

## Shear bond strength of the lingually and buccally bonded brackets via three composite systems

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### Abstract:

This study aimed to determine and compare the shear bond strength of lingually bonded brackets via: Two-paste composite (Orthodontic Mix Bonding System), No-mix composite [Orthodontic Bonding System (No-mix)] and Light-cured composite (Transbond XT).

Thirty extracted upper first premolars for orthodontic request were used for this investigation. The teeth were divided into three groups; each of which consisted of 10 teeth. The lingual surface of the tooth used to evaluate the lingual bond strength and the buccal surface of the same tooth utilized to evaluate the buccal bond strength. For each group of teeth investigated to determine the lingual and buccal bond shear strength, using one type of composite system for each group.

The lingually bonded and buccally bonded samples were subjected to shear force using the universal compression testing machine apparatus. The lingual and buccal shear bond strengths were recorded and converted into Mpa and the data were statistically analyzed.

The results showed the lingual shear bond strength insignificantly less than that of buccal shear bond strength regarding the Orthodontic Mix Bonding System and Orthodontic Bonding System (No-mix), and the lingual shear bond strength was significantly less than the buccal shear bond strength regarding Light-cured composite (Transbond XT). The lingual and buccal shear strengths of the bonded bracket via Orthodontic Mix Bonding System were the highest than the shear bond strength of the other composite systems.

### Key Words:

Lingual bond strength, buccal bond strength, composite systems.

### Introduction:

The introduction of bonding technique in 1970s made it possible to place fixed attachment on the lingual surface of teeth and produce an invisible fixed appliance which is ultimate esthetic.<sup>(1,2)</sup>

In 1973, Dr. Kurz created a lingual appliance by modifying labial brackets. In 1976, he joined with Ormco corporation to develop and produce edgewise appliance suitable

for lingual surface. In 1979, this appliance was manufactured.<sup>(3-6)</sup>

This technique is a matter of controversy in various disadvantages, such as excessive bond failures, which are undoubtedly due to combination of great biting forces and great difficulty in obtaining good isolation during bonding,<sup>(7)</sup> and the mechanical irritation of the lingual brackets and wire on the tongue and soft tissue.<sup>(7-9)</sup> The availability of lingual appliance nowadays makes it necessary for more

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investigation this technique and to compare it with the buccal bonding technique.

There are various types of orthodontic bonding adhesives and different techniques in the polymerization of the adhesive systems, such as chemically and light-cured and combination of chemical and light cured reaction. For each technique, there are advantages and disadvantages and the selected type of orthodontic bonding adhesive by the orthodontist mostly depends on the enough working time, high bond strength and easy debonding with bracket adhesive failure site that avoid the enamel damage.

Lingual orthodontic technique had added a new dimension to the bonding spectrum, so it is necessary to evaluate the procedures for bonding of orthodontic appliances onto the lingual surfaces and to see if they should be the same procedures followed for labial surfaces, or they should wholly differ from them such as increasing etching time and roughening lingual surfaces for achieving satisfactory bond strengths.<sup>(10)</sup>

The advantages of the lingual appliances are:

1. Esthetics; most adults and many young patients prefer invisible lingual appliance because of its compatibility with their professional and personal needs.<sup>(11-18)</sup>
2. The position of the teeth could be more precisely seen when their surfaces are not obstructed by brackets and arch wires.<sup>(12)</sup>
3. Prevention of a trauma from the appliance during the treatment of patients who participated in such sports as football and judo.<sup>(8)</sup>
4. Physiologic bite opening deep-bite and cross-bite cases.<sup>(11)</sup>
5. Facial surfaces of the teeth are not damage from debonding and decalcification.<sup>(12)</sup>

6. Facial gingival tissues are not adversely affected.<sup>(12)</sup>

While the most important disadvantages of lingual appliances are:

1. Loss of posterior occlusion.<sup>(7-9)</sup>
2. The mechanical irritation of the lingual brackets and wires on the tongue and tissue.<sup>(7-9)</sup>
3. Difficulty of removal of adhesive flash.<sup>(7)</sup>
4. Transient speech defect.<sup>(2, 7, 9, 17)</sup>
5. Excessive bond failures due to great biting forces.<sup>(7)</sup>
6. Quite difficult to adjust.<sup>(1, 11)</sup>
7. Brackets are attached to very irregular and inconsistent lingual surface.<sup>(12)</sup>

The indications of treatment with lingual appliances are: When the patient's appearance is very important for businessman, singer and lawyers,<sup>(16, 19)</sup> and when there is veneer porcelain or large amalgam or composite fillings on the facial surface of the teeth.<sup>(1)</sup> The contra-indications of the treatment with lingual appliances are: The short clinical crown and partially erupted teeth.<sup>(7)</sup>

