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Ex vivo evaluation of the effectiveness of bleaching agents on the shade alteration of blood-stained teeth

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Abstract

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Aim To evaluate *ex vivo* effectiveness of the three formulations of bleaching materials for intracoronal bleaching of root filled teeth using the walking bleach technique.

Methodology Extracted premolar teeth were stained artificially with human blood. After biomechanical preparation, the root canals were filled and a 3-mm thick intermediate base of zinc phosphate cement was placed at the level of the cementoenamel junction. The teeth were divided into four groups ($n = 12$): C (control, without bleaching material), A1 (sodium perborate + distilled water), A2 (sodium perborate + 10% carbamide peroxide) and A3 (sodium perborate + 35% carbamide peroxide). The bleaching materials were changed at 7 and 14 days. Evaluation of shade was undertaken with aid of the VITA Easyshade™ (ΔE^*ab) and was performed after tooth staining and at 7, 14 and 21 days after bleaching, based on the CIELAB system. Data were analysed by ANOVA for repeated measurements, Tukey and Dunnett tests ($\alpha = 0.05$).

Results The Tukey test revealed that group A1 (10.58 ± 4.83 ΔE^*ab) was statistically different from the others (A2, 19.57 ± 4.72 ΔE^*ab and A3, 17.58 ± 3.33 ΔE^*ab), which were not different from each other. At 7 days: A1 was significantly different from A2; at 14 and 21 days: A2 and A3 were significantly better than A1; the Dunnett test revealed that the control group was different from A1, A2 and A3 at all periods ($P < 0.05$).

Conclusion Sodium perborate associated with both 10% and 35% carbamide peroxide was more effective than when associated with distilled water.

Keywords: carbamide peroxide, dental materials, nonvital tooth, shade, sodium perborate, tooth bleaching.

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Introduction

Correct diagnosis of the cause of tooth discolouration is important, as shade changes as a result of different aetiologies may require different treatment strategies. Thus, teeth with healthy pulps may be bleached by the home technique, termed night guard vital bleaching or vital tooth bleaching, in-office techniques or an association of both (Barghi 1998). Root filled teeth may be treated by the walking bleach technique, thermocathalytic technique or an association of techniques (Ari & Üngör 2002).

Shade change associated with root filled teeth are related primarily to improper coronal access, haemorrhage during pulpotomy, pulpectomy and trauma or because of the intracanal medicaments and filling materials remaining in the pulp chamber (Grossman 1978). The intracoronal bleaching technique was

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introduced by Spasser (1961), who employed a paste made of sodium perborate and water, which was temporarily placed in the pulp chamber. This technique was modified by Nutting & Poe (1963), who replaced water by superoxol. Stewart (1965) described the thermocathalytic method, in which a cotton pellet saturated with superoxol should be placed in the pulp chamber and heated with an instrument.

In the presence of acids, warm air or water, sodium perborate decomposes to form sodium metaborate, hydrogen peroxide and nascent oxygen (Cohen & Burns 1998). Hydrogen peroxide then forms free radicals by the alkaline pH of the solution, resulting in hydroperoxyl ($HO_2\bullet$) and hydroxyl ($HO\bullet$), free radicals with unpaired electrons. These are electrophilic and unstable, and will attack most other organic molecules to achieve stability, resulting in the oxidation-reduction reaction that makes darkly pigmented organic molecules into simpler and brighter molecules (Goldstein & Garber 1995).

Hydrogen peroxide, when in an acidic medium, breaks down into oxygen ions and hydroxyl free radicals, whereas in an alkaline medium (between 9.5 and 10.8) it produces hydroperoxyl free radicals that are oxidizing, improving the bleaching effect (Goldstein & Garber 1995, Sun 2000). Utilization of hydrogen peroxide for bleaching of root filled teeth has been associated with undesirable side effects, such as external cervical root resorption (Harrington & Natkin 1979), increased dentinal permeability (Dezotti *et al.* 2002) and alterations in the chemical structure of dentine (Rotstein *et al.* 1992).

