



## pH-changes during Intracoronal Bleaching: An *in vivo* Study

Daphne Câmara Barcellos, Alessandra Buhler Borges, Regina Célia dos Santos Pinto Silva  
Luciana Maria Ribeiro, Cesar Rogério Pucci, Carlos Rocha Gomes Torres

### ABSTRACT

**Objectives:** This study aimed to measure pH changes during 14 days intracoronal bleaching with hydrogen peroxide/sodium perborate and carbamide peroxide/sodium perborate.

**Materials and methods:** Twenty patients presenting endodontically treated central maxillary incisors with color alterations were divided in two groups (n = 10): Group CP + SP: 37% carbamide peroxide + sodium perborate paste; Group HP + SP: 30% hydrogen peroxide + sodium perborate paste. The pH values were measured using a digital microprocessor at different times: Baseline, 2, 7 and 14 days. Data were analyzed with two-way ANOVA followed by Tukey's test ( $\alpha = 0.05$ ).

**Results:** ANOVA showed  $p < 0.00$  which indicated significant difference between the groups. The mean values ( $\pm$  sd) and the results of the Tukey's test were: HP + SP/14 days—7.98 ( $\pm 0.58$ )a; HP + SP/7 days—8.59 ( $\pm 0.18$ )b; HP + SP/2 days—8.83 ( $\pm 0.32$ )bc; HP + SP/Baseline—8.83 ( $\pm 0.01$ )bc; CP + SP/Baseline—8.89 ( $\pm 0.01$ )bc; CP + SP/14 days—9.11 ( $\pm 0.58$ )cd; CP + SP/7 days—9.54 ( $\pm 0.16$ )de; CP + SP/2 days—9.66 ( $\pm 0.08$ )de. The group HP + SP resulted in significantly lower pH values compared with group CP + SP.

**Conclusion:** It can be concluded that both associations showed alkaline pH values; however, there was significant reduction in the pH values of the 30% hydrogen peroxide associated with sodium perborate after 14 days.

**Clinical Significance:** The association of hydrogen peroxide and carbamide peroxide with sodium perborate paste presented alkaline characteristics during the 14-day evaluated period. Thus, regarding pH changes, both associations can be considered safe as intracoronal bleaching agents.

**Keywords:** Bleaching agents, Peroxides, Intracoronal, pH.

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### INTRODUCTION

In 1976, Nutting and Poe<sup>1</sup> introduced the 'walking bleach' intracoronal bleaching technique and used to regain the

natural color of dental crown. This technique combine sodium perborate and hydrogen peroxide (concentrations of 30-35%) which is inserted into the pulp chamber. More recently, carbamide peroxide (concentration of 37%) has also been used in the 'walking bleach' intracoronal bleaching technique showing good results.<sup>2</sup>

However, these bleaching agents can cause adverse effects, among them external cervical root resorption and superficial structural changes in dentin.<sup>3,4</sup> External cervical root resorption may occur due to inflammatory reaction caused by internal bleaching procedure.<sup>5,6</sup> The pH decrease caused by bleaching agents at the periodontal tissue<sup>7</sup> can stimulate osteoclastic activity resulting in bone resorption.<sup>8</sup> Additionally, peroxides might change the organic and inorganic compounds of dentin tissue<sup>9,6</sup> and can generate denaturation of dentin proteins, which induces a foreign body reaction.<sup>6,10</sup> Some authors state that pH variation of the bleaching agents can cause this denaturation.<sup>6,11-13</sup>

When a bleaching agent is inserted into the pulp chamber, oxidation reactions initiate resulting in variation of pH solution.<sup>14</sup> However, most studies have been carried *in vitro*,<sup>7,8,15</sup> and it is difficult to consider the real change of pH values that occur *in vivo*. Due to the occurrence of side effects associated to pH decrease of bleaching agents inside pulp chamber and because the available data on the pH values of bleaching agents were conflicting and the need of *in vivo* studies, the purpose of this study was to measure, *in vivo*, the pH values of the materials commonly used for bleaching pulpless teeth (walking bleach technique) at different time intervals after application. The null hypothesis investigated was that both bleaching agents present no pH change during the study period.

