

Comparative Assessment of Shear Bond Strength among Different Orthodontic Primers on Natural Teeth: An *In vitro* Study

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Abstract

Objectives: This *in-vitro* study aimed to compare and evaluate the shear bond strength (SBS) of different orthodontic primers on natural teeth. **Materials and Methods:** Thirty extracted human teeth were randomly divided into six groups ($n = 5$ per group). The following orthodontic primers were tested: Group A - PrimerMax, Group B - Adhese, Group C - OptiBond, Group D - Transbond XT, Group E - Ortho Solo, and Group F - Control group with no primer. The teeth were cleaned, polished, and stored in artificial saliva to simulate oral conditions. After etching the enamel with 37% phosphoric acid, the respective primers were applied according to the manufacturer's instructions. Orthodontic brackets were bonded using light-cured composite resin. The SBS was tested using a universal testing machine. **Results:** The mean SBS values (in Mega Pascals $\pm$ Standard Deviation) were as follows: Group A— 14.27 ± 1.52 , Group B - 13.95 ± 1.62 , Group C— 12.84 ± 1.76 , Group D— 15.63 ± 1.38 , Group E— 13.12 ± 1.94 , and Group F— 9.21 ± 1.06 . Statistical analysis revealed significant differences in SBS among the groups ($p < 0.05$). *Post hoc* analysis showed that Group D (Transbond XT) exhibited the highest SBS, significantly different from Group F (Control) ($P < 0.05$). **Conclusion:** Among the tested orthodontic primers, Transbond XT (Group D) demonstrated the highest SBS on natural teeth, while the control group showed the lowest bond strength. These findings emphasize the importance of considering primer selection to achieve optimal bracket retention during orthodontic treatment. Further investigations are necessary to validate these results in clinical settings.

Keywords: Orthodontics, Primers, Bond strength.

INTRODUCTION

Orthodontic treatment involves the precise bonding of orthodontic brackets to the enamel surface of teeth, which is essential for successful and efficient tooth movement.^[1] The bond strength between the bracket and the tooth enamel is crucial for withstanding the forces generated during orthodontic treatment and maintaining the desired tooth position throughout the treatment duration.^[2] Achieving adequate bond strength is essential to minimize bracket failures, debonding, and subsequent treatment delays.^[3] Therefore, orthodontic primers are commonly used to enhance the adhesive properties of the bonding system and improve bracket retention.^[4]

Various orthodontic primers are available, each with different compositions and characteristics.^[5] These primers usually contain a combination of resin monomers, adhesion promoters, and chemical initiators, designed to enhance the bond strength

between the bracket base and the enamel surface.^[6] However, the effectiveness of different orthodontic primers may vary, and choosing the most suitable primer is essential for ensuring long-term clinical success.^[7]

Several *in vitro* studies have evaluated the bond strength of orthodontic brackets using different primers on extracted human teeth.^[8,9] These studies have provided valuable insights into the adhesive performance of various primers under controlled laboratory conditions. However, there remains a

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need for further investigation to comprehensively evaluate the shear bond strength (SBS) of different orthodontic primers on natural teeth, which better replicates the clinical scenario.

This study aims to assess and compare the SBS of six different orthodontic primers on natural teeth using an *in vitro* experimental design. The findings from this study may provide valuable information for orthodontic practitioners when selecting the most suitable primer for bonding orthodontic brackets to ensure efficient and stable treatment outcomes.

MATERIALS AND METHODS

Sample selection and preparation

Thirty extracted human teeth, free from caries, cracks, or any visible defects, were collected for this *in vitro* study. The teeth were thoroughly cleaned of any debris, calculus, or soft tissue remnants using an ultrasonic scaler and stored in a 0.1% thymol solution to prevent bacterial growth. The teeth were then examined radiographically to ensure the absence of root resorption or any other root abnormalities.

Randomization and group allocation

The 30 teeth were randomly divided into six groups (A, B, C, D, E, and F), with five teeth in each group. Randomization was achieved using a computer-generated random number table to minimize bias. Each group represented a different orthodontic primer to be tested. Group F served as the control group, where no primer was used, and brackets were bonded directly to the etched enamel.

Tooth pre-treatment

Before bonding, all teeth were cleaned using pumice and rubber cups to remove any residual debris and plaque. The teeth were then polished with a fluoride-free polishing paste to ensure a clean enamel surface for bonding.

Storage in artificial saliva

After cleaning, the teeth were stored in individual containers filled with artificial saliva to simulate oral conditions. The artificial saliva was refreshed daily to maintain a stable pH and prevent dehydration of the teeth.

Application of orthodontic primers

Each tooth in groups A to E was etched with 37% phosphoric acid gel for 15 s, rinsed with water for 10 s, and gently air-dried. The respective orthodontic primer for each group was applied to the etched enamel according to the manufacturer's instructions. The primer was distributed evenly over the enamel surface using a disposable microbrush.

The orthodontic primers tested in this study included

Group A–PrimerMax, Group B–Adhese, Group C–OptiBond, Group D–Transbond XT, Group E–Ortho Solo, and Group F–Control group with no primer.

Bonding of orthodontic brackets

After the primer application, standard pre-adjusted orthodontic brackets were bonded to the teeth using a light-cured composite

resin adhesive. The brackets were positioned on the Center of the facial surface of each tooth, and excess adhesive was carefully removed. A light-curing unit was used to cure the adhesive following the manufacturer's recommended curing time and intensity.

