Original Article

# Effect of Self-Etching and Single-Bottle Bonding Systems On Shear Bond Strength of Fissure sealant to Primary and Permanent Enamel

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**Abstract**

**Background and Aim:** Application of self-etching bonding systems to primary and permanent teeth has increased due to the simplicity of work and fewer steps. This experimental study aimed to compare the effect of conventional acid etching and single-bottle and self-etching bonding systems on shear bond strength (SBS) of light-cured fissure sealant to primary and permanent enamel.

**Materials and Methods**: In this experimental study, the smoothest unprepared proximal enamel surfaces of 30 primary molars (groups 2, 4 and 6) and 30 permanent premolar teeth (groups 1, 3 and 5) were divided into 6 groups of 10. Groups 1 and 2 (control) were acid-etched and received light-cured fissure sealant (Concise 3M-ESPE). Groups 3 and 4 (SB) were subjected to acid etching + Single Bondadhesive + fissure sealant. Groups 5 and 6 (PLP) received self-etching bonding system (Prompt L-Pop, 3M, ESPE) + fissure sealant. Specimens were then subjected to 500 thermal cycles with the dwell time of 30 seconds. Shear bond strength was determined using Universal Testing Machine (Zwick, Germany). Mode of fracture was determined under stereomicroscope and data were analyzed using ANOVA, (between-subjects effect) and LSD.

**Results:** SBS was not significantly different between the control and PLP or SB and PLP groups ($P>0.05$). However, the difference in SBS between the control and SB groups was statistically significant ($P=0.022$). The SBS in primary teeth was less than in permanent teeth in all groups ($P<0.05$).

**Conclusion:** Self-etching bonding system (PLP), similar to conventional acid etching technique, provides adequate bond between the light-cured fissure sealant and unprepared enamel. Application of Single Bond Adhesiveeffectively increased the fissure sealant bond strength.

**Key Words:** Shear bond strength , Pit and fissure sealant , Self-etching bonding system

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## Introduction

Efficacy of fissure sealants for prevention of primary and secondary caries in permanent teeth has been well documented.

Primary molar teeth similar to permanent molars are at risk of occlusal caries and benefit from the application of pit and fissure sealants [1]. Efficacy of fissure sealants in prevention of caries directly depends on their ability to completely seal the pit and fissures of the occlusal surface, retention of the sealant, good marginal adaptation and performance of clinician. Sealant retention directly depends on the resin bond to enamel [2]. Application of a layer of hydrophilic bonding agent beneath these materials is a technique suggested for increasing the fissure sealant bond strength. Hitt and Feigal recommended the application of a layer of bonding agent beneath the fissure sealant to increase the bond strength [3]. It has been demonstrated that this technique, in both moist and dry conditions, increases the bond strength and decreases the microleakage. However, some authors do not recommend this technique due to higher cost and longer duration of treatment [4]. Another approach is the application of self-etching instead of acid etchingsystem. Self-etching bonding systems provide adequate bond strength and are less sensitive to saliva contamination; thus, their application increases the rate of treatment success. The advantage of self-etching adhesive systems, aside from simplifying the bonding technique, is shorter working time and decreased risk of saliva contamination [5-6]. Both these factors are extremely important when the patient is not cooperative [7]. Also, by elimination of washing and drying steps, risk of over-moisture or over-drying (that both have a negative effect on the bond strength) is decreased [8]. Despite the adequate bond strength of self-etching systems to dentin, their bond strength to enamel is still a matter of debate [9-10]. There is a concern that simplifying the application steps in these systems compromises the fissure sealant bond to enamel and this system may not be a good substitute for the conventional method of bond to enamel [10]. Some studies have shown that application of self-etching system has equal or greater efficacy than the acid etching technique [6, 11-14] when it comes to the quality of the fissure sealant bond to enamel. This finding is in contrast to the results of some other studies regarding the superiority of acid-etch technique over the self-etchingsystem [10].

Data regarding the bond strength of adhesive systems to unprepared intactprimary enamel is sparse. In the majority of studies on the bond strength of self-etchingsystems to primary enamel, the prismless non-crystalline surface enamel was eliminated by the use of burs and laser [16-17]. Also, the results of fissure sealant bond strength to primary and permanent enamel have been variable. Some studies have reported higher bond strength in permanent teeth [1]; whereas, othershave reported equal bond strength in primary and permanent teeth [7, 18].

