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Efficacy of intracoronal bleaching techniques with different light activation sources

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Abstract

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Aim To evaluate *ex vivo* the efficacy of 35% hydrogen peroxide for intracoronal bleaching when activated by LEDs, halogen lamp or by the walking bleach technique.

Methodology Forty extracted human maxillary central incisors had their crowns resected 1 mm below the amelo-cemental junction and were submitted to artificial staining in centrifuged rat haemolysed blood. A 2-mm thick glass ionomer cervical plug was placed inside the canal, at the level of the amelo-cemental junction. Samples were divided randomly into five groups: group I received 35% hydrogen peroxide gel activated by LEDs. Group II received 35% hydrogen peroxide gel activated by a halogen lamp-based light curing unit. Group III received 35% hydrogen peroxide gel followed by the walking bleach technique. Group IV was neither artificially stained nor bleached (positive control) and group V was stained, but not bleached (negative control). The shade of the teeth was assessed visually by three independent and calibrated evaluators, before and after bleaching. The results were analysed using Kruskal–Wallis one-way analysis of variance and Dunn's post-test.

Results No statistical differences regarding sample shades were found amongst groups for the tested internal bleaching techniques ($P > 0.05$).

Conclusions Hydrogen peroxide for intracoronal bleaching when activated either by LEDs, halogen lamp or by the walking bleach technique presented similar efficacy.

Keywords: halogen lamp, hydrogen peroxide, internal dental bleaching, LED, light activation.

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Introduction

Tooth discolouration is an aesthetic problem that may require treatment based on bleaching (Kaneko *et al.* 2000). Internal dental bleaching is an established, simple, conservative and cost-effective method of improving the colour of discoloured teeth that have received root canal treatment (Lee *et al.* 2004, Lim *et al.* 2004).

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Many techniques have been used for dental bleaching, especially for root-filled teeth. The majority rely on an oxidation reaction in order to reverse the chromatic alteration of the dental tissues (Smigel 1996, Sulieman 2004).

Heat sources have been used to accelerate the bleaching process of concentrated hydrogen peroxide. However, activation of the bleaching agent by such means has been questioned, because of its possible deleterious effects on tooth and surrounding tissues (Trope 1997). More recently, the techniques and materials used for dental bleaching rely on methods which are less harmful to the tooth, surrounding tissues and oral mucosa, but still remaining efficient in promoting the desired colour change. The use of

bleaching agents activated by light sources allows more rapid treatment with controlled temperature variations (Pelino *et al.* 2001) as the product absorbs most of the energy, instead of the tooth (Baik *et al.* 2001, Zanin & Brugnera 2002).

The recent bleaching agents intended for professional application are based on 35–50% hydrogen peroxide with photosensitive components that act as starters to initiate and catalyse the reaction when exposed to light sources (Sun 2000). Such sources can be derived from blue-coloured halogen curing lamps, LEDs, infrared CO_2 lasers, blue-coloured plasma arc lamps, blue argon lasers and 980-nm GaAlAs lasers (Dostalova *et al.* 2004).

LEDs are a cost-effective alternative to lasers, with less energy needed to generate light (Kurachi *et al.* 2001). The efficiency of LEDs is also better when compared with halogen lamps from light curing units, producing less heat (Yap & Soh 2003).

The efficacy of different methods of activation of 35% hydrogen peroxide gels for the intracoronal bleaching technique has not yet been determined. The aim of this study was to evaluate the intracoronal bleaching ability of 35% hydrogen peroxide when activated by LEDs, halogen lamp or when used in the walking bleach technique.

Materials and methods

Maxillary central incisors from 30 to 70-year-old patients extracted within a 6-month period and stored in 0.4% sodium azide solution at 4 °C were used. Teeth were scaled with an ultrasonic scaler (Profi III Bios, Dabi Atlante, Ribeirão Preto, SP, Brazil) to remove calculus and remnants of periodontal ligament, polished with water/pumice slurry in dental prophylactic cups, thoroughly rinsed and dried with absorbent paper. After careful visual inspection and tactile examination using the tip of a dental probe under a stereoscope (10× magnification, 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 (1 mm below the cement–enamel junction) and the crowns were immersed in 17% Ethylene Diamine Tetraacetic Acid (EDTA) for 5 min to remove smear layer.

