and, at this age, the child is usually not ready to cooperate in effective treatment of fissure sealant and sometimes rubber dam cannot be used due to insufficient growth of the tooth, the enamel may be contaminated with saliva. In case of insufficient accuracy, appearance of some contamination on the etched enamel will be common and this contamination will prevent the resin from penetrating into micromechanical spaces and will cause microleakage and premature failure (Pinkham et al., 2005).

Adhesive systems have been introduced to enhance the sealing power between the restoration and the tooth. Meanwhile, self-adhering flowable composites are gaining increasing popularity, which is mainly due to simple application of this type of flowable composite (Barroso et al., 2005). In this type of composite, the etching and bonding steps are eliminated and, due to the reduced treatment steps, proper insulation is more likely (Vichi et al., 2011). These composites are highly flowable, that allows them easily spread on cavity walls, making the restoration more compatible with the tooth and reducing microleakage at the edges (Vichi et al., 2011; Craig & Powers, 2012). In an in vitro study by Margvelashvili et al., (2013) in Italy, a universal testing machine was used for micro-shear testing. The results showed that shear strength of the self-adhering composite (first group) is statistically similar to the third group and higher than the second group (Margvelashvili et al., 2013). Veli et al., (2014) conducted a study in Turkey on bond strength of self-adhering composite when used for a lingual retainer bond. A universal testing machine was used to measure the shear bond strength. The results showed that the first group had the lowest shear strength and the fourth group had the highest shear strength (Veli et al., 2014). Biria et al., (2014) evaluated shear bond strength of self-etched sealants versus conventional sealants. Shear strength of the samples was measured in a microtensile testing machine. The results showed that the first group had the highest shear strength and the third group had the lowest shear strength (Biria et al., 2014).

Bektash et al., (2013) in Turkey studied 30 third molars in vitro; they assigned the samples to three groups. Universal testing machine was used for micro-shear testing. The results showed that there is a statistically significant difference between the groups and the third group has the highest shear bond strength (Bektash et al., 2013). Asefzadeh et al., (2009) examined shear bond strength of a new self-bonding composite to dentin. After thermocycling, the specimens were placed in a bond shear strength tester. The mean shear strength of EW composite bond in the second, third and fourth groups was significantly lower than the first group; the mean shear strength of EW composite bond in the third and fourth groups was significantly lower than the first and second groups; the mean shear strength of the bond was not statistically significant in the third and fourth groups (Asefzadeh & Merati, 2009). Such studies, although limited, introduce better and higher quality materials and instructions to dentists so that they can provide better services to patients. Particularly in pediatric dentistry, despite special conditions such as difficulty in complete isolation, inability of the child to cooperate with the dentist, short opportunity to perform dental services to the child and the importance of preventive treatments in children.

Due to the ease of use and elimination of difficult clinical stages, it seems that application of these materials is very useful in pediatric dentistry. The question is whether easier application of newer materials will have better results; do sealant kits with simpler application necessarily have higher or the same quality of previous materials?. Therefore, the purpose of this study is to investigate the micro-shear strength when using various materials and techniques of placing sealants on grooves of the chewing surface, particularly the self-adhering system.

2. MATERIALS AND METHODS

In this in-vitro experiment, the studied population included healthy premolars, without decays, restorations, cracks, or any other defects extracted for orthodontics. Inclusion criteria included: 1) premolars, 2) healthy and without caries, restoration or cracks, and 3) extracted due to orthodontics. According to the previous study, the sample size was estimated at 30 (Casamassimo et al., 2012). Fifteen dental specimens were divided into two parts and finally 30 specimens were studied. Teeth were selected by easy and convenient methods and randomly divided into one of three groups. The information obtained from in-vitro observations was recorded in the information form.

In this study, 15 healthy premolars without caries, restoration, cracks or any other defects extracted due to orthodontics were kept in 0.2% thymol solution at room temperature after obtaining informed consent. At the beginning of the study, all teeth were thoroughly cleaned with a scalpel and brush and placed in distilled water. The teeth were divided into buccal and lingual halves with a paper separator disc and a handpiece. In this way, 30 pieces were obtained and then randomly studied in one of three groups.

