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Effect of mechanical disturbances during and after acid etching on shear bond strength

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ABSTRACT

Objectives: To study the effect of mechanical disturbances during and after acid etching on shear bond strength and their debonding characteristics.

Materials and methods: An in vitro study was performed taking 60 extracted human first premolars divided equally in three groups. Samples in Group A were bonded according to manufacturer instructions; in Group B, they were etched by rubbing a sponge that contained 37% orthophosphoric acid over the enamel for 15 s, and then bonded, and in Group C they were etched for 15 s, washed and air dried. After etching and drying, they were rubbed with a dry sponge for 5 s and then bonded. Shear bond strength testing was performed.

Results: The differences in bond strengths and adhesive remnant index (ARI) scores between the groups were assessed by one-way ANOVA test and Post hoc Tukey test. Both the tests revealed statistically significant differences for bond strengths and ARI scores. Group A shows higher values for bond strength (13.825 MPa) as compared with Group B (12.996 MPa) and Group C (10.146 MPa). Group A shows higher values for ARI (3.89) as compared with Group B (3.55) and Group C (1.8).

Conclusion: Mechanical disturbances during and after acid etching reduce the shear bond strength of composite resin. Etchant and primer should be applied on the tooth surface by dabbing the solutions.

1. Introduction

The introduction of acid etch bonding technique has changed the practice of orthodontics. Buonocore demonstrated increased adhesion produced by acid pretreatment using 85% phosphoric acid (1955).[1] Newman applied these findings to direct bonding in orthodontics.[2] Since then, the use of resin bonding agents is superior in many ways over banding for the placement of orthodontic brackets.

Acid etch bonding is a multistep process where a variation at any step may affect the ultimate bond strength. The etching of the enamel results in increased porosity, and thus increasing total retentive surface area available for bonding. Practice of orthodontics often requires bonding under difficult conditions of moisture or blood contamination.[3] Another factor like mechanical disturbances may also affect the etched surface.

The overall etch surface pattern depends on the dissolution and reprecipitation of surface enamel. The reprecipitation of

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dissolved materials during the etching process is an important factor in the etch pattern formation, which causes elevation of the enamel prism sheaths and hence improves the quality of the etch surface for retention. However, rubbing/vigorous agitation during acid etching causes a different etched pattern formation. Rubbing the enamel surface during the etching process may disrupt the normal pathway of etching. Consequently, the reprecipitation of the dissolved material, and the elevation of the prism sheaths reported during the static etching condition, may not occur during rubbing.[4]

After drying the etched enamel surface, every effort must be made to apply polymer coatings immediately to secure the maximum effect from a properly conditioned surface. Dennison and Craig observed that a freshly etched enamel surface is extremely sensitive and fragile.[5] The surface structure can be destroyed easily with even a slight abrasive process, so it is important not to disturb etched enamel surface.

Only one study, which evaluates quantitative differences in bond strength under conditions of mechanical disturbances during etching, has been reported in the literatures. This study was designed to investigate the effect of mechanical disturbances, both during and after the acid etching process on shear bond strength of adhesive composite resin.

2. Materials and methods

Sixty sound human first premolars were collected (12–18 yrs), which were extracted for orthodontic purpose. Teeth with restorations, carious lesions, enamel defects, or cracks were excluded. All teeth were stored in 37% formaldehyde for maximum of 6 months to inhibit bacterial growth. Teeth were randomly divided into 3 equal groups.

Retentive groves were placed on the root portion of each tooth. Teeth were mounted in acrylic blocks (Fig. 1). The buccal surfaces were cleaned with pumice and water slurry for 15 s, and washed with water for 5 s. Etching was done with 37% phosphoric acid for 15 s, rinsed with water, and dried with oil free compressor air for 3 s.[6] Metal 0.018 brackets[#] were bonded with adhesive and primer and light cured for 40 s, as per the manufacturer's instructions.

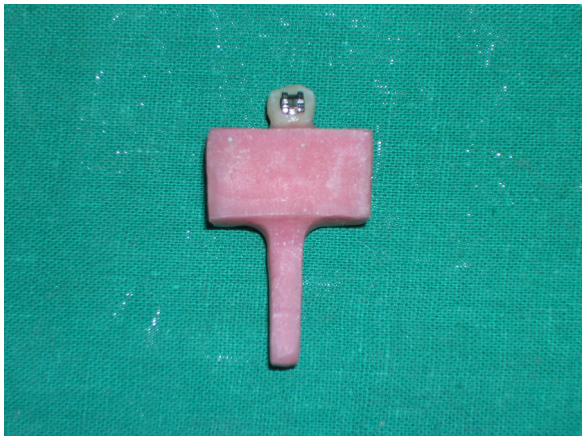

Fig. 1 – Sample being tested. Tooth mounted in acrylic block and bonded.

Group A: The teeth in group A were bonded with adhesive[*] and primer[**], as per the manufacturer's instructions.
Group B: The teeth in group B were etched by rubbing the sponge that contained 37% orthophosphoric acid over the enamel surface for 15 s, rinsed with water, and the teeth were air dried and then bonded with adhesive and primer.
Group C: The teeth in group C were etched for 15 s, rinsed with water, and air dried. After etching they were rubbed with a dry sponge for 5 s; the teeth were then bonded with adhesive and primer.

All teeth were stored in distilled water at room temperature for 24 h.

– Gemini metal brackets; Unitek
* Adhesive – Transbond XT; 3M
** Primer – Transbond MIP; 3M Unitek, Monrovia, CA

2.1. *Determination of shear strength*

After 24 h of bonding and storage in artificial saliva, the acrylic blocks with teeth embedded were removed from water and allowed to dry for 5 min. The testing was done on KMI tensile testing machine (working within accuracy of −1% and +1% and is of Class 1 of IS: 1828 (Pt. I)-1991). The sensitivity range of the testing machine is 0–500 N. The machine consists of 2 crossheads mounted on a frame, one of which moves away from the other. The acrylic block with the tooth sample was fixed on the lower crosshead. A stainless steel tie wire (23 gauges) was attached to the upper head. This tie wire was the one, kept constant for testing each specimen.

The crosshead speed was set to move away from each other at 5 mm/min. As the wire was engaged into the bracket slot and the crossheads allowed to move away from each other at the above-mentioned speed, the wire became firm and gradually became parallel to the bracket slot. The load was applied till the point of fracture, i.e. till the bracket detached from the tooth. The operator recorded load in Newtons and the shear bonding strengths were calculated (megapascals: MPa) using the formula:

$$\text{Shear bond strength (MPa)} = \frac{\text{Breaking load (N)}}{\text{Area of the mesh base (mm}^2\text{)}}$$

2.2. *Adhesive remnant index (ARI)*

In addition, the surfaces of both the tooth and the bracket were examined to assess the ARI, which describes the amount of composite adhesive that remains on the surface of the tooth[7] (Fig. 2). All the data were subjected to statistical analysis by using one-way analysis of variance (ANOVA).

3. Results

Each group was subjected to statistical analysis for mean, standard deviation, and standard error of mean.

The difference in bond strength and ARI score between the groups was assessed by one-way ANOVA test and Post hoc Tukey test. One-way ANOVA test revealed that the different