The aetiology of external cervical root resorption is unknown (Trope 1997), but it has been suggested that passage of bleaching agents to the periodontal tissues through the dentinal tubules would cause an inflammatory process around the teeth (Harrington & Natkin 1979). This depends on the type of cementoenamel junction, because the small gaps existing along the cervical line would expose the dentine to the periodontium (Neuvald & Consolaro 2000).

Utilization of a cervical intermediate base following root filling is advocated for prevention of external cervical root resorption (Loguercio *et al.* 2002), in order to avoid penetration of the bleaching agent in apical (Yui *et al.* 2004) and lateral directions (Steiner & West 1994). At the same time, utilization of bleaching agents with low pH (Weiger *et al.* 1993) and application of heat (McInerney & Zillich 1992) should be avoided.

Sodium perborate is a biocompatible bleaching agent, whereas 30% hydrogen peroxide has been reported to be too aggressive (Asfora *et al.* 2005); thus, the association of sodium perborate and distilled water has been indicated, since it is as effective as the association of sodium perborate and hydrogen peroxide (Ho & Goerig 1989, Rotstein *et al.* 1993, Weiger *et al.* 1994, Ari & Üngör 2002). The mixing of sodium perborate and water forms sodium metaborate and hydrogen peroxide, which breaks down to release nascent oxygen needed for bleaching (Cohen & Burns 1998). Other materials have also been suggested for intracoronal bleaching, including 10% carbamide peroxide (Vachon *et al.* 1998, Perrine *et al.* 2000); association of sodium perborate and 35% carbamide peroxide (Yui *et al.* 2004) and 35% carbamide peroxide gel (Lee *et al.* 2004, Lim *et al.* 2004).

Carbamide peroxide decomposes on contact with moisture into urea, ammonia, carbon dioxide and hydrogen peroxide, which releases nascent oxygen needed for bleaching (Cohen & Burns 1998). Its gel form may act as a depot and slowly release carbamide peroxide (Lee *et al.* 2004). It can be surmised that as carbamide peroxide traverses dentine more slowly, and the rise in pH is aided by the resultant ammonia, the deionization of the hydrogen peroxide is facilitated (Sun 2000).

Associating sodium perborate and carbamide peroxide should increase the pH and, with the benefit of the gel form, can contribute to increasing the bleaching effect. Bleaching of root filled teeth is widely performed and the large variety of bleaching materials and techniques are available. This study compared the effectiveness of a variety of bleaching agents used in combination.

Materials and methods

Preparation of specimens

This study was approved by the Research Ethics Committee of the São José dos Campos School of Dentistry, UNESP, São Paulo, Brazil, protocol 070/2004-PH/CEP. The study sample was composed of 48 intact human premolar teeth recently extracted for orthodontic purposes, which were maintained in 10% formalin solution for 48 h, cleaned with manual instruments and rubber cup with pumice, and immersed in saline solution until used. The teeth were radiographically examined in a mesiodistal and buccolingual directions (for standardization of the pulp chamber size) and visualized under a stereomicroscope (for detection of cracks).

Coronal access was performed and the thickness of the buccal wall was standardized at 3 mm, checked with aid of a thickness meter (Bio-Art Equipamentos Odontológicos Ltda, São Carlos, São Paulo, Brazil) in the middle third of the buccal aspect. After pulpectomy, each root canal was enlarged using 1% sodium hypochlorite solution (Byofórmula Tecnopharma, São José dos Campos, São Paulo, Brazil) and Gates-Glidden burs number 3 and 4 (GS Brazil Comercial e Importadora Ltda, São Paulo, Brazil) to create root canals of the same size.

