Effect of Saliva Contamination on Shear Bond Strength of Transbond XT and Assure Universal Bonding Resin to Enamel

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Abstract

Background and Aim: Assure universal bonding resin is a modified cement with fluoride releasing property. It is claimed to provide adequate bond strength between the bracket and enamel in wet conditions; although more studies are required in this regard. This study compared the shear bond strength of Transbond XT and Assure universal bonding resin to dry and saliva-contaminated enamel in vitro.

Materials and Methods: In this in vitro study, 60 extracted human premolars were selected and stainless steel brackets were bonded to enamel surfaces. Bonding of brackets to enamel surfaces was done using Assure universal bonding resin (dry condition), Transbond XT (dry condition) and Assure (saliva-contaminated condition). The shear bond strength of brackets to the enamel was determined by Zwick/Roell machine in three groups. Data were analyzed using one-way analysis of variance (ANOVA), and the Kruskal Wallis test.

Results: The mean shear bond strength of brackets to enamel surfaces bonded with Assure (dry condition), Transbond XT and Assure (saliva-contaminated condition) was 14.18±4.78 MPa, 16.13±5.49 MPa and 13.32±4.74 MPa, respectively (with no significant differences). Non-parametric Kruskal-Wallis test found no significant differences regarding the adhesive remnant index (ARI). (p=0.053).

Conclusion: Bonding of stainless steel brackets to enamel surfaces with Assure universal bonding resin provided adequate bond strength in dry and saliva-contaminated conditions. Thus, it may be used for bonding of orthodontic brackets to the enamel surfaces in the clinical setting.

Key Words: Shear strength, Orthodontic adhesive, Dental enamel

Introduction

By the introduction of acid-etch bonding systems by Buonocore in 1995 [1], direct bonding of orthodontic brackets to teeth was made possible; orthodontic treatment was then simplified, gingival irritation decreased, oral hygiene habits became easier, esthetic needs of the patients were better achieved and orthodontic visits decreased [2]. Acid etching creates rough surfaces that enable micromechanical retention; enamel crystals become prismatic adherent. However, there is still a need to improve resinsand theirresistance to saliva contamination during bonding to reduce the incidence of failure. [2] Manufacturers have tried to increase fluoride release levels from the adhesives to prevent the incidence of white spot lesions while maintaining high bond strength values. Glass ionomer cements have been found to release fluoride in the long-term, and the amount of fluoride released from them is more...
than that of fluoride-releasing composites [3-5]. Although adequate fluoride is released from these cements, their bond strengths are poor (2.37-5.5 MPa) [6-7]. Different combinations of glass ionomer cements and composite resins were tried for bonding brackets to the enamel surfaces. Resin modified glass ionomer cements are similar to glass ionomer cements regarding fluoride release; however, their bond strength values have been reported to be in the range of 5.39-18.9 MPa [8-11]. Bond strength values reported for the polyacid-modified composite resins were in the range of 7.3-11.97 MPa [12-13].

Conventional composite resins need completely dry surfaces to achieve clinically acceptable bond strength values; however, complete isolation of the bonding site against moisture is not possible during bracket bonding [14] and saliva contamination is always probable during the process of etching the enamel surface or after using primers. [15] In the case of contaminated enamel surfaces prior to primer application, the developed porosities following acid etching are closed off and the enamel surface energy will be decreased. Due to impaired resin penetration and decreased micromechanical retention, substantial reductions occur in the bond strength of resin to etched enamel [16]. To solve this problem, some moisture-resistant primers have been developed.

According to a study by Faltermeyer and colleagues in 2007, Transbond XT showed no significant difference in shear bond strength under dry conditions. However, the bond strength was clinically unacceptable using Transbond XT after saliva and blood contamination. [17]

Saliva contamination control and use of materials that form proper bonds in the presence of saliva are needed. Also, with the introduction of lingual brackets, we need products that release fluoride to reduce white spot lesions.

