Evaluation of Shear Bond Strength of Orthodontic Bracket after Using Various Etching Systems: An *In Vitro* Study

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**Abstract**

**Aim and objective:** This study aimed to assess the shear bond potency of orthodontic brackets following the use of multiple etching systems.

**Materials and methods:** Sixty fit adult human mandibular premolars were employed in this study. Before preparation of the enamel surface, the buccal side of each premolar was subjected to pumicing, washing with a spray, and air-drying. Three groups each constituting 20 teeth were made. Group I: traditional acid etch using 37% phosphoric acid, group II: the self-etch primer namely One-Coat, group III: employing seventh-generation self-etching priming system. Universal testing machine was utilized to evaluate the shear bond test. Conversion to megapascals was done after estimating the forces for debonding in Newtons. The adhesive remnant index (ARI) was employed for every fractured sample following debonding.

**Results:** Group I (19.33 ± 0.22) had the greatest shear bond strength, pursued by group III (13.86 ± 0.37). The lowest shear bond strength was depicted by group II (11.48 ± 0.76). High statistical variation was noted amid the three etching agents after applying the analysis of variance test. The comparative assessment amongst the three dissimilar etching agents revealed a statistically significant difference between the three groups—I, II, and III. A score of 3 that is about 40% was highly prevalent in the traditional acid etch system pursued by 30% of the seventh generation self-etching priming system. The lowest score was for One-Coat primers. Employing the Chi-square test, a 0.036 probability value was obtained which was statistically significant for the compared ARI scores.

**Conclusion:** It can be thus concluded that the three groups assessed through this study depicted clinically satisfactory bond strength. The traditional acid etch system showed the greatest shear strength of bonding pursued by the seventh generation self-etching primer system and self-etch primer named One-Coat in that order.

**Clinical significance:** The bond of orthodontic brackets to the surface of enamel is a key issue in orthodontics as the importance of a steady bonding between the bracket and tooth surface is outrightly obvious. Reducing the steps involved may lessen error incorporation and may cut down the time spent by clinicians with lower chances of decalcification of enamel.

**Keywords:** Acid etching, Adhesive remnant index, Orthodontic brackets, Shear bond strength.

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**Introduction**

Attachment of brackets to the surface enamel is the basis of fixed orthodontic management. Simplified clinical practice and increased acceptability of treatment by patients can be achieved by the direct bonding of brackets to the enamel. Numerous chemical and mechanical procedures used to condition enamel can help procure a good bonding.

Elimination of smear layer for accomplishing bonding by acid etching is a routine procedure according to Buonocore. An extended bond strength stems from developing a micromechanical bond. The utility of epoxy resin for bonding brackets was reported in 1965 by Newman. Removal of the interdental space as occupied by the band, decreased gingival pain and tooth decalcification, promoting the removal of plaque enhance the therapeutic results largely. Owing to these, an array of techniques for bonding have been reported to enhance the bond strength of orthodontic bands.

It has been extensively reported that the use of self-etching primers produces a milder etch pattern than 37% phosphoric acid. Although conventional acid etching of the enamel surface leads to more enamel loss than does the utilization of self-etching primers, the etching pattern observed with 37% phosphoric acid for 15 seconds seems more conservative than the typical honeycomb etched pattern observed when the enamel surface was etched for 30 seconds.

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Additionally, brackets that are bonded to enamel must have a bond strength that is adequate to endure the orthodontic forces applied during the therapy. An orthodontic adhesive is considered ideal if it has ample bond strength. A resistance of 5.9–7.8 MPa is considered more than enough to bear the masticatory forces as stated by Reynolds.6

Based on this, the current study was performed to assess the shear bond potency of orthodontic brackets following the use of multiple etching systems.

**Materials and Methods**

In vitro research was carried out in the department of preventive dental sciences. Sixty fit mandibular human premolars that were lately removed as a part of orthodontic treatment were employed in this research. The absence of dental caries/fractures, lack of prior treatment with chemicals like formalin, alcohol, and hydrogen peroxide/other bleaching agents constituted the inclusion criteria. The premolar teeth had intact buccal surfaces that had not received any form of dental therapy in the past.

The premolars were immersed in distilled water for 15 days for storage. This water was changed every 7 days to prevent bacterial contamination. Carefully preventing contact amid the tooth and resin, the roots of the premolars were oriented in a vertical direction in self-cure acrylic with the crowns exposed. The buccal surface of the premolar teeth was then pumiced, rinsed with a spray, and air-dried before preparation of enamel. The 60 premolar teeth were randomly allocated to one of the three equivalent groups of 20 teeth each.