Group 1: Surface of the polished enamel of 10 teeth was etched with phosphoric acid (Den fil Etchant-37 / USA) for 15 seconds. After washing and complete drying, a bonding layer (Tetric N-Bond / USA) was applied, which was thinned by gentle air flow. Polymerization was performed for 10 seconds by Coltolux light curing machine (Coltene, Switzerland). Silicone molds (inner diameter 1 mm and height 1 mm) were placed in this area and filled with fissure sealant (clinpro, ESPE 3M) and cured for 20 seconds by light curing machine (Coltolux, Coltene, Switzerland) (Barroso et al., 2005).

Group 2: Enamel surface of 10 pieces of teeth was etched with phosphoric acid (Den fil Etchant-37 / USA) for 15 seconds, then rinsed with water for 10 seconds and dried with air for 5 seconds. Silicone molds (inner diameter 1 mm and height 1 mm) were placed in this area and filled with self-adhering composites (Vertise, Kerr / USA) and held for 20 seconds by Coltolux light curing machine (Coltene, Switzerland) (Veli et al., 2014).

Group 3: silicone molds (inner diameter 1 mm and height 1 mm) were placed on the surface of the polished enamel of 10 dental pieces and filled with self-adhering composites (Vertise, Kerr / USA) and cured for 20 seconds by Coltolux light cure device (Coltene, Switzerland) (Veli et al., 2014).

Then, all samples were subjected to thermal cycle by thermocycle (Baradaran, Pouya Iran) (500 thermal cycles in the temperature range of 5-55 °C with a stop time of 30 seconds and a transfer time of 10 seconds). After thermocycling, composite of all the samples of the third group was isolated from the tooth surface. Thus, only the samples of the first and second groups entered the next step. Next, shear bond strength was tested using Universal testing machine for mechanical properties of materials (Testometric M-350-10CT, England) at 0.5 mm/min and using a parallel steel blade with a diameter of 1 mm in the composite-enamel interface. By performing the test, the maximum force that each sample could withstand in the interface to fail was obtained in Newtons and shear bond strength for each sample was calculated in MPa (Shademan et al., 2012). All steps were performed by a trained dental student.

SPSS software version 21 was used to analyze the data. Shear bond strength was compared between groups 1 and 2 by Independent T-Test. This study complied with codes 1, 2, 3, 4, 6, 7, 8, 9 and 11 of the approved ethical codes in research on human organs and tissues.

3. RESULTS

In order to compare micro-shear bond strength of fissure sealant and self-adhering flowable composite in permanent teeth, 30 dental samples were examined in three equal groups. Before micro-shear testing, all samples were placed in a thermocycling device. The composite of all the samples of the third group was isolated from the tooth surface after thermocycling, which shows the weak strength of the self-adhering flowable composite without acid etching. As a result, only the samples of the first and second groups were placed in the Universal testing device after thermocycling.

Determining shear bond strength of fissure sealant in permanent teeth

Examination of shear bond strength of fissure sealants in permanent teeth shows that the mean is 12.44 MPa, which varies from a minimum of 8.4 to a maximum of 20.4 MPa (Table 1).

Table 1: Mean Descriptive statistics of shear bond strength of fissure sealant in permanent teeth

	N	Min.	Max.	Mean	SD
bond strength	10	8.47	20.44	12.4452	3.67043

Determining micro-shear bond strength of self-adhering flowable composite with acid etching in permanent teeth

Examination of micro-shear bond strength of self-adhering flowable composite with acid etching in permanent teeth shows that the mean is 11.1 MPa, which varies from a minimum of 7.3 to a maximum of 21.5 MPa (Table 2).

Table 2 Descriptive statistics of micro-shear bond strength of self-adhering flowable composite with acid etching in permanent teeth

	n	min.	max.	mean	SD
bond strength	10	7.39	21.59	11.1816	4.47477

Determining micro-shear bond strength of fissure sealant and self-adhering flowable composite with acid etching in permanent teeth

The mean of shear bond strength is 12.44 MPa in fissure sealant and 11.18 in self-adhering flowable composite with acid etching. Independent t-test does not show any significant difference in shear bond strength of two composites (P=0.49). In other words, these two materials are similar in terms of shear bond strength (Table 3 and Figure 1).

