Relative Assessment of Bonding Strength of Orthodontic Adhesives

Yusuf Ahammed A R*
Department of Orthodontics and dentofacial orthopaedics, Krishna Institute of Medical Sciences, Karad, Maharashtra, India

Article History:
Received on: 02 Mar 2020
Revised on: 08 Apr 2020
Accepted on: 05 May 2020

Keywords:
Orthodontic, Teeth, Shear Bond, Adhesives, Strength

ABSTRACT
Current study was carried for evaluating the shear bond strengths of 3 clinical micro-filled adhesives. The experiments were performed on extracted premolars for orthodontic purpose. The sample size was selected by randomized sampling technique. Sample size was 90 which were divided into three groups. The extracted maxillary first premolars were selected according to inclusion and exclusion criteria. The three adhesives selected for the study were applied to the bracket base according to manufacturer instructions. A Universal Test Machine has been utilized to record the bond shear intensity. The existing remnant adhesive on the teeth has been stereo-microscopically observed and is measured utilizing the Adhesive Remnant Index (ARI).

*Corresponding Author
Name: Yusuf Ahammed A R
Phone:
Email: kimskarad66@gmail.com

ISSN: 0975-7538
DOI: https://doi.org/10.26452/ijrps.v11i3.2440

INTRODUCTION
Orthodontic adhesive’s shear bonding strength to the tooth enamel has been a major issue since the introduction and evolution of direct bonding in orthodontics (Proffit et al., 2007). The success of bracket attachment depends on strength of adhesive system to resist orthodontic as well as masticatory forces directed to bracket. Shear bond strength of orthodontic adhesive should be good enough to keep the bracket bonded to the enamel during the treatment. It should allow easy bracket removal without any damage to enamel with least discomfort to the patient (Kundie et al., 2018).

Adhesive bonding power can overcome masticating factors including arch wire forces for motion of teeth. The shear bond performance is defined as the ability of the adhesive to endure the pressure exerted to the surface of the enamel which can de-bond the bracket. Some authors have studied the influence of adhesive filler level on Shear bond strength of experimental orthodontic adhesives (Proffit et al., 2007; Kundie et al., 2018; Øgaard and Fjeld, 2010). But Shear bond performance analysis of orthodontic adhesive products used commercially with different filler levels has not been sufficiently investigated so far. Commercially available orthodontic adhesive materials have difference in their filler size and content. Shear bond strength of these materials provides adequate retention for metallic brackets during entire span of treatment. A high-quality bond is desired to attain such an extended period of fixation (Gama et al., 2013).

Newer options can be used to ease of bonding and adhesive remnant cleanup. One of options is light cured colour changing orthodontic adhesives which aids in removal of flash after bracket placement. Transbond Plus adhesive is one them which provides excellent bond strength with metal and ceramic brackets along with the special colour change feature. It contains mixed amount of silane treated glass and quartz fillers. Fillers are microhybrid type. Filler weight is 75%. According to manufacturer Transbond plus is an affective colour inter-
change adherent that is a moisture based fatless curing attachment grouping with the convenience of transportation as demanded (Park et al., 2009).

Flowable adhesives are one more option which have mechanical properties that enables them to flow into bracket mesh increasing more surface area for bonding, as well as having good bonding strengths. The Transbond Supreme LV is a newer low viscosity flowable light cure mucilaginous beneficial for circumlocutory attachment or wherever a persistent flowable simple healing may be specified. According to manufacturer Transbond Supreme LV adhesive filler weight is 65%. Filler concentration is combination of silica, zirconia, and glass nanofillers which forms clusters exhibiting excellent strength, flow and wear properties (Ryou et al., 2008; Kohda et al., 2012; Ekhlassi, 2011).

Aim and Objectives

Aim

The Shear bond strengths of 3 distinct commercially produced composites will be measured and evaluated depending upon their filler content.

Objectives

To determine shear bond strength of three commercially available orthodontic adhesives. To compare shear bond strength of three commercially available orthodontic adhesives. To compare ARI scores of three commercially available orthodontic adhesives.

Review of Literature

Albaladejo et al., determined the impact on the degradation of micro-filled composite materials, fill substance including surface therapy. 4 micro-filled materials produced with various fillers (20, 25, 30, and 35) and Bis-GMA resin matrix. With increased filler content wear resistance increases irrespective of filler type. They concluded that wear resistance is increased with increased filler content of orthodontic adhesives (Albaladejo et al., 2011).

