Introduction

Glass ionomer cement (GIC)-based materials introduced by Wilson and Kent (1972) are available on the market for bracket bonding. In addition to the biocompatibility to the enamel and dentin, these materials have a cariostatic effect for they provide the action of the fluoride ions over the area of the enamel involved in bonding, promoting remineralization. The properties described above would be ideal for a bonding material but, unfortunately, bond strength of the cements is clinically low (Newman et al., 2001; Pithon et al., 2006; Bishara et al., 2007).

In an endeavour to increase bond strength of this material, resin-modified glass ionomer cements (RMGICs) appeared. The incorporation of resin components caused improvement in bond strength to the enamel surface making it more acceptable from a clinical point of view, but this strength is lower when compared with the strength of the resin composites (Choo et al., 2001; Ewoldsen and Demke, 2001; Wheeler et al., 2002).

Recently, Espinosa et al., (2008) suggested that the use of 5.25 per cent sodium hypochlorite as a deproteinizing agent before acid etching would increase bond strength because organic elements would be better removed, both from the enamel structure and from the acquired film. Since this procedure is a new idea, which has hardly been tested, it seems to have the potential to make NaOCl more feasible for clinical use. Therefore, the aim of this study was to test the effects of enamel deproteinization on bracket bonding with conventional and RMGIC.

Materials and methods

The experimental procedures described in study item were approved by the Research Ethics Committee of PUC Minas (Belo Horizonte, Minas Gerais, Brazil).

One hundred human premolars, extracted for orthodontic reasons, were collected, the soft tissues were removed, and the teeth were stored in artificial saliva at room temperature (7 days) until they were ready for use. Before starting the study sample, size calculation was performed which verified the necessity of using 20 specimens for each group. The teeth were randomly divided into five different enamel...
treatment groups with 20 teeth in each group. As inclusion criterion, the teeth had intact vestibular surface, with no carious lesions, cavitations, and/or restorations.

A mounting device was fabricated to standardize the tooth preparations and assure adequate control at bonding time (Oliveira, 2000; Figure 1). The teeth from each group were cleaned with a mixture of pumice (SS White, Rio de Janeiro, Brazil) and water (0.50 mg F/L) with the aid of a rubber cup operated at low speed. Brackets measuring 0.022 × 0.028" Edgewise Standard (American Orthodontics, Sheboygan, Wisconsin, USA) were bonded previously calibrated by an orthodontist in the center of the clinical crown, under light pressure, and they were divided into five groups:

**Group 1 (G1—control)**

The teeth were duly dried after polishing with pumice, enamel was etched with 35 per cent phosphoric acid for 30 seconds, washed with water for 10 seconds, and dried with oil-free compressed air. A thin layer of adhesive was applied and cured for 10 seconds. The brackets were bonded with composite resin (Transbond XT—3M/Unitek, Monrovia, California, USA).

**Group 2 (G2)**

The teeth were duly dried after polishing with pumice, enamel was etched with 10 per cent polyacrylic acid for 20 seconds, washed with water for 10 seconds, and dried with oil-free compressed air. The enamel surface was dampened with water, in accordance with the manufacturer’s recommendations. The brackets were bonded with conventional GIC (Riva Luting, SDI, Victoria, Australia) and a thin layer of varnish was applied around the bracket 4 minutes after fixation of the bracket.

**Group 3 (G3)**

The teeth were duly dried after polishing with pumice, enamel was deproteinized with 5.25 per cent sodium hypochlorite for 60 seconds, washed with water and dried with air, etched with 10 per cent polyacrylic acid for 20 seconds, and then washed with water for 10 seconds and dried with oil-free compressed air. The enamel surface was dampened with water, in accordance with the manufacturer’s recommendations. The brackets were bonded with conventional GIC (Riva Luting; SDI) and a thin layer of varnish was applied around the bracket 4 minutes after fixation of the bracket.

**Group 4 (G4)**

The teeth were duly dried after polishing with pumice, enamel was etched with 10 per cent polyacrylic acid for 20 seconds, washed with water for 10 seconds, and dried with oil-free compressed air. The enamel surface was dampened with water, in accordance with the manufacturer’s recommendations. The brackets were bonded with RMGIC (Fuji Ortho LC No encapsulated; GC America, Alsip, Illinois, USA).

**Group 5 (G5)**

The teeth were duly dried after polishing with pumice, enamel was deproteinized with 5.25 per cent sodium hypochlorite for 60 seconds, washed with water and dried with air, etched with 10 per cent polyacrylic acid for 20 seconds, and then washed with water for 10 seconds and dried with oil-free compressed air. The enamel surface was dampened with water, in accordance with the manufacturer’s recommendations. The brackets were bonded with RMGIC (Fuji Ortho LC; GC America).