Since efficient seal of fissures is achieved through the strong bond between the fissure sealant and enamel, it is necessary to assess the bond strength of fissure sealant to enamel in acid-etch, Single Bond and self-etching bonding systems. This study sought to assess the effect of Single bond adhesive and self-etching (Adper Prompt L-Pop) bonding system on the shear bond strength of fissure sealant to primary and permanent enamel.

## Materials and Methods

This laboratory experimental study was carried out on 30 permanent premolar and 30 primary molar teeth (both maxillary and mandibular) extracted in the past 6 months for orthodontic purposes. The teeth were cleaned and stored in saline solution. The teeth were intact and free from caries, cracks or occlusal attrition. Enamel surfaces were polished with fluoride-free pumice paste and rubber cup for 10s using a low speed handpiece. Specimens were then rinsed with water.

In order to prevent interference with the Universal Testing Machine during load application, the roots were cut short and any visible convexity on the root surfaces was eliminated. The teeth were mounted in a mould measuring 20x18x12 mm containing acrylic resin in such way that the smoothest part of proximal surface (mesial or distal) was parallel to the horizontal plane. Moreover, in order to prevent the interference of acrylic resin, the outline of acrylic resin was 2 mm farther than the working site.

Specimens were randomly divided into 6 groups (n=10). Groups 1, 3 and 5 contained permanent and groups 2, 4 and 6 contained primary teeth. In groups 1 and 2 (control), teeth surfaceswere air-dried and etched with 37% phosphoric acid gel (3M-ESPE) for 30s. In groups 3 and 4 (SB), teeth surfaces were air-dried, etched with 37% phosphoric acid gel (3M-ESPE) for 30s, washed and dried. Then, Single Bond adhesive (3M-ESPE) was applied as primer and bonding agent in two steps and light cured for 20s (Coltolux 50, Coltene, Switzerland).

In groups 5 and 6 (PLP), teeth surfaces were air-dried and treated with self-etch bonding agent (Prompt L-Pop, 3M-ESPE). First, self-etch bonding agent was applied and air-dried for 15s. Then, self-etch bonding agent was reapplied for 3s and air-dried.

Immediately after the abovementioned procedures, a plastic washer was separately used as a mould in the three groups in order to confine the understudy surfaces. The mould measured 1.5x3 mm and placed 0.5-1 mm above the CEJ in all specimens. In order to avoid gap formation, the material was gently injected into the mould and the tip of syringe was in contact with the cavity floor. After filling up the mould, the fissure sealant (HEMA, 3M-ESPE) was applied to the specimens and light cured for 40s. The washer was the cut with a #11 scalpel and the mould was removed. Specimens were light cured for 40s from 4 directions. The distance from light source to the specimen was 1mm.

Specimens were immersed in distilled water for 24h and then underwent 500 thermal cycles at 5-50°C with a dwell time of 30s and transfer time of 15 s. Universal testing machine (Zwick, Germany) was used for the assessment of bond strength with 10 KN load vertically applied to the fissure sealant-tooth interface at a cross head speed of 0.5 mm/min. Data were analyzed using two-way ANOVA (between-subjects effect) and LSD multiple comparison test. Mode of failure was observed under stereomicroscope at 20X magnification.

## Results

Data regarding the comparison of the effect of Single Bond adhesive and self-etching bonding system on shear bond strength of sealant to primary and permanent enamel were stored in SPSS software data bank. Table 1 shows the mean and standard deviation of shear bond strength in each group. Kolmogorov Smirnov test was used to assess the distribution of data in each experimental group. Normal distribution is determined by mean and SD. Based on this test, all the raw data in the understudy groups had normal distribution.

Two-way ANOVA with between-subjects effect test between two independent variables (bonding and type of tooth) and their interaction on the dependent variable namely bond strength revealed that:

The independent variables namely type of tooth and bonding both had a significant effect on bond strength (P=0.002 and P=0.9039, respectively). However, the effect of the interaction of the two on bond strength was not significant (P=0.765). Thus, any change in the type of bonding system would have the same effect on both primary and permanent teeth because the interaction of these two variables was not significant.