Combination of buccal and lingual bonding treatment technique facilitated the difficulties in maintaining control of the posterior segments and encroachment of the second molar tube on tongue. It was decided to produce a terminal tube for the first molar and to treat the posterior segments with conventional buccal bonding technique.<sup>(20)</sup> Mandibular bicuspid also present a limitation to lingual bonding, not visible on most patients. They can usually be bonded easily with buccal bonding technique.<sup>(21, 22)</sup>

The preferred mechanotherapy approach has evolved into a combination using both buccal and lingual posterior segments, with the lingual brackets alone being confined to the incisors, canines and maxillary

bicuspid appear to offer the best feature for both esthetic and anchorage control.<sup>(23)</sup>

The orthodontic bonding adhesive resins are polymers, which are classified as acrylic and diacrylic resins.<sup>(24)</sup> Reynolds<sup>(24)</sup> stated that acrylic resins consist of methyl methacrylate monomer and ultrafine powder; while diacrylate resins are modified epoxy resins (Bis-GMA) and they polymerized by cross-linking in three dimensional network; while the acrylic resins form only linear polymers when polymerized. The cross-linking in the diacrylate resins contributes to great strength.<sup>(25, 26)</sup>

The term "composite" refers to a three-dimensional combination of at least two chemically different materials; the most commonly composite resins is usually bisphenol A glycidyl dimethacrylate (Bis-GMA).<sup>(27)</sup>

Chemically cured composite: Two-paste system based on self-curing polymerization was the first developed for orthodontic bracket bonding,<sup>(28, 29)</sup> and No-mix system was introduced in mid 1980s.<sup>(30)</sup> It is easy to handle with less chair time,<sup>(31)</sup> while the light-cured composite especially the visible light exposure was used in curing the composite. This composite system is widely used in orthodontics.<sup>(1, 32)</sup>

This study aimed to determine and compare the shear bond strength of the lingual and buccal bonded brackets via three composite systems.

## Material and methods:

The sample was consisted of thirty sound human upper first premolars, which had been extracted for orthodontic treatment purposes. The teeth were then randomly grouped into three groups; each group consisted of ten teeth. Each group was used to

investigate one type of the composite buccally and then lingually.

These teeth were cleaned and stored in 70% ethyl alcohol<sup>(33, 34)</sup> till the time of starting the study.

The composite systems used in this study were: 1) Chemically-cured composites, which were: a) Orthodontic Mix Bonding System (Dentaurum, Germany); and b) Orthodontic Bonding System (No-mix) (Dentaurum, Germany); and 2) Light-cured composite which was Transbond XT (Unitek, USA).

The brackets used in this research were:

- 1) Lingual brackets, stainless steel, standard large (0° torque and angulation) 0.018" slot for upper first premolars (Ormco, USA).
- 2) Buccal brackets, stainless steel, standard large (0° torque and angulation) 0.018" slot for upper first premolars (Dentaurum, Germany).

The important supplies and equipment utilized in this investigation were: Surveyor (Quayle Dental, England), light-curing unit (Quayle Dental, England), and universal compression machine (Soil test Co, USA).

The methods of this study were involved mounting the tooth in situation that the middle third of the lingual surface should be parallel to the analyzing rod of the surveyor, then the plastic ring was positioned around the tooth with only the crown of the tooth was protruded, and a cold-cured acrylic resin was poured around the tooth. Resurveying of the specimen was made to ensure that the position of the crown was not changed. After testing the lingual brackets, the teeth were mounted in the new plastic rings with insuring that the middle third of the buccal surface was oriented in parallel to the analyzing rod of the surveyor.

Bonding the bracket to the lingual and buccal surfaces with composite systems was achieved according to the manufacturers' instructions.

The specimens were stored in an incubator at 37 °C and was tested after one hour.

Shear bond strength of lingual brackets was tested by using the universal compression machine with cross-head speed of 0.5 mm/minute.<sup>(35)</sup> The shear bond strength was recorded in Mpa.<sup>(36)</sup>

The study sample data were subjected to the statistical analysis of: Descriptive analysis, One Way Analysis of Variance (ANOVA) at  $p \leq 0.05$  significance level, Duncan's Multiple Range Test at  $p \leq 0.05$  level

of significance and Student's  $t$ -test at  $p \leq 0.01$  significance level.

