Effects of Two In-Office Bleaching Agents with Different Compositions on the Bond Strength to Enamel

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This study evaluates the effect of two in-office bleaching agents with different compositions on the bond strength to enamel surface. Fifty bovine teeth were divided into five groups (n = 10 teeth per group), according to the bleaching agent used and the time elapsed to perform the restorative procedures: restorative procedures performed without bleaching (control group); bleaching with 35% hydrogen peroxide (HP), with restorative procedures 24 hours or 7 days after bleaching (HP/24h and HP/7d groups, respectively); and bleaching with 35% HP with calcium compost, with restorative procedures 24 hours or 7 days after bleaching (HP AutoMixx/24h and HP AutoMixx/7d groups, respectively). The specimens were stored at 37°C in artificial saliva. Restored teeth were submitted to a micro-shear bond strength test. The specimens were analyzed using a stereoscope to determine the fracture pattern, classified as adhesive, cohesive, or mixed. The results of the bond strength test were evaluated by analysis of variance, with significance set at P < .05. The groups showed similar bond strength values without significant difference among them (P > .05). There was a predominance of the adhesive-type fracture pattern in all groups. The bleaching agents with different compositions showed similar bond strength values when the restoration was performed 24 hours and 7 days after bleaching, and the results were similar to the control group. Int J Periodontics Restorative Dent 2022;42:675–681. doi: 10.11607/prd.5943

Tooth bleaching stands out as a minimally invasive therapeutic option that aims to maximize esthetics and providing whiter teeth to patients.1 This procedure can be performed on both vital and nonvital teeth. The bleaching of vital teeth can be performed by different techniques, at home or in-office by a professional, and/or with the use of agents with several concentrations. The use of 10% carbamide peroxide and 35% hydrogen peroxide are the products most used for at-home and in-office bleaching, respectively.2,3

During bleaching treatment, oxygen (a free radical) is released on the enamel surface. The low molecular weight of hydrogen peroxide permits its penetration into dental structures, which is associated with dental permeability and allows the diffusion of oxygen through enamel and dentin. Thus, the pigments of long chains and high molecular weight (macromolecules), which are difficult to eliminate from the dental structure, are broken by means of oxyreduction reactions forming smaller molecular chains that are totally or partially eliminated from the dental structure by diffusion.4

Although tooth bleaching shows safe and effective results, some adverse effects are reported, such as tooth sensitivity and compositional changes.5 A microstructural analysis still shows a
deleterious effect of bleaching agents on dental tissues, characterized by reduced bond strength, increased surface roughness, and changes in the mineral content, with the consequent enamel demineralization. In order to minimize these adverse effects, calcium and fluorine were incorporated in the composition of the bleaching agents. These compounds are added with the intention to increase the gel’s saturation with ions and enamel resistance, and to reduce the degree of demineralization throughout the whitening procedure.

Therefore, knowledge of the technique, the composition of the bleaching agent, and the agent’s likely interactions with dental tissues are essential to minimizing undesired effects in clinical practice. Thus, the present study aimed to evaluate the effect of two in-office bleaching agents, with and without calcium, on the bond strength to enamel.

Materials and Methods

This study was approved by the Research Ethics Committee for Test Animals (no. 01200.001568/2013-87).

Sample Selection

Fifty specimens were prepared from freshly extracted bovine incisors (Vangelio Mondelli). A double-sided diamond disc (KG Sorensen) was used to remove the roots (Fig 1a). Then, a coronal cut was performed to separate the buccal and palatal surfaces. The palatal surface was not used in the study.

The buccal surface of the 50 bovine incisor specimens were embedded in resin (Epoxy Resin GR 026 and Hardener GE 024, Percilglass) using a polyvinylchloride ring mold (Fig 1b). The buccal surfaces were flattened using a polishing machine (Aropol-2V, Arotec) with silicon carbide sandpaper, using the following sequence of granulations: #600, #800, #1,200, #2,400, and #4,000. Thus, the resin layer that covered the enamel surface was removed, obtaining a flat surface (Fig 1c). Then, the specimens were washed in an ultrasonic bath (Digital Ultrasonic Cleaner CD-4820, Kondentech) for 480 seconds and stored in artificial saliva (Health Science...
Center of the Farmácia Universitária at Universidad Federal do Rio de Janeiro (FU-UFRJ) at 37°C between bleaching procedures.

### Bleaching Procedures

Two bleaching agents proposed for in-office use were evaluated in the present study: Whiteness HP Maxx (FGM) (Figs 1d and 1e) and Whiteness HP AutoMixx (FGM) (Figs 1f and 1g). The compositions of the bleaching agents are described in Table 1.