**Table 1:** The mean, standard deviation, minimum and maximum values of the shear bond strength in the understudy groups

| Bonding agent | Tooth | Number | Minimum | Maximum | Mean | Standard deviation |
|---|---|---|---|---|---|---|
| **Control** | 1: Permanent | 10 | 2/96 | 12/97 | *7/62950 | 3/85463 |
| | 2: Primary | 10 | 3/02 | 7/76 | *4/8240 | 1/84623 |
| **PLP** | 3: Permanent | 10 | 3/62 | 17/28 | •9/7960 | 5/37404 |
| | 4: Primary | 10 | 3/24 | 18/58 | •7/2100 | 4/55412 |
| **SB** | 5: Permanent | 10 | 3/44 | 17/90 | ♦11/2870 | 4/56144 |
| | 6: Primary | 10 | 4/78 | 8/27 | ♦7/0250 | 1/04343 |

**(• و ♦) و (• و *)** No significant difference
**(♦ و *)** Presence of a significant difference

Thus, post hoc test (LSD) with 95% CI was applied. In this test, all teeth, regardless of type, were placed in three groups based on the material applied and the effect of bonding agent was evaluated on them. The results showed no significant difference in bond strength between the control and self-etch (P=0.072) and self-etch and bond-etch groups (P=0.596). However, the difference in bond strength between the control and bond-etch groups was statistically significant (P=0.022).

Mode of failure was evaluated under stereomicroscope at 20X magnification and the results in this regard are demonstrated in Table 2.

**Table 2:** The frequency distribution of mode of fracture after shear bond strength testing

| | | Control group | Etch & bond group | Self-etch group |
|---|---|---|---|---|
| **Permanent Group** | **A*** | 1 | 3 | 3 |
| | **C**** | 0 | 2 | 0 |
| | **M**** | 9 | 3 | 7 |
| **Primary Group** | **A*** | 2 | 1 | 6 |
| | **C**** | 3 | 6 | 1 |
| | **M**** | 3 | 3 | 3 |

*Adhesive Failure
**Cohesive Failure
*** Mixed Failure

## Discussion

Resin bond to enamel depends on creating a porous surface by selective dissolution of hydroxy apatite crystals by acid and subsequent formation of resin tags in etched enamel leading to formation of a micromechanical bond. After achieving a successful clinical bond to enamel, various dentin bonding systems were introduced [5, 19]. Efforts were made to enhance their bonding quality, simplify the working phases and reduce their technical sensitivity [5, 6]. Prompt L-Pop (PLP) is a single-step two-component self-etch bonding system. The three steps of acid etching, primer application and resin application have been combinedyielding a two-component system. In general, the conditioning phase has been eliminated in self-etch systems and they are based on bonding to smear layer on enamel and dentin. Due to primer acidity, they are capable of etching beyond the smear layer. These bonding agents contain acidic monomers especially MET-4 and MDP-10 that are more hydrophilic than the previous hydrophobic systems. In these systems, water serves as an ionized catalyst [20]. Two main drawbacks of these systems include sparse studies on their clinical efficacy and the need for further investigations in this respect [21] as well as concerns regarding their ability to bond to enamel in the clinical setting [6, 22]. Single Bond adhesive is a 5th generation bonding system [23] and contains acetone and ethanol. Itis highly capable of flowinginto the etched enamel. On the other hand, acetone and ethanol are capable of eliminating the moisture remaining on the surface [24, 25].

This study evaluated and compared the effect of self-etch (PLP) and Single Bond bonding systems on shear bond strength of fissure sealant to primary and permanent enamel. The results showed that the self-etch bonding system yielded bond strength similar to that of acid etching of unprepared primary and permanent enamel. Bond strength of PLP adhesive system compared to Single Bond adhesive was similar in unprepared primary and permanent enamel. Also, application of Single Bond adhesiveunderneath the fissure sealant increased its bond strength to primary and permanent enamel. This finding is in agreement with the results of some previous studies. Nejad et al, in 2012 used different surface preparation techniques on the occlusal enamel of 60 third molar teeth and fissure sealant was applied afterwards. Similar to our findings, they demonstrated that microleakage of fissure sealant was not significantly different following etching with phosphoric acid and application of Prompt L-Pop bonding agent [6]. Also, Cehreli et al, in their 4-year in-vitro study in 2008 on 192 human third molar teeth (half were evaluated after 48 h and the other half after 48 months of water storage) showed that application of Helioseal F fissure sealant along with Single Bond adhesive caused less microleakage than the use of fissure sealant in combination with the application of Prompt L-Pop self-etch bonding agent and fissure sealant combined with acid etching alone [26].

Peng et al, in their one-year clinical trial in 2006 found no significant difference in terms of retention and presence of secondary caries between teeth sealed with fissure sealant along with the use of phosphoric acid and those sealed with fissure sealant in combination with the application of self-etch system [11].