All the procedures were performed in accordance with the manufacturers’ recommendations. Polymerization in groups 1, 4, and 5 was performed with a photopolymerizer (HiluxTM 250 Halogen, Benlioglu, Ankara, Turkey) for 10 seconds on the mesial, distal, cervical, and occlusal surfaces of the brackets. On the other hand, in groups 2 and 3, polymerization was chemical (setting time: 4 minutes).

After bracket bonding, the teeth were stored in distilled water for 24 hours at room temperature until they were submitted to the shear test. A Universal Test Machine with a load cell of 500 N (Instron, model 5869) was used, operating at the speed of 0.5 mm/minute. The knife-type blade was coupled to the top part of the machine and it was placed to touch the base of the brackets homogeneously (applied a downward force). The values were obtained in Newton and converted into megapascal using the area of projection of the bracket base (10.55 mm²), as informed by the manufacturer.
The vestibular surface of the premolars was microscopically photographed after debonding using a USB Digital Microscope (Digivision, Dongguan, Guangdong, China) at ×200 magnification. The images obtained were analysed by an examiner and the percentage of adhesive that remained on the enamel was quantified according to the values of the adhesive remnant index (ARI), ranging from 0 to 3, previously reported by (Artun and Bergland, 1984):

0: no adhesive remained on the enamel surface; 1: less than 50 per cent of adhesive remained on the tooth; 2: more than 50 per cent of adhesive was left on the enamel; 3: the entire adhesive remained on the tooth structure.

This study was conducted at the Laboratory Robert Hooke at the Physical Test Sector (STF) of the Technology Center Foundation of Minas Gerais—Brazil (Fundação Centro Tecnológico de Minas Gerais—CETEC).

**Statistical analysis**

The variable studied was of cardinal feature with normal distribution (normality measured by the D’Agostino Test). The existence of difference in bond strength among the groups was assessed by the analysis of variance test—a criterion followed by the Bonferroni’s post-hoc test with alpha value adjusted to 0.005. The statistical tests were performed using the BioEstat 5.0 software (Belém, Brazil).

**Results**

The bond strength values of the brackets (in megapascal) and the description of the statistical analysis are shown in Table 1 and Graph 1. The values found in group 1 (17.08 ± 6.39) were significantly higher than the ones found in the other groups. The use of NaOCl increased bond strength, but there was no statistically significant difference between the groups with and without this treatment. Whereas groups 4 (8.60 ± 5.29) and 5 (9.86 ± 2.90) showed satisfactory values. The use of NaOCl also increased the bond strength in group 5, but there was no statistically significant difference between these two groups.

With regard to ARI (Table 2), the groups in which the enamel was treated with NaOCl (G3 and G5) presented a behaviour similar to that of the resin composite, that is, in most of the samples (55 per cent in G3 and 75 per cent in G5) the cement remained more adhered onto the enamel surface, which was not observed in the other groups.

**Discussion**

In spite of all the advances in Orthodontics, a basic issue has not yet been completely solved: the increased risk of developing white spot lesions around the orthodontic accessories. Some studies have shown that more than 50 per cent of the patients undergoing orthodontic treatment present this problem (Sukontapatipark et al., 2001; Bishara and Ostby, 2008). The clinical approach with the greatest efficiency potential described in the literature to minimize the appearance of these lesions was bracket bonding with GIC (Vorhies et al., 1998). However, orthodontists are still reluctant to use this cement particularly due to the techniques described, materials available, and the issues related to shear bond strength (Justus et al., 2010). Which is the adequate enamel–bracket bond strength for orthodontic treatment? What is more important is how should maintenance of brackets bonded to teeth during the entire treatment or preservation of the enamel integrity, with no fractures or surface cracks as a result of removal and/or without the presence of white spot lesions?

In the search for answers for these questions, a recent study used sodium hypochlorite as a new stage in the bonding technique of brackets with RMGIC, whose bond strength was increased to levels compatible with the ones obtained with resin composite (Justus et al., 2010). This study was based on the technique used with success in Endodontology that has been using sodium hypochlorite for years to disinfect, remove debris, and organic matter from the root canals. According to the authors, a possible justification for the use of sodium hypochlorite is the low bond strength of brackets bonded with GIC without NaOCl due to failures during acid etching.

**Table 1** Groups, minimum, maximum, mean and standard deviation (SD) of the shear bond strength values, and statistical analysis of the groups evaluated (MPa).