### MATERIALS AND METHODS

This study was submitted and approved by the Research Ethics Committee of São José dos Campos School of

Dentistry, for research involving human beings. Patients were selected from a triage at the Department of Restorative Dentistry, from São José dos Campos School of Dentistry – UNESP. Twenty patients, age range 18 to 55 years, were chosen. The subjects had central maxillary incisors endodontically treated with discolorations. The cause of tooth discoloration was determined by medical history, and a radiograph was made to check the quality of the root filling.<sup>16,17</sup>

Patients with the following characteristics were included: no caries in the discolored tooth; medical history of trauma to dental tissue; no gingival inflammation; adequate quality of the root filling; normal width of the periodontal ligament space and no history of previous intracoronary bleaching.

All subjects signed a treatment terms agreement with the risks involved during the bleaching procedure.<sup>17</sup> Two calibrated professionals (postgraduate students) performed the bleaching procedures.

A rubber dam was applied before performing the access. The pulp chamber was opened with spherical diamond bur and cleansed with sodium hypochlorite. The endodontic filling was reduced 3 mm below the cemento-enamel junction with Gates-Glidden burs.<sup>17</sup> The root filling was sealed with a layer of 2 mm of light-cured glass ionomer cement (Vitremmer, 3M ESPE, St Paul, MN, USA) and light cured using a halogen light curing unit (Curing Light XL 3000, 3M Dental Products, St Paul, MN, USA), with an output intensity of over 500 mW/cm<sup>2</sup>, according to the manufacturer's instruction. Patients were divided into two groups (n = 10), according to the bleaching agent used.

Group CP + SP: 2 g sodium perborate-tetrahydrate (Whiteness Perborato, FGM, Joinville, SC, Brazil) per 1 mL of 37% carbamide peroxide solution (Whiteness Super, FGM, Joinville, SC, Brazil); group HP + SP: 2 g sodium perborate-tetrahydrate (Whiteness Perborato, Joinville, SC, Brazil) per 1 mL of 30% hydrogen peroxide solution (Peróxidos do Brasil Ltda, São Paulo, SP, Brazil).

The same calibrated postgraduate student mixed the paste with standard viscosity (respecting the powder/liquid or gel ratio) for all the patients treated.<sup>17</sup> Each mixture was weighed in a balance (Mettler Toledo AB204, Alameda Araguaia, São Paulo, Brazil) and diluted in distilled water at a rate of 87.5 mg/mL, then a sample was separated. The pH values of each sample of the mixtures were recorded using a digital microprocessor Hanna model HI 9224 (Hanna Instruments, Woonsocket, RI, USA), fitted with a glass microelectrode with a combined pH probe (Ingold, Switzerland) calibrated with buffers of pH 7.0 and 9.0.

The bleaching mixture was inserted in the pulp chamber. A small sterile cotton pellet was placed on the bleaching agent and the temporary filling<sup>17</sup> was done with self-etching adhesive system (One Up Bond F Plus, Tokuyama Dental

Co.) and photocured composite (TPH, Dentsply De Trey D GmbH, Konstanz, Germany).

After the periods (2, 7 and 14 days), the pulp chamber was carefully opened, and a sample of the mixture was collected for each period. The samples were collected at the same (standardized) location in the pulp chamber to avoid pH variation at different locations. The pH values were recorded following the same protocols described previously. The pH values were recorded at baseline and after 2, 7 and 14 days respectively.

Bleaching sessions were performed regularly once in 2 weeks until the color appeared to be stable. However, no measurement of pH values has been performed again. After the last bleaching session, a calcium hydroxide/propylene glycol paste was placed in the pulp cavity for 15 days to neutralize the bleaching agents' products.<sup>17</sup> The final restoration was made with photocured composite (TPH, Dentsply).

The data were submitted to the two-way ANOVA (time of measurement and bleaching agent) and the Tukey's test. The level of significance adopted was 5%.

## RESULTS

The ANOVA results for the interaction between factors (bleaching agent and time of measurement) showed  $p = 0.0000$  ( $F = 10.53$ ) with 3 degree of freedom, which resulted in significant differences among groups.