Artificial staining of teeth

The teeth were placed in 5.25% sodium hypochlorite solution (NaOCl; Byofórmula Tecnopharma) for 24 h to open the dentinal tubules, followed by irrigation with 5 mL of distilled water. The teeth were artificially stained with human blood using a modified procedure based on the study of Freccia & Peters (1982). The teeth were immersed in individual tubes containing 4 mL of whole blood each and centrifuged at 3000 g for 20 min, yielding a biphasic solution: plasma (supernatant) and precipitate (bottom of the tube), from which the supernatant was removed (nearly 1.5 mL), followed by further centrifugation for 20 min. The tubes containing the teeth were centrifuged at 7000 rpm for 20 min twice a day for a further two days, as previously described, and stored at 37 °C and 100% humidity in an incubator.

On the fourth day, 3 mL of distilled water were added to the blood samples (without the teeth) and the tubes were centrifuged for 20 min to promote haemolysis of erythrocytes. This yielded a biphasic solution in the tubes, containing the membranous precipitate and the haemolysate. The second layer was separated and placed in the tubes containing the teeth, which were centrifuged, for a total of three consecutive days. On each day, the teeth were irrigated with 5 mL of distilled water, re-inserted in the tubes containing the blood, and stored at 37 °C and 100% humidity. After 6 days, the blood was changed and all aforementioned procedures were repeated for further six consecutive days.

Bleaching procedure

The tooth roots were embedded in acrylic resin to enhance handling. The root canals were filled with gutta-percha (Dentsply Indústria e Comércio Ltda, Petrópolis, Rio de Janeiro, Brazil) and endodontic sealer (Sealer 26; Dentsply Indústria e Comércio Ltda); the filling material was removed to 3 mm below the cementoenamel junction. A 3-mm thick intermediate bases of zinc phosphate cement (SS White, Rio de Janeiro, Brazil), prepared according to the manufacturer's instructions, and was placed at the level of the cementoenamel junction.

The teeth were divided into four groups (n = 12), being one control group and three experimental groups, which received the following bleaching materials:

1. C (control): sterile cotton pellet.
2. A1 (Formulation 1): 30 mg of tetrahydrate sodium perborate, PS, (Terapêutica, São José dos Campos, São Paulo, Brazil) + 22 mL of distilled water.
3. A2 (Formulation 2): 20 mg of tetrahydrate sodium perborate + 16 mg of 10% carbamide peroxide gel, PC 10% (Opalescence; Ultradent Products Inc., South Jordan, UT, USA).
4. A3 (Formulation 3): 20 mg of tetrahydrate sodium perborate + 16 mg of 35% carbamide peroxide gel, PC 35% (Opalescence Quick; Ultradent Products Inc.).

The pulp chamber was filled with the appropriate bleaching material, followed by placement of a piece of absorbent paper (Melitta filter paper, Melitta Brasil, São Paulo, Brazil), adapted to the size of the coronal access. Sealing of the access cavity was performed with Cimpat (Spécialités Septodont, Saint-Maur-des-Fossés, France). The teeth were stored in individual tubes containing moist cotton (Costas & Wong 1991) and stored in an incubator at 37 °C and 100% relative humidity during 21 days of bleaching; the bleaching materials were changed at 7 and 14 days.

Evaluation of tooth shade

The specimens were evaluated for shade alteration with the aid of an intraoral dental spectrophotometer VITA Easyshade™ (VITA Zahnfabrik H. Rauter GmbH & Co. KG, Bad Säckingen, Germany). For that purpose, each tooth was individually placed in a chamber, which had a standardized light intensity (2 lamps: 5 W, 90–130 V, 50–60 Hz, I = 72 mA, Lm = 260 and FP = 0.55). The probe of the spectrophotometer was placed perpendicular to the buccal surface and in contact with the middle third of teeth. The region to be analysed was standardized by demarcation of two points with the pen Permanent Marker Sharpie™ (Sanford Corporation, Oak Brook, IL, USA) at the middle third (mesiodistal direction), at an approximate distance of 7 mm, besides two points on the lateral aspects of the probe of the spectrophotometer.