**Group I: Conventional Acid Etching**

Individual premolars were subjected to 37% phosphoric acid etching for 15 seconds. Following this, they were rinsed well with water and dried to achieve a white chalky appearance. This was followed by the application of the adhesive primer onto the etched surface. The orthodontic bracket was then placed on the surface of the tooth and bonding was performed using Transbond XT (3M Unitek, CA, USA).

**Group II: Self-etching Primer One-coat**

One-coat (Coltene) self-etching primer was utilized to etch and prime 20 premolars. The same was applied over the enamel for a period of 3 seconds and cautiously dried with air and a jet devoid of water vapors and oil according to the recommendations of the manufacturer. Transbond XT adhesive (3M Unitek) was used to bond the brackets followed by adhesive light-curing for a period of 40 seconds.

**Group III: Seventh Generation Self-etch Primer**

In accordance with the manufacturer’s recommendations, a self-etch primer (Adper Easy One, 3M ESPE) was employed to prepare the buccal surfaces of the premolar teeth. Employing an application tip for a period of 20 seconds, the agent was applied to the premolar, and then air blended for 5 seconds till this film immobilized which implicated total vaporization of the solvent. Then, light-curing was performed for ten seconds. Utilizing Transbond XT, the stainless steel brackets were bonded in an akin fashion.

**Evaluation of Shear Bond Strength**

A chisel head placed on the crosshead of the universal testing machine (Fig. 1) was used to evaluate the shear bond strength test. The long axis of the premolar tooth at the tooth bracket edge was subject to the machine’s loading head, at a crosshead speed of 5 mm/60 seconds. Every individual sample’s debonding force was estimated in Newtons followed by later conversion to megapascals by the division of force in Newtons to the bracket base area.

**Evaluation of Adhesive Remnant Index (Fig. 2)**

Following debonding, the fractured specimen was evaluated and the adhesive remnant index (ARI) was assessed in accordance with Artun and Bergland.7

- **Score 0**—Absence of adhesive on the tooth.
- **Score 1**—Fewer than half of the adhesive remaining on the tooth.
- **Score 2**—Greater than half of the adhesive present on the tooth.
- **Score 3**—The entire adhesive remaining on the tooth, with a discrete bracket mesh impression.

Adhesive remnant index scores were then employed to categorize the location of the breakdown of the bond amid bracket base, enamel as well as a resin for a greater comprehensive means. An optical stereomicroscope having a magnification of 40× was used to evaluate the ARI scores.

**Statistical Analysis**

SPSS version 20 was employed to perform data analysis. As data were normally distributed analysis of variance (ANOVA) and Tukey’s multiple comparison tests were employed to compare the mean values of shear bond strength. For statistical significance, a 0.05 probability level was set. Chi-square (χ²) test was utilized to determine the variation in the ARI values.

**Results**

The mean values of the orthodontic brackets’ shear bond strength with three types of etching systems are depicted in Table 1. Group I (19.33 ± 0.22) had the greatest shear bond strength, pursued by group III (13.86 ± 0.37). The lowest shear bond strength was depicted by group II (11.48 ± 0.76). High statistical variation was noted amid the three etching agents after applying the ANOVA test.
The comparative assessment amidst the three dissimilar etching agents can be appreciated in Table 2. A statistically significant difference was noted between the three groups—I, II, and III.

Table 3 depicts the ARI values of the three dissimilar etching agents. For the entire adhesive remaining on the tooth, an ARI score value was 3. The lowest was noted for the One-Coat Self-etch primer constituting 20%. Second in place was the seventh generation self-etching primer with 30%.

The highest noted value was for the traditional acid etching system at 40%. Employing the Chi-square test, a 0.036 probability value was obtained which was statistically significant for the compared ARI scores. This signified that the adhesive substance remaining on the tooth was less in the seventh generation self-etching primer and One-coat self-etch primer, in contrast to the traditional acid etching system.

**Discussion**

The time required for orthodontic therapy and the quantity of force supplied is determined by the bond strength.8 Bonding capability of the bonding agents, joining depicted at various interfaces like composite-bracket edge and tooth composite edge, polymerization of the composite bonding substance are a few of the numerous factors that affect shear bond strength.

