In vitro evaluation of extraradicular diffusion of 6% hydrogen peroxide during intracoronal bleaching

Avaliação *in vitro* da difusão extra-radicular do peróxido de hidrogênio a 6% durante clareamento coronário interno

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Abstract

Purpose: To evaluate the extraradicular diffusion of creamy 6% hydrogen peroxide (HP) associated or not with sodium perborate (SP) at the cervical region of endodontically treated teeth during intracoronal bleaching.

Methods: Thirty-two endodontically treated maxillary canines and central incisors were used. The gutta-percha was removed 3mm below the cement/enamel junction, and the external root surface was covered with cyanoacrylate except for the cervical region. The teeth were randomly allocated to 4 groups: G1: 6% HP+SP (n=11); G2: 6% HP (n=11); G3: distilled water (negative control, n=5) and G4: 30% HP (positive control, n=5). The specimens were immersed in a solution of potassium chromate (yellow), which turns blue in presence of HP. Two calibrated examiners (Kendall coefficient = 0.936) attributed scores according to the solution color (0 - unaltered color, 1 - light blue, and 2 - dark blue). Data were analyzed by Kruskal-Wallis and Mann-Whitney tests ($\alpha<0.05$).

Results: Eighteen percent of the 6% HP specimens with or without SP showed color alteration. Only G4 had score values statistically higher than the other groups ($P=0.004$).

Conclusion: It can be concluded that 6% HP cream did not have significant extraradicular diffusion during intracoronal bleaching but it was not 100% safe.

Key words: Intracoronal bleaching; hydrogen peroxide

Resumo

Objetivo: Avaliar a difusão do peróxido de hidrogênio (PH) 6% em creme, associado ou não ao perborato de sódio (PS) na região cervical de dentes endodonticamente tratados durante clareamento coronário interno.

Metodologia: Foram utilizados 32 caninos e incisivos superiores tratados endodonticamente. Removeu-se 3mm de guta-percha abaixo da junção cemento/esmalte e a superfície radicular externa foi impermeabilizada com cianoacrilato, exceto a região cervical. Os dentes foram divididos aleatoriamente em: G1: PH 6%+PS (n=11); G2: PH 6% (n=11); G3: água destilada (controle negativo, n=5) e G4: PH 30% (controle positivo, n=5). Os espécimes foram imersos em solução de cromato de potássio (cor amarela), que se torna azul na presença do PH. Dois avaliadores calibrados (coeficiente de Kendall = 0,936) atribuíram escores de acordo com a cor da solução evidenciadora (0 - cor inalterada; 1 - azul claro e 2 - azul escuro). Os dados foram analisados pelos testes de Kruskal-Wallis e Mann-Whitney ($\alpha=0,05$).

Resultados: Em 18% dos casos houve difusão extra-radicular do PH 6%, estando este associado ou não ao perborato de sódio. Apenas o G4 apresentou valores estatisticamente maiores que os demais ($P=0,004$).

Conclusão: Pode-se concluir que o PH 6% em creme não apresentou difusão extra-radicular significativa durante o clareamento coronário interno, mas não foi 100% seguro.

Palavras-chave: Clareamento interno; peróxido de hidrogênio

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Introduction

Pulpless teeth often show crown discoloration due to by-products from pulp chamber hemorrhage, incomplete removal of pulp tissue (1,2) or inadequate procedures during endodontic therapy (3). For aesthetic treatment of discolored and non-vital teeth, the use of bleaching agents directly in the pulp chamber (intracoronal bleaching) is a simple and conservative technique compared to prosthetic procedures. For many years intracoronal bleaching was performed by using 30-35% hydrogen peroxide associated with a heat source – the thermocatalytic technique (4). The rationale behind the use of peroxide for dental bleaching is that peroxide dissociates into water and oxygen ions, which are able to diffuse through the dentine and oxide the pigments responsible for color alteration (5).

