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ORIGINAL RESEARCH

Fracture Resistance of Teeth Submitted to Several Internal Bleaching Protocols

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ABSTRACT

Aim: The aim of this study was to evaluate the fracture resistance of teeth submitted to several internal bleaching protocols using 35% hydrogen peroxide (35HP), 37% carbamide peroxide (37CP), 15% hydrogen peroxide with titanium dioxide nanoparticles (15HPTiO_2) photoactivated by LED-laser or sodium perborate (SP).

Materials and methods: After endodontic treatment, fifty bovine extracted teeth were divided into five groups (n = 10): G1—unbleached; G2—35HP; G3—37CP; G4—15HPTiO_2 photoactivated by LED-laser and G5—SP. In the G2 and G4, the bleaching protocol was applied in 4 sessions, with 7 days intervals between each session. In the G3 and G5, the materials were kept in the pulp teeth for 21 days, but replaced every 7 days. After 21 days, the teeth 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 teeth fracture. The data were submitted to ANOVA and Tukey tests ($\alpha = 5\%$).

Results: The 35HP, 37CP, 15HPTiO_2 and SP showed similar fracture resistance teeth reduction ($p > 0.05$). 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.

Clinical significance: There are several internal bleaching protocols using hydrogen peroxide in different concentrations and activation methods. This study evaluated its effects on fracture resistance in endodontically-treated teeth.

Keywords: Nanoparticles, Peroxides, Tooth bleaching.

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INTRODUCTION

Internal bleaching is a conservative treatment in situations of darkening of endodontically-treated teeth.[1] The substances recommended in endodontically-treated teeth bleaching are those that promote an oxireduction reaction, mainly hydrogen peroxide (HP), in several concentrations or activation methods. Others substances, such as sodium perborate (SP) or carbamide peroxide (CP), have the hydrogen peroxide as a final subproduct and are also used in intracoronal bleaching.[1,2]

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.[3] Because of its low molecular weight, it has high diffusion and releases oxygen into the dentinal tubules, providing the bleaching of endodontically-treated teeth.[3] 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.[4,5]

Light sources may be used to activate the bleaching agents, increase the reaction and accelerate the bleaching process by hydrogen peroxide.[6,7] On the other hand, transparent bleaching agents present lower light absorption in relation to bleaching agents associated with pigments.[8-10] With the proposal to improve absorption, titanium dioxide (TiO_2) has been incorporated in bleaching agents to increase the catalysis of hydrogen peroxide.[11] 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.[11]

The halogen light or LED-laser photoactivation bleaching methods show similar whitening effectiveness in comparison to the chemical methods,[12] but also present several adverse effects, such as enamel and dentin demineralization,[13] modify the microhardness and roughness of the dental tissues.[14] These alterations may influence the fracture resistance of bleached teeth,[15,16] being even critical in endodontically-treated teeth.[16] Many of these effects are attributed to high concentrations of hydrogen peroxide used in traditional products.[6,10] 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 endondontically-treated bleaching teeth containing low concentrations of hydrogen peroxide with titanium dioxide nanoparticles and LED-laser photoactivation has been recommended. But, there are no studies that evaluate its effects on the dentinal substrate and the effect on the fracture resistance of teeth, mainly when compared with the traditional internal bleaching protocols, such as carbamide peroxide and sodium perborate.[15,16]

The aim of this study was to compare the fracture resistance of bovine teeth after internal bleaching using 35% hydrogen peroxide (35HP), 37% carbamide peroxide (37CP), 15% hydrogen peroxide gel associated with titanium dioxide nanoparticles (15HPTiO_2) or sodium perborate (SP), in comparison 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 teeth.

MATERIALS AND METHODS

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 hours to completely remove thymol residues and examined under 20× stereomicroscope magnification (Leica Microsystems, Wetzlar, Germany) to discard those 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.

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,[17] 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, Ibiporã, PR, Brazil) for 3 minutes. 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 with self-cured glass ionomer (Maxxion R A3; FGM Produtos Odontológicos, Joinville, SC, Brazil) was placed as a cervical barrier up to the cementoenamel junction. A cotton pellet was placed in the pulp chamber and the access cavity sealed with Coltosol (Vigodent, Rio de Janeiro, RJ, Brazil) and the teeth were immediately immersed in artificial saliva (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 cementoenamel junction, using a plastic matrix (16.5 mm in width × 20.0 mm in length). All specimens remained intact for 24 hours 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 second, followed by a 60 second final rinse with distilled water.[16] 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 and only restorated with Coltosol (Vigodent, Rio de Janeiro, RJ, Brazil); G2 (35 HP)—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 after an additional 15 min. This procedure was repeated after 7, 14 and 21 days; G3 (35 CP)—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_2 photoactivated with LED-laser)—15% hydrogen peroxide with 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), in total 6 minutes on each surface, divided in two equal time applications. This procedure was also repeated after 7, 14 and 21 days; G5 (SP)—2g SP mixed with 1 mL of 20% HP (Whiteness Perborato; FGM Produtos Odontológicos) was used similarly to the 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 and 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 minute –1, in an EMIC DL200 electromechanical testing machine (EMIC, São José dos Pinhais, Paraná, Brazil), until crown fracture. For specimen adaptation to the assay apparatus, a cylindrical device with a tapered tip was utilized.[16]

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.[16] 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.

