Light Cure Tip Distance and Shear Bond Strength: Does It have any Clinical Significance?

Amit Jain, Saugat Ray, Rajat Mitra, Sukhbir S Chopra

ABSTRACT

Aim: The purpose of this study was to assess whether minor change in distance of the light cure tip to the bonding surface produce any significant effect on shear bond strength of composites and resin-modified glass ionomer cement used for bonding brackets.

Materials and methods: Ninety therapeutically extracted human premolar teeth were randomly allocated to six groups of 15 specimens each. Resin-modified glass ionomer (GC Fuji Ortho LC) was used to bond brackets to the teeth in three groups with curing light held at three distances from the bracket: 2, 4 and 6 mm. For the other three groups light cured composite resin (Transbond™ XT) was used to bond brackets with curing light held at three distances from the bracket: 2, 4 and 6 mm. After bonding, all samples were stored in distilled water at room temperature for 24 hours and subsequently tested for shear bond strength.

Results and conclusion: (1) Light tip distance of 2 or 4 mm does not affect the shear bond strength of composites significantly; however increase in the distance to 6 mm significantly reduces the shear bond strength, (2) There was a significant decrease in the shear bond strength, with the progressive increase in distance of the light source from 2 to 4 and 6 mm in case of resin-modified glass ionomer cement, (3) The mean shear bond strength of light cure composites is higher than resin-modified glass ionomer cement at all the three light source distances compared, i.e. 2 or 4 or 6 mm.

Keywords: Shear bond strength, High intensity halogen, Light tip distance.

INTRODUCTION

Orthodontic brackets were first bonded directly to teeth more than 40 years ago. Successful bonding in orthodontics requires careful attention to three components of the system: the tooth surface and its preparation, the design of the attachment base and the bonding material itself.

Bond strength can be influenced by various factors, such as light-curing devices, type of enamel conditioner, acid concentration, etching time, composition of the adhesive, bracket base design and bracket material.1 Light activation of bonding agents has become a primary mode of polymerization in orthodontics. There are many variables which can influence the intensity of light during exposure and affect the properties of the set composite.

Maintenance of high values of light intensity both on the resin surface and throughout the bulk of material helps to maximize resin polymerization. One of the factors influencing light intensity that is under the control of the clinician is the distance between the tip of the activating light source and the surface of the resin to be exposed. This distance should be minimized to reduce intensity losses. Also the intensity of light exiting from the light tip decreases inversely with the square of the tooth-tip distance. However, clinically there are many situations where it is difficult to place the light tip as close to the resin surface to be cured, as desired.

Considering both the requirement and limitation of the proximity of the light tip to the resin surface the following study was taken up with the null hypothesis that minor change in distance of the light tip to the bonding surface does not produce significant effect on shear bond strength of composites and resin-modified glass ionomer cement (RMGIC) used for bonding brackets.

MATERIALS AND METHODS

A total of 90 therapeutically extracted human premolar teeth (age group of 12-18 years) were collected. All the selected teeth had intact buccal enamel, with no evidence of visible cracks resulting from extraction and had no caries or restorations. The extracted teeth were stored in a solution of 0.1% thymol. These teeth were randomly divided into six groups of 15 teeth in each group (Table 1). All the teeth were mounted on different colored self-polymerizing acrylic
blocks, with the crowns exposed and roots embedded in acrylic.

The teeth were bonded using 0.018” Preadjusted Edgewise Roth (Ortho Organizer) premolar bracket (maxillary/mandibular). The brackets were bonded either with a light cured composite resin (Transbond™ XT, 3M Unitek) or RMGIC (GC Fuji Ortho LC™), as per the group (Table 1) and polymerized with the help of high intensity halogen light curing unit with light intensity of 800 to 900 mW/cm². The curing light was kept at a distance of 2 mm for between the light source and bracket Groups A and B. The distance of 4 mm was kept for Groups C and D and for Group E and F the distance of 6 mm was kept between the light tip and the bracket. The intensity of the halogen light was checked at beginning of the bonding procedure and thereafter every fifth tooth, using lux meter. The intensity of the light was verified to be between 800 and 900 mW/cm² throughout the procedure. A digital Vernier caliper was used to verify the distance of 2, 4 and 6 mm.

In order to stabilize the light cure unit, a wooden jig was fabricated with a slot to hold the light cure unit and to make it possible to orient the light tip perpendicular to the specimen. A wax block was made to hold the tooth embedded in acrylic block at the desired distance and also to allow orienting the specimen surface to be cured, perpendicular to the light source.

