



## Effects of the Ratio between Pigment and Bleaching Gel on the Fracture Resistance and Dentin Microhardness of endodontically treated Teeth

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### ABSTRACT

**Introduction:** The aim of this study was to evaluate the effects of bleaching gel using 35% hydrogen peroxide (HP), associated with red carmine pigment (RC), in the 3:1 or 1:1 ratio, on fracture resistance and dentin microhardness of endodontically treated teeth.

**Materials and methods:** A total of 40 lower incisors were endodontically treated and divided into four groups (n = 10), according to the bleaching protocol: G1 (HP3), 35% HP + RC (3:1); G2 (HP1), 35% HP + RC (1:1); G3 (positive), 38% HP; and G4 (negative), unbleached. Four dental bleaching sessions were performed. The dental crowns were restored after the last session and submitted to the fracture resistance test. Totally, 60 specimens from the endodontically treated lower incisor crowns were prepared to evaluate the effects on dentin microhardness. The analysis was measured (in Knoop) prior to and after the last dental bleaching session using similar bleaching protocols.

**Results:** G2 presented the lowest fracture resistance (p < 0.05). The other groups were similar to each other (p > 0.05). No difference was observed in the reduction of dentin microhardness among the groups (p > 0.05).

**Conclusion:** A 1:1 ratio (bleaching gel:pigment) caused a significant fracture resistance reduction in relation to the other protocols. No effect on the dentin microhardness reduction was observed.

**Clinical significance:** The pigment addition to the bleaching agent accelerates the bleaching chemical reaction. However,

no studies have evaluated the ideal proportion to optimize tooth bleaching.

**Keywords:** Endodontics, Fracture, Hydrogen peroxide, Tooth bleaching.

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### INTRODUCTION

Peroxides are the main substances employed to bleach the endodontically treated teeth.<sup>1,2</sup> Hydrogen peroxide is a strong oxidizing agent, which produces free radicals, reactive oxygen molecules, and HP anions that act on the pigments converting them into small molecules with reduced light absorption and low molecular weight, easier to be removed from the dental structure.<sup>3,4</sup>

To improve the physical and chemical properties of HP, various components have been added to the bleaching gel, such as thickeners, desensitizers, remineralizers, and pigments.<sup>5,6</sup> Pigments facilitate the gel visualization and accelerate the chemical reaction that triggers tooth bleaching due to the bleaching gel having greater light absorption properties.<sup>2,7,8</sup>

Nonetheless, the studies have not shown consensus about the ideal proportion between bleaching gel and pigment. Torres et al<sup>7</sup> have found better results after the photosensitization of the bleaching gel associated with the pigment in a 1:1 ratio instead of a 3:1 ratio that have been routinely applied. Those results are interesting because at a 1:1 ratio, the bleaching presented a reduction of the

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total concentration of HP in the gel, but it showed better efficiency.

On the contrary, its effects on dental crown dentin, especially in endodontically treated teeth, are still unknown. Thus, before the use of the ratio between bleaching gel with the pigment, it is essential to evaluate its action on dental crown dentin and its clinical repercussion.<sup>7,9</sup>

Therefore, the present study aimed to evaluate the effects on fracture resistance and dentin microhardness of endodontically treated teeth submitted to dental bleaching protocols using 35% HP (whiteness HP) associated with RC, in a 3:1 or 1:1 ratio. The null hypothesis was the absence of effects on fracture strength and dentin microhardness.

## MATERIALS AND METHODS

### Experimental Groups

- G1 (HP3), 35% HP (Whiteness HP; FGM Produtos Odontológicos Ltda., Joinville, SC, Brazil) associated with RC (Whiteness HP; FGM Produtos Odontológicos Ltda., Joinville, SC, Brazil), 3:1 ratio;
- G2 (HP1), 35% HP (Whiteness HP; FGM Produtos Odontológicos Ltda., Joinville, SC, Brazil) associated with RC (Whiteness HP; FGM Produtos Odontológicos Ltda., Joinville, SC, Brazil), 1:1 ratio;
- G3 (positive control), 38% HP (Opalescence Boost; Ultradent, South Jordan, UT, USA);
- G4 (negative control), the tooth was immediately restored after the endodontic treatment, using etch-and-rinse adhesive system and composite resin, without bleaching protocol.

