

## Effect of Displacement of Bracket Position after Initial Placement on Shear Bond Strength: An *In vitro* Study

### Abstract

**Context:** Displacement of bracket after initial placement on tooth surface in the precure phase of bonding influences the shear bond strength. **Aims:** The aim of this study was to evaluate the influence of bracket displacement during the precure phase after initial placement on the tooth surface on shear bond strength of chemical cure and light cure composites. **Settings and Design:** *In vitro* experimental study. **Subjects and Methods:** Stainless steel orthodontic premolar brackets were bonded to the buccal surfaces of 88 maxillary 1<sup>st</sup> premolar teeth. Teeth were divided into four groups: (1) Group 1 – Control group for light-cure composites, (2) Group 2 – Displacement group for light-cure composites, (3) Group 3 – Control group for chemical cure composites, and (4) Group 4 – Displacement group for chemical cure composites. In the control groups, the brackets were bonded with no precure bracket displacement. In the displacement groups, the brackets were bonded with 2 mm precure linear displacement. Photoactivation was carried out for light-cure composites. Shear bond strength tests were carried out using the universal testing machine. Statistical analysis used: Data were analyzed using the one-way analysis of variance test. **Results:** The mean shear bond strength of Groups 1, 2, 3, and 4 were observed to be  $14.49 \pm 0.75$ ,  $13.40 \pm 0.61$ ,  $12.34 \pm 0.53$ , and  $11.55 \pm 2.43$ MPa, respectively, with the displacement groups showing lower shear bond strength when compared to the control groups. Whether displaced or not, chemically cured composites showed lower bond strength when compared to light-cured composites. **Conclusions:** Displacement of brackets during bracket placement seemed to reduce the enamel bond strength after the final positioning of the bracket.

**Keywords:** Bonding, displacement, orthodontic bracket, shear bond strength

### Introduction

Two great inventions that may be said to have revolutionized orthodontic treatment are the direct bonding technique and the preadjusted edgewise appliance (PEA). The former simplified the fixation of appliance onto the teeth while the latter obviated the need for placing delicate and complex bends on the arch wires. While the PEA simplified the arch wire fabrication, it demanded more accuracy and perfection in the bracket position.

Indirect bonding technique is a boon as far as accurate bracket positioning is concerned, but in clinical practice, direct bonding is more popular. Accurate positioning of brackets on teeth in the buccal segment is more difficult than positioning them on the anterior teeth. Often the bracket position has to be modified after the initial placement to make its position accurate.

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Oliveira *et al.* in 2014 through their study with the use of light-cured composite resin provided evidence that slight bracket displacement to correct the positioning of orthodontic brackets in relation to the long axis of the tooth can be carried out without jeopardizing immediate bond strength to enamel if excess adhesive is not removed before the displacement.<sup>[1]</sup> The results of Tam *et al.* in 2017 indicated that rotational and linear precure bracket movements did not affect the shear bond strength to enamel using light-cured composite resin.<sup>[2]</sup>

Curing/polymerization reaction in chemical-cured composites commences the moment the bracket with adhesive on its base is placed on the tooth surface. In the case of light-cured composites, polymerization is deferred till the exposure to light source is initiated. Therefore, light-cured composites provide more working time. Hence, trying to adjust the position of the bracket after initial

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placement on the tooth surface to make its position more accurate, may compromise the bond strength, especially in the case of chemical cured composites.

In writing this article, to the best of our knowledge, no study has been published evaluating the effect of bracket displacement on shear bond strength of chemical and light-cured composites. Hence, this study was carried out to determine whether the orthodontic bracket displacement during the precure phase of bonding procedure influenced the shear bond strength of brackets bonded with chemical cure and light cure composites.

## Subjects and Methods

The sample consisted of 88 human maxillary 1<sup>st</sup> premolar teeth with intact buccal enamel surface. Teeth with caries/restoration on buccal surface, hypoplastic areas, cracks or gross irregularities on enamel surface, fractured tooth, and previously bonded tooth were excluded from the study.

### Mounting

Each tooth was mounted in self-cure acrylic of circular block with an internal diameter of 13 mm and length of 32 mm so that it could properly be seated on the testing machine. The teeth were positioned in such a way that root portion was embedded in acrylic while the crown portion was fully exposed above the acrylic [Figure 1].

### Preparation of tooth surface

All the specimens were kept in distilled water with 0.1%thymol for disinfection except during the bonding and testing procedure. The teeth were dried after cleansing and polishing for 10 s with a rubber prophylactic cup using non-oily pumice.

### Bonding protocol

Thirty-seven percent buffered Orthophosphoric gel (Eazetch Anabond Steadman for light cure composite, Rely-a-Bond® etchant for chemical cure composite) was applied to the



Figure 1: Prepared sample

buccal surface of teeth for 30 s. After the etching, Facial axis of clinical crown (FACC) and long axis of the clinical crown points were marked using 0.5 mm HB lead pencil point. Premolar stainless steel brackets (ORMCO 022” MBT prescription) with bracket base of 9.63 mm<sup>2</sup> were used in this study. Latex gloves were worn throughout the procedure to prevent contamination.