<table>
<thead>
<tr>
<th>Groups</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean (SD)</th>
<th>Significance</th>
<th>Statistics*</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>5.22</td>
<td>24.3</td>
<td>17.08 ± 6.39</td>
<td>2—P = 0.000 A</td>
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<td>3—P = 0.000</td>
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<td>5—P = 0.000</td>
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<tr>
<td>2</td>
<td>0.76</td>
<td>7.56</td>
<td>3.43 ± 1.94</td>
<td>3—P = 0.996 B</td>
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<td>4—P = 0.001</td>
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<td>5—P = 0.000</td>
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<tr>
<td>3</td>
<td>2.08</td>
<td>8.17</td>
<td>3.92 ± 1.57</td>
<td>4—P = 0.004 B</td>
<td>A</td>
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<td>5—P = 0.000</td>
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<tr>
<td>4</td>
<td>2.84</td>
<td>20.57</td>
<td>8.60 ± 5.29</td>
<td>5—P = 0.866 C</td>
<td>A</td>
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<td>5—P = 0.000</td>
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<tr>
<td>5</td>
<td>5.97</td>
<td>16.49</td>
<td>9.86 ± 2.90</td>
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*Equal letters correspond to the absence of statistical differences (P < 0.05).

**Table 2** Adhesive remnant index (ARI).

<table>
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<th>ARI</th>
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<td>Group</td>
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<tr>
<td>1</td>
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This phenomenon was better studied by Espinosa et al. (2008), who observed that only 50 per cent of the enamel surface was duly etched with phosphoric acid. Clinically, a white and opaque surface may be seen after etching, showing a desired quantity but not an ideal etching quality of the affected surfaces. When enamel was deproteinized with NaOCl, more types 1 and 2 patterns of conditioning were found, while without NaOCl more type 3 patterns were found. According to Silverstone et al. (1975), the more retentive etching patterns are types 1 and 2 because the porous surface offers more retentive areas of greater size and depth. This assessment was not used in the present study.

The present study assessed the effects of enamel deproteinization during bonding of brackets bonded with conventional and RMGIC as an alternative to increase retention of these brackets. The authors observed an increase in bond strength and a better performance of the material when the enamel was treated with NaOCl, but this difference was not statistically significant (P < .005). These findings are in disagreement with those of Justus et al. (2010), whose study showed that strength was higher and statistically significant when the teeth were treated with NaOCl and bonded with resin composite or RMGIC. A possible difference found in comparison with the present study might be the fact that polyacrylic acid was used, as recommended by the manufacturer, instead of phosphoric acid, as in the study of Justus et al. (2010). Because the acid has large molecules, the polyacrylic acid does not act in depth but only cleans the surface. This acid causes moderate etching resulting in a crystalline deposit and less damage to the enamel (Smith and Cartz, 1973; Fjeld and Ogaard, 2006; Toledano et al., 2003; Bishara et al., 2007a), also observed lower bond strength when the enamel was etched with 10 or 20 per cent polyacrylic acid. For these authors, bond strength of RMGIC is only acceptable when phosphoric acid is used. Even so, the option was to test the effect of deproteinization with NaOCl and polyacrylic acid because it was the etchant suggested by the manufacturer.

The authors of the present study believed that application of NaOCl is an important step, even when polyacrylic is used, due to the removal of organic matter from enamel and the acquired film before acid etching. The aim of surface polishing is to eliminate the organic components that prevent an effective etching of the enamel, but it is possible that removal was not efficient because proteins immersed in the crystals that form the enamel might have remained. Studies have shown that it is this layer of external organic matter that prevents the acid to effectively etch the surface, resulting in inconsistent patterns of etching and a non-reliable area for orthodontic bonding (Espinosa et al., 2008; Justus et al., 2010).

In the present study, significant differences were found with regard to ARI. In the groups treated with NaOCl, most of the cement remained on the dental enamel, which was not observed in the other groups. These values are in agreement with the study of Justus et al. (2010), and a possible explanation may be related to the reduction of surface energy. It is probable that sodium hypochlorite is causing a reduction in surface stress, allowing the material to penetrate more, increasing its adherence and bond strength on the dental enamel.

Enamel deproteinization with NaOCl before acid etching is a cheap and innovative technique, but it must be further tested both clinically and in the laboratory. Other studies must be conducted in order to further understand the effect of NaOCl as a deproteinizing agent.

Conclusions

1. Enamel deproteinization with NaOCl increased bond strength of metal brackets bonded with conventional and RMGIC. However, there were no statistically significant differences among the groups treated or non-treated with NaOCl.

2. When enamel was deproteinized, a larger amount of cement remained on the enamel surface, showing a behaviour similar to that of the resin composite.

References


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