

# Evaluation of extraradicular pH after intracoronary bleaching using four bleaching agents

*Avaliação do pH externo após clareamento intracoronário utilizando quatro agentes clareadores*

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### **ABSTRACT**

The present *in vitro* study evaluated the pH values of extraradicular medium after intracoronary bleaching with 30% hydrogen peroxide or 10% carbamide peroxide and different associations of sodium perborate. The study was composed of 50 extracted human premolars, randomly divided into five groups, according to the bleaching agent employed for intracoronary bleaching of these teeth: a) distilled water; b) sodium perborate with distilled water (2g/ml); c) sodium perborate with 10% carbamide peroxide (2g/ml); d) sodium perborate with 30% hydrogen peroxide (2g/ml); e) 30% hydrogen peroxide. Coronal access was performed, followed by root canal filling, confection of a cervical intermediate base with resin-modified glass ionomer cement (Vitremmer-3M/ESPE) and application of the bleaching agents. The teeth were stored in plastic flasks containing distilled water, using a mechanical device. Measurement of pH of the extraradicular medium (distilled water) was performed immediately and 7 days after insertion of the bleaching agents. The pH values were analysed using the two-way ANOVA and Tukeys test at significance level of 5%. The results of the present study confirmed the alkalinity of associations of sodium perborate and the acidity of 30% hydrogen peroxide at the immediate period. Considering the results achieved, it can be concluded that the bleaching agents employed changed the pH of the extraradicular medium at 7-day period.

### **UNITERMS**

Non-vital tooth; tooth bleaching; intracoronary bleaching; carbamide peroxide; sodium perborate; hydrogen peroxide.

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## **INTRODUCTION**

Shade alteration of the coronal portion of non-vital teeth may be the result of several factors, such as improper coronal access, hemorrhage of the pulpal

capillaries after to trauma or surgical removal of the pulp, persistence of necrotic pulp tissue and/or remnants of filling materials in the pulp chamber<sup>7</sup>, as well as utilization of root canal dressings and sealers<sup>20</sup>. The trauma to pulpal blood vessels leads

to hemorrhage and breakage of hemoglobin, which releases iron. This released iron is combined with hydrogen sulfide and produces iron sulfide, a black component that darkens the tooth<sup>17</sup>.

The bleaching techniques for non-vital teeth include the thermocatalytic method, walking bleach method, and combined methods<sup>1</sup>. The bleaching agents that are most commonly used for whitening of root filled teeth are hydrogen peroxide, carbamide peroxide and sodium perborate<sup>20</sup>. These materials may be employed both individually and combined. Hydrogen peroxide is the active ingredient in currently used tooth bleaching materials. It might be applied directly or can be produced by a chemical reaction from carbamide peroxide or sodium perborate.

Utilization of hydrogen peroxide for bleaching of root filled teeth has been associated with undesirable side effects<sup>18,26</sup>, such as external cervical resorption<sup>8,12,13</sup>, increased dentinal permeability<sup>4</sup>, alterations in the chemical structure of dentine<sup>23</sup> and morphological changes in the cemento-enamel junction<sup>5</sup>. The etiology of external cervical resorption is unknown, 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<sup>12</sup>. This depends on the type of cemento-enamel junction, because the small gaps existing along the cervical line would expose the dentine to the periodontium<sup>19</sup> and decrease the pH at the cemento-enamel junction<sup>14,22</sup>.

Considering the hypothesis that the acidity of bleaching agents is one of the main factors causing external cervical root resorption, it seems logical to expect that maintenance of neutral or close to neutral pH would prevent the establishment of inflammation.

In an attempt to keep this neutrality of the periodontal pH, the association of sodium perborate and water has been recommended to prevent or minimize the occurrence of external cervical root resorption<sup>1,17,27,28</sup>.

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. According to Yui et al.<sup>29</sup> (2008), sodium perborate with both 10% and 35% carbamide peroxide was more effective than when associated with distilled water. Moreover, Souza-Zaroni et al.<sup>25</sup> (2009) verified that the sodium perborate and 37% carbamide peroxide association for intracoronary bleaching has proven to be as effective as sodium perborate and distilled water.

Bleaching of root filled teeth is widely performed and the large variety of bleaching materials are available<sup>6</sup>. Most studies investigating the pH or radicular penetration of hydrogen peroxide during intracoronary bleaching have been performed using non-vital teeth. Carbamide peroxide, which has more recently recommended for use in intracoronary bleaching, has not been evaluated<sup>16</sup>. This study investigated the pH values resulting from the combination of different agents used for intracoronary bleaching, in order to evaluate the influence of these substances on the pH changes of the extraradicular medium.

