

# Fracture resistance of endodontically-treated teeth submitted to bleaching treatment with hydrogen peroxide and titanium dioxide nanoparticles photoactivated by LED-laser

*Resistência à fratura de dentes tratados endodonticamente submetidos a tratamento clareador com peróxido de hidrogênio e nanopartículas de dióxido de titânio fotoativado por LED-laser*

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## Resumo

**Objetivo:** Avaliar a resistência à fratura de dentes tratados endodonticamente após tratamento clareador usando peróxido de hidrogênio a 15% com nanopartículas de dióxido de titânio (15HPTiO<sub>2</sub>) fotoativado por LED-laser, em comparação aos protocolos usando peróxido de hidrogênio 35% (35HP), peróxido de carbamida 37% (37CP) ou perborato de sódio (SP). **Material e método:** Após tratamento endodôntico, 50 incisivos bovinos extraídos foram divididos em 5 grupos ( $n = 10$ ): G1- sem clareamento; G2- 35HP; G3- 37CP; G4- 15HPTiO<sub>2</sub> fotoativado por LED-laser e G5- SP. Nos grupos G2 e G4, o protocolo de clareamento foi aplicado em 4 sessões, com 7 dias de intervalo entre cada sessão. Nos grupos G3 e G5, os materiais foram inseridos na câmara pulpar por 21 dias e trocados a cada 7 dias. Após 21 dias, as coroas foram submetidas à força de compressão com velocidade de 0,5 mm/min, aplicada a 135° em relação ao longo eixo da raiz, empregando máquina de ensaios mecânicos, até a fratura. Os dados foram submetidos aos testes de ANOVA e Tukey ( $p = 0.05$ ). **Resultado:** O tratamento clareador em dentes tratados endodonticamente com 15HP e nanopartículas de TiO<sub>2</sub> fotoativado por LED-laser proporcionou redução da resistência à fratura semelhante ao 35HP, 37CP ou SP ( $p > 0,05$ ). Todos os tratamentos clareadores reduziram a resistência coronária à fratura quando comparados aos dentes sem tratamento ( $p < 0,05$ ). **Conclusão:** Todos os protocolos de clareamento reduziram a resistência à fratura dos dentes tratados endodonticamente, sem diferenças estatisticamente significantes entre os grupos.

**Descritores:** Nanopartículas; peróxidos; clareamento dental.

## Abstract

**Objective:** The aim of this study was evaluate the fracture resistance of endodontically-treated teeth after bleaching treatment using 15% hydrogen peroxide plus titanium dioxide nanoparticles (15HPTiO<sub>2</sub>) photoactivated by LED-laser, in comparison with protocols using 35% hydrogen peroxide (35HP), 37% carbamide peroxide (37CP) or sodium perborate (SP). **Material and method:** After endodontic treatment, fifty bovine extracted incisors were divided into five groups ( $n = 10$ ): G1- without bleaching; G2- 35HP; G3- 37CP; G4- 15HPTiO<sub>2</sub> photoactivated by LED-laser and G5- SP. In G2 and G4, the bleaching protocol was applied in 4 sessions, with a 7 day interval between each session. In G3 and G5, the materials were kept in the pulp chamber for 21 days, but replaced every 7 days. After 21 days, the crowns were subjected to compressive load at a cross head speed of 0.5 mm/min, applied at 135° to the long axis of the root using an eletromechanical testing machine, until fracture. The data were submitted to ANOVA and Tukey tests ( $p = 0.05$ ). **Result:** The bleaching treatment in endodontically-treated teeth with 15HP plus TiO<sub>2</sub> nanoparticles and photoactivated by LED-laser caused reduction of the fracture resistance similarly provided by 35HP, 37CP or SP ( $p > 0.05$ ). All bleaching treatments reduced the fracture resistance compared to unbleached teeth ( $p < 0.05$ ). **Conclusion:** All bleaching protocols reduced the fracture resistance of endodontically-treated teeth, but there were no differences between each other.