The specimens were divided into five groups (n = 10 specimens per group) according to the bleaching agent used and the time elapsed to perform the restorative procedures (Table 2). The control group was not subjected to any bleaching treatment. In the HP/24h and HP/7d groups, the bleaching was done with Whiteness HP Maxx by following the manufacturer's recommendations (three 15-minute applications), with restorative procedures performed 24 hours and 7 days after bleaching, respectively. In the HP AutoMixx/24h and HP AutoMixx/7d groups, Whiteness HP AutoMixx was used as the bleaching agent (a single application lasting 45 minutes), with restorative procedures performed 24 hours and 7 days after bleaching, respectively. For all test groups, three sessions were carried out, each with an interval of 7 days between them.

During all bleaching procedures, the specimens were kept at 37°C and stored in artificial saliva, which was changed daily.

### Restorative Procedures

Either 24 hours or 7 days (depending on the experimental group) after the final bleaching procedures, the enamel surface of each specimen was etched with 37% phosphoric acid (Condac 37, FGM) for 30 seconds (Fig 2a), rinsed with water for 30 seconds, and dried with an air jet through a triple syringe for 30 seconds. Two consecutive coats of adhesive agents (Ambar, FGM) were applied with a microbrush (KG Sorensen) (Fig 2b) and light

<p>| Table 1 Bleaching Agent Compositions According to Manufacturer Specifications |
|-------------------------------------------------|-------------------|------------------|--------------------------------------------------|</p>
<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer</th>
<th>Active principle</th>
<th>Composition</th>
<th>Instructions for use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whiteness HP Maxx</td>
<td>FGM</td>
<td>Hydrogen peroxide 35%</td>
<td>Hydrogen peroxide 35%, thickeners, mixture of dyes, glycol, and deionized water</td>
<td>Three applications for 15 min each. Three sessions should be performed, with an interval of 7 d between each session.</td>
</tr>
<tr>
<td>Whiteness HP AutoMixx</td>
<td>FGM</td>
<td>Hydrogen peroxide 35%</td>
<td>Hydrogen peroxide 35%, thickeners, neutralizer composed of calcium, glycol, dye, and deionized water</td>
<td>Single application for 45 min. Three sessions should be performed, with an interval of 7 d between each session.</td>
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<th>Table 2 Experimental Groups</th>
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<tr>
<td>Groups</td>
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<tr>
<td>--------</td>
</tr>
<tr>
<td>Control</td>
</tr>
<tr>
<td>HP/24h</td>
</tr>
<tr>
<td>HP AutoMixx/24h</td>
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<tr>
<td>HP/7d</td>
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<tr>
<td>HP AutoMixx/7d</td>
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polymerized for 20 seconds with an LED light-curing unit (Biolux Plus, Bio-Art).

Composite resin cylinders were made with a silicone matrix (1.5-mm diameter) that was positioned under the center of the buccal face. The composite resin (Opallis, shade A1, FGM) was inserted perpendicularly to the enamel previously treated by the adhesive system, with the aid of a Suprafil spatula (Golgran). Then, the composite resin was light cured for 40 seconds (Fig 2c).

**Micro-Shear Test**

For the micro-shear test, a beveled test tip was adapted at the interface between the composite resin cylinder and the buccal face, with a 200-kg load cell running at crosshead speed of 0.5 mm/second until failure occurred (Fig 2d). The load required for the fracture of each specimen was recorded in Newtons (N) and was converted into Megapascal units (MPa), dividing the failure load by the adhesive area.

After the test, the fracture surfaces were observed with a stereo-microscope under ×10 magnification (SMZ800, Nikon) to determine the fracture mode. The failure modes were classified into three types: adhesive failure (total displacement of the composite resin cylinder from the buccal face of the tooth), cohesive failure (failure within the enamel or within the enamel and dentin), and mixed failure (fractures involving adhesive and cohesive failures, where fragments of composite resin remain on the buccal surface, and there are traces of enamel and/or dentin in the composite resin cylinder).10

**Statistical Analysis**

The values obtained for bond strength were subjected to Kolmogorov-Smirnov normality test (\(P > .05\)). Then, analysis of variance (ANOVA) was used to evaluate the bond strength among the experimental groups. Data were analyzed using SPSS software (version 20.0 for Windows, IBM) at \(\alpha = .05\).

**Results**

All groups showed similar bond strength values without statistical difference among them (ANOVA; \(P > .05\)), as shown in Table 3. Regarding the fracture pattern, there...
was a predominance of adhesive type fracture for all groups (Fig 3).

