

Influence of the Number of Bleaching Sessions on Fracture Resistance and Dentin Microhardness of Endodontically Treated Teeth

¹Lorena DMA Garrido, ²Milton C Kuga, ³Natália G Kalatzis-Sousa, ⁴Andrea AR Dantas, ⁵Mateus R Tonetto
⁶Renato DT Leonardo, ⁷Keren CF Jordão-Basso, ⁸Suellen L Lima, ⁹Alvaro H Borges, ¹⁰Matheus C Bandeca

ABSTRACT

Objectives: To evaluate the effects of number of bleaching sessions on fracture resistance and dentin microhardness in endodontically treated teeth using 15% hydrogen peroxide with titanium dioxide nanoparticles (15HPTiO₂) associated to light emitting diode (LED)-laser system.

Materials and methods: Forty human incisors were endodontically treated and divided according to the number of bleaching sessions (n=10, each group): G1 – no treatment G2 – one; G3 – two; and G4 – three sessions. The 15HPTiO₂ was applied within the pulp chamber and on the buccal surface, then photoactivated using LED-laser. All experimental specimens were restored with ionomer glass cement between each session and in the final treatment. Specimens were then subjected to the fracture resistance test (kN), using an electromechanical machine. To the dentin microhardness evaluation, 40 crown extracted endodontically treated human teeth were longitudinally sectioned, divided into groups as previously described (n=10), and submitted to similar bleaching protocol. Dentin microhardness was evaluated before and after the final dental bleaching session in each group using Knoop indentator. Data were analyzed by analysis of variance (ANOVA) and Tukey tests (p=0.05).

Results: The fracture resistance values were similar among all groups (p > 0.05). The number of dental bleaching sessions had a negative influence on the microhardness dentin, because G4 > G3 > G2 > G1 (p < 0.05).

Conclusion: The number of bleaching sessions using 15% hydrogen peroxide with titanium dioxide nanoparticles associated to LED-laser system had no influence on the fracture resistance of the endodontically treated teeth crowns, but promoted a reduction in dentin microhardness.

Keywords: Dental bleaching, Dentin, Endodontics, Hydrogen peroxide, Lasers.

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INTRODUCTION

Bleaching techniques are divided into internal or external bleaching.¹ Several bleaching agents have been recommended to use in endodontically treated teeth, and the most employed is the hydrogen peroxide and its derivatives (sodium perborate or percarbonate and carbamide peroxide).¹

When the bleaching agent is placed within the pulp chamber, the active oxygen is released and the colored pigments are chemically reduced and converted into a colorless substance.² However, high concentrations of hydrogen peroxide cause alterations in the dental structure, such as increase in dentin permeability, microhardness reduction, surface morphology alteration, and some changes in the dentin chemical composition.³⁻⁶

The dentin is the major portion of the tooth structure and any change in its biomechanical properties after bleaching have an impact on the dental resistance.⁷ Moreover, it is still unknown how the oxidizing agents cause this resistance reduction. After endodontically treated dental bleaching, 37% carbamide peroxide does not affect the crown fracture resistance.⁸ On the contrary, this resistance is affected negatively by hydrogen peroxide.⁹

Dental bleaching substances effects are based an oxiredution reaction, and this process depends on the local pH, presence of metal particles, temperature, and light activation.^{1,10} It has been shown that the heat activation of the bleaching agent using light and/or laser may enhance or accelerate the bleaching process.^{2,11}

The light source energizes the peroxides, accelerating the dental bleaching process. These substances contain substances capable of promoting maximum light absorption and converting into heat.^{12,13} Recently, several devices use laser and light emitting diode (LED) as sources of

1,3,7,8Student, 2,4-6,9,10Professor

1-4,6,7Department of Restorative Dentistry, Araraquara Dental School, Universidade Estadual Paulista Júlio Mesquita Filho-UNESP, Araraquara, São Paulo, Brazil

5,9Department of Postgraduate Program in Integrated Dental Science, University of Cuiabá, Cuiabá, Mato Grosso, Brazil