Ornaghi et al. demonstrated that bond strength values higher than 9.7 MPa can lead to enamel fractures. Orthodontic adhesive material that provides bond strength between 8 MPa to 13 MPa is considered good orthodontic adhesive (Mithra et al., 2003).

Mitra, Wu & Holmes developed two new nanoparticles-Nanomeric particles and Nanoclusters. They used combination of these nanofillers in commercial resin matrix to create a nanocomposite of different opacities and shades. Properties like compressive, tensile, flexural, and shear bond strength were evaluated. Nanocomposite showed excellent physical properties along with high polish and translucency (Correr et al., 2016).

MATERIALS AND METHODS

The present study was carried out in Department of Orthodontics and Dentofacial Orthopaedics, School of Dental Sciences, after approval of ethical committee of, KIMSDU, Karad, Maharashtra. Study was carried out on Maxillary premolars extracted for orthodontic treatment purpose. The sample size was selected by randomized sampling technique. Total 90 specimens were separated into three groups comprising 30 samples as follows in Table 1 in Table 2, Graph 1.

Graph 1: 3 orthodontic adhesive's mean shear bond strength

Materials and Armamentarium


Orthodontic adhesive kit

Group A

Transsbond XT - 3M (Unitek)

Group B

Transbond Plus - 3M (Unitek)

Group C

Transbond supreme low viscosity -3M Unitek

Table 1: Orthodontic adhesives used in study

<table>
<thead>
<tr>
<th>Group</th>
<th>Material</th>
<th>Manufacturer</th>
<th>Filler Size</th>
<th>Filler Weight/ Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>Transbond XT</td>
<td>3M Unitek</td>
<td>Micro hybrid</td>
<td>78.5%</td>
</tr>
<tr>
<td>Group B</td>
<td>Transbond plus</td>
<td>3M Unitek</td>
<td>Micro hybrid</td>
<td>75%</td>
</tr>
<tr>
<td>Group C</td>
<td>Transbond supreme LV</td>
<td>3M Unitek</td>
<td>Nano filled</td>
<td>65%</td>
</tr>
</tbody>
</table>

Table 2: Shear Bond Strengths of Orthodontic adhesives

<table>
<thead>
<tr>
<th>Samples</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21.87</td>
<td>4.3</td>
<td>5.94</td>
</tr>
<tr>
<td>2</td>
<td>7.38</td>
<td>2.91</td>
<td>6.1</td>
</tr>
<tr>
<td>3</td>
<td>5.71</td>
<td>4.8</td>
<td>9.13</td>
</tr>
<tr>
<td>4</td>
<td>8.5</td>
<td>3.3</td>
<td>11.58</td>
</tr>
<tr>
<td>5</td>
<td>9.73</td>
<td>5.3</td>
<td>9.43</td>
</tr>
<tr>
<td>6</td>
<td>10.92</td>
<td>5.11</td>
<td>10.76</td>
</tr>
<tr>
<td>7</td>
<td>6.14</td>
<td>4.66</td>
<td>5.07</td>
</tr>
<tr>
<td>8</td>
<td>20.73</td>
<td>10.75</td>
<td>17.43</td>
</tr>
<tr>
<td>9</td>
<td>10.62</td>
<td>7.21</td>
<td>6.28</td>
</tr>
<tr>
<td>10</td>
<td>4.11</td>
<td>2.11</td>
<td>8.95</td>
</tr>
<tr>
<td>11</td>
<td>7.63</td>
<td>6.13</td>
<td>12.15</td>
</tr>
<tr>
<td>12</td>
<td>6.98</td>
<td>4.77</td>
<td>4.1</td>
</tr>
<tr>
<td>13</td>
<td>7.16</td>
<td>4.26</td>
<td>7.64</td>
</tr>
<tr>
<td>14</td>
<td>2.68</td>
<td>4.55</td>
<td>6.2</td>
</tr>
<tr>
<td>15</td>
<td>3.69</td>
<td>2.66</td>
<td>2.95</td>
</tr>
<tr>
<td>16</td>
<td>17.94</td>
<td>6.33</td>
<td>3.3</td>
</tr>
<tr>
<td>17</td>
<td>8.13</td>
<td>10.21</td>
<td>5.3</td>
</tr>
<tr>
<td>18</td>
<td>6.77</td>
<td>8.67</td>
<td>5.24</td>
</tr>
<tr>
<td>19</td>
<td>8.13</td>
<td>7.75</td>
<td>4.66</td>
</tr>
<tr>
<td>20</td>
<td>9.34</td>
<td>8.35</td>
<td>10.75</td>
</tr>
<tr>
<td>21</td>
<td>10.15</td>
<td>5.98</td>
<td>7.22</td>
</tr>
<tr>
<td>22</td>
<td>6.14</td>
<td>5.86</td>
<td>2.23</td>
</tr>
<tr>
<td>23</td>
<td>20.11</td>
<td>4.75</td>
<td>6.13</td>
</tr>
<tr>
<td>24</td>
<td>3.11</td>
<td>8.34</td>
<td>4.77</td>
</tr>
<tr>
<td>25</td>
<td>7.63</td>
<td>5.31</td>
<td>4.26</td>
</tr>
<tr>
<td>26</td>
<td>6.98</td>
<td>6.23</td>
<td>4.55</td>
</tr>
<tr>
<td>27</td>
<td>7.16</td>
<td>7.38</td>
<td>4.85</td>
</tr>
<tr>
<td>28</td>
<td>2.68</td>
<td>6.15</td>
<td>6.3</td>
</tr>
<tr>
<td>29</td>
<td>3.69</td>
<td>4.87</td>
<td>2.83</td>
</tr>
<tr>
<td>30</td>
<td>10.3</td>
<td>7.21</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Table 3: Tukey-Kramer Comparative Evaluation for determining Mean Shear Bond strengths