**Descriptors:** Nanoparticles; peroxides; tooth bleaching.

## INTRODUCTION

Intra-coronal bleaching is a conservative treatment used in situations of darkening of endodontically-treated teeth<sup>1</sup>. The substances recommended for bleaching endodontically-treated teeth are those that promote an oxidation reaction, mainly hydrogen peroxide (HP), in several concentrations or combinations. Other substances, such as sodium perborate (SP) or carbamide peroxide (CP), have the hydrogen peroxide as a final subproduct and are also used in intra-coronal bleaching<sup>1,2</sup>.

Hydrogen peroxide is used as bleaching substance at concentrations ranging from 5% to 40%. In high concentrations it is caustic, aggressive to oral tissues, with the possibility of releasing free radicals<sup>3</sup>. Because of its low molecular weight, it has high diffusion and releases oxygen into the dentinal tubules, and this is the main mechanism of bleaching in endodontically-treated teeth<sup>3</sup>. With the objective to obtain an efficient and fast bleaching, it is possible to provide the catalysis of hydrogen peroxide using heat or photoactivation by LED-laser<sup>4,5</sup>.

Light sources may be used to activate the bleaching agents, increase the reaction and accelerate the bleaching process by hydrogen peroxide<sup>6,7</sup>. On the other hand, transparent bleaching agents present lower light absorption compared to bleaching agents associated with pigments<sup>8-10</sup>. With the proposal to improve absorption, titanium dioxide (TiO<sub>2</sub>) has been incorporated in bleaching agents to increase the catalysis of hydrogen peroxide<sup>11</sup>. This particle is a white opaque pigment, inorganic, chemically stable and with a high light reflectance. However, its higher bleaching effectiveness compared with conventional bleaching agents occurs only when using ultraviolet photoactivation<sup>11</sup>.

The halogen light or LED-laser photoactivation bleaching methods show similar whitening effectiveness in comparison to the chemical methods<sup>12</sup>, but also present several adverse effects, such as enamel and dentin demineralization<sup>13</sup>, and modification of the microhardness and roughness of the dental tissues<sup>14</sup>. These alterations may influence the fracture resistance of bleached teeth<sup>15,16</sup>, which is most critical in endodontically-treated elements<sup>16</sup>. Many of these effects are attributed to high concentrations of hydrogen peroxide used in traditional products<sup>6,10</sup>. Therefore it would be interesting to use agents with low concentrations of hydrogen peroxide associated with pigments that optimize bleaching procedures.

Recently, a new product for intra-coronal bleaching containing low concentrations of hydrogen peroxide plus titanium dioxide nanoparticles and LED-laser photoactivation has been launched. However, no studies that evaluating its effects on the dentinal substrate and on the fracture resistance of teeth, compared with the traditional internal bleaching protocols, such as carbamide peroxide and sodium perborate, have been published<sup>15,16</sup>.

The aim of this study was to compare the fracture resistance of bovine teeth after internal bleaching using 15% hydrogen peroxide gel associated with titanium dioxide nanoparticles (15HPTiO<sub>2</sub>) photoactivated by LED-laser, sodium perborate (SP), 37% carbamide peroxide (37CP) and 35% hydrogen peroxide (35HP), compared with unbleached teeth. The tested

null hypothesis was that different internal bleaching protocols do not reduce the fracture resistance of bovine teeth compared to unbleached ones.

## MATERIAL AND METHOD

Fifty recently extracted bovine incisors with similar anatomy were selected and stored in 0.1% thymol, at 4 °C. The teeth were immersed in distilled water for 24 h to completely remove thymol residues and examined under 20× stereomicroscope magnification (Leica Microsystems, Wetzlar, Germany) to discard elements with fractures and/or cracks. Mesiodistal and buccolingual radiographs were taken to certify that all teeth had only one canal and similar internal anatomy. To prevent dehydration, the teeth were stored in water until use. The present study is in accordance with the ethical norms (61/11).