**Discussion**

The present study evaluated the effects of two bleaching agents with different compositions on bond strength to enamel of bovine teeth. The use of bovine was due to the easy acquisition and standardization of samples. Further, previous studies have shown that bovine and human teeth have similar characteristics in relation to the chemical and morphologic structure of enamel and dentin.\textsuperscript{11,12} Moreover, bovine teeth have been used as substitute for human teeth in bond strength studies.\textsuperscript{13,14} During bleaching, the dissociation of hydrogen peroxide forms free radicals, such as nascent oxygen. The presence of this oxygen on the enamel surface is associated with a reduction in the bond strength values when the restoration is performed immediately after bleaching; this is due to the inhibited polymerization of the adhesive systems by nascent oxygen.\textsuperscript{12,15–17} Thus, it is recommended to perform the restorative procedure at least 7 days after bleaching.\textsuperscript{15–17} For times shorter than 7 days, the literature findings are controversial.\textsuperscript{18,19}

Bleaching procedures are sought by patients who aim to improve their esthetics with lighter teeth.\textsuperscript{20} However, in cases of anterior teeth extensively restored with composite resin, the tooth is darkened in relation to the other teeth because the bleaching agent has no effect on the restorative material.\textsuperscript{21} At that moment, the professional must take into account the patient’s desire to finish the treatment, the

**Table 3** Mean Bond Strength for the Experimental Groups

<table>
<thead>
<tr>
<th>Groups</th>
<th>Bond strength, MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>15.7 ± 6.5</td>
</tr>
<tr>
<td>HP/24h</td>
<td>17.8 ± 7.5</td>
</tr>
<tr>
<td>HP/AutoMixx/24h</td>
<td>15.1 ± 5.5</td>
</tr>
<tr>
<td>HP/7d</td>
<td>17.6 ± 5.0</td>
</tr>
<tr>
<td>HP/AutoMixx/7d</td>
<td>17.3 ± 5.4</td>
</tr>
</tbody>
</table>

Values are presented as mean ± SD. See Table 2 for descriptions of each group. No significant difference was found among bond strength of each group ($P > .05$).
replacement of the restoration as soon as possible, and the time needed to eliminate residual oxygen left by the bleaching agent.

In order to analyze shorter restoration times after bleaching for a possible elimination of the residual oxygen, the present study evaluated the bond strength of the restorative material to enamel 24 hours after the final bleaching, comparing agents with different compositions. After 24 hours, the present test groups had no significant difference in bond strength when compared to the control group (without bleaching). These results partially agree with a study on anterior teeth, which verified the restored bond strength values 24 hours after completing a 14-day at-home bleaching technique, whereas in-office bleaching was simulated in the present study. However, the authors did not observe restored bond strength values when the bleaching agent was used for 28 days, showing that not only the length of time the bleaching agent is used can also influence the bond strength, in addition to the bleaching agent itself and its concentration.

However, Topcu et al, who evaluated both at-home and in-office bleaching techniques, found lower bond strength values for groups that performed the restorative procedure after 24 hours when compared to the nonbleaching group, which differs from the present study. These differences can be associated with the product application interval (3 days vs 7 days) and with the test used (microtensile vs micro-shear test).

Regarding the analysis after 7 days, the results of the present study agree with those found in the literature, where the bond strength values were restored regardless of the composition of the bleaching gel.

Calcium, phosphate, and fluorine are minerals that are present in saliva, which has the function of remineralizing the tooth and returning the minerals lost by demineralizing agents, such as bleaching agents. The components present in artificial saliva reproduce the same functions as natural human saliva. In the present study, when the effect of the bleaching agent (with and without calcium) on the bond strength was evaluated, no significant differences were found after 24-hour and 7-day periods. This result can be explained by the presence of calcium in the artificial saliva used to store the samples until the restorative procedure, which may have remineralized the enamel. The other possible explanation for this phenomenon is the fact that the mineralizing effects of bleaching agents on tooth enamel can be temporary.

Different adhesion strategies have been employed in restorative dentistry, including the use of conventional etch-and-rinse (three- and two-step), self-etch, and—more recently—Universal systems. In the present study, a two-step conventional etch-and-rinse system was used. It is a less-sensitive technique with reduced clinical steps and working time compared to the three-step system. It also shows good performance in enamel when compared with self-etch and Universal systems.

The present study showed that the composition of the bleaching agent did not affect the bond strength values of restorative procedures 24 hours and 7 days after bleaching. However, it is important to note that this is an in vitro study where factors related to patient habits were not considered, emphasizing the importance of clinical studies to confirm these findings.

Conclusions

The in-office bleaching agents with different compositions showed similar bond strength values when the restorative procedure was performed 24 hours or 7 days after bleaching, and these results were also similar to the control group. Moreover, the addition of calcium to hydrogen peroxide did not show a significant effect in relation to bond strength.

Acknowledgments

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References