Teeth were divided into four groups of 22 each. The acrylic blocks were color coded for the easy identification of groups.

- Group 1: Control group for light-cure composites
- Group 2: Displacement group for light-cure composites
- Group 3: Control group for chemical cure composites
- Group 4: Displacement group for chemical cure composites.

### Group 1 and 2 (light cure composites)

A thin coat of adhesive primer (Transbond XT primer, 3M Unitek, Monrovia, CA, USA) was applied to etched and dried tooth surface. Transbond XT adhesive paste (3M Unitek, Monrovia, CA, USA) [Figure 2] was applied to the bracket base, and in Group 1, the bracket was positioned on the center of the tooth with bracket slot oriented perpendicular to long axis of tooth with standard pressure used in clinical practice. While in Group 2, bracket was intentionally placed in an inaccurate position 2 mm gingival from the center of the tooth. The bracket was then displaced 2 mm occlusally to the center of the tooth and positioned with standard pressure used in the clinical practice [Figure 3]. Flash was carefully removed and then light cured for 20 s (Koden reliable dental products) each on mesial and distal sides of the bracket using a light-emitting diode curing unit.

### Group 3 and 4 (Chemical cure composites)

A thin coat of Rely-a-Bond primer was applied to etched and dried tooth surface, and to the bracket base. Rely-a-Bond (Reliance Orthodontic Product, Itasca, Illinois, USA) adhesive paste [Figure 4] was applied to the bracket base, and in Group 3, the bracket was positioned on the center of the tooth with the bracket slot oriented perpendicular to the long axis of the tooth with standard pressure used in clinical practice. While in Group 4, the bracket was intentionally placed in an



Figure 2: Transbond XT (3M UNITEK) light-cure composite

inaccurate position 2 mm gingival from the center of tooth. The bracket was then displaced 2 mm occlusally to the center of the tooth and positioned with standard pressure used in the clinical practice. Flash was carefully removed from the sides of the bracket.

All procedures were done by the same operator to eliminate the interobserver errors.

### Preparation of bonded tooth for shear bond strength test

The acrylic blocks with the teeth mounted with bonded brackets were stored in distilled water at the room temperature before subjecting to shear bond strength test. After 1 month, the specimens were subjected to testing for the shear bond strength.

### Testing of shear bond strength

The laboratory testing was done with a universal testing machine (Shimadzu Autograph AG-IS). The standard knife edge chisel on the universal testing machine was positioned to make contact with the bonded brackets, and the specimen was submitted to a compressive load at a crosshead speed of 1 mm/min until the bracket detached [Figure 5]. The load at the site of bracket failure was recorded by a computer connected to Lloyd machine. The shear bond strength values were calculated in megapascals (MPa) by dividing the force by the area of the bracket base.

$$\text{Bond strength (in MPa)} = \frac{\text{Debonding Force (in Newton's)}}{\text{Surface area of brackets (sq. mm)}}$$

## Results

The results of mean shear bond strength are shown in Table 1. The control group using light-cure composite Group 1 showed the highest shear bond strength ( $14.48 \pm 0.75$  MPa). The lowest mean shear bond strength was observed in Group 4 ( $11.55 \pm 2.43$  MPa) [Graph 1]. Multiple comparison tests showed that the difference between the mean shear bond strength of each group was statistically significant [Table 2].

## Discussion

Placing the anterior teeth in their most favorable and ideal position is one of the principal goals of orthodontic treatment. According to Sondhi, the advent of direct bonding improved the clinician's ability to position the brackets more accurately than when using bands.<sup>[3]</sup> Great emphasis is being laid on accurate bracket positioning for the efficient application of biomechanics and for utilizing the full potential of PEA appliance. Andrews advocated the system of bracket placement wherein the center of the slot of the bracket is placed on the facial axis point which is situated midway along a vertical line on the facial surface of the tooth.<sup>[4]</sup>

Achieving a low bond failure rate should be a high priority objective, since replacing loose brackets is

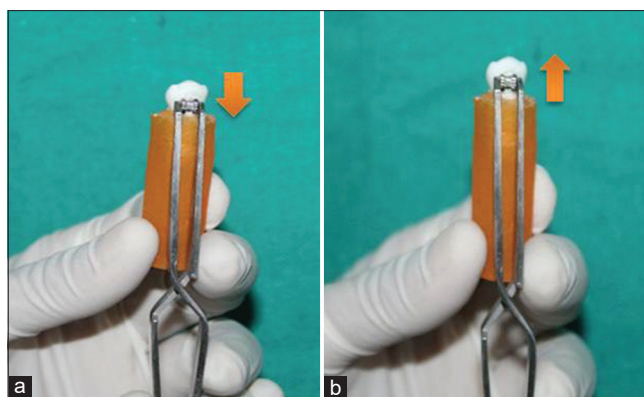


Figure 3: (a) In displaced group, bracket positioned 2 mm gingival from the center of the tooth. (b) The bracket was then displaced 2 mm occlusally to the center of the tooth