Perdigao et al, in their 3-year study in 2005 detected no difference in fissure sealant retention following the application of self-etch bonding systems and the conventional acid etching of unprepared saliva-contaminated enamel [12]. Ram et al, in

2005 reported that the effect of self-etch systems was similar to the etching effect of phosphoric acid [13].
On the other hand, Predigao et al, in 2011 evaluated the sealing potential of two types of fissure sealants (Clinpro and Enamel Loc) in combination with Prompt L-Pop and Single Bond adhesive systems and conventional acid etching through the microleakage assessment. They reported that microleakage was not significantly different between Single Bond and self-etch bonding systems. Use of conventional acid etching yielded the best seal [10]. Asselin et al, in 2009 assessed the bond strength of sealant to permanent enamel in three application protocols and stated that bond strength in self-etch technique had no significant difference with that of Single Bond adhesive. However, the bond strength in both mentioned techniques was higher than that of acid-etching alone [15].
One probable explanation for the reported differences is that the PLP bonding does not have equal compatibility with all resin materials. Peutzfeldt in 2004 [1] mentioned that the shear bond strength of 6 composite resins to dentin by use of PLP bonding agent changed between 1 to 13 MPa. Significant changes in bond strength may be attributed to the fact that unlike etching with phosphoric acid, PLP bonding agent cannot yield an optimal bond to enamel with all types of fissure sealants and the bond strength is influenced by the mechanical properties of the resin material [1]. Another explanation for the variable efficacy of self-etch bonding system is that numerous parameters namely tooth structure, enamel preparation, test method, bonding surface area, speed of load application (cross-head speed) and the operator-related factors may affect the results [27]. Moreover, duration of water storage and thermocycling also play a role in this respect [13]. Small number of studies have evaluated the bond strength of self-etch bonding systems to unprepared enamel of primary teeth reporting different bonding quality in primary and permanent teeth. Marquezan et al, in 2008 compared the microtensile bond strength of self-etch and Total Etch systems to primary enamel and dentin and reported equal bond strength of self-etch to primary enamel and dentin [18]. Furthermore, Ramires et al, in 2007 evaluated the microtensile bond strength of fissure sealants and adhesive systems to primary enamel and reported equal microtensile bond strength between total etch and the conventional technique in primary teeth.However, both had higher microtensile bond strength than the self-etch technique [28]. Shimada et al, in 2002 evaluated the composite bond to prepared primary and permanent enamel with the use of self-etch and Single Bond adhesive and found no significant difference in bond to primary and permanent enamel in the two systems [7]. Peutzfeldt also reported higher bond strength of fissure sealant combined with PLP bonding and phosphoric acid to unprepared enamel of permanent teeth compared to primary teeth [1]. Our study showed that the bond strength of fissure sealant to primary enamel was lower than that to permanent enamel.
Controversial results reported by various studies may be attributed to different surface preparation techniques. Some in-vitro studies have evaluated bond strength to prepared enamel while some others have investigated unprepared intact enamel surfaces. Enamel preparation in smooth teeth surfaces provides a larger area that facilitates the fit of mould to the surface. The non-crystalline hypermineralized surface enamel is eliminated as well. Moreover, some specific areas of primary enamel (particularly the cervical area) have higher thickness of non-crystalline enamel (than permanent teeth) that probably interferes with resin penetration and formation of resin tags and subsequent bond. Peutzfeldt reported that in about 10% of cases, the fissure sealant is spread in the proximal area beneath the mould. Thus, the bonding area is enlarged yielding a higher bond strength value compared to other studies. In order to prevent this occurrence in our study, placement of mould and application of fissure sealant were carried out by two clinicians. Thus, the bond strength to primary enamel was found to be less than that to permanent enamel [1]. Also, no association was observed between the type of adhesive system and fracture mode in primary and permanent teeth. Ramires et al, in their study in 2007 found no association between resin-enamel fracture mode and bond strength of adhesive systems [28]. Other studies have also confirmed the lack of correlation between the fracture mode and bond strength [1, 29, 30]

## Conclusion

Within the limitations of this study, the following conclusions may be drawn:

1.Prompt L-Pop self-etch bonding agent similar to conventional acid-etch technique can form an efficient bond to unprepared enamel of permanent and primary teeth.

2.Application of Single Bond adhesive increased the bond strength to primary and permanent enamel

3.The bond strength of fissure sealant to permanent teeth was greater than that to primary teeth

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