Despite its successful bleaching effect, the thermocatalytic technique is not used nowadays due to its adverse effects, particularly external root resorption (6). Several studies demonstrated that hydrogen peroxide may diffuse through defects in the cement/enamel junction (CEJ) to the periodontal tissue, increasing local acidity and osteoclastic activity (4,7,8). Thus, other techniques with different bleaching agents were developed. Spasser (9) introduced the use of sodium perborate associate with distilled water. When in contact with water, sodium perborate dissociates into sodium metaborate and hydrogen peroxide. In 1963, Nutting and Poe (10) proposed the use of sodium perborate with "superoxol" (30% hydrogen peroxide) and introduced the "walking bleaching" technique for intracoronal bleaching, which is the main technique used at present (11).

For the "walking bleaching" procedures, different vehicles and concentrations of hydrogen peroxide have been used such as solution at 30% w/w (original technique) (12), solution at 3% w/w (13), or cream at 20% v/v (14), corresponding to 6% w/w. These concentrations of hydrogen peroxide have different caustic effect and may induce external root resorption. In addition to caustic effect, the diffusion capacity of these solutions through the dentine tubules in the cervical area to the periodontal tissue may also lead to tissue alterations (15,16).

Thus, the aim of this study was to evaluate the diffusion of creamy hydrogen peroxide (6% w/w), associated or not with sodium perborate, through the cervical area of extracted human teeth during intracoronal bleaching. The *a priori* hypothesis was that 6% creamy hydrogen peroxide does not have high extraradicular diffusion.

Methods

This study was approved by the Committee of Ethics in Research of the State University of Montes Claros – Unimontes (Protocol 069/2003). The sample comprised thirty-two extracted human maxillary incisors and canines, with completely formed root and intact crown, stored in thymol solution at 9°C.

The coronary access was initially accomplished with a #1557 tapered carbide bur (S.S. White Dental Products, Rio de Janeiro, RJ, Brazil) at high speed, followed by #2 and #4 *Batt burs* (Dentsply/Maillefer Instruments, Ballaigues, Switzerland) at low speed. The finishing of the cavity walls was performed with a Endo-Z bur (Dentsply/Maillefer). The root canals were prepared by using a crown-down manual technique with K files and # 2 to # 6 Gates Glidden drills (Dentsply/Maillefer). During instrumentation, the irrigation was accomplished with 2.5% sodium hypochlorite solution (Biodinâmica Produtos Químicos Ltda, Ibiporã, PR, Brazil). Sequentially, the root canals were filled with gutta-percha cones (Konne, Belo Horizonte, MG, Brazil) and endodontic sealer Endofill (Dentsply, Petrópolis, RJ, Brazil) using the lateral condensation technique.

After the conclusion of the endodontic procedures, the cervical portion of the filling was removed 3 mm below the CEJ. For this, it was measured 3 mm in the external surface of the root with a millimeter periodontal probe. The guta-percha was removed with a heated Paiva condenser accomplishing the vertical condensation simultaneously in the cervical portion of the filling until that there was correspondence with the external radicular reference. The external cervical region was marked in the buccal, palatal, mesial, and distal surfaces. Afterwards, the entire external radicular surface was covered with three layers of cyanoacrylate (SuperBonder®, Loctite, Itapeva, SP, Brazil) except for 3 mm of the root corresponding to the desobtured root canal. Holes in the incisal portion of each tooth were made with a #1 round drill (S.S. White Dental Products) at high speed for posterior tooth fixation in the assay tube.

The teeth were randomly divided into four groups according to the material put into the intracoronal cavity: G1 – 6% creamy hydrogen peroxide associated with sodium perborate (n=11); G2 – 6% creamy hydrogen peroxide (n=11); G3 – distilled water (negative control, n=5); and G4 – 30% peroxide hydrogen solution (positive control, n=5). The aqueous solution of 30% hydrogen peroxide and the sodium perborate were obtained from a manipulation pharmacy (Nature Farm, Montes Claros, MG, Brazil). The creamy 6% (20 volumes) hydrogen peroxide is commercially available (Biocolor®, Niasi, Taboão da Serra, SP, Brazil). Wax was used as a provisory sealer and was covered with three layers of cyanoacrylate (SuperBonder®, Loctite).