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Mean Difference</th>
<th>Tukey-Kramer Value</th>
<th>95% CI From</th>
<th>95% CI To</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A vs Group B</td>
<td>2.863</td>
<td>4.199</td>
<td>0.5587</td>
<td>5.168</td>
<td>S p&lt;0.05</td>
</tr>
<tr>
<td>Group A vs Group C</td>
<td>2.04</td>
<td>2.992</td>
<td>-0.2643</td>
<td>4.345</td>
<td>N.S p&gt;0.05</td>
</tr>
<tr>
<td>Group B vs Group C</td>
<td>-0.823</td>
<td>1.207</td>
<td>-3.128</td>
<td>1.482</td>
<td>N.S p&gt;0.05</td>
</tr>
</tbody>
</table>

© International Journal of Research in Pharmaceutical Sciences
Table 4: ARI Scores in Percentages

<table>
<thead>
<tr>
<th>Material</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>6.67</td>
<td>66.67</td>
<td>26.67</td>
<td>0</td>
</tr>
<tr>
<td>Group B</td>
<td>0</td>
<td>33.33</td>
<td>20</td>
<td>46.67</td>
</tr>
<tr>
<td>Group C</td>
<td>46.67</td>
<td>50</td>
<td>3.33</td>
<td>0</td>
</tr>
</tbody>
</table>

### Inclusion Criteria and Exclusion Criteria

#### Inclusion criteria

Maxillary Premolars revealing no pathological signs like caries, enamel cracks or erosion on buccal surface.

#### Exclusion criteria

1. Premolars with hypoplastic enamel Teeth with enamel fracture.
2. Pre-existing external defects or cracks on root surface. Anatomical irregularities.
3. Caries involving the buccal surface.
4. Heavily restored or endodontically treated teeth.

The analytical analyzes were conducted utilizing differential analysis (ANOVA) to track the statistical differences, which revealed significant difference between shear bond strengths of the 3 groups (0.0118<0.005)(Table 4). Transbond XT showed highest mean values (8.737) with SD value(5.135) , whereas Transbond Plus showed lowest mean value among all groups(5.874) with SD value(2.089) in Table 3.

Tukey-Kramer Multiple Comparison Test (Table 3) for Mean Shear Bond Strength showed significant difference between Transbond XT and Transbond Plus while it was non-significant in case of Transbond Supreme LV and Transbond XT, Transbond Plus and Transbond Supreme LV. Bartlett's test showed significance during comparison between all groups (Ornaghi et al., 2014).

To determine the significance between ARI scores, Chi-square test was used between all the groups. This test showed significant difference between all three groups.