## MATERIALS AND METHODS

The study was composed of 50 intact human premolar teeth recently extracted, which were maintained in 10% formalin solution for 48h, cleaned with manual instruments and immersed in saline solution (0.9% NaCl solution; Halex Istar) until utilization.

Coronal access was performed and after pulpectomy, each root canal was enlarged using 1% sodium hypochlorite solution (Byofórmula Technopharma, São José dos Campos, SP) and Gates-Glidden burs number 2 and 3 (GS Brazil Comercial e Importadora Ltda., São Paulo) up to 5mm below the root canal opening in apical direction. The root canals were prepared and filled with gutta-percha points (Dentsply Indústria e Comércio Ltda., Petrópolis, RJ) and endodontic sealer (Sealapex – Kerr®/Sybron). After root canal filling, the teeth were radiographically examined in a mesio-distal and bucco-lingual directions.

The filling material was removed to 3mm below the cemento-enamel junction. A 3-mm thick cervical intermediate base of resin-modified glass ionomer cement (Vitremex, 3M/Espe) was prepared according to the manufacturer's instructions and placed at the level of the cemento-enamel junction.

The teeth were randomly divided into five groups (n=10), which received the following bleaching materials:

- G1 – Control (distilled water);
- G2 – Sodium perborate + distilled water (2g:1ml);
- G3 – Sodium perborate + 10% carbamide peroxide (2g:1ml);
- G4 – Sodium perborate + 30% hydrogen peroxide (2g:1ml);
- G5 – 30% hydrogen peroxide.

All materials were weighed on an analytical balance and the bleaching agents were prepared following the proportions. The pulp chambers were filled with the bleaching agents, following by placement of a cotton pellet. Sealing of the coronal access was performed with temporary cement (Citodur, Dorident, Vienna, Austria), with approximately 3-mm thickness (Figure 1).

Twenty milliliters of distilled water were placed in plastic flasks (FujiFilm - LDPE), and the pH of this water was evaluated with a pHmeter (Digimed DM-20, São Paulo, SP, Brazil) (Figure 2).

Immediately after application of the bleaching agents and sealing, the teeth were fixated to the plastic flask (Figure 3) with a metallic orthodontic wire (Morelli Ortodontia, 0,70mm, Sorocaba – SP, Brazil) and were kept immersed in distilled water. The pH values were evaluated immediately and 7 days after the intracoronal bleaching. During this period, the tooth was kept immersed in the same medium without any change of distilled water or bleaching agent.

The results were analysed using the two-way ANOVA and Tukeys test at significance level of 5%.

## RESULTS

The mean of pH values verified after immersion of teeth in distilled water, immediately and after 7-day period are presented in Table 1.

Evaluation of the effect of bleaching agent by the Tukeys test (5%), displayed in Table 2, revealed that the control – distilled water (G1) differed from the bleaching agents W+SP (G2), HP (G5), SP+HP (G4) and SP+CP (G3).

## DISCUSSION

During bleaching, the hydrogen peroxide and rising oxygen, produced by decomposition of the former, are diffused through the root dentin and reach the periodontal space, especially in the presence of defects at the cemento-enamel junction<sup>19,21,24</sup>. In contact with the periodontal tissues, these products may trigger an inflammatory process, which is one of the main factors leading to external cervical root resorption<sup>3,11,12,15</sup>.

Comparison among the study groups revealed that the association of sodium perborate and distilled water presented the highest mean pH value at the immediate period, whereas the lowest values were

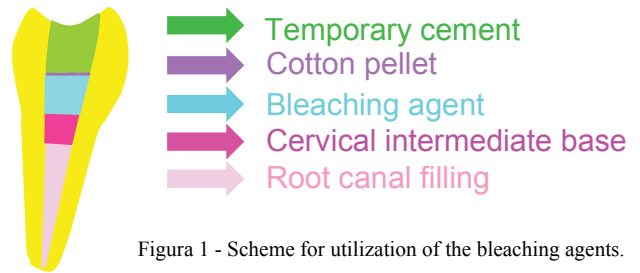


Figure 1 - Scheme for utilization of the bleaching agents.



Figure 2 – pHmeter (Digimed DM 20).



Figure 3 – Device for fixation of teeth.

observed for 30% hydrogen peroxide (Table 1). These results confirm the alkalinity of the association of sodium perborate with water and the acidic pH of hydrogen peroxide, observed during analysis of pH of these materials.

At the immediate period, the highest pH values of the extraradicular medium were observed for bleaching performed with the association of water

and sodium perborate (G2). However, the increase in these values with time was not significant during the 7-day period (Table 1).