To assess the extraradicular diffusion in the cervical region a chemical method modified from a previous study (17) was used. Each tooth was perpendicularly fixed in an assay tube using a metallic wire inserted through the holes made in the incisal portion. The assay tube contained a solution of potassium chromate of yellow color (Fig. 1), which turns blue in presence of HP. The solution composition was 50 mL of deionized distilled water, 10 drops of sulfuric acid 10 N, 2 mL of 10% potassium chromate, and 2 mL of sulfuric ether.

Two calibrated evaluators attributed scores according to the color of the indicator solution (0 – unaltered color, 1 – light blue with presence of bubbles and 2 – dark blue) after 2 h (Fig. 2). The Kendall coefficient showed a high inter-examiner agreement (0.0936). Score data were analyzed by

non-parametric tests (Kruskal-Wallis and Mann-Whitney tests) at the 0.05 level of significance using the statistical package SPSS 11.0.

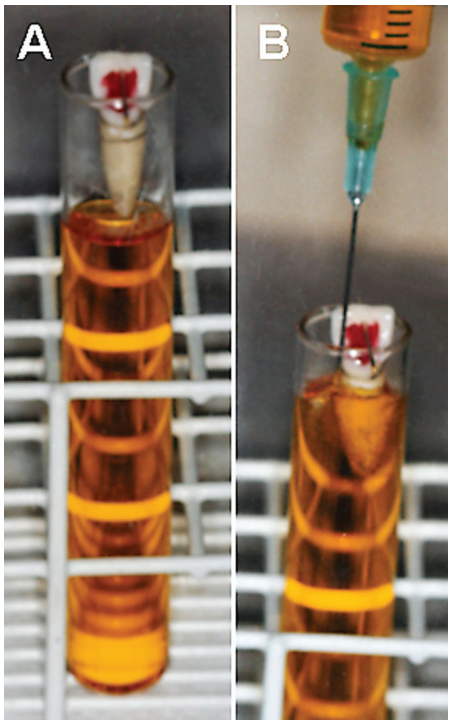

Fig. 1. **(A)** Fixation of the tooth into the assay tube containing the chemical indicator solution. **(B)** Completion with the solution until the external cervical limit.

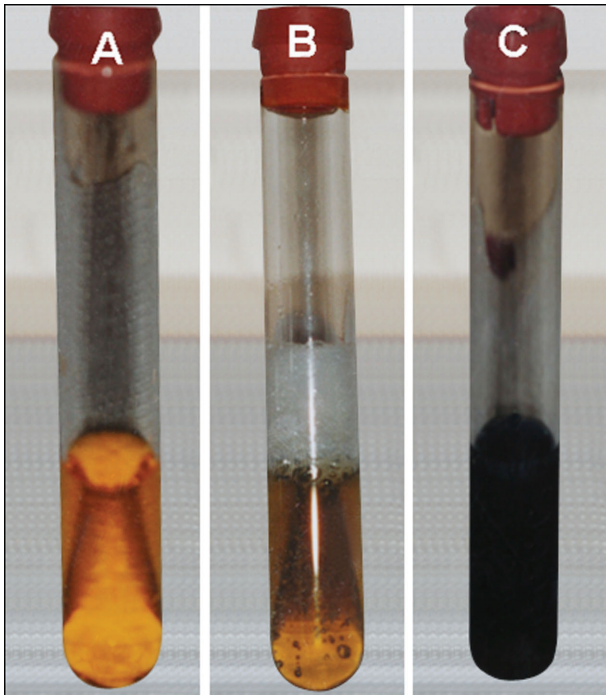

Fig. 2. Score system used for examiner's calibration according to the indicator solution color: **(A)** Score 0, **(B)** Score 1, **(C)** Score 2.

Results

As expected, G3 (negative control group) did not show any color change of the indicator solution. In G4 (30% hydrogen peroxide), the color alteration occurred immediately for 2 teeth and faster than 2 minutes for 3 teeth. For G1 and G2, which used 6% hydrogen peroxide associated or not with sodium perborate, the color alteration occurred between 10 min and 1 hour. Only G4 had higher scores than the other groups (P=0.004) (Table 1).

Table 1. Absolute and relative frequency of the scores given to specimen group according to color alteration of the indicator solution.

