Original Article

In vitro Evaluation of Shear Bond Strength of Orthodontic Brackets Bonded with Different Adhesives

Abstract

Background: There is necessary of dry operating field for bonding of orthodontic brackets. The presence of moisture can alter the bond strength. Hence, the aim of the present study was to evaluate the shear bond strength of orthodontic brackets with different adhesives. **Materials and Methods:** In this *in vitro* study, a total of 100 orthodontically extracted premolars with sound crown structure were divided into 4 equal groups of different primers. Bonding on the buccal surface of all teeth was done after acid etching with upper premolar brackets using different primers followed by light curing. Shear bond strength was evaluated with or without salivary contamination with both adhesives. A shear force for deboning the bracket was done with universal testing machine. The debonded specimens were examined at ×10 magnification to check site of bond failure and remaining adhesive on tooth using adhesive remnant index (ARI). The obtained data were statistically evaluated using SPSS 20 for Windows (SPSS Inc., Chicago, IL, USA) using ANOVA, Kolmogorov–Smirnov, and Levene's test at the statistical significance of $P < 0.05$. **Results:** Transbond Plus showed higher shear bond strength of 8.92 MPa under dry and 5.65 MPa with saliva contamination over Transbond XT of 7.24 MPa under dry and 2.43 MPa with saliva contamination, respectively. Higher ARI score was found without contamination in both adhesives. **Conclusion:** Transbond Plus hydrophilic resin had good shear bond strength under both dry and contamination condition compared to hydrophobic Transbond XT resin material.

Keywords: *Adhesive, bond strength, hydrophilic, hydrophobic, primers, shear strength*

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Introduction

Contamination of etched tooth surface during orthodontic bonding procedure can result in poor bond strength hence control of moisture contamination is necessary. Saliva and blood contamination is major cause for bond failure.[1] Klocke *et al*. stated that contamination during bonding procedure reduces the bond strength.[2] Many methods are used to maintain dry operatory filed such as saliva ejector, antisialagogue medicine, and cotton rolls. However, these methods are not adequate for bonding procedures during orthodontic treatment. The maintenance of dry field is required for orthodontic bonding since most of the primers and adhesives have hydrophobic components.[1,3]

Recently, hydrophilic resin systems and moisture insensitive primers (MIP) are introduced to provide adequate bond strength in the presence of moisture. These are self-etching primers, hydrophilic resin-modified glass ionomer cement (GIC), and MIP such as Transbond MIP, Transbond XT, Opal Primo, and GC Fuji Ortho LC. Rix *et al*. found that MIP with adhesive was effective in both dry and wet areas.[4]

The use of fluoride-releasing adhesives can inhibit caries lesion development during fixed orthodontic treatment. The use of these cements for direct bonding of orthodontic brackets has been proposed because of their ability to adhere to base metal alloys.[5]

Self-etching primers are recently introduced in orthodontics for reducing the bonding steps and to eliminate the need of etching, primers thus eliminates the chances of contamination. Self-etching primers are combination of etching and primer, hence have lesser chairside time and salivary contamination.[6]

The bond strength of bonded orthodontic brackets should be sufficient to withstand orthodontic forces applied during treatment. The ideal orthodontic adhesive should have

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adequate bond strength.[6] Reynolds mentioned 5.9–7.8 MPa resistances are sufficient to withstand masticatory force.[7] Bishara *et al*. observed 10.4 and 11.8 MPa of mean bond strength respectively with composite resin and conventional adhesive system.[8]

The purpose of the present study was to evaluate the shear bond strength of orthodontic brackets bonded with hydrophilic and hydrophobic primers.

Materials and Methods

In this *in vitro* study, a total of 100 orthodontically extracted premolars with intact sound crown structure and absence of caries, cracks, any developmental defects or restorations were selected. All the selected teeth were cleaned with nonfluoridated pumice for any debris or stain and stored in saline until its use. All the teeth were mounted on acrylic block. Buccal surface of enamel of each tooth was treated with 37% orthophosphoric acid for 15 min and later rinsed with water for 10 s and air dried. These teeth were randomly divided into 4 groups (25 samples in each group) depending on the use of primers as follows; Transbond Plus Color Change (3M Unitek, St. Paul, MN, USA), Transbond XT® system (3M Unitek).