The groups presenting the largest changes, with increase in pH of the extraradicular medium during the 7-day period, were the associations of sodium perborate with carbamide peroxide (G3) and sodium perborate with hydrogen peroxide (G4) (Table 1).

Only the control group (G1) and the association of water with sodium perborate (G2) kept a stable pH of the medium at 7-day period. All other groups revealed a significant increase in the mean pH values with time, with observation of highest value for the association of sodium perborate with carbamide peroxide (G3) at 7-day period (Table 1).

The increase in the pH value of the extraradicular medium with time for the association of sodium perborate with carbamide peroxide (G3) may be explained by degradation of carbamide peroxide into hydrogen peroxide and urea, followed by decomposition of hydrogen peroxide into water and

oxygen and urea into carbon dioxide and ammonia, the latter being highly alkaline<sup>16</sup>.

In this study, after 7 days of intracoronary bleaching, all groups presented an increase in pH of the extraradicular medium, with values higher than 7.0, except for the control group, due to the passage of bleaching agents through the dentinal tubules, allowing extraradicular diffusion of hydrogen peroxide. According Gökay et al.<sup>10</sup> (2008), both hydrogen peroxide and carbamide peroxide bleaching agents penetrate to the extraradicular region of teeth; however, the level of peroxide penetration from carbamide peroxide gels was significantly lower than that of an hydrogen peroxide and sodium perborate mixture. Carbamide peroxide gels may carry less risk of post-bleaching external root resorption than hydrogen peroxide and sodium perborate bleaching agents.

Dezotti et al.<sup>4</sup> (2002) also observed diffusion of bleaching materials through the cervical root dentin, achieving an increase in pH of water in which the teeth were placed, except for the control group. The

**Table 1 – Mean (± standard deviation) of pH values verified after immersion of teeth according to time**

Period	G1 (Control)	G2 (W+SP)	G3 (SP+CP)	G4 (SP+HP)	G5 (HP)	Line (mean±sd)
Immediate	6.53±0.16	7.03±0.21	6.72±0.20	6.95±0.47	6.44±0.16	6.73±0.34
7-day	6.65±0.23	7.14±0.35	8.47±0.58	7.88±0.52	7.26±0.20	7.48±0.75
Column (mean±sd)	6.59±0.16	7.09±0.28	7.60±0.99	7.42±0.68	6.85±0.45	

**Table 2 – Tukeys test (5%) for 7-day period**

Groups	Mean	Homogeneous groups
G1 (Control)	6.650	A
G2 (W + SP)	7.143	B
G5 (HP)	7.262	B
G4 (SP + HP)	7.887	C
G3 (SP + CP)	8.476	D

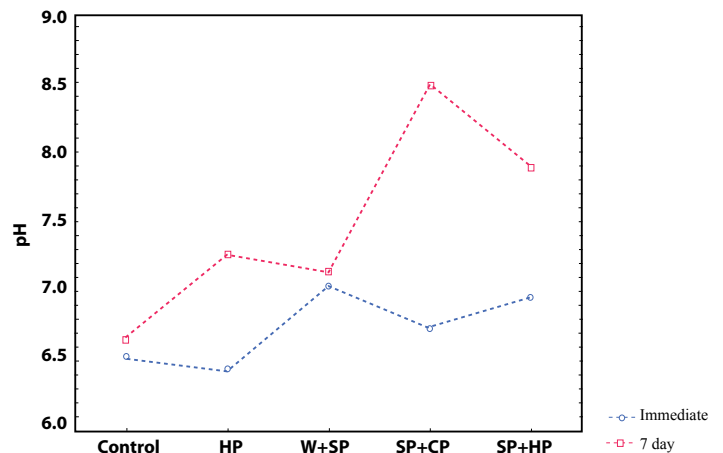


Figure 4 – Means graph of pH values verified for experimental conditions.

study conducted by Dezotti et al.<sup>4</sup> (2002) demonstrated that the pH of the paste prepared with 2g of sodium perborate powder and 1ml of 30% hydrogen peroxide liquid is alkaline. These results agree with the reports of Rotstein and Friedman<sup>22</sup> (1991), yet Dezotti et al.<sup>4</sup> (2002) did not observe an increased alkalinity with time, in disagreement with the present results, which revealed an increase in pH from the immediate period to the 7-day period for all associations of sodium perborate.

