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Different Self-Etching Adhesives in Bonding Orthodontic Brackets

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Abstract

The aim of this study was to evaluate and compare the shear bond strength of three different self-etch adhesive systems used for bonding orthodontics brackets. This study was designed as an in vitro experimental study. A total of 60 extracted human premolars were selected and randomly divided into six equal groups (n = 10) according to the type of self-etch adhesive used. Etching significantly increased the shear bond strength (SBS) of all tested self-etch adhesive systems. Under the non-etched condition, GC showed the highest mean SBS (17.60 MPa), followed by Tokuyama (15.25 MPa), while Any Com recorded the lowest value (8.80 MPa). After etching, SBS values increased markedly for all materials, with GC remaining the highest (25.30 MPa), followed by Tokuyama (22.66 MPa) and Any Com (19.33 MPa). Two-way ANOVA demonstrated significant effects of both adhesive material and etching condition on SBS ($p < .001$), with a significant interaction between them. All materials exceeded the clinically acceptable bond strength, while etching produced a notable improvement in bonding performance, particularly for Any Com. Both the type of self-etch adhesive and enamel etching significantly affect the shear bond strength of orthodontic brackets. Etching improves bonding performance, although the degree of improvement varies among adhesive systems.

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Introduction

Bonding of orthodontic attachments using orthodontic adhesives is one of the important procedures in clinical orthodontic practice and is the most significant development over the past three decades. Direct bonding technique has opened new horizons for researchers to introduce new adhesive materials and improved techniques in orthodontic bonding to simplify the clinical workflow by merging etching and priming into a one-step [1,2].

The primary use is to reduce chair time, minimize iatrogenic damage to the tooth enamel, increase adhesion of acrylic filling material to enamel surface by acid pre-treatment with and 37% phosphoric acid [3-12].

This paved the way for direct bonding of bracket in orthodontic practice. The first successful bonding material was Bowen's resin (Bis-GMA), developed in 1962 for restorative purpose. Bowen's resin is an acrylic-modified epoxy resin with setting advantage of acrylic and dimensional stability and strength of epoxy resin [3,4].

As new adhesives, composite resins and newer bonding techniques were being introduced in restorative dentistry; orthodontists also adapted some of these innovations [13-18]. Various modifications were made to Bowen's resin with the addition of co-monomer, variable amounts of fillers and silane coupling agent to alter their properties and enhance their performance for the clinical use. Addition of filler particles to these resins to form composites greatly increased their strength and mechanical properties [15-17].

Shear bond strength (SBS) in orthodontics measures the force required to dislodge brackets from teeth, typically requiring 6–8 MPa to withstand masticatory forces, while remaining below 14 MPa to prevent enamel damage [16-19].

Optimal bond strength is essential for an ideal orthodontic adhesive when the brackets are bonded to the etched enamel surface to withstand masticatory forces and forces of the orthodontic appliance [20-22]. On the other hand, it should also de bond without causing any damage to the enamel at the end of the treatment [11]. The bond strength and debonding character of widely used orthodontic adhesive for bonding metal and ceramic brackets to tooth surfaces have been extensively studied and reported to have optimal bond strength with wide clinical acceptance he invention of direct bonding of brackets to

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enamel surfaces of teeth has dramatically changed orthodontic treatment [16,20].

Materials and Methodos

This study was designed as an in vitro experimental study. A total of 60 extracted human premolars were selected and randomly divided into six equal groups (n = 10) according to the type of self-etch adhesive used.

Group I: Tokuyama adhesive "etched"
Group II: Tokuyama adhesive "unetched"
Group III: GC adhesive "etched"
Group IV: GC adhesive "unetched"
Group V: Any-com adhesive "etched"
Group VI: Any-com adhesive "unetched".

The independent variable in this study was the type of self-etch adhesive, while the dependent variable was the shear bond strength (SBS) of orthodontic brackets. The aim of this study was to evaluate and compare the shear bond strength of three different self-etch adhesive systems used for bonding orthodontic brackets.

The samples were collected from the Dental Clinic of Tikrit University between November 2025 and February 2026. A total of 60 extracted human premolars indicated for orthodontic treatment purposes were selected for this study. Inclusion criteria included intact teeth with sound enamel surfaces, free from caries, cracks, restorations, fluorosis, or structural defects. Teeth with hypoplastic enamel, developmental defects, or previously bonded surfaces were excluded from the study. The teeth preserved in distilled water at ambient temperature until used.

All teeth were polished with a Perio Brush and pumice, then mounted in acrylic resin blocks with only the crowns exposed. Enamel was etched with 37% phosphoric acid for 15 seconds, rinsed, dried, treated with Tokuyama bonding agent, and brackets were bonded using Tokuyama light-cured composite resin.

Group II: a self-etching approach was adopted. Tokuyama self-etch primer was placed directly onto enamel surface for 20s without any prior acid etching or rinsing steps. Bracket bonding was completed using the same light activated composite material employed in the first group.

Group III: followed conventional etch and rinse protocol described earlier; however, GC bonding system was used instead of Tokuyama. Brackets were secured using GC light-cured composite resin.

Group IV: GC self-etch primer was applied directly to the enamel for 20s, without separate phosphoric acid etching. The bracket was then bonded utilizing the same GC composite resin mentioned for the third group.

Group V: underwent the conventional acid etch technique like (first and third) groups, but Any com adhesive system was used. Bracket were bonded with Any com light-cured composite resin.

Group VI: Any com self-etch primer was applied directly to the enamel surface for 20s, without rinsing or pre-etching, followed by bracket fixation using its corresponding light cured composite resin.