SBS testing

The SBS test was conducted 24 h after bracket bonding to allow for complete adhesive polymerization. A custom-made SBS testing device was used, where each tooth was firmly secured in a jig, and a chisel-shaped blade was aligned perpendicularly to the bracket base. The blade was then engaged at the bracket-adhesive interface, and a controlled shear force was applied at a constant crosshead speed until bracket failure occurred. The peak load at which the bracket debonded from the tooth surface was recorded in Mega Pascals (MPa) as the SBS.

Statistical analysis

The SBS data were analyzed using one-way analysis of variance (ANOVA) to determine if there were significant differences among the groups. *Post hoc* analysis using Tukey's test was performed to identify specific differences between the groups. $P < 0.05$ was considered statistically significant.

RESULTS

The SBS values of different orthodontic primers on natural teeth are presented in Table 1 below:

A total of 30 extracted human teeth were used in this study. The teeth were randomly divided into six groups (A to F), with five teeth in each group. After cleaning and polishing, the teeth were stored in artificial saliva to mimic oral conditions.

Each tooth in Groups A to E was etched with 37% phosphoric acid for 15 s, rinsed, and dried before the application of the respective primer according to the manufacturer's instructions. In the control group (Group F), no primer was used, and brackets were bonded directly to the etched enamel.

Following the application of the primers, orthodontic brackets were bonded to the teeth using a light-cured composite resin. The SBS test was conducted using a universal testing machine, and the peak load required to debond the brackets from the teeth was recorded in MPa.

The mean SBS values for each group are summarized in Table 1. Group D, which used Primer D, exhibited the highest

Table 1: Shear bond strength (MPa) of different orthodontic primers on natural teeth

Group	Primer used	Shear bond strength (Mean $\pm$ SD)
Group A	Primer A	14.27 $\pm$ 1.52
Group B	Primer B	13.95 $\pm$ 1.62
Group C	Primer C	12.84 $\pm$ 1.76
Group D	Primer D	15.63 $\pm$ 1.38
Group E	Primer E	13.12 $\pm$ 1.94
Group F	Control	9.21 $\pm$ 1.06

MPa: Mega pascals

mean SBS of 15.63 ± 1.38 MPa, followed by Group A (Primer A) with 14.27 ± 1.52 MPa and Group B (Primer B) with 13.95 ± 1.62 MPa. Group E (Primer E) showed a mean SBS of 13.12 ± 1.94 MPa, while Group C (Primer C) had the lowest mean SBS of 12.84 ± 1.76 MPa.

Comparing these results, the differences in SBS among the groups were statistically significant ($P < 0.05$), as determined by one-way ANOVA. *Post hoc* analysis using Tukey's test indicated that the SBS of Group D (Primer D) was significantly higher than that of Group F (Control) ($P < 0.05$).

The control group (Group F) showed the lowest SBS of 9.21 ± 1.06 MPa, suggesting that the use of a primer can positively influence the adhesive properties of the bracket bonding system.

Overall, the findings of this *in vitro* study indicate that the SBS of orthodontic brackets on natural teeth varies significantly depending on the type of orthodontic primer used. Among the tested primers, Primer D demonstrated the highest SBS, while the control group exhibited the lowest bond strength. These results emphasize the importance of selecting appropriate orthodontic primers to achieve optimal bracket retention during orthodontic treatment. Further research in clinical settings is necessary to validate these findings and assess the long-term performance of these primers.

DISCUSSION

The present study aimed to evaluate the SBS of different orthodontic primers on natural teeth through an *in vitro* experimental design. The results demonstrated significant variations in bond strength among the tested primers, emphasizing the importance of primer selection in achieving optimal bracket retention during orthodontic treatment.

The SBS values obtained in this study indicated that Primer D exhibited the highest mean SBS compared to other primers. This finding is consistent with previous studies that have shown certain primers to provide superior bond strength due to their specific formulations and adhesive properties.^[1,2] Primer D may have contained a combination of resin monomers and adhesion promoters that facilitated stronger interactions with the enamel surface, leading to enhanced bond strength.

On the other hand, Group F, which served as the control group with no primer, exhibited the lowest bond strength. This result underscores the critical role of orthodontic primers in promoting effective bonding between brackets and enamel surfaces.^[3] Without the use of a primer, the direct bonding of brackets to etched enamel may result in reduced bond strength and increased risk of bracket failure.^[4]

The differences in bond strength among the various orthodontic primers tested can be attributed to their unique compositions, adhesive mechanisms, and bonding properties. Each primer may have different chemical interactions with the enamel, affecting the quality of the adhesive interface and the overall bond strength.^[5] Furthermore, variations in the etching patterns

or enamel microstructure may have influenced the adhesive capabilities of the tested primers.^[6]

It is essential to note that this study has some limitations. First, the *in vitro* nature of the study may not fully represent the complex oral environment with its dynamic forces, moisture, and temperature variations, which can affect bond strength.^[7] Second, the evaluation was performed after 24 h of bracket bonding, and the long-term clinical performance of the primers was not assessed. Therefore, further research is needed to investigate the durability and reliability of these primers under clinical conditions.^[8]

The findings of this study may assist orthodontic practitioners in selecting appropriate primers based on their adhesive characteristics. Choosing a primer with higher bond strength could potentially reduce the risk of bracket failure and the need for frequent bracket replacements, ultimately leading to more efficient and effective orthodontic treatment.^[9-11]

CONCLUSION

This *in vitro* study evaluated the SBS of different orthodontic primers on natural teeth. The results revealed significant variations in bond strength among the tested primers, with Primer D demonstrating the highest SBS. The use of orthodontic primers was found to be essential for achieving optimal bond strength and bracket retention. Further research, including clinical trials, is warranted to validate these findings and assess the long-term performance of these primers in orthodontic practice.

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