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Evaluation of dentin permeability after light activated internal dental bleaching

Carrasco LD, Guerisoli DMZ, Pécora JD, Fröner IC. Evaluation of dentin permeability after light activated internal dental bleaching. © Blackwell Munksgaard, 2006.

Abstract – The aim of this *in vitro* study was to assess quantitatively the dentin permeability of human teeth after intracoronal bleaching therapy with 35% hydrogen peroxide activated by LEDs, halogen lamp or using the walking bleach technique. Forty human maxillary central incisors had standard access cavities performed and the cervical thirds of the canals were prepared with Gates-Glidden drills up to a size 130. Roots were resected between the coronal and middle thirds and the apical portions were discarded. A glass ionomer, 2 mm thick cervical plug was placed inside the canal, at the cement-enamel junction level. Group I received 35% hydrogen peroxide gel activated by LEDs. Group II was submitted to 35% hydrogen peroxide gel activated by halogen lamp. Group III received 35% hydrogen peroxide gel and the walking bleach technique was followed. Group IV (control) received a dry cotton pellet inside the pulp chamber with temporary restoration. Dentinal permeability was quantified by copper ion penetration. Linear measurements were obtained by analysis of digital images under ×5 magnification. Mean values and SD for the experimental groups were: I, 7.1% (±3.2%); II, 8.4% (±3.0%); III, 9.1% (±3.0%); IV, 1.3% (±2.8%). One-way ANOVA was used to analyze the results. Results showed an increase of permeability values for groups I, II and III when compared to group IV (control); however, no statistical differences were found between the three tested bleaching techniques. It can be concluded that 35% hydrogen peroxide activated by LED, halogen lamp or used following the walking bleach technique produced similar increase in dentinal permeability.

Laise Daniela Carrasco, Danilo M. Zanello Guerisoli, Jesus Djalma Pécora, Izabel Cristina Fröner

Department of Restorative Dentistry, Ribeirão Preto Dental School, University of São Paulo, Ribeirão Preto, SP, Brazil

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Dr Izabel Cristina Fröner, Departamento de Odontologia Restauradora, Faculdade de Odontologia de Ribeirão Preto, Universidade de São Paulo, 14040-904, Ribeirão Preto, SP, Brazil
Tel.: +55 16 602 4055
Fax: +55 16 633 0999
e-mail: froner@forp.usp.br

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Many techniques have been used for dental bleaching, especially for non-vital teeth. The majority of them rely on an oxidation reaction in order to reverse the chromatic alteration of the dental tissues (1–3).

Success of dental bleaching is related to the ability of the bleaching material to penetrate through dentinal tubules. The deeper the penetration, the more the pigment that causes chromatic alteration can be reversed by the oxidation reaction, converting dark molecules into carbon dioxide and water (2).

Several procedures have been reported to increase dentinal permeability, including phosphoric acid etching of tooth structure before placing bleaching agents (4), smear layer removal (5), ultrasonic-activated irrigants (6) and heat application (7). However, thermocatalytic bleaching techniques have recently been questioned because of the deleterious effects that may be produced on dentinal structures (8), as well as light sources that generate heat (9).

To date, the development of techniques and materials for dental bleaching relies not only on their efficiency and quick recovery of tooth natural color, but also on their ability not to cause damage to dental structures, oral mucosa and patient's health. Dental bleaching performed by the clinician allows a better control over the products used, as peroxides and free radicals may harm tissues (10).

New bleaching agents based on high concentrations (35–50%) of hydrogen peroxide are able to start the bleaching process on activation of photoinitiators by light sources operating on the 450–500 nm spectrum range. Thus, dental bleaching performed by the clinician would be quicker and more efficient when a light source is used to activate hydrogen peroxide (11). Light-cure units based on halogen lamps can be used for this purpose.

However, two different light sources have been recently used by clinicians to initiate the bleaching process: lasers and LEDs. Previous studies on laser activation of bleaching agents report advantages of this technique, as it acts on the bleaching agent and not on dental structures (11). Thus, temperature variations are lower (12, 13).

The LEDs present an efficient and more cost-effective alternative to lasers, using less energy to generate light (14). Despite the broader spectrum of LEDs when compared with laser emission, the first still presents a much more monochromatic emission than halogen lamps. Thus, there is a superior performance of LEDs when compared with halogen lamps (15).

Reports on the effects, advantages and disadvantages on the use of lasers for activating dental bleaching agents have been extensively researched. However, little is known about the influence of dental bleaching agents activated by LEDs or halogen lamps on the dentinal permeability. Therefore, the objective of this *in vitro* study is to assess quantitatively dentin permeability after intracoronal bleaching therapy with 35% hydrogen peroxide activated by LEDs, halogen lamp or the walking bleach technique.

Material and methods

Human maxillary central incisors extracted within a 6-month period and stored in 0.4% sodium azide solution at 4°C were scaled with ultrasonic scaler to remove calculus and remnants of periodontal ligament, polished with water/pumice slurry in dental prophylactic cups, thoroughly rinsed and dried. After careful visual inspection and tactile examination using the tip of a dental probe under ×10 stereoscopic magnifying lens (Carl Zeiss, Jena, Germany), 40 sound teeth with no sign of cracks or structural anomalies were selected.