Table 3 Comparison of micro-shear bond strength of two materials

	n	Mean ± SD	Independent T Test		
			t-value	df	P-value
fissure sealant	10	12.3±44.67	0.690	18	0.499
self-adhering flowable composite with acid etching	10	11.4±18.47			

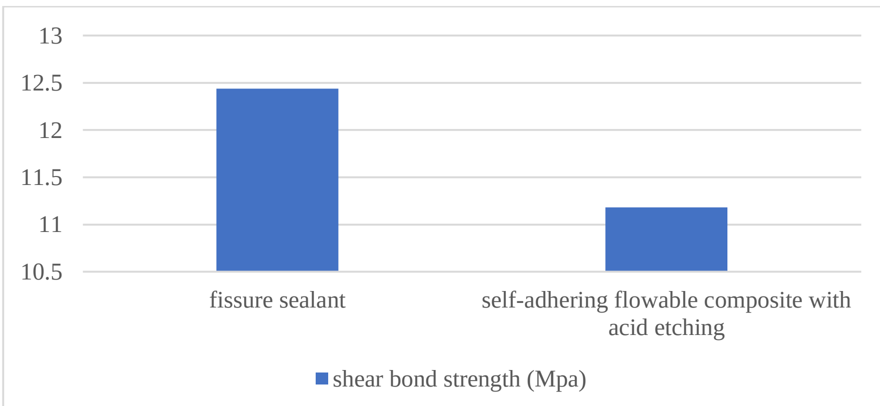

Figure 1 Comparison of micro-shear bond strength of fissure sealant and self-adhering flowable composite with acid etching in permanent teeth

4. DISCUSSION

The present study was performed to compare the shear bond strength of fissure sealant and self-adhering flowable composite in permanent teeth. The main factor in efficiency and durability of a sealant is the material bond to the enamel (Perez-Lajarin et al., 2003; Alonso et al., 2005). Evaluation of bond strength, particularly micro-shear bond strength test, has advantages such as evaluation at smaller levels, reduced effect of enamel defects, easy preparation of samples, application of small amounts of materials and suitability for bond-enamel evaluation (Placido et al., 2007). It seems that fissure sealants and self-etching and self-priming flowable composites such as Vertise and Kerr eliminate the need for etching and bonding and make the use of these materials especially suitable for non-cooperating children. Our study showed that micro-shear strength of self-adhering composite (Vertise Flow, Kerr) without acid etching is significantly lower than conventional sealants. Wadenya reported that shear bond strength of conventional sealants following the etching step is significantly higher than self-etching sealants (Enamel Loc), which is consistent to results of our study (Wadenya et al., 2009).

The Vertise Flow bond mechanism relies on monomeric properties of glycerolphosphate dimethacrylate (GPDM) adhesive. Phosphate group plays the role of acid etches and forms chemical bonds with calcium ions in dental tissue. Mechanical strength of a material results from cross-linking of active methacrylate groups with other methacrylate monomers. To increase and improve the effects of acid monomers in Vertise Flow, the manufacturer recommends that a thin layer of 0.5 mm Vertise Flow be applied on the tooth surface for 15-20 seconds. The manufacturer also recommends using a phosphoric acid etching step before applying the Flow.

In our study, an etching step increased micro-shear bond strength so that the micro-shear bond strength of the self-adhering composite with acid etching is similar to conventional sealants. Self-etch composites have become common following the successful application of self-etch adhesives. Conventional etch rinsing adhesives (ERA) are still the golden standard in dentistry. But self-etching adhesives (SEAs) simplify clinical procedures and take less time to perform. Technical sensitivity of these methods is also less than ERA (Van Meerbeek et al., 2003).

In self-etching methods, the tooth surface is first demineralized and penetrates deep into the adhesive demineralization. Then a chemical reaction occurs between active monomers and hydroxyapatite of the tooth (Yoshida et al., 2004). Enamel attachment mechanism is micromechanical attachment between the resins inside the micro-porosities of the etched surface of the tooth (Van Meerbeek et al., 2003). The ability of self-etching adhesives (SEAs) for enamel etching is significantly lower than that of phosphoric acid; most studies have shown that the bonding capacity of these materials is lower than the conventional method (ERA) (Van Meerbeek et al., 2003; Yazici et al., 2007; Inoue et al., 2003). Enamel etching with phosphoric acid is recommended to improve SEA bond to enamel structure. In our study, bond strength was significantly increased by acid etching. Noorbakhsh et al., (2012) also reported that acid etching increased enamel bond strength of self-etching adhesive. In fact, acid preconditioning can significantly increase the bonding strength outcomes.

