EFFECT OF ENAMEL PRETREATMENT ON SHEAR BOND STRENGTH OF BRACKETS BONDED WITH RESIN-MODIFIED GLASS-IONOMER CEMENT

Aim: To evaluate the shear bond strength of brackets bonded with resin-modified glass-ionomer cement (RMGIC) using various methods of enamel conditioning. Methods: Forty-five human premolars were randomly divided into five groups. The roots of these teeth were fixed in acrylic resin cylinders, and brackets were bonded to the teeth’s crowns using the following material combinations: RMGIC only; RMGIC and corresponding primer; RMGIC, acid etching, and Scotchbond Multipurpose; RMGIC and two-step self-etching primer; and RMGIC and one-step primer. All specimens were submitted to pH cycling for 14 days before shear bond strength was assessed in a universal test machine. Results: The medians and standard deviations (in MPa) were RMGIC only = 8.34 ± 1.11; RMGIC and corresponding primer = 7.05 ± 2.24; RMGIC, acid etching, and Scotchbond Multipurpose = 7.00 ± 4.79; RMGIC and two-step self-etching primer = 0.54 ± 0.30; and RMGIC and one-step primer = 10.61 ± 4.58. The value for RMGIC and two-step self-etching primer was significantly lower than all other values. Conclusion: It can be concluded that the tested RMGIC is suitable for bonding orthodontic brackets, even when used by itself. Different enamel preparations do not improve its performance. However, they can worsen its bonding capacity as the combination with the two-step primer system clearly shows. World J Orthod 2010;11:11–15.

Key words: adhesive systems, resin-modified glass-ionomer cement, shear bond strength, enamel conditioning, glass-ionomer cement

With the introduction of adhesives used with acid etching as proposed by Buonocore in 1955, brackets were bonded directly onto the teeth. Among the adhesives commonly used are resin composites and glass-ionomer cements. Resin composites offer a high bond strength, but they need previous acid etching, which could harm the tooth surface during bracket removal. Glass-ionomer cements adhere chemically to enamel. They release fluoride ions into the oral cavity, which diminish and even help prevent enamel loss. However, their bond strength is lower than that of composite resins. More recently developed resin-modified glass-ionomer cements (RMGIC) are a considerable alternative because they have a superior bond strength but still release fluoride ions.
At present, adhesive systems can be divided into conventional and self-etching categories. The self-etching system may be further categorized into one- and two-step procedures. In two-step self-etching adhesives, the conditioner and primer come in separate compartments. Despite their name, one-step adhesives come in a two-blister receptacle unit in which the two components are conveniently mixed before application. All self-etching adhesive systems etch the dental enamel less intensively.

The optimum bracket adhesion would be one with a sufficient bond strength that would not harm the enamel during bracket removal. This is why it is important to assess bracket bonding with RMGIC with different enamel-preparation procedures.

**MATERIALS AND METHODS**

Brackets were bonded with RMGIC to 45 extracted human premolars assigned to five experimental groups of nine teeth each. The evaluated parameters were shear bond strength (MPa, quantitative) and type of fracture (qualitative).

After extraction, all teeth were stored in 0.1% thymol before their roots were embedded in a 2.0 × 2.5 cm PVC tube with chemically activated acrylic resin (Jet Clássico). Thus, only the crown of each tooth would be exposed and cleaned with pumice (S.S. White) for 10 seconds. To delineate the adhesion area, 4.0-mm × 4.0-mm molds of adhesive tape were attached to the vestibular surfaces of all teeth. Subsequently, all test specimens were painted with nail polish. After this polish had dried, the adhesive tape strip was removed so only the 4.0-mm × 4.0-mm area of untreated enamel was exposed to the following procedures.

The brackets bonded were maxillary Edgewise Slim brackets (Dental Morelli) with a base of approximately 10.5 mm² (3.0 mm × 3.5 mm). In all cases, the primary bonding material was the RMGIC Vitremer (3M ESPE). The various enamel pretreatments were as follows:

**Group 1 (Vitremer only).** One spoonful of powder and one full drop of the corresponding liquid were mixed on a block with a cement spatula for 30 seconds on average. This mixture was spread over the entire bracket base before the bracket was placed with holding tweezers and slight pressure onto the tooth. Excess cement was removed with an exploratory probe before the RMGIC was light polymerized for 40 seconds (10 seconds on each side, Optilight Plus; Gnatus).

**Group 2 (Vitremer with previous application of the corresponding primer).** Before bonding, primer was applied to the enamel surface with a disposable brush (FGM, Joinvile) for 30 seconds, in accordance with the manufacturer’s instructions. This coat was dried for 20 seconds and light polymerized for 20 seconds. All other manipulations were identical to group 1.

**Group 3 (Vitremer with previous conventional acid-primer application).** All enamel surfaces were acid etched (37% phosphoric acid; FGM, Joinvile) for 30 seconds, followed by 20 seconds of water spray and 10 seconds of drying with air from a triple syringe. Scotchbond Multipurpose (3M ESPE) was applied with a disposable brush (FGM, Joinvile) for 20 seconds before this coat was light polymerized for 20 seconds. All other manipulations were identical to group 1.