Standard access cavities were performed and the cervical thirds of the canals were prepared with Gates-Glidden drills (Dentsply-Maillefer, Ballaigues, Switzerland) up to size 130 with a low-speed engine. Roots were resected between the coronal and middle thirds and the apical portions were discarded.

A cervical plug of glass ionomer cement (Vidrion, SS White Artigos Dentários Ltda., Brazil), was placed 1 mm inside the pulp chamber and 1 mm below the cement–enamel junction. Samples were randomly divided in four experimental groups of 10 teeth each, according to the bleaching technique used.

For each group, an amount of 0.2 ml of bleaching agent was used in the pulp chamber (groups 1, 2 and 3) as well as on the buccal surface (groups 1 and 2), measured with a calibrated syringe.

Group I received 35% hydrogen peroxide gel (Whiteness HP, FGM, Joinville, SC, Brazil) activated by a LED unit (Laser Light, Kondortech, São Carlos, SP, Brazil) with a wavelength of 470 ± 10 nm provided by eight LEDs with 4 μcd each, associated to a therapeutic diode laser (790 nm, 30 mW, continuous emission). Group II received 35% hydrogen peroxide gel activated by halogen lamp (XL 3000, 3M Dental Products, Saint Paulo, MN, USA), with a light intensity of 450 mW cm^{-2}.

In these groups, the light source was placed perpendicularly to the dental surface and activated for 30 s on the buccal and another 30 s on the lingual aspects of the teeth. After 2 min, the bleaching agent was removed from the dental surface with 3% hydrogen peroxide solution. This operation was performed four times overall.

Group III received 35% hydrogen peroxide gel and the walking bleach technique was followed. The 35% hydrogen peroxide gel was placed inside the pulp chamber, a dry, small cotton pellet was positioned over it and sealed with a hygroscopic, hydraulic and eugenol-free temporary restorative material (Dentalville, Dentalville do Brasil, Joinville, SC, Brazil) (16, 17). The bleaching agent was replaced every 5 days, with three changes after the first procedure. During this time, samples were stored in artificial saliva at 37°C, 100% humidity. Group IV (control group) received a dry cotton pellet inside the pulp chamber sealed with temporary restoration. Samples were kept under the same circumstances as Group III.

After the bleaching procedures, the coronal chamber of the teeth were washed with distilled water and filled with a neutralizing paste prepared with calcium hydroxide (Merck KGaA, Darmstadt, Germany) and distilled water for 15 days (18).

The temporary restorations were removed and the coronal chamber was entirely cleaned and rinsed with distilled water. Teeth were externally

waterproofed with two layers of ethyl cyanoacrylate (Super Bonder®, Henkel Loctite Adesivos Ltda, Itapevi, Brazil) and immersed in a 10% copper sulfate aqueous solution (Merck KGaA, Darmstadt, Germany) for 30 min, in vacuum for the first 5 min. Specimens were then removed from the copper sulfate solution, dried with absorbing paper and immersed in a 1% rubianic acid alcohol solution (Merck KGaA, Darmstadt, Germany), following the afore-mentioned technique: the first 5 min in vacuum and another 25 min in the solution (19). Copper ions were revealed by the rubianic acid, resulting in specific coloration that ranged from dark blue to black, depending on the amount of copper ion penetration.

Afterwards, specimens were individually positioned in a sectioning machine with a water-cooled 300 μm thick diamond saw (Minitom, Struers A/S, Copenhagen, Denmark). Specimens were embedded in chemically activated acrylic resin blocks, and serially sectioned in a mesiodistal direction, thus providing three transverse cuts 500 μm thick. The first sectioning was accomplished at the level of the cervical plug and the subsequent cuts were obtained incisally from that point. The sections were grounded under water refrigeration using no. 400–600-grit silicon carbide paper to obtain a flattened, smooth surface and a final thickness of approximately 100 μm. The cuts were washed under tap water for 4 h, carefully fixed on microscopic slides and observed under ×5 magnification using a digital imaging system provided by an optical microscope (Axiostar Plus, Carl Zeiss) connected to a camera (Cybershot DSC-575, Sony Corp., Tokyo, Japan). The images obtained were analyzed using the AxioVision v3.1 software (Carl Zeiss-Jena Vision).

Each cut was divided into four areas of similar size (Fig. 1). Two quantitative measurements (in mm) were obtained in each quadrant the largest extent of dye penetration (Fig. 2a) and the total extent of dentin (Fig. 2b). Then, the percentage of dye penetration and the mean value for each section were calculated. Final percentage of copper ion penetration in each tooth resulted from the mean of the three cuts. Data obtained were submitted to one-way ANOVA using a factorial design with bleaching technique as independent variable.

Results

The results for the experimental groups are illustrated in Table 1. Results showed an increase of permeability values for groups I, II and III when compared with group IV ($P < 0.05$); however, no statistical differences where found between the three tested bleaching techniques ($P > 0.05$). Activation of 35% hydrogen peroxide by LEDs or halogen lamp, or the walking bleach technique produced similar increase on dentinal permeability.