The results of our study showed that micro-shear bond strength of the self-adhering composite (Vertise Flow) is significantly lower than ordinary sealants. Goracci et al., (2013) also concluded that total etch group had the highest shear bond strength and the self-adhering composite group had the lowest shear bond strength, which is consistent to our results. Juloski et al., (2012) reported that addition of acid etching did not significantly increase the shear bond strength of the self-adhering composite. In our study, however, addition of acid etching significantly increased shear strength of the self-adhering composite. Veli et al., (2014) also concluded that shear bond strength of this composite significantly increased by adding acid etching. In fact, the etching step increases the enamel porosities, leads to better locking of the resins and increases the micro-mechanical trapping (Hashimoto et al., 2003). Biria et al., (2014) reported that ordinary sealants with acid etch have higher shear bond strength than self-etch bond and self-etch sealant, which is consistent to our study. Bektas et al., (2013) showed that the self-adhering composite is a useful material with acceptable bond strength. According to their study, bond strength of self-adhering composite (Vertise Flow) is well comparable and similar with similar one-stage self-etching systems. Margvelashvili et al., (2013) suggest that bond strength of self-adhering composite (Vertise Flow) is similar to conventional sealants and recommend it as a fissure sealant.

Asmussen et al., (2003) reported that bond strength of self-etch and total etch methods are similar in the short run and in the long run. Different results of these studies are probably due to the difference in procedure and type of the material used. One of the reasons for lower bond strength of the self-etching system is persistence of un-neutralized hydrophilic phosphoric acid on the contact surface of the sealant with the enamel; as a result, self-etching primers tend to absorb water, which reduces bond strength (Nikaido et al., 2002; Hosaka et al., 2007; Hikita et al., 2007). In self-etching systems, conditioning and priming of the tooth surface occurs simultaneously. Therefore, the depth of demineralization is low and as a result, penetration depth of the resin into the enamel is limited, which causes a weak bond (Jaberi Ansari & Sadr, 2007). Another reason for higher bond strength of conventional total etching methods with self-etching is that etching enamel increases the contact surface of resin and enamel; in this way, it reduces the contact angle, increases the wetting and penetration of the resins, and increases the depth and number of resin tags. Wadeyna et al., (2009) suggested that micro-shear bond strength of self-adhering composites significantly increased by etching the enamel with phosphoric acid for 10 seconds (Kenshima et al., 2005).

Thermocycling is a standardization method for restoring the aging materials; that is, as materials change in the mouth over time, the device restores heat, time, and pressure inside the mouth. Different thermocycling protocols are used by different research groups. According to the International Standardization Organization (ISO), a cycle of thermocycling involves 500 cycles in water at 5-55 °C, which actually restores aging (Veli et al., 2014). It seems that hygroscopic expansion and solubility phenomenon following water adsorption in the self-adhering flowable composite are the reasons for reducing bond strength after thermocycling over time (Wei et al., 2011). After thermocycling, the self-adhering flowable composite without acid etch was removed from the tooth surface, which indicates its very weak bond strength. Goracci et al., (2013) showed that total etch group had higher bond strength and the Vertise Flow self-adhering composite group had the lowest strength after thermocycling. The acid etch + Vertise Flow group hadhigher strength than the Vertise Flow group, which is consistent to our results. Finally, it is concluded that a definite statement about application of self-adhesive composites in comparison with other types of fissure sealants requires long-term evaluations.

5. CONCLUSION

According to the findings of this study, it can be concluded that the self-adhering system cannot form acceptable resin microtags and hybrid layer in enamel and dentin compared to Etch & Rinse bonding systems without separate etching and priming steps; this will lead to low bond strength. The micro-shear bond strength of self-adhering composites is significantly increased by adding an etching step for at least 15 seconds. Therefore, if proper insulation is possible, the surface should be etched before using these materials even for self-adhering systems. Due to elimination of the bonding step and consequent reduction of clinical stages of the work, it seems that this material is useful in pediatric dentistry, particularly in non-cooperating children. Finally, future studies can address the shear strength of self-etching + self-adhering composite bonds and compare with acid etching + self-adhering composite bonds. In order to complete the study, it was better that other complementary method, such as electron microscopy and other self-adhering composites, was used along with the work done. But limitations, including funding and facilities prevented this. It is hoped that these will be considered in future studies.

Ethical Statement

The study was approved by the Ethics Committee of KUMS Registration No: Ethical Code: IR.KUMS.REC.1393.6689.

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Conflict of interests

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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