### RESULTS AND DISCUSSION

The essential of successful orthodontic treatment was to create better facial aesthetics. The efficiency of achieving such goals is dependent on the orthodontist’s skill to properly control tooth movement during treatment. Orthodontic tooth movement relies on the interface between the wire and the bracket to effectively move teeth. Therefore, orthodontic adhesive that bond the bracket to the enamel surface of the tooth must be strong enough to resist all masticatory forces and should remain adherent to the tooth and bracket throughout the entire course of treatment (Kloukos et al., 2017; dos Santos Oliveira et al., 2017). If the bracket is debonded from the tooth during course of the treatment, then orthodontist no longer has control over tooth movement. The treatment is interrupted and an additional appointment is required. This also increases patient inconvenience with increased treatment duration. Adhesive used in orthodontic are constitute of two components,

1. Resin matrix containing monomers/ oligomers, polymerizing initiators, accelerators and inhibitors.
2. Inorganic filler particles.

The following adhesives were used in the current study,

#### Group A

**Transbond XT**

Resin matrix
Bis-GMA, TEGDMA,
Filler
Microhybrid Quartz silica with 78.5% wt (Almosa and Zafar, 2018).

#### Group B

**Transbond Plus**

Resin matrix
Bis-GMA
Filler
Microhybridsilane treated glass and quartz with 75% wt (Soonthodu et al., 2018).

#### Group C

**Transbond Supreme LV**
Resin matrix
Bis-GMA, UDMA, TEGDMA,
Filler
Nanosized silica, glass and zirconia with 65% wt (Vicente et al., 2009).

Transbond XT has been used in this study as it is the most widely used and researched orthodontic adhesive. Transbond Plus has a distinct pink colour which can be easily differentiated from enamel. This facilitates in removal of excess flash material and it becomes transparent after curing. Shade and colour of conventional adhesive makes it difficult to clearly delineate the enamel-adhesive interface, which may subsequently result in incomplete removal of the adhesive or loss of enamel during flash removal. Transbond Supreme LV provides an important property of “flow on demand” characteristic, allowing the material to flow under pressure. This material is a nanofilled resin that shows a reduction in filler size and uniform distribution of filler particles (nanoclusters), lower filler weight and better mechanical properties (Bebber et al., 2011). Use of nanoparticles has distinct advantage of better shear bond strength over traditional flowable adhesive (Ryou et al., 2008). The present study was designed to estimate the shear bond strength and ARI of these newly developed adhesive.

Literature review shows numerous article published in relation to size and content of fillers in orthodontic adhesive system (Proffit et al., 2007; Ornaghi et al., 2014). Soonthodu et al. have suggested that filler content of orthodontic adhesive always have direct effect on shear bond strength. The filler as well as quality of the bond between both the filler layer as well as the resin medium have been shown to perform a significant role in deciding the binding characteristics than in considering the monomeric particle (Soonthodu et al., 2018).

Shear Bond Strength
According to Vicente et al., no filler is supreme, since any form of filler shows benefits as well as weaknesses across clinical application (Vicente et al., 2009). As we see Group A, had the highest bond strength of 21.87 MPa and the lowest was 2.68 MPa with mean shear bonding strength of 8.737 MPa. The highest shear bond strength for Group B was 10.75 MPa and lowest was 2.66 MPa with mean value of 5.874 MPa. While the highest shear bond strength exhibited by group C was 17.43 MPa and the lowest was 2.23 MPa with mean value of 6.697 MPa. The probable reason for this wide range of shear bond strength in tested groups could be because of differences in morphology of extracted tooth which was selected for the study.

Oliveira et al., stated that shear bond strength of an adhesive should be between 5.9-7.8 MPa which is sufficient to withstand masticatory forces and it is considered optimal shear bond strength for an orthodontic adhesive (dos Santos Oliveira et al., 2017). Modern orthodontic adhesives have silane treated filler particles to ease in bonding between resin matrix and filler particles.

The statistical acceptance of the shear bond strengths of the 3 adhesives was different. Group A showed better shear bond strength followed by Group C and Group B. In our study we used Transbond primer for all the adhesives, whereas the manufacturer recommends the use of self-etching primer for Transbond Plus. This could be one of the reasons for differences between shear bond strengths across all the adhesives. The use of conventional Group A primer instead of Group B self-etching primer could be the reason. The results obtained from three groups were within the ideal shear bond strength values (dos Santos Oliveira et al., 2017). There was statistical significant difference noted in the shear bond strength of both the group A and B. The results obtained were contradictory to the manufacturer’s claim, where the Group B colour changing adhesive has bond strength comparable with Group A. This could be because of similarity in the filler particle size and content. The findings have shown that Group C’s shear bond power was slightly lower than Group A.