Artificial staining of the crowns was performed following a modification of the method proposed by Freccia & Peters (1982). Blood from adult male Wistar rats (weighing 200–250 g) was obtained, heparin was added to avoid coagulation (Cristália Produtos Químicos e Farmacêuticos LTDA, Itapira, SP, Brazil) and centrifugation was performed at 11 180 ***g*** for 10 min. The blood serum was discarded and distilled, deionized water was added to 60 mL of the precipitated blood to complete 100 mL.

The mixture was centrifuged at 11 180 ***g*** for 20 min. The haemoglobin rich haemolysed blood was collected and samples were immersed in it, undergoing centrifugation following the same parameters described for every 24 h for 4 days. During this period, the crowns were immersed in the haemolysed blood solution. The samples were then washed in distilled water, dried with absorbent paper and kept at 37 °C, 100% air humidity for 15 days.

A cervical plug of glass ionomer cement (Vidrion, SS White Artigos Dentários Ltda., Rio de Janeiro, Brazil), was placed 1 mm above and 1 mm below the cement–enamel junction. Samples were divided into three experimental groups of 10 teeth each, according to the bleaching technique used, as well as positive and negative control groups of five samples each.

Group I received 35% hydrogen peroxide gel (Whiteness HP, FGM Produtos Odontológicos, Joinvile, SC, Brazil) on the buccal surface and inside the pulp chamber. Light activation was performed with LEDs (Brightness LaserLight, Kondortech, São Carlos, SP, Brazil) for 30 s on the buccal and another 30 s on the lingual aspect of the tooth, at a distance of 5 mm. After 2 min, the bleaching gel was removed from the samples with cotton pellets immersed in 3% hydrogen peroxide solution, and the process repeated until four applications were performed. Group II was given the same treatment as group I, but activation was performed with an halogen lamp based light curing unit (XL 3000, 3M Dental Products, Saint Paul, MN, USA). Group III received the bleaching gel inside the pulp chamber, a cotton pellet was placed on it and the cavity was sealed a with temporary restorative material (Dentalville, Dentalville do Brasil, Joinville, SC, Brazil), simulating the walking bleach technique. The bleaching agent was replaced every 5 days, for a total of four applications. Group IV was neither artificially stained nor bleached (positive control) and group V was stained, but not bleached (negative control). All samples were kept immersed in artificial saliva (Faculdade de Ciências Farmacêuticas de Ribeirão Preto - USP,

Ribeirão Preto, SP, Brazil) at 37 °C during the period of the experiment.

The colour of each tooth was assessed visually by three independent and calibrated evaluators. Calibration was obtained by asking the evaluators to match two Vita shade guides, one of them without colour identification. When correct matching was 75% or greater, the evaluator was considered calibrated. Assessment was performed before and after tooth bleaching, using the Vita Lumin shade guide (VITA, Zahnfabrik, Bad Säckingen, Germany) under a white background and standardized lighting conditions, comparing the crowns to the shade guide. When at least two evaluators agreed on a sample shade, the value was recorded. If all evaluators failed to obtain a common decision, the sample was re-evaluated by all of them. The shade guide was ordered by value order from lightest to darkest, as determined by the manufacturer, and a corresponding position number assigned (Table 1) to allow statistical analysis. This evaluation method is similar to the one proposed by Lim *et al.* (2004). Data was analysed using Kruskal–Wallis one-way analysis of variance, complemented by Dunn's post-test.

Results

After artificial staining with haemolysed blood, groups were compared to verify inter-group differences that could affect results. Statistical analysis (Kruskal–Wallis) performed before the tooth bleaching procedures revealed differences regarding shade colour amongst groups ($P = 0.036$). Dunn's post-test revealed that these differences were restricted to group IV (positive control, mean shade colour = 6, SD = 2), which did not undergo the artificial staining process, thus revealing an uniform sample and the efficacy of the staining method.

The shade colours were also compared after bleaching procedures. Statistical analysis (Kruskal–Wallis) revealed the differences between shade colours of the groups ($P = 0.030$). However, Dunn's post-test specified only group V (negative control) as being different from the others (mean shade colour = 11, SD = 2), indicating that the bleaching methods were able to lighten the samples.

The differences between shades before and after the dental bleaching process were also compared amongst groups I–III (Kruskal–Wallis), revealing a homogenous efficacy between the tested methods ($P = 0.901$). Thus, no statistical differences were found between the internal bleaching techniques ($P > 0.05$). Table 2 shows the mean tab positions before and after bleaching, as well as the mean numeric changes of the samples of groups I–III.