Figure 4: Rely-a-Bond® chemical cure composite



Figure 5: Sample mounted on the universal testing machine

inefficient, time-consuming, and costly. Reynolds *et al.* (1975) observed that the minimum amount of bond strength for resistance to debonding was between 5.88 to 7.85 MPa.<sup>[5]</sup>

Only few studies have been reported in the literature on bond strength with regard to bracket displacement. Study by Oliveira *et al.* in 2014 showed that the displacement of orthodontic brackets during fixation did not affect bond

**Table 1: Group, mean, standard deviation, maximum and minimum of shear bond strength values of evaluated groups**

Group	Mean±SD	Minimum	Maximum	P
Group 1 control-LC without displacement	14.49±0.75	12.52	15.54	<0.001*
Group 2-LC with displacement	13.40±0.61	12.65	15.89	
Group 3-CC without displacement	12.34±0.53	11.85	14.07	
Group 4 CC with displacement	11.55±2.43	6.01	15.54	

\*One way ANOVA; \*P<0.05 is statistically significant; \*\*P<0.001 highly significant. SD: Standard deviation; CC: Chemical cure; LC: Light cure

**Table 2: Post hoc comparison within the group by least significant difference test**

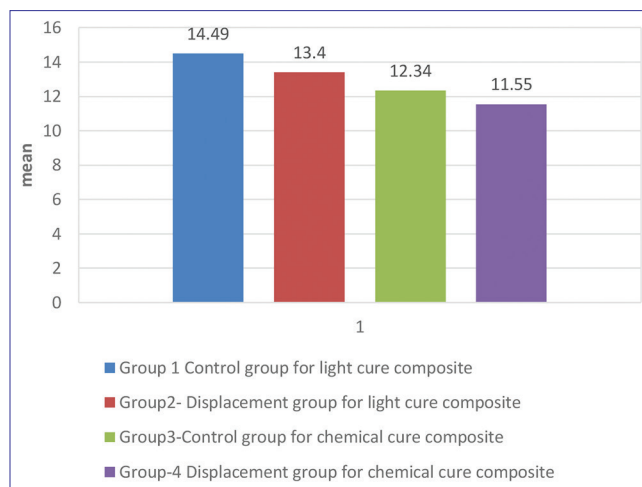
Group	Mean±SD
Group 1	14.49 <sup>abc</sup> ±0.75
Group 2	13.40 <sup>adc</sup> ±0.61
Group 3	12.34 <sup>bd</sup> ±0.53
Group 4	11.55 <sup>bc</sup> ±2.43

Same alphabets indicate significant difference across the groups

strength to enamel when excess bonding agent is removed after the final positioning of the bracket on the dental surface.<sup>[1]</sup> The shear bond strength (SBS) of control group in their study when bonded with Transbond XT was found to be 9.7 MPa, whereas displacement group showed bond strength of 9.1 MPa, which was lower than the values obtained in the present study when bonded with light cured composite resin.<sup>[1]</sup>

The results of the study by Tam *et al.* in 2017 are in agreement with Oliveira *et al.* and thereby inferred that rotational and linear precure bracket movement do not affect the shear bond strength to enamel. The control group bonded with Transbond XT showed a mean SBS of 12.51 MPa, whereas the displacement group was shown to have shear bond strength of 11.13 MPa which are in agreement with the values of our present study.<sup>[1,2]</sup>

Both light-cured and chemically cured composites have been shown to be clinically acceptable and effective. The polymerization of self-cured resin with the two-paste system or the one-paste system starts immediately on mixing; thus the operator is unable to manipulate the setting time, which affects bracketing accuracy and positioning on the tooth surface. Sharma *et al.* in 2014 found that Transbond XT (15.49 MPa) attained the highest shear bond strength; also the SBS of Rely a Bond was 12.26 MPa, which corresponds to the value got in the present study.<sup>[6]</sup> Chung *et al.* in 2002 observed that new brackets bonded with Transbond XT had a higher mean bond strength of 15.66 MPa which is in agreement to the study by Murray and Hobson in 2003 (14.34 MPa), Oztoprak *et al.* in 2007 (15.28 MPa) and Oesterle and Shellhart in 2008 (14.99 MPa) which correlates to the values of the present study.<sup>[7-10]</sup> In the present study, whether displaced or not, chemically cured composites showed lower shear bond strength when compared to light cured composites, but are in an acceptable range with regard to the bond strength.

**Graph 1: Comparison of mean shear bond strength of the four groups**

## Conclusion

The findings of this present study thereby indicate that when a bracket is displaced vertically, the amount of adhesive that is left beneath the bracket base would probably be insufficient to infiltrate the etched enamel and create mechanical interlocking for bonding. This could be the possible explanation for a slight reduction in shear bond strength following the displacement of brackets in both the chemically cured and light-cured composite groups. Therefore, it is recommended to bond the brackets with minimal displacement as possible so that chances of bracket failure can be minimized.

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## Conflicts of interest

There are no conflicts of interest.

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