The HOYTOM tensile strength device is a Japanese-manufactured mechanical testing machine designed to evaluate shear bond strength between two bonded surfaces [23,24]. It functions by applying a controlled and gradually increasing tensile load to a specimen until mechanical failure occurs. The system records the maximum force at the moment of debonding, typically expressed in Newtons (N) [25,26].

In our study, each extracted tooth was securely embedded in a custom holder to maintain stability during testing. The orthodontic bracket was connected to the testing arm of the device. A chisel-edged loading blade was positioned at the junction between the bracket and enamel surface. The testing machine was operated at a crosshead speed for 1mm/min, and force was applied continuously until bracket separation occurred. The highest load measured at the moment of debonding was documented and used to calculate the bond strength for each individual specimen [27-29].

Results

The present study evaluated the effect of different self-etching adhesive materials and etching conditions on the shear bond strength (SBS) of orthodontic brackets. A total of 30 specimens were included in the analysis, with 10 samples allocated to each material group (Tokuyama, GC, and Any Com).

Following the application of etching, all materials demonstrated a marked increase in bond strength. GC again recorded the highest mean SBS (25.30 ± 0.23 MPa), followed by Tokuyama (22.66 ± 0.44 MPa). Any Com showed a substantial improvement after etching, reaching 19.33 ± 0.22 MPa.

Table.1 Etching significantly increased bond strength values in all materials.

Material	N	Without Etch (Mean ± SD)	With Etch (Mean ± SD)
Tokuyama	10	15.25 ± 0.3	22.66 ± 0.44
GC	10	17.6 ± 0.26	25.3 ± 0.23
Any Com	10	8.8 ± 0.24	19.33 ± 0.22

To determine the statistical significance of these differences, a two-way ANOVA was performed to evaluate the main effects of material type and etching condition, as well as their interaction effect on shear bond strength.

The analysis revealed a statistically significant main effect of material (F 2, 54 = 4850.4, $p < 0.001$, indicating that bond strength significantly differed among the tested adhesive systems.

A statistically significant main effect of etching was also found (F 1, 54 = 39210.7, $p < 0.001$, demonstrating that the application of etching significantly increased SBS values regardless of material type.

Furthermore, a statistically significant interaction between material and etching condition was observed (F 2, 54 = 1685.3, $p < 0.001$). This interaction indicates that the magnitude of the etching effect varied depending on the adhesive material used. Although all materials benefited from etching, Any Com showed the greatest relative increase in bond strength after etching, while GC consistently maintained the highest overall SBS values in both etched and non-etched conditions. Overall, the results confirm that both the type of self-etching adhesive and the use of etching significantly influence the shear bond strength of orthodontic brackets.

Based on the two-way ANOVA results, all null hypotheses were rejected. Significant differences were observed among materials, etching conditions, and their interaction ($p < 0.001$), indicating that both adhesive type and etching procedure significantly affect the shear bond strength (SBS) of orthodontic brackets.

The application of etching resulted in a significant increase in bond strength across all tested materials. However, the magnitude of improvement differed among the groups, as confirmed by the significant interaction effect in the two-way ANOVA.

Tokuyama showed an increase from 15.25 MPa to 22.66 MPa, representing a substantial improvement in bonding performance. GC increased from 17.60 MPa to 25.30 MPa, maintaining the highest absolute bond strength values in both conditions.

Any Com demonstrated the greatest relative improvement, increasing from 8.80 MPa without etching to 19.33 MPa with etching. This suggests that Any Com is more dependent on enamel surface preparation compared to the other tested materials.

These findings indicate that while all materials benefit from etching, some adhesive systems are more sensitive to surface conditioning procedures than others.

Discussion

The present study evaluated the influence of different self-etching adhesive systems and assessment of the relationship between etching procedure and bracket shear bond strength. The findings demonstrated that both material

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type and etching condition significantly affected bond strength values [2,30].
The two-way ANOVA revealed statistically significant main effects for material and etching, as well as a significant interaction between them (p < .001). These findings indicate that bond strength is not only dependent on the adhesive system used but is also significantly influenced by enamel surface preparation [31,33].
GC demonstrated the highest bond strength values in both etched and non-etched conditions. This may be attributed to its chemical composition, filler content, and the presence of functional monomers that enhance micromechanical and chemical bonding to enamel. These findings are consistent with previous studies that reported higher and more reliable bond strengths with contemporary universal adhesive system [30,34].
Tokuyama also showed clinically acceptable bond strength values under both conditions, with a significant improvement after etching. This supports previous literature suggesting that proper enamel surface conditioning enhances resin penetration and micromechanical retention [29,35].
Any Com exhibited the lowest bond strength without etching but showed the greatest relative improvement after etching. This suggests that this material is more dependent on enamel surface roughness for optimal bonding. Similar observations have been reported in studies evaluating self-etching primers, where bond performance significantly improved when additional enamel conditioning was performed [36].
All recorded SBS values exceeded the minimum clinically acceptable range (6–8 MPa), as mentioned in orthodontic literature. However, excessively high bond strength values, particularly those exceeding 20 MPa, may increase the risk of enamel damage during bracket debonding. Therefore, while higher bond strength improves bracket retention during treatment, it must be balanced against the risk of enamel fracture at the end of treatment [5].
The significant interaction effect observed in this study highlights that the effect of etching is material-dependent. This emphasizes the importance of selecting an adhesive system based on both its intrinsic properties and the clinical bonding protocol [11].

Conclusion

Within the limitations of this in vitro study, shear bond strength is significantly influenced by the type of self-etching adhesive used. The application of enamel etching significantly increases bond strength values. A significant interaction exists between material type and etching condition, indicating that the effect of etching varies depending on the adhesive system. The results suggest that modification of self-etch adhesive composition could improve their bonding performance and durability.

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