In the present study, Group C exhibited statistically significant shear bond strength than Group B, inspite of having lower filler weight which was in accordance to Albaladejo.43 Group A and Group B comprises of microhybrid sized particle, still Group C comprised of nanosized filled particles. Group C showed similar mean bond strength. Hence it can be proved that filler volume may also have an impact on bond strength than filler size. Group A adhesive had significantly greater shear bond strength than Group C which was similar to the study by Gama (Mithra et al., 2003).

Ideally bond strength increases with increase in filler content (Ryou et al., 2008). On the contrary, Group C showed better shear bond than Group B, inspite of having lower filler weight. This implies that only filler weight is not responsible for better shear bond strength. Similar finding was achieved by Lim et al where, increasing concentration of filler particles does not necessarily increase the properties of orthodontic adhesives (Iijima et al., 2010). It has also been stated that along with content, the size of the filler also has considerable effect on
shear bond strength (Gama et al., 2013). Hence, it becomes evident that filler type, volume and concentration prove major role in shear bond strength of orthodontic adhesive.

**Adhesive Remnant Index**

Once the treatment is completed, the brackets should be debonded with least discomfort to the patient and with minimal damage to enamel surface. In case of Group A adhesive 6.67% samples had score 0, 66.67% samples had score 1 while 26.67% samples showed score 2 which indicated that there was cohesive failure in the adhesive. The results attained were in accordance to those evaluated by Ryoo (Ryoo et al., 2008). However, contradictory results were shown by to Northrup et al and Lee et al where they reported an ARI score of 3 in 90% and 40% respectively (Almosa and Zafar, 2018; Soonthodu et al., 2018). The difference in the ARI scores could be due to the influence of other variables such as study design, bracket base, and enamel pre-treatment.

In group B minimal amount of adhesive was retained on the tooth surface as showed by the results which depicted that 33% of samples scored 1 and 20% scored 2. In 47% of the brackets bonded with group B adhesive, all or most of the adhesive remained on the tooth after bracket removal, while with group A or group C, none of the sample showed similar score. Group C in spite of having low filler content had least amount of adhesive remaining on tooth surface. 46.67% samples showed score 0 and 50% samples had showed score 1 while 3.37% samples showed score 2. The results significantly showed that adhesive remnants are not dependent on filler contents. This could be due to flowable properties of Group C which allows adhesive to adapt to bracket mesh surface which gives better adhesion and shear bond strength. But in turn, adhesive failed to maintain bond failure at bracket mesh surface (Bebber et al., 2011). This could be due to cluster formation of nanosized filler particles which exhibited better resin matrix–filler interface, but its relation to adhesive remnant index could not be established.

In the present study, after comparison of ARI scores of all groups it was seen that Group B had lowest shear bond strength within range of optimal shear bond strength, but had good bond failure minimizing risk of enamel tears. While Group A and Group C with better shear bond strength had risks of enamel injuries due bond failure at enamel surface.

**CONCLUSION**

In present study, shear bond strength was affected by filler content. The results obtained were within ideal shear bond strength values. In present study, resin products had different amounts of filler content have shown that Transbond XT with highest filler content showed better shear bond strength followed by Transbond Supreme LV. Transbond Plus showed lowest bond strength. In the present study, all the adhesives showed statistically significant difference when their shear bond strength were compared. According to the results of present study we can conclude that, Bond strength of orthodontic adhesives depends on the filler level. Higher filled Transbond XT seems to provide greater bond strength than do lower filled Transbond supreme LV and Transbond Plus.

Adhesive remnant index is not dependent on filler content of adhesives used in study. Transbond plus colour change adhesive has better bond failures than Transbond supreme LV and Transbond XT when ARI of all groups were compared.

**ACKNOWLEDGEMENTS**

Authors would like thank to Department of Orthodontics and dentofacial orthopaedics, Krishna Institute of Medical Sciences, Karad, Maharashtra, India.

**Funding Support**

Nil

**Conflict of Interest**

I hereby declare that there is no conflict of interest related to this manuscript.

**REFERENCES**


Soonthodu, R., Shetty, S. K., Kharyal, S., Kumar, M., Zaheer, F. 2018. Comparison of shear bond strength of four different flowable composites and conventional orthodontic adhesive with and without prior adhesive primer application. IJSR, 7(8).