After pulp chamber access with a 1014 round diamond bur (KG Sorensen, Cotia, SP, Brazil), the access cavity was standardized with a diameter similar to #12 round steel bur. In sequence, root canal preparation was performed by the crown-down technique<sup>17</sup>, using K-files (Maillefer, Ballaigues, Switzerland) and 2.5% sodium hypochlorite. Specimens were apically prepared to #80K-file followed by final irrigation with 5.0 mL of 17% EDTA (Biodinâmica, Ibioporã, PR, Brazil) for 3 min. After that, the canals were irrigated with 10 ml of distilled water and dried with absorbent paper points (Dentsply-Herpo, Petropolis, RJ, Brazil). Subsequently, the root canals were obturated by lateral condensation with gutta-percha (Dentsply Ind Com, Petropolis, RJ, Brazil) and AH Plus sealer (Dentsply De Trey, Konstanz, Germany). Radiographs were taken to verify the quality of the obturation.

A heated plugger was used to remove 3 mm of gutta-percha from the canal and a cervical barrier was built with self-cured glass ionomer (Maxxion R A3; FGM Produtos Odontológicos, Joinville, SC, Brazil) up to the cemento-enamel junction. A cotton pellet was placed in the pulp chamber, the access cavity sealed with Coltosol (Vigodent, Rio de Janeiro, RJ, Brazil) and the teeth were immediately immersed in artificial saliva (0.375 g/l CaCl<sub>2</sub>.2H<sub>2</sub>O, 0.125 g/l MgCl<sub>2</sub>.6H<sub>2</sub>O, 1.2 g/l KCl, 0.85 g/l NaCl, 2.5 g/l NaHPO<sub>4</sub>.12H<sub>2</sub>O, 1 g/l sorbine acid, 5g/l hydroxyethyl cellulosesodium, and 43 g/l sorbitol solution) (Ribeirão Preto School of Pharmaceutical Sciences, Ribeirão Preto, SP, Brazil), at 37 °C for 1 day, to allow complete setting of the glass ionomer. Then, the roots were embedded in polyester resin (Maxi Rubber, São Paulo, SP, Brazil), up to the cemento-enamel junction, using a plastic matrix (16.5 mm in width × 20.0 mm in length). All specimens remained intact for 24 h to allow resin polymerization.

After this period, the temporary restoration was removed and the pulp chamber was irrigated with 5.0 mL of 2.5% NaOCl. The smear layer was removed by applying 37% phosphoric acid (Condac 37; FGM Produtos Odontológicos, Joinville, SC, Brazil) for 15 s, followed by a 60 s final rinse with distilled water<sup>16</sup>. In sequence, the fifty teeth were randomly distributed into five

groups ( $n = 10$ ), one control and four experimental groups according to the following internal bleaching protocol: G1 (control): unbleached tooth, restored with Coltosol (Vigodent, Rio de Janeiro, RJ, Brazil); G2 (35HP): a 35% hydrogen peroxide gel (Whiteness HP; FGM Produtos Odontológicos, Joinville, SC, Brazil) was applied on the enamel and inside the pulp chamber for 15 min and replaced for an additional 15 min. This procedure was repeated after 7, 14 and 21 days; G3 (35CP): a 35% carbamide peroxide gel (Whiteness Superendo; FGM Produtos Odontológicos, Joinville, SC, Brazil) was maintained in the pulp chamber for 21 days. The gel was replaced each 7 days; G4 (15HPTiO<sub>2</sub> photoactivated with LED-laser): a 15% hydrogen peroxide plus titanium dioxide nanoparticles gel (Lase Peroxide Lite; DMC Equipamentos, São Carlos, SP, Brazil) was applied on all external surface crowns and inside the pulp chamber and photoactivated by a LED-laser system (Whitening lase II; DMC Equipamentos, São Carlos, SP, Brazil), for 6 min on each surface, divided in two equal time applications. This procedure was also repeated after 7, 14 and 21 days; G5 (SP): 2 g sodium perborate mixed with 1 mL of 20% hydrogen peroxide (Whiteness Perborato; FGM Produtos Odontológicos) was used similarly to G3. For the G2 and G4, the pulp chamber was filled with a cotton pellet between the bleaching sessions and only the access cavity was temporarily restored with glass ionomer cement.