8,10Department of Postgraduate Program in Dentistry, CEUMA University, São Luis, Maranhão, Brazil

Corresponding Author: Matheus C Bandéca, Professor Department of Postgraduate Program in Dentistry, CEUMA University, São Luis, Maranhão, Brazil, e-mail: mbandeca@gmail.com

concentrated and selective energy, whose radiation is emitted at specific wavelength (peak of emission of 470 nm).^{14,15}

The possible effects of the light activation on the bleaching agents are: Bleaching agent heating, electric excitation of the hydrogen peroxide molecules by the photons, and the physicochemical action on the colorants or pigments interfering in the hydrogen peroxide stability.¹⁶ Recently, bleaching gels contain hydrogen peroxide at low concentrations and those containing titanium dioxide (TiO₂) were proposed to dental bleaching.^{14,15}

The TiO₂ is an inorganic white pigment, chemically stable presenting high power of reflectance and opacity. Bleaching is enhanced by generation of oxidative radicals via TiO₂ photocatalysis.¹⁷ Despite TiO₂ nanoparticles is incorporated in the hydrogen peroxide bleaching gel, few studies have evaluated its effects on dental structure.

Therefore, this study evaluated the effects of the number of dental bleaching sessions on dental fracture resistance and dentin microhardness of endodontically treated teeth using 15HPTiO₂ photoactivated LED–laser system.

MATERIALS AND METHODS

Crown Fracture Resistance Evaluation

Forty human mandibular central incisors were kept in 1% thymol solution (4°C) until the beginning of the research. All teeth presented straight root, single canal, and root apex fully formed. They were then radiographed and examined using a stereomicroscope (Leica Microsystems, Wetzlar, Germany) at a magnification of 20×, in order to avoid teeth presenting crack or fracture line. Then the selected teeth were rinsed in running water during 24 hours to avoid possible residues from thymol solution.

After coronal access with a #1012 diamond bur (KG Sorensen, São Paulo, Brazil), the cervical third was prepared using S1 and SX instruments (ProTaper Universal System; Dentsply Maillefer, Baillagues, Switzerland). The working length was established 1.0 mm shorter than the total tooth length and it was radiographically confirmed. Chemical–mechanical preparation of the root canal was performed up to a F2 instrument (ProTaper Universal System; Dentsply Maillefer, Baillagues, Switzerland), using the technique proposed by Guelzow et al.¹⁸ The root canal was irrigated with 5 mL of 2.5% sodium hypochlorite (Asfer, São Caetano do Sul, São Paulo, Brazil) between each instrument change and a final rinse with 5 mL of 17% ethylenediaminetetraacetic acid (EDTA) (Biodinâmica, Ibiporã, PR, Brazil) was performed for 1 minute. Irrigation final was concluded using 5 mL of 2.5% NaOCl solution and the canals were dried using paper points (Tanariman, Manaus, AM, Brazil). Single-cone technique with F2

gutta-percha point (Dentsply, Petrópolis, RJ, Brazil) and AH Plus sealer (Dentsply DeTrey, Konstanz, Germany) was performed and radiographs were obtained to verify the quality of the endodontic obturation.

A heated Donaldson-plugger instrument removed 3 mm of gutta-percha from each root canal and a cervical barrier made of glass ionomer cement (Vidrion R; SS White, Rio de Janeiro, RJ, Brazil) was placed at the cemento-enamel junction. The teeth were stored at 37°C, for 1 hour to allow the final setting time of glass ionomer cement. In sequence, teeth were embedded in auto-polymerized acrylic resin (Classic Jet, São Paulo, Brazil) 2 mm below the cemento-enamel junction, using a plastic circular matrix (16.5 mm in width × 31.0 mm in length). The specimens remained untouched for 1 hour to assure resin setting.

Subsequently, the specimens were randomly divided into four groups (n = 10) according to the number of bleaching sessions: G1 – no treatment (control); G2 – one session; G3 – two sessions; and G4 – three sessions. The bleaching agent was 15% hydrogen peroxide plus TiO₂ nanoparticles (Lase Peroxide Lite; DMC Equipamentos, São Carlos, São Paulo, Brazil) photoactivated using the LED–laser system (Whitening Lase II; DMC Equipamentos, São Carlos, São Paulo, Brazil).