Score	Group 1		Group 2		Group 3		Group 4	
	n	%	n	%	n	%	n	%
0	9	82	9	82	5	100	0	0
1	2	18	2	18	0	0	0	0
2	0	0	0	0	0	0	5	100
*	A		A		A		B	

* Different letters indicate statistically significant difference at the 5% level of significance.

Discussion

This study showed that extraradicular diffusion of 6% creamy hydrogen peroxide occurred in only 18% of the cases, either associated or not with sodium perborate. In the presence of 6% creamy hydrogen peroxide, the indicator color was closer to the distilled water than the liquid 30% hydrogen peroxide.

Previous laboratory studies have been conducted to assess the behavior of bleaching agents, mainly hydrogen peroxide, during intracoronal bleaching of human extracted teeth, particularly maxillary central incisors (18,19). In the current study maxillary canines were included due to the difficulty to obtain incisors to complete the sample. Maxillary canines present large pulp chamber, which facilitates the experimental procedures in studies on intracoronal bleaching (17,20).

In the present investigation, although the teeth were not totally immersed in the indicator solution, the coronary openings were protected in order to prevent the leakage of bleaching agents through this area. Thus, the diffusion of the bleaching material occurred only through the cervical dentin tubules, exposed by CJE defects (21). It is important to emphasize the difficulty to obtain teeth with similar CJE characteristics, which lead some researchers to create artificial defects along the external cervical area to standardize the diffusion of bleaching agents (13,19). In the methodology of the current experiment, this procedure was not performed, and the anatomic gap/CJE variability could be a limitation of this study. However, the teeth were randomly divided into all the experimental and control groups to reduce any anatomic bias.

The literature does not always present a positive association between intracoronal bleaching and presence of root

resorption (22,23). These contradictory results are mainly related to the causes of dental discoloration; for example, previous trauma can lead to external root resorption and color alteration, which could induce erroneous conclusions about the bleaching effect in this pathology. Regarding the bleaching agent, its presentation form and concentration of hydrogen peroxide may also explain some different results for intracoronal bleaching and external root resorption.

The high concentration of hydrogen peroxide in bleaching agents has been related to the external root resorption in animal models (16). However, the exact mechanism of root resorption caused by intracoronal bleaching is not completely understood. It is believed that the bleaching agent reaches the periodontal tissues and begins an inflammatory reaction by increasing the local acidity (7,8,24), which may cause dentin denaturation and start a immunological reaction (25). Thus, two factors seem to be important to promote external root resorption: peroxide concentration and quantity that reaches the periodontal tissue.

The hypothesis tested in this study was that the 6% creamy hydrogen peroxide does not present high diffusion through CJE. The indicator solution was used and validated previously (17) and has its color altered from yellow to blue in presence of hydrogen peroxide. Thus, the color alteration is directly proportional to the amount of peroxide. The use of 6% creamy hydrogen peroxide, associate or not with sodium perborate, did not significantly alter the color of the indicator solution, similarly to distilled water, but 30% hydrogen peroxide promoted significant color alteration. This suggests that lower concentration of 6% hydrogen peroxide and its creamy presentation turns the bleaching agent more viscous and reduces its flowing capacity and diffusion to cervical dentin (4,19). Thus these findings suggest that it would be safer to use creamy 6% hydrogen peroxide than liquid 30% hydrogen peroxide considering the risk for external root resorption following intracoronal bleaching.

It is necessary to point out that approximately 18% of the cases treated with creamy 6% hydrogen peroxide displayed some color alteration. In contrast, only distilled water would be 100% safe considering the acidity of the bleaching agent and its potential external root resorption. In this manner, some studies have suggested the association of distilled water with sodium perborate for intracoronal bleaching (7,9). Further studies should evaluate the extraradicular diffusion of the association of creamy 6% hydrogen peroxide with sodium perborate, and the need of a cervical barrier in the root canal entrance previously to the bleaching procedure (1,11,12,14,15).

Conclusion

According to the methodology used it can be concluded that creamy 6% hydrogen peroxide did not have significant extraradicular diffusion during intracoronal bleaching but it was not 100% safe.

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