### Fracture Resistance Evaluation

A total of 40 central incisors with dental crowns of similar dimensions with respect to height and width were selected and stored in thymol solution (0.1%; pH 7.0) at 4°C. Coronary access, chemical and mechanical preparation, root canal obturation, and temporary restoration were performed according to Garrido et al.<sup>10</sup>

The roots of all specimens were included in a plastic matrix (16.5 mm internal width × 20.0 mm length), embedded in polyester resin (Maxi Rubber, São Paulo, Brazil) and placed 2.0 mm below the cemento-enamel junction. The specimens were left untouched for 24 hours until the resin polymerization was complete.<sup>5</sup>

Then, the provisional restoration was removed and the pulp chamber was irrigated with 2.5 mL of 2.5% sodium hypochlorite (Asfer, São Caetano do Sul, SP, Brazil) and 2.5 mL distilled water. Nearly 37% phosphoric acid (Condac 37; FGM Produtos Odontológicos Ltda., Joinville, SC, Brazil) etched the dentin for 15

seconds, and the pulp chamber was rinsed with distilled water.<sup>5</sup>

The teeth were divided into four groups (n = 10), according to the bleaching protocol, as described previously. The bleaching gel was handled according to the manufacturer's recommendations and applied on the tooth buccal surface and within the pulp chamber for 15 minutes in G1 and G2. In G3, the gel was kept for 10 minutes on the buccal surface and within the pulp chamber. Another two applications were carried out using similar protocol in the same session.

After the bleaching session, all the bleaching gel was aspirated and the dental crown irrigated with distilled water. Coronary access was temporarily restored (Villevie; Dentalville do Brasil Ltda., Joinville, SC, Brazil). Three bleaching sessions were performed after 7, 14, and 21 days, totaling four dental bleaching sessions.

In G4 (negative control), after endodontic treatment, the dental crown was restored with composite resin. The dentin was acid-etched using 37% phosphoric acid (Condac 37, FGM Produtos Odontológicos Ltda., Joinville, SC, Brazil), the etch-and-rinse adhesive system (Adper Scotchbond Multipurpose, 3M ESPE, Sumaré, SP, Brazil) was applied, and the esthetic restoration was performed using composite resin (Charisma, Heraeus Kulzer, São Paulo, SP, Brazil).

After the last bleaching session, the dental crowns were immediately restored in a similar fashion to G4. The teeth were kept in artificial saliva at 37°C for 7 days and were submitted to the fracture resistance test in a electromechanical test machine (EMIC DL 2000; São José dos Pinhais, PR, Brazil), in accordance with Kuga et al.<sup>5</sup>

The last force applied before the crown fracture was determined. All data were evaluated using analysis of variance and Tukey's tests (p = 0.05).

### Dentinal Microhardness Evaluation

A total of 60 lower incisors were endodontically treated similar to the ones described earlier. Then, the dental crowns were sectioned using a diamond disk at the cemento-enamel junction level in a buccolingual direction with a hard-tissue cutting machine (Isomet, Buehler Ltd, Lake Bluff, IL, USA).

A hemisection of each dental crown was selected and properly prepared for the dentin microhardness test, according to Aranda-Garcia et al.<sup>11</sup> After that, the dentin surface was gradually flattened using #300 to #1200 sandpapers (Norton, Lorena, SP, Brazil). After polishing with aluminum oxide (Profill; SS White, Rio de Janeiro, Brazil), the specimens were rinsed with distilled water after polishing.

Initial dentin microhardness measurements were performed on each section at 100  $\mu\text{m}$  from the pulp–dentin interface using Knoop microdurometer (HNV2; Shimadzu, Tokyo, Japan), in the pulp chamber’s buccal face. Three indentations were performed per specimen, spaced apart at 200  $\mu\text{m}$ . A 10 gm load was applied for 20 seconds on each specimen. The mean value of the dentin microhardness was calculated using three measurements per specimen. Measurements were carried out 7 days after the root canal obturation.

Afterward, the specimens were submitted to similar protocols ( $n = 15$ ) and bleaching sessions as described before. After each bleaching session, the specimens were irrigated using 5 mL of distilled water, dried with absorbent paper, and stored at 37°C under 99% humidity level. During the sessions, the dentin surface was only irrigated with distilled water in G4.

After the last bleaching session, the dentin microhardness was measured, similar to the initial dentin microhardness measurement; however, it was performed on lingual surface of the dental crown. The difference between the start and the end of each bleaching session was interpreted as an effect on dentin microhardness. The value was expressed in percentage. The percentage of dentin microhardness change was analyzed using Kruskal–Wallis test ( $p = 0.05$ ).

## RESULTS

The means and standard deviation (SD; kN) of the fracture resistance of the endodontically treated teeth according to treatment protocols and control groups are shown in Table 1. G2 presented the lowest value of fracture resistance ( $p < 0.05$ ), other groups were similar to each other ( $p > 0.05$ ).