## Results:

The shear bond strengths of lingual and buccal bonded brackets via Two-paste composite (Orthodontic Mix Bonding System) showed the highest shear bond strength of the buccally bond bracket, while the lowest shear bond strength was seen in No-mix composite (Orthodontic Bonding System "No-mix") of lingual bonded bracket; and in general, the shear bond strengths of buccal bonded bracket had higher than shear bond strengths of the lingual bonded bracket (Table 1 and the Figure 1).

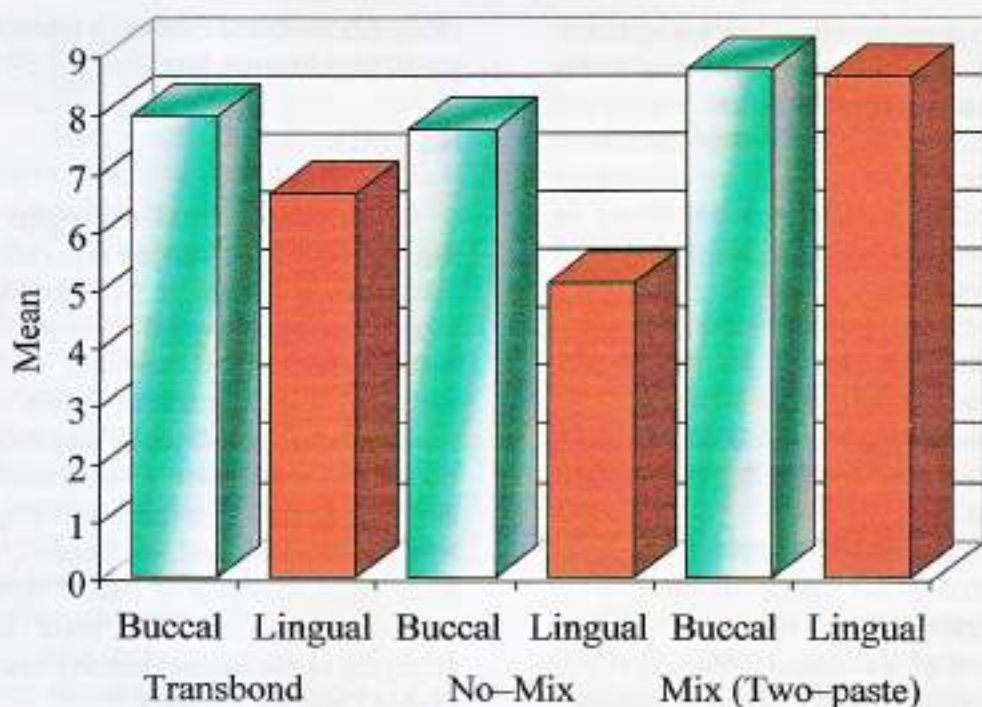
**Table (1):** Buccal and lingual mean shear bond strengths

| Type of the Adhesive                | Tooth Surface | No. | Shear Bond Strength |             |         |         |
|-------------------------------------|---------------|-----|---------------------|-------------|---------|---------|
|                                     |               |     | Mean                | +SD         | Maximum | Minimum |
| Transbond                           | Buccal        | 10  | 7.949               | $\pm 2.214$ | 9.512   | 7.256   |
|                                     | Lingual       | 10  | 6.607               | $\pm 2.459$ | 8.224   | 6.324   |
| Orthodontic Bonding System (No-mix) | Buccal        | 10  | 7.694               | $\pm 1.534$ | 9.832   | 7.168   |
|                                     | Lingual       | 10  | 5.040               | $\pm 0.935$ | 6.764   | 4.832   |
| Orthodontic Mix Bonding System      | Buccal        | 10  | 8.720               | $\pm 1.916$ | 10.124  | 8.264   |
|                                     | Lingual       | 10  | 8.590               | $\pm 1.066$ | 8.922   | 7.842   |

### *Comparison of Shear Bond Strength of the Lingually Bonded Bracket*

One-Way Analysis of Variance at  $p \leq 0.05$  significance level (Table 2) revealed that there was a significant difference among the three types of composite systems: Two-paste composite (Orthodontic Mix Bonding System), Light-cured composite (Transbond XT) and No-mix composite (Orthodontic Bonding System "No-mix").

Duncan's Multiple Range Test at  $p \leq 0.05$  significance level (Table 3) explored that the Two-paste composite (Orthodontic Mix Bonding System) had significantly the highest shear bond strength, followed by the Light-cured composite (Transbond XT) and the latter had significantly higher bond strength than the No-mix composite (Orthodontic Bonding System "No-mix").