For evaluation of the shade alteration of teeth, the L^*, a^* and b^* values and the shade of teeth according to the Vita Classical shade guide were determined before staining and at 7, 14 and 21 days after bleaching. This evaluation was based on the CIELAB colour system – CIE1976 ($L^*a^*b^*$) (Commission Internationale d'Eclairage, Vienna, Austria) (Westland 2003), which allows numerical definition of shade and its three-dimensional representation, defined by the coordinates L^* from 0 to 100, which represents shade alterations in the black and white scale; a^*, which represents shade and saturation in the red–green axis; and b^*, which represents saturation in the blue–yellow axis, according to the Commission Internationale dÉclairage (CIE).

Three measurements were obtained and the mean calculated for each tooth, at each period. The effectiveness of bleaching agents (ΔE^*ab = shade alteration) was evaluated by comparison of variations in the L^*, a^* and b^* values (ΔL^*, Δa^* *e* Δb^*) at each period (7, 14 and 21 days) in relation to the initial period (stained teeth), using the following formulas (O'Brien *et al.* 1997, Chu 2003, Westland 2003, Ishikawa-Nagai *et al.* 2004, Cronin *et al.* 2005):

$$\Delta L^* = L_1^* - L_2^*$$

$$\Delta a^* = a_1^* - a_2^*$$

$$\Delta b^* = b_1^* - b_2^*$$

$$\Delta E^*ab = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{0,5}$$

The term ΔE^* is derived from the German word *Empfindung*, which means sensation. Thus, ΔE^* means the difference in sensation of shade alteration. On the other hand, ΔE^*ab is a Euclidean distance between two points in the three-dimensional space of shade.

The study followed a 3×3 factorial scheme; the study variables were **formulation** (A1, A2 and A3) and **studied periods** (7, 14 and 21 days). The response variable was the shade alteration value, expressed in ΔE^*ab unit. Data were submitted to statistical analysis using MINITAB (version 14.12, 2004) and STATISTICA (version 5.5, Stat Soft Inc., Tulsa, OK, USA, 2000). Descriptive statistics comprised calculation of mean and SD followed by analysis of variance for repeated measurements (two-way ANOVA: **formulation** and **studied period**, considering the repeated factor) and the Tukey and Dunnett tests.

Results

Comparison of bleaching formulations with the control group

The Dunnett test was performed to check the possibility of rejecting the hypothesis that the median values of the three formulations of bleaching materials were similar to the control group. The Dunnett test revealed that the shade alteration values achieved for the three formulations were significantly different from the values obtained for the control group at 7, 14 and 21 days ($P < 0.05$).

Comparison of formulations

Data on shade alteration achieved after bleaching, according to the groups and studied periods, are presented in Table 1. The ANOVA test for repeated measurements indicated that the interaction effect of the variables **formulations** and **studied period** was significant (statistic$-F_{df(4;66)} = 3.90$; P-value $= 0.006 < 0.05$). Figure 1 reveals that the relationship between the three formulations at the 7-day period was not maintained at the other periods.

The Tukey test for multiple comparisons (5%) performed to formulation effect (statistic$-F_{df(2;33)} = 21.74$; P-value $= 0.001 < 0.05$) revealed that the formulation A1 (10.58 ± 4.83 ΔE^*ab) was significantly different (P-value $= 0.00012$) from the A2 (19.57 ± 4.72 ΔE^*ab), and significantly different

Table 1 Mean (±SD) of shade alteration data (ΔE^*ab unit) achieved in the specimens after bleaching, with utilization of three fomulations of bleaching materials at three studied periods

	Formulation			
Period (days)	A1	A2	A3	line (mean ± SD)
7	8.97 ± 5.28	16.91 ± 5.53	13.93 ± 2.09	13.27 ± 5.55
14	9.82 ± 4.38	20.80 ± 4.28	19.20 ± 2.38	16.61 ± 6.14
21	12.94 ± 4.20	21.00 ± 3.22	19.62 ± 1.85	17.85 ± 4.76
column (mean ± SD)	10.58 ± 4.83	19.57 ± 4.72	17.58 ± 3.34	