**BONDING PROCEDURE**

All the teeth were cleaned for 10 seconds, with a mixture of water and fluoride-free pumice with a rubber polishing cup by using a low-speed handpiece. The enamel surface was rinsed with water to remove pumice and debris, and then dried with an oil-free air stream. Transbond™ XT primer was coated on the etched surface and then the adhesive was coated on the bracket base. The brackets were positioned on the teeth near the center of the facial surface at a distance of 4 mm from occlusal surface, measured by a bracket positioning device. Sufficient pressure was applied to express excess adhesive, which was removed from the margins of the bracket base with a sharp probe prior to polymerization.

Polymerization for the samples in Group A was done using a high intensity halogen light at a distance of 2 mm between the light source and bracket. This distance was measured using a digital Vernier caliper (Fig. 1). First, the mesial side of the tooth was secured in the wax block and cured for 40 seconds after adjusting the light tip distance to 2 mm as desired. Then the tooth along with the wax block was rotated 180° so that the distal side now faced the light tip. Again after ensuring the desired distance the curing was done for 40 seconds. So, each bracket was cured for 40 seconds on the mesial side and 40 seconds on the distal side with a total cure time of 80 seconds.

The similar procedure was followed for Groups C and E except that the light tip distance between light source and bracket was kept at 4 and 6 mm respectively.

**Resin-modified Glass Ionomer Cement (GC Fuji Ortho LC™)**

**Groups B, D and E**

Similar procedure was followed for Groups B, D and E. The difference being the bonding material which was RMGIC (mixed in the powder and liquid ratio of 3.0 gm/1.0 gm, i.e. one level of large scoop of powder to two drops of liquid on a mixing pad.

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**Table 1: Grouping**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Bonding material</th>
<th>Light tip distance</th>
<th>No. of samples</th>
<th>Color coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>Composite resin (Transbond XT, 3M Unitek)</td>
<td>2 mm</td>
<td>15</td>
<td>White</td>
</tr>
<tr>
<td>Group B</td>
<td>RMGIC (GC Fuji Ortho LC)</td>
<td>2 mm</td>
<td>15</td>
<td>Pink</td>
</tr>
<tr>
<td>Group C</td>
<td>Composite resin (Transbond XT, 3M Unitek)</td>
<td>4 mm</td>
<td>15</td>
<td>Light orange</td>
</tr>
<tr>
<td>Group D</td>
<td>RMGIC (GC Fuji Ortho LC)</td>
<td>4 mm</td>
<td>15</td>
<td>Dark orange</td>
</tr>
<tr>
<td>Group E</td>
<td>Composite resin (Transbond XT, 3M Unitek)</td>
<td>6 mm</td>
<td>15</td>
<td>Light blue</td>
</tr>
<tr>
<td>Group F</td>
<td>RMGIC (GC Fuji Ortho LC)</td>
<td>6 mm</td>
<td>15</td>
<td>Dark blue</td>
</tr>
</tbody>
</table>

**Fig. 1: Bonding**
and mixed) and another difference was that after etching the tooth was moistened with a wet cotton roll before bracket placement. The moist cotton roll was applied with a feather touch with a single stroke occlusogingivally.

The light tip distance between light source and bracket was kept at 2, 4 and 6 mm respectively, for Groups B, D and E. On completion of bonding all samples were stored in distilled water at room temperature for 24 hours.

All the brackets were subsequently tested for evaluation of shear bond strength with a universal testing machine (Model H25KS). Each sample was secured in the lower jaw of the machine so that the bonded bracket base was parallel to the shear force direction. In the upper jaw of the machine a custom-made metal jig with bevelled edge was secured. Then each sample was stressed in the occlusogingival direction at a crosshead speed of 1 mm per minute.

The maximum load required to debond each bracket was recorded in Kg/cm² and then converted into Megapascals (MPa) for statistical analysis. The surface area of the individual bracket was 0.1225 cm².

Residual Adhesive

After debonding, all teeth and brackets were evaluated at ×10 magnification using a microscope (5240, Olympus, Tokyo, Japan) to determine the adhesive remnant index scores.