**Group 4 (Vitremer with application of a two-step self-etching primer).** One drop from bottle 1 (acidified primer) of the self-etching adhesive system Self Etch Bond (Vigodent) was spread for 20 seconds on the enamel surface with a disposable brush (FGM, Joinvile). This coat was lightly dried before one drop from bottle 2 (adhesive) was applied, which was also dried before it was light polymerized for 20 seconds. All other manipulations were identical to group 1.

**Group 5 (Vitremer with application of one-step self-etching primer).** The compartments of Adper Prompt L-pop (3M ESPE) were squeezed for 5 seconds to mix the two components. This mixture was applied with the coupled disposable brush for 20 seconds, followed by slight drying and light polymerization for 10 seconds. All other manipulations were identical to group 1.
After bonding, all brackets were pH cycled for 14 days to simulate intraoral conditions. All specimens were immersed in an acid solution for 6 hours (pH 4.3; Ca 2.0 mM; P 2.0 mM; acetate buffer 0.075M) and a neutral solution for 18 hours (pH 7.0; Ca 1.5 mM; P 0.9 mM; KCl 0.15 M; TRIS buffer 0.02M).9

The shear strength test was performed with a universal testing machine (EMIC Equipamentos e Sistemas de Ensaio) with a 200 kgf load cell at a crosshead speed of 0.5 mm/min. The shear strength was calculated in kgf/cm² with the formula: R = F/A, with R = shear strength, F = load required to rupture the bracket-tooth bond, and A = bracket base area (0.105 cm²). The shear strength in kgf/cm² was transformed into MPa by multiplying the individual values by 0.0980665.

Further, after fracture, the enamel and bracket surfaces were observed through a stereoscopic lens (EK3ST, Eikonal Equipamentos Ópticos e Analíticos) at 45× magnification to verify the fracture mode. Adhesive failure was considered when the bonding material detached from the bracket base or tooth surface and cohesive failure when the fracture occurred within the bonding material.

RESULTS

Table 1 presents the shear strength values obtained in the five experimental groups. Group 4 gave a significantly lower shear bond strength than any of the other groups. There were no other significant differences among groups 1, 2, 3, and 5.

In all cases, the fracture mode was of the cohesive type, and no comparisons were deemed necessary.

DISCUSSION

Since the introduction of acid etching into orthodontics, many studies have been conducted to detect the best method for bonding brackets to teeth.6,10–12 Mostly, composite resins are used for orthodontic bonding. These require initial etching of the enamel and the application of a primer. This can be avoided when RMGICs are used instead.4,13,14

The results of the shear bond strength obtained in this study with RMGIC, except when used with a two-step self-etching primer system, corroborated the results of other studies.16–22

The similar values of group 1 and 2 can be explained by the fact that the pH of the Vitremer liquid (pH 2.5 to 3.5) is similar to the pH of its primer (pH 2.9 to 4.0). Thus, both products are initially acidic with a pH below the critical pH for enamel (5.523), causing a similar demineralization as regular etching. The existing chemical bond between RMGIC and the enamel is therefore increased mechanically.

Group 4 resulted in a median bond strength of 0.54 MPa, which is unacceptable for clinical bracket bonding. The
weak performance is in agreement with the study of Cehreli et al.\textsuperscript{24} This inferior behavior could be related to the pH of the product, allegedly because two-step self-etching primers are less acidic than one-step self-etching systems.\textsuperscript{8} If this is the case, the etching will not increase the bond strength but impede the chemical bond because the direct contact between the ionomeric GIC and enamel is prevented.

The result of group 5 is confirmed by other studies.\textsuperscript{15,25–27} The rather high strength of median = 10.61 MPa could perhaps be explained by the initial pH of the etch-primer liquid, which is lower (around 1.0) than that of other products, which likely enhances the formation of more or deeper microretentions.

When comparing the various enamel preparations tested in this study, it becomes clear that group 5 obtained a better result than group 3. This was combined with the advantage of a more convenient application, thus diminishing the chance of technical failures. However, the higher costs of this self-etching primer must be considered, which might prevent some orthodontists from using it regularly.

It has been suggested that a shear bond strength of 6.0 to 8.0 MPa is adequate for orthodontic bonding purposes.\textsuperscript{28,29} All tested groups in this study presented MPa values within this range (with the exception of groups 4 [0.57 MPa] and 5 [11.55 MPa]). This hints at a recent theory, according to which the internal strength of the RMGIC not only plays a role in bonding performance but also its elasticity and that of the other components of the bracket-cement-enamel system.\textsuperscript{30}

In regard to the type of fracture, the result of this study is similar to the results of other studies.\textsuperscript{2,13,19} Clinically, this is significant because considerable chair time is needed to remove the residual adhesive, and there is a possibility of damaging the enamel.

Overall, RMGIC is adequate for bracket bonding and may be used with or without primer. It has the great advantage of releasing fluoride ions, thus diminishing or preventing enamel demineralization around orthodontic brackets.

**CONCLUSIONS**

From this study, it can be concluded that:

- RMGIC has an adequate shear bond strength for bonding brackets to enamel.
- When using RMGIC, enamel pretreatment does not regularly improve bond shear strength.

**REFERENCES**