Assure Universal Bonding Resin is a new system with fluoride releasing properties. Assure hydrophilic resin system (Reliance orthodontic products, Itasca, IL) was examined under saliva-contaminated conditions and bond strength values were found to be clinically acceptable. [14, 15]

The current study compared the bond strength of Transbond XT (3M Unitek), and Assure Universal Bonding Resin (Reliance orthodontic products, Itasca, IL) to dry and saliva-contaminated enamel.

Materials and Methods
Sixty human premolar teeth without carious lesions, fracture, crack or attrition were collected and stored in distilled water until the experimentation. They were randomly allocated to three equal groups and their buccal crown surfaces were polished with pumice paste for 15 seconds, rinsed and dried. Stainless steel metal premolar brackets were bonded to the teeth with different adhesives.

Stainless steel brackets (AO, American Orthodontics) (12.68 mm²) were used in this study. They were bonded to the enamel surfaces of the teeth with light-cured Transbond XT (3M) composite in the control specimens. In this group, the buccal enamel surfaces were etched with 37% phosphoric acid for 30 seconds, rinsed for 20 seconds, and dried with oil-free air until the enamel became white. Transbond XT primer was applied to the etched surface in a thin film and Transbond XT composite was applied to the bracket base. The bracket was then positioned exactly on the tooth and compressed to expel the excess adhesive. The specimens were cured for one second to obtain adequate appearance. Then, additional adhesives were removed from around the brackets’ base followed by another round of light curing for 10 seconds. All these were done according to the manufacturer’s directions.

In the first experimental group, Assure Universal Bonding Resin (Reliance orthodontic products, Itasca, IL) was used. All etching, rinsing and drying procedures were done according to Transbond XT protocol. Assure sealant was applied in two coats to the buccal crown surface, left for 10 seconds, and dried slowly. Assure adhesive and Transbond XT composite were applied to the bracket base, and the bracket was positioned exactly on the tooth and compressed to expel the excess adhesive. The specimens were cured for one second to obtain adequate appearance. Then, excess adhesives were removed from around the brackets’ base followed by another round of light curing for 10 seconds.

In the second experimental group, all etching, rinsing and drying procedures were done according to Transbond XT protocol; however, before sealant application...
application, a thin layer of natural saliva was applied to the enamel surface. The saliva was collected by the operator after teeth washing and not eating any food for one hour. The brackets were bonded similar to the previous group.

After bonding, all specimens were immersed in chloramine T solution for 24 hours at 37°C followed by storage in an incubator for one week at 37°C temperature. The specimens were thermocycled at 5°C-50°C for 1000 cycles (each cycle for 30 seconds). Each specimen was then mounted in a custom device by means of 17×25 wire. Shear loads were applied to the specimens at a crosshead speed of 1mm/min and 0.5 N preload force by means of Zwick machine (Zwick Roell, Germany) until bracket debonding occurred. The debonding force was recorded. Shear bond strength forces were calculated by testXpert V11.0 (Zwick Roell, Germany) software in Megapascals by dividing force (N) to bracket base area (mm²).

The debonded enamel surfaces were examined by a stereomicroscope at 10× magnification and the residual adhesive remaining on the teeth was scored from 0 to 5 using the adhesive remnant index (ARI):

- Scale 5: Adhesive and resin remained on 100% of the bracket surface
- Scale 4: Adhesive and resin remained on 75%-100% of the bracket surface
- Scale 3: Adhesive and resin remained on 50%-75% of the bracket surface
- Scale 2: Adhesive and resin remained on 25%-50% of the bracket surface
- Scale 1: Adhesive and resin remained on less than 25% of the bracket surface
- Scale 0: No adhesive and resin remained on the bracket surface [14].

The shear bond strength values were analyzed by one-way ANOVA and the Kruskal Wallis test was used to assess significant differences in ARI.