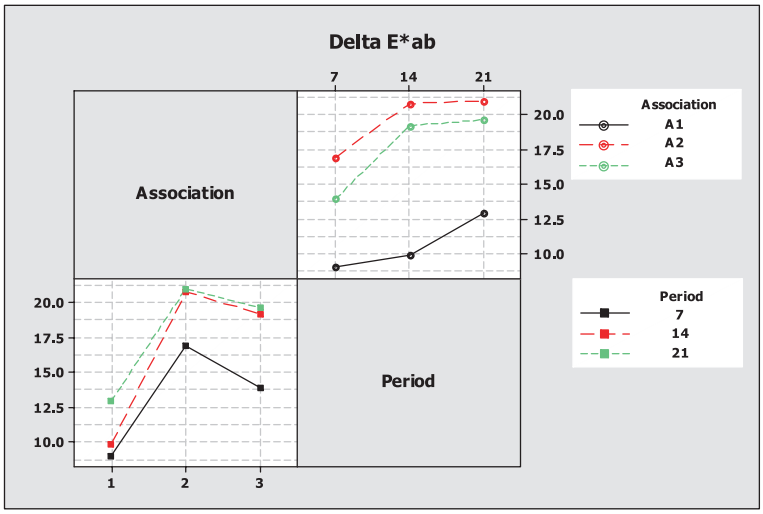

Figure 1 Graph of mean of shade alteration values (ΔE^*ab), according to the experimental conditions established by the variables: formulation and study period.

(*P*-value = 0.00019) from the A3 (17.58 ± 3.34 ΔE^*ab) which in turn were not different (*P*-value = 0.35876) from each other.

Comparison among the three formulations at each period revealed that:

- At 7 days, the formulation A1 was significantly different from A2 (*P*-value = 0.00013)
- At 14 days, the formulation A1 was significantly different from A2 (*P*-value = 0.00013)
- At 14 days, the formulation A1 was significantly different from A3 (*P*-value = 0.00013)
- At 14 days, A2 was not different from A3 (*P*-value = 0.6462)
- At 21 days, A1 was significantly different from A2 (*P*-value = 0.00014)
- At 21 days, A1 was significantly different from A3 (*P*-value = 0.00014)
- At 21 days A2 was not different from A3 (*P*-value = 0.79942)

For the formulation A1, the 7-day period was not different from the 14-day period (*P*-value = 0.98604), whereas the 21-day period was different from both the 7-day (*P*-value = 0.00072) and 14-day periods (*P*-value = 0.01562).

For the formulation A2, the 7-day period was significantly different from the 14-day (*P*-value = 0.00097) and significantly different from the 21-day period (*P*-value = 0.00049), whereas the 14-day period was not different (*P*-value = 1.000) from the 21-day period.

For the formulation A3, the 7-day period was significantly different from the 14-day (*P*-value = 0.00014) and significantly different from the 21-day period (*P*-value = 0.00014), whereas the 14-day period was not different (*P*-value = 0.99992) from the 21-day period.

Comparison of shade with aid of the Vita Classical shade guide

The teeth of the Vita shade guide were arranged as follows: B1-A1-B2-D2-A2-C1-C2-D4-A3-D3-B3-A3, 5-B4-C3-A4-C4, and were assigned increasing values from 1 to 16, from B1 to C4. The shade of specimens was analysed by the Easyshade™ scale at all periods; calculation of the shade alteration after 21 days was performed as follows: shade alteration = final shade−initial shade, e.g. B2−C4 = 3−16 = −13. The shade alteration after 21 days is presented in Table 2.

Table 2 reveals that the teeth in the control group did not undergo shade alterations, with values close to zero. For group A1, there was a mean shade alteration of 8.50 positions on the Vita shade guide; groups A2 and A3 exhibited shade alterations of 11.538 and 12.385 on the Vita shade guide, respectively.