The bleaching gel was applied on the buccal surface and inside the pulp chamber. The LED–laser was applied on buccal surface and within the pulp chamber for 3 minutes with a 15-minute interval between a new reapplication of LED–laser. The bleaching agent was aspirated and this protocol was repeated three times each and every session. Between the bleaching session, the specimens were stored for 7 days in artificial saliva (Faculdade de Ciências Farmaceuticas de Ribeirão Preto, Universidade de São Paulo, São Paulo, Brazil), at 37°C. The untreated specimens (control group) remained in artificial saliva for 21 days that was replaced every 7 days. Between bleaching sessions, all specimens were temporarily sealed using glass ionomer cement (Ketac Molar Easymix; 3M Espe AG, Seefeld, Germany).

After the last bleaching session, the specimens were restored using glass ionomer cement (Ketac Molar Easymix; 3M Espe AG, Seefeld, Germany) and immediately subjected to the fracture test using an EMIC DL2000 electromechanical testing machine (EMIC, São José dos Pinhais, PR, Brazil) and a compressive load at a crosshead speed of 0.5 mm/minute was applied until fracture. A cylindrical device with tapered tip was used in order to improve the specimens adaptation to the assay apparatus.¹⁹ This cylindrical design allowed specimens to be fixed at a 45° angle, and the load was applied to the buccal surface of the teeth at a 135° angle in relation to the long axis of the root (3.0 mm from the incisal portion).

The last force for the crown fracture was recorded and the data were submitted to analysis of variance (ANOVA) test at 5% significance level.

Dentin Microhardness Evaluation

Forty freshly human upper canines extracted due to periodontal reasons were obtained from patients, mean age ranging from 40 to 55. Initially, the teeth were kept in 1% thymol solution at 4°C until the beginning of the research. Subsequently, the teeth were washed in running water for 24 hours to remove the thymol residues. All teeth were examined using a stereomicroscope (Leica Microsystems, Wetzlar, Germany) at a magnification of 20×, to discard teeth presenting anatomical anomalies, structural defects, or pathological alterations. The teeth were chosen according to their dimensions and morphological similarities.

The endodontic treatment was carried out similarly as described before. After the pulp chamber cleaning using 95% ethanol, the crowns were sectioned at the cementoenamel junction using a diamond disk (Isomet; Buehler Ltd, Lake Bluff, IL, USA). Grooves were made on the crown buccal and lingual surfaces using a water-cooled diamond disc, and each crown was sectioned along the long axis. One half of each crown was selected and mounted in an individual silicone device with acrylic resin. The dentin surfaces from the root sections were grounded smooth using silicon carbide papers (Norton, Lorena, São Paulo, Brazil) of decreasing abrasiveness (from #300 to #1200 grit) and completed with aluminum oxide suspension (Profill; S.S. White, Rio de Janeiro, Brazil). The specimens were cleaned using distilled water after polishing.

Initial dentin microhardness measurements were performed on each section at 100 μm from the pulp-dentin interface with Knoop microhardness (HMV2; Shimadzu, Tokyo, Japan), in buccal face of pulp chamber. For each measurement, three indentations were made. A 25 gm indentation load was applied for 10 seconds. Mean value was calculated from the three measurements of each specimen. Then the specimens were divided into four groups (n = 10), according to numbers of bleaching session, as previously described. After the last bleaching session to each group, the specimens were dried with absorbent paper and immediately new dentin microhardness evaluations were performed, but now in pulp chamber palatal face.

The difference between initial and final bleaching session was obtained and interpreted as the effects on dentin microhardness. This value was expressed in percentage. During all experiments, between the bleaching sessions, the specimens were kept in 99% humidity, at 37°C. The percentage of reduction in dentin microhardness was subjected to ANOVA and Tukey's tests at 5% significance level.