STATISTICAL ANALYSIS

MINITAB-16 software was used for statistical analysis with Windows 7 operating system. Descriptive statistics including mean, standard deviation, median, and minimum and maximum values were calculated for each group. A two-way analysis of variance (ANOVA) and one-way ANOVA were carried out to determine whether significant differences in debond values existed among the various groups. Since, ANOVA results were significant; Tukey’s test for pairwise comparison was carried out.

RESULTS

Descriptive statistics for shear bond strengths are presented in Tables 2 and 3.

The results of the two-way analysis (Table 4) showed that the two bonding agent groups differ significantly in their mean shear bond strength (p = 0.0001). The differences in the mean shear bond strength due to distances were also statistically significant.

Overall mean shear bond strength and standard deviations for the two bonding agents was calculated. The overall mean shear bond strength of Transbond™ XT is 20.14 ± 3.6 MPa and for that of GC Fuji Ortho LC™ corresponding value is 17.19 ± 3.1 MPa.

The overall mean shear bond strength (considering both bonding agents together) at a distance of 2 mm was 21.50 MPa, at 4 mm distance was 19.85 MPa and for 6 mm the mean shear bond strength was 15.82 MPa. Differences among these three were statistically significant.

To find out which pair of different levels of factor is significantly different from each other, Tukey’s simultaneous pairwise comparisons was carried out (Table 5).

The difference of –2.16 MPa between Transbond™ XT and GC Fuji Ortho LC™ was statistically significant (p = 0.0001). Transbond™ XT is significantly superior to GC Fuji Ortho LC™. As regards to the effect of distances the difference between each pair was statistically significant, each at a level of p-value of 0.00001. The highest shear bond

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| Table 2: Transbond XT and GC Fuji Ortho LC™ shear bond strength (MPa) (arranged in ascending order) |
|-------------|-----------|-----------|-----------|-----------|
| No.         | 2 mm      | 4 mm      | 6 mm      |           |
|             | Transbond XT | RMGIC | Transbond XT | RMGIC | Transbond XT | RMGIC |
| 1.          | 18.7      | 16.1      | 16.6      | 15.0      | 13.5      | 11.6   |
| 2.          | 18.9      | 17.4      | 17.9      | 15.5      | 13.7      | 11.9   |
| 3.          | 19.2      | 18.4      | 18.4      | 16.8      | 13.8      | 12.7   |
| 4.          | 19.9      | 18.9      | 18.8      | 16.9      | 14.1      | 12.9   |
| 5.          | 21.2      | 19.4      | 19.1      | 17.4      | 14.2      | 13.4   |
| 6.          | 21.3      | 19.8      | 19.2      | 17.9      | 14.9      | 13.5   |
| 7.          | 22.3      | 20.2      | 21.9      | 18.3      | 15.3      | 14.3   |
| 8.          | 22.9      | 20.5      | 22.1      | 18.4      | 15.9      | 14.6   |
| 9.          | 23.5      | 20.6      | 22.8      | 18.8      | 16.5      | 14.9   |
| 10.         | 24.3      | 21.4      | 23.1      | 18.9      | 17.8      | 15.6   |
| 11.         | 24.8      | 21.6      | 23.4      | 19.8      | 18.4      | 16.4   |
| 12.         | 24.9      | 21.8      | 23.6      | 19.9      | 19.3      | 17.9   |
| 13.         | 25.4      | 22.9      | 23.8      | 20.4      | 19.7      | 18.2   |
| 14.         | 25.6      | 23.5      | 24.1      | 21.1      | 20.6      | 19.1   |
| 15.         | 25.9      | 23.7      | 24.4      | 21.2      | 20.7      | 19.3   |
| Mean        | 22.58 ± 2.57 | 20.41 ± 2.17 | 21.28 ± 2.63 | 18.42 ± 1.88 | 16.56 ± 2.63 | 15.08 ± 2.57 |

<p>| Table 3: Descriptive statistics |</p>
<table>
<thead>
<tr>
<th>Cement</th>
<th>N</th>
<th>Mean</th>
<th>Std. dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strength by bonding agents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (Transbond XT)</td>
<td>45</td>
<td>20.142</td>
<td>3.660</td>
</tr>
<tr>
<td>2 (GC Fuji Ortho LC)</td>
<td>45</td>
<td>17.973</td>
<td>3.111</td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
<td>Std. dev.</td>
</tr>
<tr>
<td>2 mm</td>
<td>30</td>
<td>21.500</td>
<td>2.592</td>
</tr>
<tr>
<td>4 mm</td>
<td>30</td>
<td>19.850</td>
<td>2.682</td>
</tr>
<tr>
<td>6 mm</td>
<td>30</td>
<td>15.823</td>
<td>2.666</td>
</tr>
</tbody>
</table>
strength was achieved at 2 mm distance (21.50 MPa) and the lowest at 6 mm distance (15.82 MPa).