Fuss et al.<sup>9</sup> (1989) evaluated the ability of infiltration of bleaching agents in the pulp chamber through the dentinal tubules, by measurement of pH changes of the external medium to the root surface. The significant pH increase of the external medium, from 7.0 to 9.0 in three days, indicated that the bleaching agents penetrated through the dentinal tubules and reached the external medium. However, the study of Fuss et al.<sup>9</sup> (1989) was conducted on young teeth, which present wider dentinal tubules, besides removal of the cervical cementum to simulate a gap between the enamel and cementum at the cervical region.

Lee et al.<sup>16</sup> (2004) verified that the extraradicular diffusion of hydrogen peroxide was inversely proportional to the increase in external root pH. The quantity of hydrogen peroxide detected in the extraradicular medium in group of carbamide peroxide was significantly lower than group of hydrogen peroxide and not significantly different from group of sodium perborate. However, regardless of the bleaching agent employed, there was ion diffusion through the dentinal tubules, with change in pH of the extraradicular medium to the root surface.

The hydrogen peroxide group, which had a slightly acidic pH at the immediate period, demonstrated an

increase in the mean pH value, leading to alkalinity of the medium after the 7-day period, which suggests that 30% hydrogen peroxide employed for internal bleaching without utilization of heat and after performed of an effective cervical intermediate base would not be a predisposing factor to external cervical root resorption. These results support the view of Rotstein and Friedman<sup>22</sup> (1991) that it is unlikely that cervical root resorption is the result of an acidic extraradicular pH environment produced by the bleaching agents. Bleaching agents can cause alterations in the chemical structure of dentine<sup>23</sup> and the acid pH probably produces an acid-etch effect on dentine, opening up the smear layer covered cut surface dentinal tubules, increasing its permeability<sup>2</sup>. This then probably permits greater diffusion of hydrogen peroxide through the dentinal tubules, particularly at cemental defects that may be present at the cements-enamel junction<sup>19,24</sup>. Perhaps if the level of hydrogen peroxide goes beyond the critical level, then destructive cervical root resorption is seen<sup>16</sup>.

## CONCLUSION

The present study confirmed the alkalinity of associations of sodium perborate and acidity of 30% hydrogen peroxide at the immediate period. Considering the results achieved, it can be concluded that the bleaching agents employed changed the pH of the extraradicular medium at 7-day period.

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## RESUMO

O objetivo deste estudo foi avaliar *in vitro* os valores de pH do meio externo após a realização do clareamento interno utilizando o peróxido de hidrogênio a 30% e diferentes associações de perborato de sódio. Foram utilizados 50 pré-molares humanos, distribuídos aleatoriamente em cinco grupos, de acordo com o agente clareador utilizado para o clareamento interno desses dentes: a) água destilada; b) perborato de sódio com água destilada (2g/ml); c) perborato de sódio com peróxido de carbamida 10% (2g/ml); d) perborato de sódio com peróxido de hidrogênio 30% (2g/ml); e) peróxido de hidrogênio 30%. Foi realizada a abertura coronária, obtenção do canal radicular, confecção de um tampão cervical com cimento de ionômero de vidro modificado por resina (Vitremmer-3M/ESPE), e, posteriormente, a inserção do agente clareador. Os dentes foram armazenados em potes plásticos com água destilada, utilizando um dispositivo mecânico. A mensuração do pH do meio (água destilada) foi realizada imediatamente e 7 dias após a inserção dos agentes clareadores. Os dados obtidos foram submetidos a ANOVA – dois fatores e Teste de Tukey a 5%. Os resultados deste estudo confirmaram a alcalinidade das associações de perborato de sódio e a acidez do peróxido de hidrogênio a 30% no período inicial. Considerando os resultados obtidos, pode-se concluir que os agentes clareadores utilizados modificaram o pH do meio externo em um período de 7 dias.

## UNITERMOS

Dente desvitalizado; clareamento de dente; clareamento interno; peróxido de carbamida; perborato de sódio; peróxido de hidrogênio.