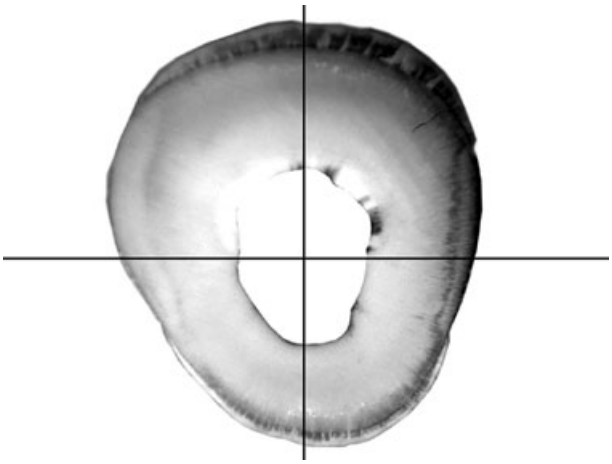

Fig. 1. Transverse section of sample, with schematic drawing illustrating the four quadrants.

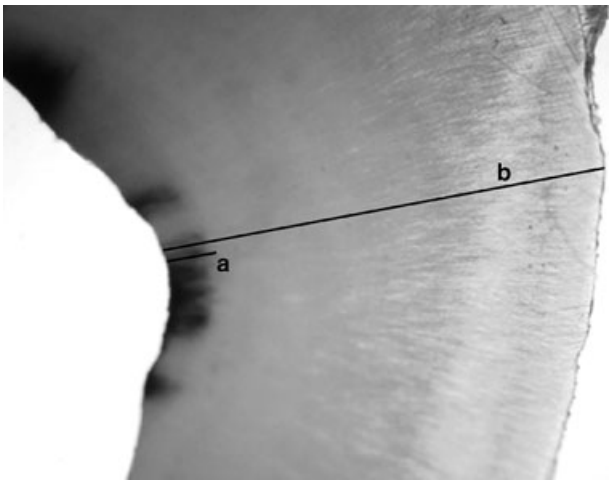

Fig. 2. Quantitative measurements: (a) the largest extent of dye penetration in the quadrant; (b) the total extent of dentin in the quadrant.

Table 1. Mean values (%) and standard deviation of dentinal permeability after intracoronal bleaching therapy

	LED	Halogen lamp	Walking bleach	Cotton pellet (control)
Copper ions penetration	5.64% (±5.51) a	7.33% (±5.28) a	8.89% (±5.88) a	0.13% (±0.28) b

Values followed by the same letters (a or b) indicate statistical similarity.

Discussion

Variations on dental bleaching techniques have been studied in order to obtain a more effective treatment (20). In this study, the alterations on

dentinal permeability of pulpless teeth after intracoronal bleaching therapy with 35% hydrogen peroxide activated by LEDs, halogen lamp or the walking bleach technique were assessed.

The walking bleach technique, reported by Nutting & Poe (21), is performed by placing sodium perborate and 30% hydrogen peroxide in the pulp chamber with periodic replacements until the desired color is reached. Many clinicians consider this as an effective method (22), with a good success rate that endures for years after the procedure (23).

Recently, dental bleaching agents activated by lasers, LEDs or halogen lamps are routinely used by clinicians, but the correct understanding of their implications on dental hard tissues still need more consideration. The protocol used in this study is the same followed for external dental bleaching in vital teeth.

Hydrogen peroxide dissociation is a slow process; however, when associated to a catalyst, it will rapidly decompose into water and free radicals (3), enhancing bleaching process (26).

The dental bleaching agent used in this study (Whiteness HP, FGM, Joinville, SC, Brazil) is presented as a two-component system, where a thickening agent is added to 35% hydrogen peroxide. The first has in its composition an organic pigment that dies the mixture producing a carmine color, which after photoactivation is decomposed, returning the mixture to a transparent color (11). LEDs and lasers produce a minimum increase in temperature, which does not happen when halogen lamp-based curing units are used to activate such agents (9).

Independent of the technique used, success of dental bleaching is directly related to the ability of the whitening substance to penetrate deep into dentinal tubules and reach the discolored molecules (2, 9).

Dentinal permeability has been evaluated in previous studies with different bleaching agents (25–27) and techniques (6, 7). In the present study, the penetration of copper ions observed in experimental groups was similar, indicating an equal increase of dentinal permeability produced by the three techniques evaluated.

Light-activated dental bleaching has the advantages of being less time-consuming (12), more comfortable to the patient, producing immediate results (28) and is more controllable by the clinician (24). While the higher cost for the patient may be a drawback for some patients, the convenience may be a determining factor for others (29). The clinician must evaluate the necessities of each patient, indicating the best technique.

Based on these results, it can be concluded that 35% hydrogen peroxide based dental bleaching agents activated by LED, halogen lamp or used following the walking bleach technique produce the same increase in dentinal permeability.

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