The Dunnett test with Bonferroni's correction (5%/3) revealed that the shade alteration distribution values obtained for the three formulations were significantly different from the distribution values obtained for the control group (A1 vs. control: $P = 0.0045 < 0.017$;

Table 2 Mean, SD, minimum, maximum and median of the shade alteration values achieved for each studied group and control group, after 21 days, evaluated by the Vita shade guide

Groups	Mean	SD	Minimum	Median	Maximum
Control	0.333	0.778	0.00	0.00	2.00
A1	−8.50	4.32	−13.00	−10.00	−1.00
A2	−11.538	2.504	−14.00	−12.00	−4.00
A3	−12.385	1.121	−14.00	−12.00	−10.00

A2 vs. control: $P = 0.0001 < 0.017$ and A3 vs. control: $P = 0.0001 < 0.017$), with significant differences between groups A1 and A3 ($P = 0.0016$), and A1 and A2 ($P = 0.0149$), that is, the bleaching effect for groups A2 and A3 showed significantly difference from group A1 and the comparison among them (A2 vs. A3) showed no difference statistically significant ($P = 0.4597 > 0.017$).

Discussion

Discolouration of root filled teeth may occur because of pulp necrosis or haemorrhage secondary to dental trauma and is an aesthetic problem that may require bleaching or prosthetic treatment. Blood vessels may rupture after trauma, causing blood extravasation in the pulp chamber; this may allow erythrocytes to enter the dentinal tubules, undergo haemolysis and release haemoglobin. The haemoglobin is a conjugated protein composed of a proteic portion called globin and a nonproteic portion known as the haeme group, which is iron–protoporphyrin. The haemoglobin is decomposed and releases iron, which in turn is combined with hydrogen sulphide and gives rise to iron sulphide (Fe_2S_3), which is responsible for tooth discolouration (Freccia & Peters 1982).

The teeth were submitted to staining with human blood in order to simulate tooth discolouration caused by blood pigments (Freccia & Peters 1982, Kaneko *et al.* 2000). After centrifugation, the blood containing anticoagulant (heparin) was separated into two distinct phases: a continuous, liquid, yellowish phase called plasma; and a discontinuous, red, dense phase represented by the blood cells, thus containing haemoglobin.

Tooth discolouration was demonstrated using the Vita shade guide, to be in the C3 and C4 range, thus achieving sufficient staining for evaluation of the bleaching materials. Among the several methods available for analysis of shade alteration, the visual method by comparison of the tooth shade with porcelain or acrylic resin shade guides is the most often employed.

However, this method is subjective and may be influenced by several factors, including room lighting conditions, experience and age of the assessor and eye fatigue. Moreover, shade guides are not identical (Paul *et al.* 2002) and often do not match with the nominal shade. Despite these limitations, utilization of shade guides is a rapid and accessible method that has been employed successfully in several studies on tooth bleaching (Leonard *et al.* 1998). Elter *et al.* (2005) observed that more experienced professionals were more accurate when assessing shade and that it was a subjective process with agreement being reached in only 26.6–46.6% of cases when confirmed with the values achieved by spectrophotometers. According to Johnston & Kao (1989), variations in room lighting, the patient skin colour, wearing of make-up, colour of clothes or tooth alignment may affect the evaluation of tooth shade, making it an unreliable method of shade evaluation.

Colorimeters measure shades by the three-stimuli method, similar to the human eye, with aid of known international chromatic systems (XYZ stimuli, shade space $L^*a^*b^*$, shade space $L^*C^*h^*$ and shade space Yxy). In general, colorimeters have provided good reproduction of the shade of natural teeth, both *ex vivo* and *in vivo* (Johnston & Kao 1989, Cronin *et al.* 2005). They are designed for measurement of plain surfaces; however, teeth are not plain and may present surface anomalies (Joiner 2004). Moreover, the reliability of this system depends on the constancy of the light source, and slight misadjustments may interfere with the outcomes (Baltzer & Kaufmann-Jinoian 2005).