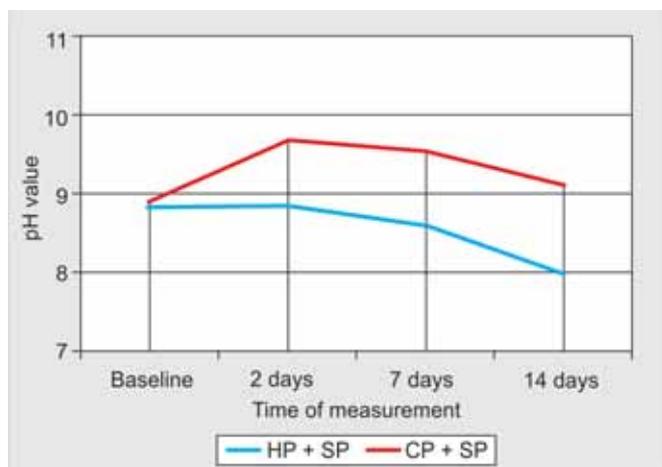
Table 1 shows the results of Tukey's test for interaction between bleaching agent and time of measurement. The group HP + SP showed significantly lower pH values than the group CP + SP. The group HP + SP/14 days showed pH values significantly lower than all other groups and the groups CP + SP/7 days and CP + SP/2 days showed the highest pH values.

Graph 1 shows the behavior of pH value means for bleaching agents in different periods of measurement.

**Table 1:** Results of Tukey's test for interaction between bleaching agent and time of measurement

Bleaching agent	Time	Mean ( $\pm$ SD)	Homogeneous sets*
HP + SP	14 days	7.98 ( $\pm$ 0.58)	A
HP + SP	7 days	8.59 ( $\pm$ 0.18)	B
HP + SP	2 days	8.83 ( $\pm$ 0.32)	B C
HP + SP	Baseline	8.83 ( $\pm$ 0.01)	B C
CP + SP	Baseline	8.89 ( $\pm$ 0.01)	B C
CP + SP	14 days	9.11 ( $\pm$ 0.58)	C D
CP + SP	7 days	9.54 ( $\pm$ 0.16)	D E
CP + SP	2 days	9.66 ( $\pm$ 0.08)	D E

\*Means accompanied by the same letters presented no statistically significant differences (HP + SP—30% hydrogen peroxide + sodium perborate-tetrahydrate; CP + SP—37% carbamide peroxide + sodium perborate-tetrahydrate)



**Graph 1:** Mean of pH values for bleaching agents according to the time of measurement. (HP + SP—30% hydrogen peroxide + sodium perborate-tetrahydrate; CP+SP—37% carbamide peroxide + sodium perborate-tetrahydrate)

## DISCUSSION

Sodium perborate contains about 95% perborate and 9.9% available oxygen.<sup>18,19</sup> When sodium perborate contacts moisture, it decomposes in hydrogen peroxide and sodium metaborate. Sodium metaborate is alkaline and raises the pH of bleaching solution. Carbamide peroxide decomposes into 6.4% urea and 3.6% hydrogen peroxide when in contact with tooth structure.<sup>18</sup> The byproduct urea decomposes into CO<sub>2</sub> and ammonia, which raises the pH value of the bleaching agent.<sup>19</sup> The hydrogen peroxide (30%) has pH value around 4.0 (acidic) and decomposes in water and nascent oxygen when in contact with the dental substrate. The nascent oxygen is responsible for bleaching.<sup>19</sup>

Some reports<sup>6,20</sup> suggest that peroxides can diffuse through the dentinal tubules, reach periodontal ligament and, consequently, bone.<sup>6</sup> This can cause complications, such as inflammatory reactions, osteoclastic activity, bone, and external cervical root resorptions.<sup>6,21,22</sup> According to Rostein and Friedman,<sup>7</sup> one of several etiological factors associated with these complications is the pH of the bleaching materials; since the low pH value of 30 to 35% hydrogen peroxide results in an acidic environment, which is favorable for osteoclastic activity and, consequently, bone resorption.<sup>6,23,24</sup> Also, bleaching agents can cause superficial structural changes to dentin,<sup>25</sup> because the low pH may produce an acid-etch effect on dentin, dissolving the smear layer and increasing diffusion of hydrogen peroxide through dentinal tubules.<sup>6,26,27</sup>