Since, both bonding agents differ significantly in their mean shear bond strength, as evidenced by the two-way ANOVA and pairwise comparisons of the two bonding agents, one-way analysis for Transbond™ XT as well as GC Fuji Ortho LC™ was carried out to see if the effect of distances has the same pattern of differences in both the bonding agent groups individually.

The results of the one-way analysis (ANOVA) with respect to Transbond™ XT showed that the differences in the mean shear bond strength of the three distances differ significantly ($F = 21.99$, $p = 0.0001$) (Table 6).

The highest mean shear bond strength with Transbond™ XT at a distance of 2 mm was 22.58 MPa followed by 21.28 MPa at 4 mm distance and lowest in case of 6 mm distance at 16.56 MPa (Graph 1).

To see in which pairs the difference in mean shear bond strength is statistically significant, pairwise comparisons were carried out using Tukey’s criterion (Table 7).

There was a difference of 0.94 MPa between 2 and 4 mm distances, which was not statistically significant, but, the differences of 6.02 MPa between 2 and 6 mm distances was statistically significant at 1% level ($p < 0.01$) and so was the difference between mean shear bond strength of 4 and 6 mm (4.72 MPa, $p < 0.01$).

Similarly for testing if the effect of distances follows the same pattern statistically in GC Fuji Ortho LC™ as in case of Transbond™ XT, a one-way ANOVA for GC Fuji Ortho LC™ was also carried out with respect to different distances (Table 6). The differences in the mean shear bond strength of the three distances was significantly different ($F = 21.87$, $p = 0.0001$). The mean values of the three distances were 21.41, 18.42 and 15.08 MPa, respectively (Graph 2).

As in case of Transbond™ XT pairwise comparison using Tukey’s criteria was made for GC Fuji Ortho LC™ as well (Table 7).

Although in case of Transbond™ XT the difference in the mean shear bond strength between 2 and 4 mm was not statistically significant, the difference of 1.99 MPa in GC Fuji Ortho LC™ was statistically significant at 1% level ($p < 0.01$).

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>1</td>
<td>105.84</td>
<td>105.84</td>
<td>17.91</td>
<td>0.0001</td>
</tr>
<tr>
<td>Distance</td>
<td>2</td>
<td>511.61</td>
<td>255.81</td>
<td>43.28</td>
<td>0.0001</td>
</tr>
<tr>
<td>Cement*Distance</td>
<td>2</td>
<td>7.21</td>
<td>3.61</td>
<td>0.61</td>
<td>0.546</td>
</tr>
<tr>
<td>Error</td>
<td>84</td>
<td>496.52</td>
<td>5.91</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Total</td>
<td>89</td>
<td>1121.18</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factors</th>
<th>Difference of means</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>Cement 2-Cement 1 = –2.169</td>
<td>–4.232</td>
<td>0.0001</td>
</tr>
<tr>
<td>Distance</td>
<td>Distance 2-Distance 1 = –1.650</td>
<td>–2.628</td>
<td>0.0001</td>
</tr>
<tr>
<td>Distance 3-Distance 1 = –5.677</td>
<td>–9.043</td>
<td>0.00001</td>
<td></td>
</tr>
<tr>
<td>Distance 3-Distance 2 = –4.027</td>
<td>–6.415</td>
<td>0.00001</td>
<td></td>
</tr>
</tbody>
</table>

Cement 2 = GC Fuji Ortho LC; Cement 1 = Transbond XT; Distance 1 = 2 mm; Distance 2 = 4 mm; Distance 3 = 4 mm

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB</td>
<td>2</td>
<td>301.53</td>
<td>217.29</td>
<td>150.77</td>
<td>21.99</td>
</tr>
<tr>
<td>GIC</td>
<td>2</td>
<td>287.90</td>
<td>208.62</td>
<td>6.85</td>
<td>21.87</td>
</tr>
<tr>
<td>TB*GIC</td>
<td>2</td>
<td>150.77</td>
<td>108.64</td>
<td>6.85</td>
<td>21.99</td>
</tr>
<tr>
<td>Error</td>
<td>42</td>
<td>42</td>
<td>287.90</td>
<td>208.62</td>
<td>—</td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
<td>44</td>
<td>589.43</td>
<td>425.91</td>
<td>—</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distances</th>
<th>Difference of means (column row)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>2 mm</td>
</tr>
<tr>
<td>Transbond XT</td>
<td>RMGIC</td>
</tr>
<tr>
<td>4 mm</td>
<td>0.949 (NS)</td>
</tr>
<tr>
<td>6 mm</td>
<td>6.027**</td>
</tr>
</tbody>
</table>