RESULTS

The control group required the highest load values (1.2 ± 0.3 kN) to fracture the teeth than other groups ($p < 0.05$). There were no differences among the internal bleaching protocols ($p > 0.05$). The load required to fracture the teeth in these groups were (in kN): G2 (0.5 ± 0.2), G3 (0.6 ± 0.2), G4 (0.7 ± 0.1) and G5 (0.8 ± 0.1). Figure 1 shows the mean and standard deviation of load required (in kN) to fracture the endodontically-treated teeth of each group.

DISCUSSION

In the present study, the internal bleaching protocols provided reduction of the fracture resistance of the teeth, when compared with the unbleached endodontically-treated teeth. However, the reduction of fracture resistance teeth was similar among the several internal bleaching protocols. Therefore, the null hypothesis was rejected.

The significative 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 present oxidizing action, which modifies the structure and mechanical properties of the teeth tissues,[6] providing the degradation of collagen fiber and hyaluronic acid.[18] These changes cause dentin microhardness reduction and consequently reduction of crown resistance to fracture.[19-22]

There is controversy over the negative effects of the bleaching agents on the coronal fracture resistance of endodontically-treated teeth.[6,7,15,22] However, the similar results among the experimental groups is in accordance with previous studies,[7,15,23] 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,[6,24] 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.[6]

According to the manufacturer, to optimize the teeth bleaching 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.[7] On the other hand, it also can produce or accentuate fractures lines and/or cracks,[6] 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.[6,7,16] The unavoidable loss of dentin during endodontic treatment can increase tooth susceptibility to fracture.[25] Therefore, only endodontically-treated teeth were used to avoid the comparison with intact teeth. The reason for the choice of bovine teeth was because of its ultimate tensile strength and modulus of dentin elasticity are similar to human teeth.[16,26] During the fracture assays, 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.[6,16] All internal bleaching protocols reduced the fracture resistance of endodontically-treated

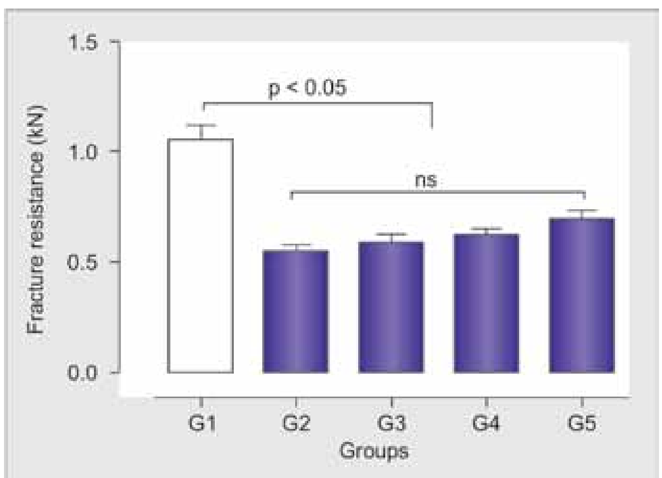

Fig. 1: Comparison of ultimate load required to fracture the bovine crowns in the different groups (kN). G1: control; G2: 35% hydrogen peroxide (35HP); G3: 37% carbamide peroxide (37CP); G4: 15% hydrogen peroxide with TiO_2 nanoparticles photoactivated by LED—laser (15HPTiO_2) and G5: sodium perborate (SP)

teeth in comparison to unbleached teeth. However, in present study the coronal access was only restored with temporary material (Coltosol). Further studies are necessary to evaluate the fracture resistance teeth after internal bleaching protocols and coronal access restored with composite resin and/or glass ionomer cement.

CONCLUSION

Within the limitations of this study, it is possible to conclude that internal bleaching protocols (35% hydrogen peroxide, 35% carbamide peroxide, 15% hydrogen peroxide with titanium dioxide nanoparticles photoactivated with LED-laser and sodium perborate mixed with 20% hydrogen peroxide) reduced, in similar values, the fracture resistance of endodontically-treated teeth, in comparison to unbleached endodontically-treated teeth.

CLINICAL SIGNIFICANCE

There are new internal bleaching protocols using different hydrogen peroxide concentrations and activation methods. However, their effects on dental structure are unknown. This study evaluated the effects on fracture resistance of endodontically-treated teeth after dental bleaching protocols.

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