- Group (A) – Transbond XT primer and Transbond XT without saliva contamination
- Group (B) – Transbond XT primer and Transbond XT with saliva contamination
- Group (C) – Transbond self-etching primer and Transbond Plus color without saliva contamination
- Group (D) – Transbond self-etching primer and Transbond Plus color with saliva contamination.

Transbond XT has hydrophobic properties and Transbond self-etching primer with Transbond Plus color has hydrophilic properties. Teeth in Group B and D were contaminated with natural saliva before application of primer. The excess of saliva was blotted out. Bonding on the buccal surface, all teeth were done with upper premolar brackets (MBT 0.22 slot diamond, Miniseries 2000 Ormco, USA) using different primers. The primers and adhesives were light cured after application with 3M Unitek halogen light for 40 s. All the procedure was done by single operator.

All the samples were stores at room temperature in distilled water after bonding for 48 h. Each specimen was placed on mounting jig in the Lloyd's Universal testing machine with bracket base parallel to the shear load. A shear force for deboning was applied to bracket base in occlusogingival direction at a crosshead speed of 1 mm/min. The maximum force required to debonding or fracture of the bracket was recorded in megapascal (MPa). The debonded specimens were examined at ×10 magnification to check site of bond failure and remaining adhesive on tooth using adhesive remnant index (ARI) as described by Artun and Bergland.[9] This index uses 4 scores – (0) no adhesive residue in bonding area on tooth, (1) <½ of adhesive residue remaining in bonding area on the tooth, (2) >½ of the adhesive remaining in the bonding area on the tooth, and (3) all the adhesive remaining on the tooth in the bonding area. The obtained data were statistically evaluated using SPSS 20 for Windows (SPSS Inc., Chicago, IL, USA) using ANOVA, Kolmogorov–Smirnov and Levene's test at the statistical significance of $P < 0.05$. The one-way ANOVA was carried out for the comparison of groups.

Results

Table 1 indicates the mean bond strength of different groups in MPa under dry and with salivary contamination. Transbond Plus showed higher shear bond strength under dry (8.92 MPa) and saliva contamination (5.65 MPa) over Transbond XT of 7.24 MPA under dry and 2.43 MPA with saliva contamination, respectively. Table 2 indicates ARI score among the groups. There were higher ARI scores in both groups under dry condition compared to salivary contamination. Transbond Plus has higher ARI score in both the condition compared to Transbond XT.

Discussion

Bond strength determines the amount of force delivered and also affects the treatment duration.[10-12] Shear bond strength depends on various factors including the adhesive properties of the bonding materials, the attachment at the different interphases such as the tooth to composite interphase and the composite to bracket interphase, as well as the polymerization of the composite bonding material.[11] Bonding procedure involves etching, primer solution, and adhesive application followed by composite application. Different generations of adhesive were developed to improve the bond strength and to reduce the duration.[10,12,13] There is a search for methods to improve the bond strength in the presence of moisture using light cured or self-cured material and hydrophilic adhesives. A major drawback of the auto-cured adhesive system is the inability of the practitioner to manipulate the setting time of the composite resin. Ahmed compared concise, Transbond, Alpha dent and Fuji GIC to assess the shear bond strength of brackets bonded with these materials and he observed higher bond strength with concise and Transbond.[12]

Hydrophilic primers are usually used in restorative dentistry. Recently, these primers are tried for bonding orthodontic brackets in moisture condition to provide similar bond

Table 1: Bond strength among groups

Groups	Contamination type	Resin type	Mean SD (Mpa)
A	No	Transbond XT	7.24±3.82
B	Saliva	Transbond XT	2.43±1.31
C	No	Transbond Plus	8.92±2.17
D	Saliva	Transbond Plus	5.65±2.38

P<0.05. SD: Standard deviation

Table 2: Adhesive remnant index for different groups

Groups	*n*	Contamination type	Resin type	ARI score (%)			
				0	1	2	3
A	25	No	Transbond XT	40	25	15	20
B	25	Saliva	Transbond XT	80	10	0	0
C	25	No	Transbond Plus	25	25	20	25
D	25	Saliva	Transbond Plus	55	20	15	5