**Figure (1):** Mean buccal and lingual shear bond strengths of the investigated adhesives

**Table (2):** One-way analysis of variance test for the groups: No-mix adhesive lingual bond, Transbond adhesive lingual bond and Mixed adhesive lingual bond

| SOV    | df | SS    | MS    | F Cal. | F Tab. |
|--------|----|-------|-------|--------|--------|
| Factor | 2  | 63.3  | 31.65 | 11.79* | 3.355  |
| Error  | 27 | 72.5  | 2.69  |        |        |
| Total  | 29 | 135.8 |       |        |        |

\* F Cal. > F Tab.

**Table (3):** Duncan's analysis for the groups: No-mix adhesive lingual bond, Transbond adhesive lingual bond and Mixed adhesive lingual bond

| Ci | Yi    | LSR** | NL     | TL     |
|----|-------|-------|--------|--------|
|    |       |       | 5.040  | 6.607  |
| ML | 8.590 | 1.582 | 3.550* | 1.983* |
| TL | 6.607 | 1.507 | 1.567* |        |

\* Significant at  $p < 0.05$ .

\*\* LSR: Least significant range.

NL: No-mix adhesive lingual bond.

TL: Transbond adhesive lingual bond.

ML: Mixed adhesive lingual bond.

#### **Comparison of Shear Bond Strength of the Buccally Bonded Bracket**

One-Way Analysis of Variance at  $p \leq 0.05$  significance level (Table 4)

showed that there were no significant differences among the shear bond strength of the buccally bonded bracket for the tested three composite systems.

**Table (4):** One-way analysis of variance test for the groups: No-mix adhesive buccal bond, Transbond adhesive buccal bond and Mixed adhesive buccal bond

| SOV    | df | SS      | MS    | F Cal. | F Tab. |
|--------|----|---------|-------|--------|--------|
| Factor | 2  | 5.710   | 2.850 | 0.780* | 3.355  |
| Error  | 27 | 98.330  | 3.640 |        |        |
| Total  | 29 | 104.030 |       |        |        |

\* F Cal. &lt; F Tab.

### Comparison of Shear Bond Strength of Lingually Bonded Bracket Versus Shear Bond Strength of Buccally Bonded Bracket

Student's t-test was applied at significance level of  $p \leq 0.01$  for the comparison of the mean value of shear bond strength between the lingually and buccally bonded bracket for the used three composite systems as shown in Table (5), which revealed that there was a significantly increase in shear bond strength of the buccally bonded

bracket than lingually bonded bracket via No-mix composite (Orthodontic Bonding System "No-mix"); while there was no significantly increase in shear bond strength of buccally bonded bracket than lingually bonded bracket of Light-cured composite (Transbond XT) and nor between shear bond strength of buccally and lingually bonded brackets via Two-paste composite (Orthodontic Mix Bonding System).

**Table (5):** Comparison of shear bond strengths between buccal and lingual surfaces for each adhesive by student's t-test

| Adhesive        | No. of Specimens |         | Mean Bond Strength |         | t-test | Significance |
|-----------------|------------------|---------|--------------------|---------|--------|--------------|
|                 | Buccal           | Lingual | Buccal             | Lingual |        |              |
| Transbond       | 10               | 10      | 7.949              | 6.607   | 1.28   | NS           |
| No-mix          | 10               | 10      | 7.694              | 5.040   | 4.67   | S            |
| Mix (Two-paste) | 10               | 10      | 8.720              | 8.590   | 0.19   | NS           |

S: Significant.

NS: Not significant.

## Discussion:

### Shear Bond Strength of Lingually and Buccally Bonded Brackets

The shear bond strength of the lingually and buccally bonded brackets via Two-paste composite (Orthodontic Mix Bonding System), No-mix composite (Orthodontic Bonding System "No-mix") and Light-cured composite (Transbond XT) showed higher than the clinically adequate (6-8 Mpa) as recorded by Reynolds<sup>(24)</sup> and Whitlock *et al.*<sup>(37)</sup> Furthermore, it was reported that successful clinical

bonding with adhesive has an *in vitro* bond strength of approximately 5 Mpa.<sup>(38)</sup>

The shear bond strength of the lingually and buccally bonded brackets via Two-paste composite (Orthodontic Mix Bonding System) revealed higher than shear bond strengths of the No-mix composite (Orthodontic Bonding System "No-mix") and Light-cured composite (Transbond XT) that could be due to the existence of different filler in their composites. The higher shear bond strength of the Two-paste composite (Orthodontic Mix Bonding System) was in accordance with other

studies<sup>(39-45)</sup> that tested the Two-paste composite system (Concise). The studies were achieved for buccally bonded brackets.