RESULTS

The ANOVA test showed that G1 (0.23 ± 0.08 kN), G2 (0.23 ± 0.07 kN), G3 (0.22 ± 0.07 kN), and G4 (0.21 ± 0.06 kN) were statistically similar among each other (p > 0.05). G2, G3, and G4 presented fracture resistance values similar to G1 (control group).

The bleaching sessions caused dentin microhardness reduction. G1 (no treatment) presented the percentage of dentin microhardness reduction of 6.01 ± 2.84. G2 (one session), G3 (two sessions), and G4 (three sessions) presented 13.71 ± 5.60, 25.82 ± 9.13, and 38.93 ± 9.99 respectively, the percentage of dentin microhardness reduction. Significant differences were found among all groups (p < 0.05).

DISCUSSION

This present study showed that the fracture resistance did not reduce, even though the dentin microhardness presented a significant reduction after each bleaching sessions.

Various substances have been proposed for internal bleaching, such as hydrogen peroxide at high concentration, alone or in combination with sodium perborate or sodium percarbonate. Due to the adverse effects provoked by these substances, other combinations have been proposed, such as carbamide peroxide and hydrogen peroxide at low concentration photoactivated using LED-laser system.¹

The bleaching gel used in this present study presented TiO₂ nanoparticles as light-absorbing heat-producing agent. According to the manufacturer, nanoparticles enhance the release of oxygen, allowing the use of lower concentrations of hydrogen peroxide. Caneppele et al¹⁴ observed that the presence of TiO₂ particles in 35% hydrogen peroxide gel, photoactivated with LED-laser (470 nm) or ultraviolet (345 nm) did not present bleaching result better than conventional hydrogen peroxide. They reported that the light absorption and photocatalysis may have been compromised by the amount and size of TiO₂ particles embedded in the bleaching gel. On the contrary, Suyama et al²⁰ concluded the combination of 3.5% hydrogen peroxide, and TiO₂ is more effective than only hydrogen peroxide, especially when it is activated using high-intensity halogen lamp, in comparison to blue LED light or low-intensity halogen lamp.

Owing to the similar photocatalytic effects presented by various sources, this study chose the LED-laser system.²¹ The LED device presents a blue light with a wavelength of 470 nm, similarly to previous studies^{14,21} and infrared laser emitting 0.2 W of power, with a wavelength of 808 nm. Coelho et al¹¹ observed that neither 35% carbamide peroxide nor 38% hydrogen peroxide or the light sources alone changed the teeth fracture resistance.

Three bleaching sessions did not reduce the fracture resistance in the experimental groups. The results found in this study were different to Pobbe et al² evaluation, that observed reduction of the dental fracture resistance after two bleaching sessions. However, these authors used a concentration of 38% hydrogen peroxide. High concentrations of hydrogen peroxide tend to reduce the dental fracture resistance.²² According to the manufacturer, the TiO₂ nanoparticles allow greater absorption of light from the LED-laser system, providing an optimization of the heat generated by the light units, requiring a lower concentration of hydrogen peroxide, favoring the teeth fracture resistance.

The application of hydrogen peroxide on enamel and dentin reduce the microhardness and is related to carbamide and/or hydrogen peroxides concentrations.^{23,24} The present study showed a reduction of dentin microhardness after several bleaching session and the percentage increased according to the number of sessions. This reduction may be related to chemical alterations in the dentin structure, such as reduction of dentin organic components and alterations in the morphology of the dental substrate that promote changes in the dentin mechanical properties.^{1,4,25}

Despite the microhardness reduction after the tooth bleaching, the fracture resistance was similar to control group, even after three bleaching sessions. Therefore, this is a practicable and safe bleaching protocol in nonvital teeth.

CONCLUSION

The number of bleaching sessions using 15% hydrogen peroxide with TiO₂ nanoparticles associated to LED-laser system had no influence on the fracture resistance of the endodontically treated teeth crowns, but promoted a reduction in dentin microhardness.

CLINICAL SIGNIFICANCE

The number of bleaching sessions only has adverse effects on the dentin microhardness, but this fact does not reduce the fracture resistance in endodontically treated teeth.

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