With regard to the spectrophotometers, the light is emitted within a reference tooth and the reflected light is decomposed into its spectral components by diffraction and compared with the incident light. The accuracy of results does not depend on the quality of incident light (Baltzer & Kaufmann-Jinoian 2005); thus, spectrophotometers provide highly accurate measurement of absolute shades. In dentistry, they are used for measurement of tooth shade, thus reducing the margin of error (Ishikawa-Nagai *et al.* 2004), being considered more accurate and reproducible than human visual evaluation (Paul *et al.* 2002), indicating the exact shade of teeth before and after bleaching (Chu 2003).

The method employing software for analysis of digital images has been employed successfully to evaluate the effectiveness of bleaching materials,

quantitatively expressing the shade alterations by the $L^*a^*b^*$ values (CIE). According to Elter *et al.* (2005), the higher the resolution of digital cameras, the higher will be the image detail, allowing more accurate shade determination, even though it is not a routine clinical method. When the groups were compared with each other, it was observed that the associations of sodium perborate and carbamide peroxide (10% and 35%) were more effective for bleaching than the association of sodium perborate and distilled water.

Distribution of the ΔL^*, Δa^* and Δb^* values indicated that the L^* values (luminosity) were increased in all groups; the Δa^* values were increased, i.e. the a^* values were more negative and thus less reddish. On the other hand, the b^* values of groups A1 and A2 increased at 7 days and reduced at 14 and 21 days, indicating an increase in yellowish shades at 7 days and reduction at 14 and 21 days; for group A3, there was a reduction in b^* values, demonstrating that the teeth were less yellowish. Reductions in the L^*, a^* and b^* values were also observed for the control group, yet these values were smaller compared with the experimental groups. The results achieved are in agreement with others, who observed increases in L^* values and reduction in a^* and b^* values after tooth bleaching (Ishikawa-Nagai *et al.* 2004) and increase in ΔL^*, Δa^* and Δb^* values (Cronin *et al.* 2005).

The mean shade alteration for formulation containing sodium perborate and 10% carbamide peroxide was 1.99 ΔE^*ab units higher than the shade alteration achieved with sodium perborate and 35% carbamide peroxide. This suggests that the bleaching effect of carbamide peroxide at lower concentrations was better, despite the lack of statistically significant difference between these two groups.

Moreover, at all studied periods, formulation A2 (sodium perborate and 10% carbamide peroxide) provided a better bleaching effect. Utilization of carbamide peroxide at lower concentrations may be recommended, since Carrasco *et al.* (2003) observed that utilization of 37% carbamide peroxide for intracoronal bleaching increased dentinal permeability, which was not observed for 27% carbamide peroxide.

Comparison of shade alteration at 21 days by the values achieved by the Easyshade™ on the Vita shade guide revealed that groups A2 and A3 were also different from A1, in agreement with the evaluation by values ΔE^*ab, and groups A2 and A3 were not different from each other. The shade alterations observed were A1 = 8.50; A2 = 11.538 and A3 = 12.385 positions on the Vita shade guide. In this evaluation, the group employing 35% carbamide peroxide was marginally, although not statistically significant, better. This in agreement with the results of Lim *et al.* (2004) who observed that 35% carbamide peroxide may be recommended for intracoronal bleaching, since the 35% carbamide peroxide gel and 35% hydrogen peroxide gel at 7 days after bleaching provided alteration of eight positions on the Vita Lumin shade guide, whereas sodium perborate associated with distilled water provided alteration of five positions ($P < 0.05$); at 14 days, the three groups provided alteration of 10 positions, without these being a significant difference among them.

Conclusion

Sodium perborate associated with both 10% and 35% carbamide peroxide was more effective than when associated with distilled water.

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