ARI: Adhesive remnant index

strength as of in dry condition. The bracket adhesion quality is an important parameter for successful orthodontic treatment.[14] A hydrophilic primer contains 2-hydroxyethyl methacrylate (HEMA), polyalkenoate copolymers, ethanol along with carboxylate groups. This HEMS allows readily bonding to resin composite by lowering contact angle and an extension of the molecule.[3]

In our study, we tested both hydrophobic and hydrophilic primers in both dry and salivary contamination condition on etched tooth enamel. Clinically, 5–8 MPa of bond strength is acceptable for orthodontic brackets to withstand tensile load.[7] Grandhi *et al*. observed higher bond strength with Transbond MIP than Transbond XT on contamination with fresh saliva of bovine teeth.[15] We have found higher shear bond strength with Transbond Plus (hydrophilic) in dry or wet condition compared to Transbond XT (hydrophobic) which is in agreement with results of Nirupama *et al*. and Cunha *et al*. study.[1,16] Similarly, Santos *et al*. observed higher bond strength with self-etching primers (hydrophilic) compared to hydrophobic Transbond XT on blood contamination.[17] Schaneveldt and Foley observed higher bond strength in conventional Transbond XT primer of 14.82 ± 2.62 MPa under dry condition and 12.23 ± 2.53 MPa for Transbond MIP primer under wet condition compared to our results.[18]

Tessore *et al*. compared shear bond strength and ARI scores of two resin adhesives by direct and indirect method. They found similar shear bond strength and failure sites with resin cements; Kurasper and Transbond with orthodontic brackets bonded to bovine enamel either or indirect technique.[14] Toledano *et al*. evaluated the shear bond strength of stainless steel orthodontic brackets bonded with light cure and self-cure cements. They observed highest bond strength with chemically cured composite resins and lower but within acceptable range bond strength with light cured resin and GIC.[5] Banerjee and Banarjee compared the shear bond strengths of five different orthodontic light cure bonding materials cured with traditional halogen light and lowintensity lightemitting diode (LED) light curing unit. They found higher than clinically acceptable range of shear bond strength with Halogen and LED light.[11]

Sreedhara *et al*. compared the shear bond strength and ARI score of brackets bonded with traditional technique and with prompt-L-pop. They found lower shear bond strength with sixth-generation adhesives compared to 4th and 5th generation, but it was clinically acceptable bond strength.[13] Pillai *et al*. compared shear bond strength of brackets bonded with three different adhesive systems (Biofix, Transbond XT and Unite) and they found superior bond strength with Biofix compared to others.[10] Nirupama *et al*. observed highest bond strength with Transbond XT compared to other tested groups. They also observed that bond strength was higher in dry condition compared to wet.[1] Many researchers observed decrease in bond strength with contamination.[1,19]

ARI is one of the most commonly used methods of assessing the quality of adhesion between the composite and tooth and also between bracket base and composite. In our study, we observed ARI score was higher without salivary contamination for both hydrophilic and hydrophobic groups. It was higher in Transbond Plus of 25, 20, and 25 respectively at 1, 2, and 3. Our results are in accordance to Nirupama *et al*.[1]

Sharma *et al*. from their study on comparing the Transbond XT with self-Rely-a-bond (etching adhesives) Transbond Plus and Xeno V and they found ARI scores of 30% in Rely-e-bond, 15% with Transbond Plus, Transbond XT, 10% with Xeno V. There was higher shear bond strength in the tested adhesives which was higher than recommended bond strength. They suggested possible reason for higher ARIO score in Transbond XT and Rely-a-bond due to enamel conditioning with 37% phosphoric acid.[6]

Evan and Powers stated that lower bond strength could be due to increased thickness of layers and differences in film thickness between composite resins.[20]

Rastelli *et al*. compared concise, Ultrabond, and Rely-a-Bond material for shear bond strength. They found highest bond strength with concise and lowest in Ultrabond group but there was no significant difference in ARI index between the groups.[21]

The limitation of the present study is that it is an *in vitro* study, further clinical studies are necessary to evaluate the performance of these hydrophilic resins under clinical condition.

Conclusion

Transbond Plus hydrophilic resin had good shear bond strength under both dry and contamination condition compared to hydrophobic Transbond XT resin material.

Hydrophilic adhesive are advantages under wet condition bonding.

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Conflicts of interest

There are no conflicts of interest.

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