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## REFERENCES

1. Ari H, Ungor M. In vitro comparison of different types of sodium perborate used for intracoronar bleaching of discoloured teeth. *Int Endod J.* 2002 May;35(5):433-6.
2. Carrasco LD, Froner IC, Corona SA, Pecora JD. Effect of internal bleaching agents on dentinal permeability of non-vital teeth: quantitative assessment. *Dent Traumatol.* 2003;19:85-9.
3. Cvek M, Lindvall AM. External root resorption following bleaching of pulpless teeth with oxygen peroxide. *Endod Dent Traumatol.* 1985;1(2):56-60.
4. Dezotti MSG, Souza Júnior MHS, Nishiyama CK. Avaliação da variação de pH e da permeabilidade da dentina cervical em dentes submetidos ao tratamento clareador. *Pesqui Odontol Bras.* 2002;16(3):263-8.
5. Esberard R, Esberard RR, Esberard RM, Consolaro A, Pameijer CH. Effect of bleaching on the cemento-enamel junction. *Am J Dent.* 2007;20(4):245-9.
6. Fearon J. Tooth whitening: concepts and controversies. *J Ir Dent Assoc.* 2007;53(3):132-40.
7. Freccia WF, Peters DD. A technique for staining extracted teeth: a research and teaching aid for bleaching. *J Endod.* 1982 Feb.;8(2):67-9.
8. Friedman S. Surgical-restorative treatment of bleaching related external root resorption. *Endod Dent Traumatol.* 1989;5(1):63-7.
9. Fuss Z, Szajkis S, Tagger M. Tubular permeability to calcium hydroxide and to bleaching agents. *J Endod.* 1989 Aug.;15(8):362-4.
10. Gökay O, Ziraman F, Çali Asal A, Saka OM. Radicular peroxide penetration from carbamide peroxide gels during intracoronar bleaching. *Int Endod J.* 2008;41:556-60.
11. Gonzales JR, Rodekirchen H. Endodontic and periodontal treatment of an external cervical resorption. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2007;104:70-7.
12. Harrington GW, Natkin E. External resorption associated with bleaching of pulpless teeth. *J Endod.* 1979 Nov.;5(11):344-8.
13. Heller D, Skriber J, Lin LM. Effect of intracoronar bleaching on external cervical root resorption. *J Endod.* 1992 Apr.;18(4):145-8.
14. Kehoe JC. Ph reversal following in vitro bleaching of pulpless discolored teeth. *J Endod.* 1987 Jan.;13(1):6-9.
15. Lado EA, Stanley HR, Weisman MI. Cervical resorption in bleached teeth. *Oral Surg Oral Med Oral Pathol.* 1983;55(1):78-80.
16. Lee GP et al. Extraradicular diffusion of hydrogen peroxide and pH changes associated with intracoronar bleaching of discoloured teeth using different bleaching agents. *Int Endod J.* 2004;37(7):500-6.
17. Macey-Dare LV, Williams B. Bleaching of a discoloured non-vital tooth: use of a sodium perborate/water paste as the bleaching agent. *Int J Paediatr Dent.* 1997;7(1):35-8.
18. Marin PD. Intra-coronar bleaching: the past, present and future. *Ann R Australas Coll Dent Surg.* 2006;18:36-9.
19. Neuvald L, Consolaro A. Cementoenamel junction: microscopic analysis and external cervical resorption. *J Endod.* 2000;26:503-8.
20. Plotino G, Buono L, Grande NM, Pameijer CH, Somma F. Nonvital tooth bleaching: a review of the literature and clinical procedures. *J Endod.* 2008;34(4):394-407.
21. Rotstein I. In vitro determination and quantification of 30% hydrogen peroxide penetration through dentin and cementum during bleaching. *Oral Surg Oral Med Oral Pathol.* 1991;72(5):602-6.
22. Rotstein I, Friedman S. Ph variation among materials used for intracoronar bleaching. *J Endod.* 1991 Aug.;17(8):376-9.
23. Rotstein I, Lehr Z, Gedalia I. Effect of bleaching agents on inorganic components of human dentin and cementum. *J Endod.* 1992;18:290-3.
24. Rotstein I, Torek Y, Misgav R. Effect of cementum defects on radicular penetration of 30% H2O2 during intracoronar bleaching. *J Endod.* 1991 May;17(5):230-3.
25. Souza-Zaroni WC, Lopes EB, Ciccone-Nogueira JC, Silva RC. Clinical comparison between the bleaching efficacy of 37% peroxide carbamide gel mixed with sodium perborate with established intracoronar bleaching agent. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2009;107(2):43-7.
26. Tredwin CJ, Naik S, Lewis NJ, Scully C. Hydrogen peroxide tooth-whitening (bleaching) products: review of adverse effects and safety issues. *Brit Dent J.* 2006;200(7):371-6.
27. Weiger R, Kuhn A, Lost C. Effect of various forms of sodium perborate on the pH of bleaching agents. *J Endod.* 1993 May;19(5):239-41.
28. Weiger R, Kuhn A, Lost C. Radicular penetration of hydrogen peroxide during intra-coronar bleaching with various forms of sodium perborate. *Int Endod J.* 1994 Nov.;27(6):313-7.
29. Yui KCK, Rodrigues JR, Mancini MNG, Balducci I, Gonçalves SEP. *Ex vivo* evaluation of the effectiveness of bleaching agents on the shade alteration of blood-stained teeth. *Int Endod J.* 2008;41:485-92.

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