NS: Nonsignificant; *: significant (5% level); **: significant (1% level)
Ortho LC™ was statistically significant (p < 0.05). The differences in the mean shear bond strength of 2 and 6 mm pair as well as 4 and 6 mm pair was statistically significant at 1% level (p < 0.01). There was a difference of 5.32 MPa between the mean shear bond strength of 2 and 4 mm pair and it was 3.33 MPa with respect to 4 and 6 mm pair.

### DISCUSSION

One of the most active areas of orthodontic materials research is evaluation of the strength of the adhesive bond between a bracket and etched tooth enamel or some other surface. Bond strength testing is one of the most popular and scientific analysis conducted in evaluation of dental materials. Bond strength is measured in the laboratory, and is used to estimate material performance and hence clinical performance. The value of bond strength is calculated as the quotient of the force at which debonding occurs (determined from the load drop on the mechanical testing machine) and the interfacial area of the adhesive or bracket base. Shear bond strength of clinically successful composites bonded to human enamel and dentin have been reported to be in the range of 15 to 35 MPa. In the oral cavity, bonded brackets are subject to either shear, tensile, torsion or a combination of these forces. It is difficult to measure or quantify these forces.

Bond strength can be influenced by various factors, such as type of light-curing devices, type of enamel conditioner, acid concentration, etching time, composition of the adhesive, bracket base design and bracket material. On the other hand, factors affecting light curing of a resin-based composite are the material’s composition (including opacity), the choice of photoinitiators and the concentration of the initiators. The peak wavelength and bandwidth of the curing light, the intensity of the light and the irradiation time (exposure duration) also have profound effects on the depth of cure. Variables that may affect the amount of light energy received at the surface of a resin composite, which may result in ineffective polymerization are the design and size of the light guide, distance of the light guide tip from the resin composite, power density, exposure duration, increment thickness and material composition.

In the present study the etchant, acid concentration, etching time, composition of the adhesive, bracket base design and bracket material, light-curing device, the intensity of the light and the photoactivation time and size of the light guide were kept constant and similar for bonding brackets with both the bonding agents.

The source of curing light in the present study was high intensity halogen lamp. Though there are other light curing sources available, such as light emitting diode (LED) and plasma arc, literature has shown that the shear bond strength achieved by all the three sources of curing is comparable and the only advantage of using sources other than halogen is the
rather the orthodontic material influenced the bracket 
the shear bond strength of orthodontic brackets to enamel; 
that the light-curing units (halogen or LED) did not influence 
with RMGIC was done as it was recommended by the 
140
acid when maximum bond strength is desired. 15,16 Retamoso 
have advised to treat the tooth surface with 37% phosphoric 
teeth in resin-modified glass ionomer group as several studies 
and Erickson who have found significantly lower bond 
brackets in the present study. Oesterle et al quoted Barkmeier 
5 to 10 mm dramatically decreases the light intensity. 
under the bracket base and the clinically realistic distances of 
to position the light guide at 0 mm distance from the adhesive 
polymerization.13 According to Oyama et al,12 it is impossible 
that the light guide is perpendicular to the surface of the adhesive to 
be light cured. As the light guide is tipped, the circular spot 
changes to an ellipse, whose area is greater than that of the 
circular spot, and thus the light intensity is decreased. Oyama 
et al quoted Williams and Johnson that tipping at 40° from the 
perpendicular, decreased light intensity by 18% and concluded 
that the light guide tipped by more than 30° might lead to the 
risk of inadequate curing. In the present study a wooden jig 
was used to stabilize the light cure unit by resting it on top of 
it so that the light tip could be oriented perpendicular to the 
surface to be cured.