**Results**

The shear bond strength of brackets to the enamel surfaces was 16.13±5.49 MPa (range 7.66-27.32 MPa) when bonded with Transbond XT; these values were 14.18±4.78 MPa (range 7.54-25.82 MPa) for the specimens bonded with Assure Universal Bonding Resin and 13.32±4.74 MPa (range 5.6-26.9 MPa) for those bonded with Assure Universal Bonding Resin in the saliva-contaminated enamel surfaces. One-way ANOVA showed no significant differences regarding the shear bond strength of the brackets to the teeth using Transbond XT light-cured composite, Assure and Assure in the saliva-contaminated enamel (p=0.2) (Table 1).

**Table 1**: Minimum, maximum, mean and standard deviation of the adhesive bond strength to stainless steel brackets using Transbond XT and Assure (dry and wet enamel)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean ± Std.Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transbond XT</td>
<td>20</td>
<td>7/66</td>
<td>27/32</td>
<td>16/13±5/49(a)</td>
</tr>
<tr>
<td>Assure</td>
<td>20</td>
<td>7/54</td>
<td>25/82</td>
<td>16/13±5/49(a)</td>
</tr>
<tr>
<td>Assure/Salvia</td>
<td>20</td>
<td>5/6</td>
<td>26/9</td>
<td>16/13±5/49(a)</td>
</tr>
</tbody>
</table>

A indicates lack of a significant difference (P>0.05)

Different values of ARI using Assure, Transbond XT and Assure in saliva contaminated groups are presented in Table 2. Non-parametric Kruskal-Wallis test showed no significant differences in ARI among groups (p=0.053). ARI was 2 in Assure dry enamel group, 4 in the wet enamel group and 3 in the Transbond XT group. In Assure dry enamel and Transbond XT groups, the failure rate between the bracket - adhesive and enamel - adhesive was relatively equal. In the group of Assure on wet enamel, higher failure rate between the enamel - adhesive was noted.

**SEM results**

As seen in Figures 1 and 2, the enamel surface under the bracket in Assure dry enamel and Transbond XT was the same. But in Assure wet enamel group a rough surface with circular holes that are likely to be related to saliva trapped in the holes, can be seen.

**Discussion**

One of the main causes of bracket bond failure is contamination during the bonding process. It has been found that the presence of water [19, 20] or saliva [19, 21-22] can decrease the bond strength in orthodontic resin bonding systems. In the current study, the shear bond strengths of stainless steel brackets to the enamel bonded with Transbond XT and Assure in dry conditions were
16.13±5.49 MPa and 14.18±4.78 MPa, respectively; while the bond strength decreased to

**Table 2:** Frequency of different values of ARI using Transbond XT and Assure (dry and wet enamel)

<table>
<thead>
<tr>
<th>Group</th>
<th>Assure</th>
<th>Count</th>
<th>.00</th>
<th>1.00</th>
<th>2.00</th>
<th>3.00</th>
<th>4.00</th>
<th>5.00</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transbond</td>
<td>Count</td>
<td>0</td>
<td>1</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>1</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>%within group</td>
<td>0%</td>
<td>5/0%</td>
<td>40/0%</td>
<td>30/0%</td>
<td>20/0%</td>
<td>5.0%</td>
<td>100/0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saliva</td>
<td>Count</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>0</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>%within group</td>
<td>5/0%</td>
<td>5/0%</td>
<td>30/0%</td>
<td>35/0%</td>
<td>25/0%</td>
<td>0%</td>
<td>100/0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Count</td>
<td>2</td>
<td>2</td>
<td>17</td>
<td>17</td>
<td>19</td>
<td>3</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>%within group</td>
<td>3/3%</td>
<td>3/3%</td>
<td>28/3%</td>
<td>28/3%</td>
<td>31/7%</td>
<td>5.0%</td>
<td>100/0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SEM results**

**Figure 1:** From left to right, enamel surface under orthodontic bracket respectively: Transbond XT, Assure on wet enamel, Assure on dry enamel. Magnification 500X (The first column), 2000X (the second column), 10,000X (the third column), 20,000X (the fourth column). Trans bond XT group has a smooth surface; in Assure on wet enamel group, surface is uneven and many round holes can be seen.