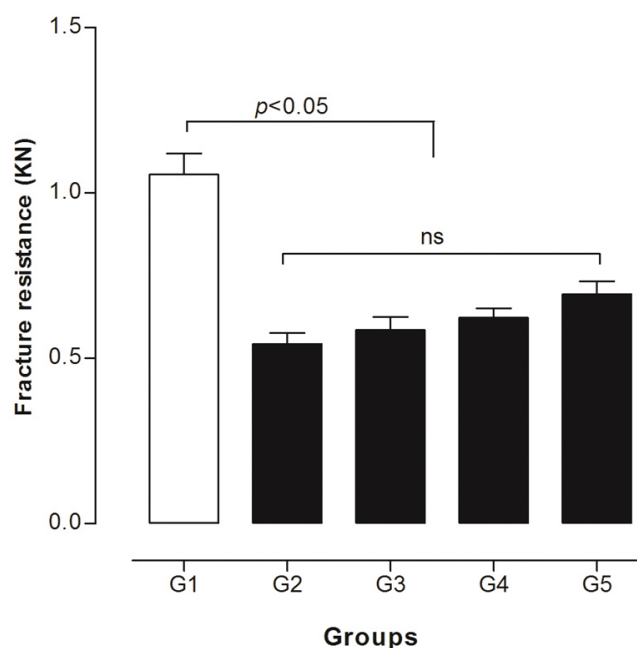
All specimens were kept in artificial saliva during all experiments, at 37 °C which was replaced between each session. After finishing the bleaching treatment, the pulp chamber was rinsed with distilled water for complete removal of the bleaching agents, and air-dried. Specimens (experimental groups) were sealed with Coltosol (Vigodent, Rio de Janeiro, RJ, Brazil), and kept in artificial saliva until the fracture resistance tests were conducted.

Specimens were subjected to a compressive load at a cross head speed of 0.5 mm.min<sup>-1</sup>, in an EMIC DL200 electromechanical testing machine (EMIC, São José dos Pinhais, Paraná, Brazil), until crown fracture. For specimen adaptation to the testing apparatus, a cylindrical device with a tapered tip was used<sup>16</sup>.

The cylinder design allowed specimens to be fixed at a 45° angle, in such a way that the load was applied to the buccal surface of the teeth at a 135° angle in relation to the long axis of the root<sup>16</sup>. The ultimate strength required to cause fracture in the crown was recorded, and data were analyzed statistically by the ANOVA and Tukey tests, at a 5% significance level.

## RESULT

Figure 1 represents the mean and standard deviation of load required (in kN) to fracture the crowns in each group. The control group required the highest load values (1.11 + 0.26 kN) to fracture the dental crowns, and differed significantly from the experimental groups ( $p < 0.05$ ). No statistical difference was observed among the experimental groups G2 (0.54 + 0.10 kN), G3 (0.58 + 0.13 kN), G4 (0.62 + 0.09 kN) and G5 (0.69 + 0.13 kN), with different internal bleaching treatments ( $p > 0.05$ ).



**Figure 1.** Comparison of ultimate load required to fracture bovine crowns in the different groups (kN). G1 - control; G2 - 35% hydrogen peroxide (35HP); G3 - 37% carbamide peroxide (37CP); G4 - 15% hydrogen peroxide plus TiO<sub>2</sub> nanoparticles photoactivated by LED-laser (15HPTiO<sub>2</sub>) and G5 - sodium perborate (SP).