Another important factor for decreased light intensity is 
the distance of the light guide tip from the surface of resin 
composite. Clinically it is difficult to control the distance of 
the light tip especially in the premolar area. When the distance 
is greater than 2 mm, the light dispersion from the light curing 
unit increases, and it becomes difficult to obtain effective 
polymerization.13 According to Oyama et al,12 it is impossible 
to position the light guide at 0 mm distance from the adhesive 
under the bracket base and the clinically realistic distances of 
5 to 10 mm dramatically decreases the light intensity.

Extracted human premolar teeth were used to bond the 
brackets in the present study. Oesterle et al quoted Barkmeier 
and Erickson who have found significantly lower bond 
strengths with bovine enamel; which was 35% below that of 
human enamel. Oesterle et al have shown that the bond strength 
to bovine permanent tooth controls were 40% weaker than 
human incisors, bovine permanent incisors were 44% weaker, 
bovine deciduous controls were 35% weaker, and bovine 
deciduous incisors were 21% weaker than the human incisors.14

In this study, 37% phosphoric acid was used for etching 
teeth in resin-modified glass ionomer group as several studies 
have advised to treat the tooth surface with 37% phosphoric 
acid when maximum bond strength is desired.15,16 Retamoso 
et al11 showed that no enamel etching prior to the use of the 
RMGIC for bracket attachment reduced the bond strength to 
levels (2-4 MPa) that are not clinically acceptable.

The moistening of the etched tooth surface before bonding 
with RMGIC was done as it was recommended by the 
manufacturer. Jobalia et al17 have shown that moisture is 
required for optimal adherence of glass ionomer cement to 
the tooth surface. Even Cacciafesta et al18 suggested that 2-
hydroxyethyl methacrylate in the resin component of Fuji 
Ortho LC is responsible for higher bond strength under wet 
conditions compared with the dry tooth surface.

On completion of bonding, the specimens were stored in 
distilled water for 24 hours. Rawls19 has mentioned that even 
though photopolymerizable composites set on command by 
light activation, the maximum bond strength of composite to 
tooth structure might not occur for at least 24 hours. The same 
is true for glass ionomer materials because the acid-base 
reaction continues after the initial set.20 Wendl and Drosch21 
have also shown an increase in bond strength of both 
composite and RMGIC after 24 hours. They suggested that 
the light activated resin adhesive showed the largest increase, 
indicating that the polymerization process (the chain reaction 
where methacrylate monomers are networked by splitting the 
double bonds) continues even after the exposure to light has 
ceased.

All the above measures such as that of use of human teeth, 
etching, use of same brackets and following manufacturer 
recommended bonding protocol and similar storage protocol 
during routine clinical use. All mean shear bond strength values 
of the bonding agents used in the present study were above this 
minimum requirement and within clinically acceptable range.

When comparing the effect of light tip distance on the 
mean shear bond strength the results showed that, the 2 and 4 
mm light tip guide distances did not show statistically 
significant differences, with respect to composite (Trans-
bondTM XT), whereas the mean shear bond strength at 6 mm 
distance showed statistically significant difference when 
compared to the mean shear bond strength achieved at 2 and 4 
mm distance. However, with respect to RMGIC, mean shear 
bond strength at all the three distances (2, 4 and 6 mm) showed 
a statistically significant difference. These results are in 
agreement with those of Correr Sobrinho et al25 and Caldas et 
al23 who stated that resin composite polymerization depends 
greatly on the distance from the curing tip. Prati et al22 
demonstrated that the distance between the light guide and the 
resin composite can affect the light intensity. The drop in light 
intensity with distance is exponential, and 1 mm of air reduces 
light intensity by approximately 10%. Sakaguchi et al24 also 
showed that the light output diminished severely at distances 
more than 2 mm and was just by 25% of the maximum value at 
4 mm distance. Aguiar et al13 also showed that samples light 
cured at 2 and 4 mm presented significantly higher hardness 
values than samples light cured at 8 mm.
From the study it can be concluded that:

1. **Suitability for use of either light cure composites or RMGIC as orthodontic bracket bonding agents has been re-established as both achieved clinically acceptable shear bond strength.**

2. **Light tip distance of 2 or 4 mm does not affect the shear bond strength of composites significantly; however increase in the distance to 6 mm significantly reduces the shear bond strength.**

3. **There was a significant decrease in the shear bond strength, with the progressive increase in distance of the light source from 2 to 4 and 6 mm in case of RMGIC.**

4. **The mean shear bond strength of light cure composites is higher than RMGIC at all the three light source distances compared, i.e. 2, 4 or 6 mm.**

**REFERENCES**