Application of composite involves a bonding process comprising of etching, application of primer, and adhesive.9 A dual requirement of shear bond strength is to gratify ample bracket retention but be low enough to permit ease of cleansing remnant adhesive following bracket removal.10 Conventionally, appropriate drenching and diffusion of the sealant into the surface of enamel, use of acid etching, and primer application are essential to achieve bonding of composite adhesives. Old primers were acidic and discerningly compatible with some adhesive agents and resultantly provided less bond strength or required greater working periods. As a result of advances in their compositions, the naïve self-etching primers offer clinically suitable shear bonding strengths.11

The mean shear bond strength (SBS) value of the traditional acid etch method was 19.33 ± 0.22 and the greatest among all groups in the current study which is in accordance with previous studies. An SBS of 11.2 for traditional acid-etching adhesive was documented by Pickett et al.12 and Arnold et al.13 Vilchis et al.14 on comparing the tradition acid etch group (control) with Transbond Plus and three other self-etch adhesive agents. The deepest diffusion of the enamel surface by the adhesive, the higher the dispersion of the adhesive and more is the damage risk to the enamel. The results of our study

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**Table 1:** Comparison of mean shear bond strength of orthodontic brackets with three etching systems

| Groups                        | Mean ± SD (MPa) | F value | p value |
|-------------------------------|-----------------|---------|---------|
| Group I: Conventional acid etching | 19.33 ± 0.22    | 28.248  | 0.0001* |
| Group II: Self-etching primer One-Coat | 11.48 ± 0.76    |         |         |
| Group III: Seventh generation self-etch primer | 13.86 ± 0.37    |         |         |

*Highly significant

**Table 2:** Comparisons of three different etching systems using Tukey’s post hoc test

| Group         | Compared with | Mean difference | Sig. |
|---------------|---------------|-----------------|------|
| Group I       | Group II      | 7.85            | 0.001|
| Group II      | Group I       | −7.85           | 0.001|
| Group III     | Group I       | −2.38           | 0.08 |
| Group III     | Group II      | −5.47           | 0.001|

**Table 3:** Adhesive remnant index scores of three different etching systems

| Groups     | n  | Score 0 (%) | Score 1 (%) | Score 2 (%) | Score 3 (%) |
|------------|----|-------------|-------------|-------------|-------------|
| Group I    | 20 | 4 (20)      | 5 (25)      | 3 (15)      | 8 (40)      |
| Group II   | 20 | 8 (40)      | 6 (30)      | 2 (10)      | 4 (20)      |
| Group III  | 20 | 5 (25)      | 6 (30)      | 3 (15)      | 6 (30)      |

Chi-square ($\chi^2$) = 18.68; $p = 0.036$
are consistent with that of Yap et al., who reported that self-etch primers greatly lower SBS values in comparison to traditional acid etch bonding.

The time saved does not only imply the bonding process but also the debonding step and eliminating remaining resin from the surface of the tooth which are critical factors for the proficient and idyllic flow of work. More the adhesive agent stuck to the base of the bracket, less will be the time required and the procedure will be safer and easier.

Adhesive remnant index is a triple-scaled scoring procedure for remaining adhesive material commenced by Artun and Bergland, which is an often utilized index to analyze adhesive material in orthodontia.

The ARI scores were 3 that are approximately 40% which constitutes a high figure. This hence proved that the specimen tested had a higher numerical that signified a successful bond at the enamel and adhesive joint which is not in accordance with the results of the research by Fleischmann et al. and Lin et al. Due to decreased remaining adhesive on the surface of enamel that resulted in decreased iatrogenic damage during polishing of enamel, ARI score values of 0 and 1 according to the research by Chang et al. and Bishara et al. may be considered reasonable.

This study assessed a self-etching primer system and traditional etching with 37% phosphoric acid. The comparative analysis of bond strengths revealed that although the bond strength with traditional acid etching (mean—13.34) was slightly higher than that attained with self-etch priming agents (mean—12.15), there were no statistically significant differences between the two. This is in concordance with the research by Özer et al.

As in vitro researches are not able to precisely duplicate the actual situation in an in vivo atmosphere, the results of the study must be construed cautiously as regards the limitation of this research. Also, the bond strength of brackets is just a single component that lends contribution to the clinical efficiency of bonding. Hence, future research must be aimed toward addressing the biocompatibility and bonding power of systems used in etching in routine clinical orthodontic practice.

**Conclusion**

It can be thus concluded that the three groups assessed through this study depicted clinically satisfactory bond strength. The traditional acid etch system showed the greatest shear strength of bonding pursued by the seventh generation self-etching primer system and self-etch primer named One-Coat in that order.

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