Discussion

Evaluation of tooth bleaching methods relies either on spectrophotometer analysis (Vachon *et al.* 1998, Wetter *et al.* 2004) or visual colour determination (Lim *et al.* 2004). The visual shade guide has some deficiencies, and possibly the most evident is the lack of colour variation between the thirds of crowns (Amengual Lorenzo *et al.* 1996). However, statistically significant differences between shades assessed by a spectrophotometer are not perceptible by human eye (Vachon *et al.* 1998). Tung *et al.* (2002) evaluated colour matching either by experienced clinicians or a colorimeter, attesting the reliability of the second. Okubo *et al.* (1998) reported similar readings obtained by a colorimeter or visual means when shade guides were compared. Therefore, although subjective, visual colour determination is reliable enough to be used either by researchers or clinicians (Horn *et al.* 1998, Li *et al.* 2003, Lim *et al.* 2004).

The method proposed by Freccia & Peters (1982) to artificially stain extracted teeth *ex vivo* proved to be reliable, consistent and easily reproducible. It simulates one of the main causes of intrinsic tooth discolouration, which is the oxidation of haemoglobin inside dentinal tubules after pulp haemorrhage in traumatized teeth (Ingle & Bakland 1994, Ari & Üngör 2002). Comparison amongst experimental groups in the present study revealed that this method is able to produce standardized, visually noticeable and statistically significant tooth discolouration.

The walking bleach technique was initially proposed to be used with sodium perborate, as reported by Nutting & Poe (1963). It is an effective and economic method to treat tooth discolouration, with a good

Table 1 Vita lumen shade tabs arranged in order of increasing value and the position value ascribed (from Lim *et al.* 2004)

Vita tab	B1	A1	B2	D2	A2	C1	C2	D4	A3	D3	B3	A3.5	B4	C3	A4	C4
Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Table 2 Summary of the shade position before and after dental bleaching sessions using different methods

Group	Before, mean (SD)	After, mean (SD)	Mean (Δ)
LED	12 (4)	7 (2)	5
Halogen lamp	12 (4)	7 (4)	5
Walking bleach	11 (3)	6 (2)	5
Positive control	6 (2)	6 (2)	0
Negative control	11 (2)	11 (2)	0

SD, standard deviation.

success rate (Glockner *et al.* 1999). However, reports state that 30–35% hydrogen peroxide is more effective than sodium perborate for intracoronal bleaching (Ho & Goerig 1989, Lim *et al.* 2004).

The bleaching action is because of the oxidoreduction reaction between the whitening agent and the darkened substrate. This reaction modifies the dyed molecule and alters some of its characteristics, including colour. The success of bleaching therapy is directly related to the ability of the whitening substance to penetrate deep into dentinal tubules and reach the discoloured molecules (Carrasco *et al.* 2003).

External cervical resorption associated with intracoronal bleaching is a common concern amongst clinicians, and a cervical plug over the root canal filling is mandatory to avoid such accidents (Baratieri *et al.* 1995). In the present study, a 2 mm cervical plug with glass ionomer cement was placed at the cement–enamel junction to simulate optimum clinical conditions.

The use of light activation methods that do not produce considerable amounts of heat are able to catalyse the dissociation of hydrogen peroxide into water and free oxygen, thus hastening the reaction (Smigel 1996). This method is well accepted by patients, as it requires less treatment time, is more comfortable and has immediate results (Benjamin 2002).

In the present study, two different light sources for hydrogen peroxide activation were used, a LED-based device and a light curing unit. The results obtained are similar to the ones registered for the walking bleach technique using professionally applied hydrogen peroxide gels. Activation by light sources seems to hasten the reaction and provide the same level of bleaching that would require some days to be reached by the walking bleach technique.

As hydrogen peroxide is unstable, production of free oxygen will eventually occur with or without the use of a light source. In the present study, the hydrogen peroxide gel was left inside the pulp chamber for 5 days, a length of time that probably caused most of the gel to degrade into oxygen and water. The fact that the samples were kept at 37 °C might also have contributed to the oxygen production. This may explain the similar results obtained for the walking bleach and light activated techniques.

The walking bleach technique requires less overall chair time than the light activated ones, but the patient will not experience immediate results. The choice of which method to be used relies on the preference of the clinician and the patient, as they are equally effective.

Conclusions

The results of the present study indicate that 35% hydrogen peroxide is as effective in lightening discoloured teeth either when used in the walking bleach technique, activated by LEDs or halogen lamp based curing units.

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