## DISCUSSION

In the present study, bleaching treatment using 15% hydrogen peroxide gel plus titanium dioxide nanoparticles and photoactivated by LED-laser provided reduction of the fracture resistance of the teeth, when compared with the unbleached endodontically-treated teeth. However, the reduction in fracture resistance was similar to the other bleaching treatments (35% hydrogen peroxide, 35% carbamide peroxide or sodium perborate). Therefore, the null hypothesis was rejected.

The significant reduction in fracture resistance of the teeth reduction presented by the experimental groups can be attributed to the presence of hydrogen peroxide in the bleaching agents, independently of the concentration. Peroxides show an oxidizing action, which modifies the structure and mechanical properties of the tooth tissues<sup>6</sup>, providing the degradation of collagen fiber and hyaluronic acid<sup>18</sup>. These changes cause dentin microhardness reduction and consequently reduction of crown resistance to fracture<sup>19-22</sup>.

There is some controversy about the negative effects of the bleaching agents on the coronal fracture resistance of endodontically-treated teeth<sup>6,7,15,22</sup>. However, the similar results among the experimental groups is in accordance with other studies<sup>7,15,23</sup>, except in relation to the G4, since there were no studies conducted with this treatment protocol. Despite this bleaching agent presenting a lower hydrogen peroxide concentration, the fracture resistance reduction presented in this study was also similar to other experimental groups. The amount of bleaching sessions and applications time on teeth surfaces could have interfered in the results<sup>6,24</sup>, because LED-laser photoactivation

was applied on this gel for 6 minutes on each surface for 4 sessions of application. In a recent study, it was shown that the fracture resistance of endodontically-treated teeth decreases after two sessions of bleaching with 38% hydrogen peroxide activated by a LED-laser system<sup>6</sup>.

According to the manufacturer, to optimize the teeth bleaching action provided by hydrogen peroxide with titanium dioxide nanoparticles gel, LED-laser photoactivation is recommended. This system provides increased temperature, pigment activation and accelerates the catalysis of hydrogen peroxide<sup>7</sup>. On the other hand, it also can produce or accentuate fractures lines and/or cracks<sup>6</sup>, reducing the fracture resistance of teeth, mainly after several treatment sessions, as previously discussed.

The methodology used in present study was similar to other studies<sup>6,7,16</sup>. The unavoidable loss of dentin during endodontic treatment can increase tooth susceptibility to fracture<sup>25</sup>. Therefore, only endodontically-treated teeth were used to avoid the comparison with intact teeth. The reason using bovine teeth in the present study was due to its dentin ultimate tensile strength and modulus of dentin elasticity similar to human teeth<sup>16,26</sup>. During the fracture tests, the load cell impacted the coronal surface at an angle of 135° in relation to the long axis of the root, with the intent of reproducing the angle formed between the maxillary and the mandibular incisors<sup>6,16</sup>.

Based on the results of this study, it should be noted that the 15% HP plus titanium dioxide nanoparticles photoactivated

by LED-laser reduced the fracture resistance in teeth, with similar values provided by routinely bleaching agents used in endodontically-treated teeth, such as HP, CP or SP. However, all experimental groups presented lower resistance fracture in comparison with unbleached teeth. Furthermore, this study suggested that the bleaching agent composition, LED-laser photoactivation, number of sessions and time of application can interfere in the fracture resistance of teeth. But, it should also be remembered that, if the bleached dental crown is restored, there is a significant increase in its fracture resistance<sup>2,15</sup>. Thus, further studies are necessary to corroborate the effectiveness of photoactivated bleaching gels, resulting in safer and efficient procedures.

## CONCLUSION

Within the limitations of this study, it is possible to conclude that bleaching procedures in endodontically-treated with 15% hydrogen peroxide plus titanium dioxide nanoparticles and photoactivated with LED-laser caused a reduction in fracture resistance compared with teeth without any bleaching procedure. This reduction was, however, similar to that caused by other bleaching procedures, namely 35% hydrogen peroxide, 35% carbamide peroxide or sodium perborate associated with 20% hydrogen peroxide.

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## CONFLICTS OF INTEREST

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The authors declare no conflicts of interest.

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