#### **Comparison the Shear Bond Strength of Lingually Bonded Brackets Via Three Composite Systems**

The shear bond strength of the lingually bonded bracket via Two-paste composite (Orthodontic Mix Bonding System) had significantly increase than that shear bond strength of the lingually bonded bracket via Light-cured composite (Transbond XT) and No-mix composite (Orthodontic Bonding System "No-mix"). This difference may be due to existence of different filler material in composition of the bonding systems. This result was in agreement with the findings of King *et al.*,<sup>(46)</sup> who investigated the Concise (Two-paste) and Heliosite orthodontic (light-cured) composite systems.

The shear bond strength of the lingually bonded bracket via Light-cured composite (Transbond XT) revealed significantly increase than shear bond via No-mix composite (Orthodontic Bonding System "No-mix"). This difference could be due to different type of filler material of the composites or due to various techniques of the polymerization. This result in contrast with King *et al.*,<sup>(46)</sup> who tested the Light-cured composite (Heliosite Orthodontic) and No-mix composite (Right-ON).

#### **Comparison the Bond Strength of Buccally Bonded Brackets Via Three Composite Systems**

The shear bond strength of the buccally bonded bracket of the Two-paste composite was insignificantly higher than shear bond strength of the other composite systems, and that the shear bond strength of the Light-cured composite was insignificantly higher

than that of No-mix composite. The insignificant differences among the three composite systems may be due to more smooth and even buccal surface than the lingual surface that approximated the influence of the composite fillers. The insignificant difference in shear bond strength regarding the Two-paste composite and Light-cured composite was in agreement with the findings of Graenlaw *et al.*,<sup>(40)</sup> who tested Two-paste composite (Unite) and Light-cured composite (Heliosite Orthodontic), and with Chamad and Stein,<sup>(40)</sup> who studied the Two-paste composite (Composite). On the other hand, disagreed with the findings of Joseph and Rossow,<sup>(47)</sup> who found that the shear bond strength of the Two-paste composite (Concise) was higher than that of No-mix composite (Orthodontic Bonding System "No-mix").

The insignificant difference of shear bond strength of the Two-paste composite and No-mix composite could be due to smooth and even buccal surface which minimize the significantly influence of the composite fillers. The result was in agreement with other studies,<sup>(44, 48)</sup> although the compared the Two-paste composite (Concise) and No-mix composite (Right-ON). Also, the result was in contrast to the findings of Irland and Sherriff,<sup>(49)</sup> who found the bond strength of the Two-paste composite (Panavia Ex) had higher than that of No-mix composite (Bond East), and the research of Trimpeneers *et al.*,<sup>(50)</sup> who revealed that the No-mix composite (Right-ON) had a significantly higher shear bond strength than that Two-paste composite (Concise).

The insignificant differences of shear bond strength of the Light-cured composite and the No-mix composite could be due to the less influence of

filler of the composite on shear bond strength. This result was in agreement with other researchers,<sup>(44, 47)</sup> who tested the No-mix composite (Right-ON), and in contrast with Sunna and Rock,<sup>(51)</sup> who found that the shear bond strength of the No-mix composite (Right-ON) was significantly higher than that of Light-cured (Transbond XT).

#### **Comparison the Shear Bond Strength between the Lingually and Buccally Bonded Brackets Via Three Composite Systems**

It was revealed that the shear bond strength of the Two-paste and Light-cured composites had insignificantly increase in the buccally bonded bracket than lingually bonded bracket. This result could be due to that the different smoothness of the buccal and lingual crown surfaces had no significant influence on shear bond strength. These results were in agreement with Chumak *et al.*,<sup>(10)</sup> who investigated the chemically-cured composite systems, and in contrast with the findings of Wang *et al.*<sup>(52)</sup> Furthermore, the shear bond strength of buccally bonded brackets was significantly higher than that lingually bonded brackets when using No-mix composite (Orthodontic Bonding System "No-mix"). This difference could be due to that light exposure achieves more complete polymerization of the composite than chemical cured composite after one hour evaluation.

#### **Conclusion:**

The conclusions of this study can be present in that the Tow-paste (Orthodontic Mix Bonding System) had the highest shear bond strength of lingually and buccally bonded brackets.

There was insignificant

difference between lingually and buccally bonded bracket via Two-paste and Light-cured composites.

No-mix composite (Orthodontic Bonding System "No-mix") had the lowest bond strength and there was significantly decrease in shear bond strength of the lingually bonded bracket than buccally bonded bracket.

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