13.32±4.74 MPa in the saliva-contaminated teeth thusing Assure system although with no significant difference. Therefore, saliva contamination did not cause significant decreases in the shear bond strength of brackets to enamel surfaces. In other underdry and saliva-contaminated conditions did not lead to obvious changes in the shear bond strength of brackets to the enamel surfaces of the teeth. It seems that Assure hydrophilic primer is able to tolerate saliva contamination of etched enamel. As suggested by the manufacturer, Assure universal bonding agent with the fluoride-releasing potential can bond to normal, atypical, dry, or slightly contaminated enamel. Furthermore, it can
be used with any light- or chemical-curing systems.

Other studies regarding the bond strength of bonding systems under saliva-contaminated conditions have reported controversial findings; some have noted an increase in bond strength values [23, 24], while others found no significant changes [25] or a significant decrease. [26] Differences in the experimental protocols, use of artificial or human saliva as well as the quantity of the applied saliva can explain such different results. In addition, the composition of saliva can be different based on the conditions under which it was produced.

The other possible reason can be the presence of water in the composition of hydrophilic primers. All these can affect bond strength of the brackets to the enamel.

Rix et al. (2001) reported higher bond strength values for Transbond XT specimens; although adequate bond strength of brackets to the enamel was noted in their study when bonding with Assure in dry and wet conditions (10.74 MPa and 10.99 MPa); similar to our findings [27]. They showed that bond strength of the Assure adhesive was not significantly affected by dry or wet conditions. In contrast to our results, Oztoprak et al. (2007) showed that saliva (10.66 MPa versus 16.4 MPa) and blood contamination (6.83 MPa versus 16.4 MPa) significantly decreased bond strength values compared to dry conditions [23]. Furthermore, Webster et al. (2001) reported the Assure system to show more tolerance against saliva contamination similar to our study results [28]. Again, Schanewaldt et al. (2002) concluded that the bond strength of Assure and MIP primers are not affected by saliva contamination [15]. Similarly, Nemeth et al. (2006) reported that bond strength of Assure to enamel contaminated with saliva is better than other materials [21]. It seems that bonding to both dry and wet enamel surfaces depends on the material itself and sufficient bond strengths to wet and saliva-contaminated enamel surfaces can be achieved using appropriate materials.

The reported bond strength in different studies maybe related to the factors such as thermocycling tests, bond strength testing machines, direction of the force applied to debond the brackets, the crosshead speed, bracket type, standardization of moisture application, quality and quantity of the products as well as the diversity in the used materials and methods [29].

In routine orthodontic practice, achievement of adequate bond strength for safe debonding is more favorable than obtaining the maximum possible bond strength [30]. Therefore, ARI scores are used in different studies to determine the site of bond failure between the enamel, the adhesive, and the bracket base via observation of the remaining composite on the enamel surfaces. In orthodontic bond strength examinations, cohesive failures in the composite (ARI score 3) indicate the internal strength of the composite rather than the adhesion to the surface under investigation [31].

In the current study, the frequency of ARI scores of 2 (40%) and 3 (30%) was higher for Assure composite system; ARI scores of 3 (25%) and 2 (30%) were found frequently in Transbond XT and scores of 4 (50%) and 3 (20%) were higher for Assure in the saliva-contaminated conditions. When bonding to wet enamel, higher scores of ARI were recorded suggesting unfavorable bonding at the bracket-adhesive interface. According to the SEM results, the mentioned finding is likely due to the accumulation of saliva in the area and creation of bubbles under the brackets reducing the enamel - bracket bond strength and increasing failures in this area.

**Conclusion**

Bonding stainless steel brackets to the enamel surfaces with Assure Universal Bonding Resin produced adequate bond strength in both dry and saliva-contaminated conditions. Thus, it can be used for bonding orthodontic brackets to the enamel surface in the clinical setting.

**References**

25. Cacciafesta V, Sfondrini M, DeAngelis M, Scribante A, Klersy C. Effect of water and saliva contamination on shear bond strength of brackets bonded with conventional, hydrophilic, and self-