The median, first, and third quartiles of the reduction percentage of dentin microhardness (Knoop), according to the treatment protocols and control groups, are described in Table 2. The bleaching protocols and control groups showed dentin microhardness reduction; however, the reduction percentage was similar among all the evaluated groups ( $p > 0.05$ ).

**Table 1:** Mean and SD (kN) of fracture resistance of endodontically treated teeth according to the different protocols of tooth bleaching

Groups		Mean (SD)
G1	35% HP (3:1)	0.62 (0.17) <sup>a</sup>
G2	35% HP (1:1)	0.36 (0.12) <sup>b</sup>
G3	38% HP	0.61 (0.11) <sup>a</sup>
G4	Unbleached and restored teeth	0.69 (0.11) <sup>a</sup>

<sup>a,b</sup>Different letters indicate statistically significant differences ( $p < 0.05$ ). G1 (HP3), 35% HP using pigment (3:1 ratio); G2 (HP1), 35% HP using pigment (1:1 ratio); G3 (positive control), 38% HP; G4 (negative control), unbleached

**Table 2:** Median and values of the first and third quartiles of the percentage (Knoop) of microhardness of the dentin surface reduction

	G1	G2	G3	G4
Median	22.7	25.9	29.2	21.4
Q1	19.2	16.7	23.8	15.7
Q3	27.9	33.6	41.0	27.5

No significant differences were found among the bleaching protocols ( $p > 0.05$ ). G1 (HP3), 35% HP using pigment (3:1 ratio); G2 (HP1), 35% HP using pigment (1:1 ratio); G3 (positive control), 38% HP; G4 (negative control), unbleached

## DISCUSSION

The internal bleaching protocol using 35% HP and red carmine dye in 1:1 ratio caused a significant reduction of dental fracture resistance in relation to the other treatment protocols, although no differences among the teeth dentin microhardness reduction were observed. Therefore, the null hypothesis was rejected.

Pigments are added to the final composition of the bleaching gel to accelerate the chemical and thermal reactions with HP.<sup>8</sup> The most common proportion in dental bleaching protocols used the 3:1 ratio between the bleaching gel and the pigment.<sup>3</sup> Torres et al<sup>7</sup> have reported that proportion is questionable and empirical. Henceforth, this study evaluated the possible effects on dental structure using different proportions between bleaching gel and pigment.

G2 presented higher pigment volume; thus, the total concentration of HP in the bleaching gel probably decreased in comparison with the total volume in G1. Despite its lower concentration, it was concluded that the reduction of the tooth fracture resistance occurred due to the higher HP catalysis caused by the pigment during the bleaching chemical reaction. Hence, the effects of HP degradation were sharper since it is the main factor responsible for the changes in the organic and inorganic components in dentin.<sup>2,12-14</sup> Moreover, Torres et al<sup>7</sup> have also observed greater effectiveness in the rate similar to the one used in G2; however, these authors used light-emitting diode laser photoactivation.

In the present study, the dental crown restoration was performed immediately after the bleaching treatment completion. The fracture resistance reduction occurred due to the higher HP catalysis; so, it is also possible that a higher release and concentration of oxidative radicals have occurred, which negatively affected the physical properties of the composite resin in accordance with Bandeca et al.<sup>15</sup>

The HP at high concentrations causes deleterious effects on the organic and inorganic components of the dental structure.<sup>16-21</sup> In contrast, the addition of greater amount of pigment in the total volume of the bleaching

gel increases the chemical catalysis, due to the increase in local temperature.<sup>22</sup> Those factors contributed to dentin microhardness reduction, but those reductions were similar within experimental and control groups.

The similar results may have occurred due to a possible interference of the endodontic sealer residues in dentin during the microhardness measurement since AH Plus sealer presents 894.54  $\mu\text{m}$  intradentinal penetrability and a final setting time of approximately 75 hours.<sup>23-25</sup> Once the microhardness measurement was performed at 100  $\mu\text{m}$  of the interface between the pulp chamber and the dentin and carried out after 7 days of root canal obturation, the indentation probably occurred on the dentin surface and also on the polymerized endodontic sealer.

Further studies should be conducted to find a proper ratio between bleaching gel and pigment to obtain an efficient bleaching of the endodontically treated teeth without damaging the dental structure.

## CONCLUSION

Tooth bleaching using 35% HP with RC in a 1:1 ratio reduced the fracture resistance of endodontically treated teeth; however, the reduction of the final dentin microhardness was similar among all evaluated protocols.

## CLINICAL SIGNIFICANCE

The pigment addition into the bleaching agent accelerates the bleaching chemical reaction and reduces the total volume of HP. No studies have evaluated the ideal proportion between pigment and bleaching gel to optimize tooth bleaching and reduce the total volume of HP in the bleaching gel.

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