In this study, the null hypothesis was rejected because both bleaching agents showed pH variation during the study period. The group that associated 37% carbamide peroxide and sodium perborate showed pH values statistically higher than the group that associated 30% hydrogen peroxide and

sodium perborate. Confirming the findings of this study, Weiger et al<sup>15</sup> stated that the lower the hydrogen peroxide concentration, the higher the initial pH value. Thus, the 37% carbamide peroxide is equivalent to 12% hydrogen peroxide and 25% urea content which significantly reduces the final concentration of the active principle and, consequently, the pH value. Consequently, this concentration is lower as compared with the group HP + SP which used 30% hydrogen peroxide. Moreover, the urea decomposes into CO<sub>2</sub> and ammonia which raises the pH value of the bleaching agent.<sup>15</sup> Therefore, it maintains the pH value closer to the neutral pH of 7.0, decreasing the probability of side effects. Also, the byproduct of the sodium perborate decomposition is sodium metaborate which is alkaline and raises the pH of the bleaching agents.<sup>15</sup>

The group CP + SP at 2 and 7 days showed pH values significantly higher compared with group CP + SP at baseline. Perhaps, the lower pH values measurement at baseline occurred before, and the sodium perborate decomposes into sodium metaborate (alkaline compound), hydrogen peroxide and nascent oxygen. However, there is no significant difference in pH values at baseline and at 14 days for the group CP + SP. Several studies state that the alkalinity of bleaching agents increases with time, regardless of the diluting agent used,<sup>7,8,15</sup> contradicting the findings of this study. According to Haywood,<sup>9</sup> the pH value of carbamide peroxide is slightly alkaline at baseline, because it will decompose when in contact with the dental substrate. Also, for the first moment, the carbamide peroxide decomposed into hydrogen peroxide (acid) and urea (alkaline) that justify a pH value of 8.89 at baseline. Over time, the pH value increase is due to second reaction, in which hydrogen peroxide decomposes into water, oxygen and urea into CO<sub>2</sub> and ammonia which is very alkaline. In this study, the pH values were above 9.0 at 2 and 7 days of measurement.

The group HP + SP, which used 30% hydrogen peroxide associated to sodium perborate, presented significant lower pH values at 14 days of measurement. According to Rostein and Friedman,<sup>7</sup> sodium perborate is alkaline, whereas 30% hydrogen peroxide is acidic. However, the pH of the materials when mixed together gradually changed from acidic to alkaline. Also, the pH value in extraradicular environment increases with bleaching time.<sup>8,15,26</sup> This result probably is because the peroxide decomposes into oxygen and water.<sup>7</sup>

However, the pH values at 14 days of measurement showed significant decrease when compared with other times of measurement. Fuss et al<sup>8</sup> evaluated the dentinal tubular permeability of bleaching agents and found that the baseline mean pH value of the medium surrounding the teeth

with bleaching agents (sodium perborate and hydrogen peroxide 30%) was 7.0, after 1 hour increased to 7.9, increased to 9.0 after 3 days, however, after 10 days showed a slight drop to the mean 8.3.

Although the bleaching agents showed significant differences between them, all bleaching agents showed pH values above 7.0 or alkaline characters. Under the aspect that these bleaching agents do not have acidic characteristics, results of the present study are in agreement with the studies reported by Rostein and Friedman,<sup>7</sup> Fuss et al<sup>8</sup> and Wieger et al<sup>15</sup> and do not support the theory that bleaching solution probably induce side effects due to an acidic pH of the bleaching pastes.

Although the null hypothesis was rejected, this *in vivo* study suggested that the most important result was that both the associations HP/SP and CP/SP showed alkaline characteristics in all evaluated period. So, we can suggest that they can be considered safe to be used as intrapulpal bleaching agents.

However, the permanence time of bleaching agent in the pulp chamber should be controlled, and other *in vivo* studies should be performed to ensure the pH variation of bleaching agents over time.

## CONCLUSION

According to results of this *in vivo* study, it can be concluded that the 30% hydrogen peroxide associated with sodium perborate-tetrahydrate resulted in significantly lower pH values when compared with 37% carbamide peroxide associated with sodium perborate-tetrahydrate. The lowest pH values were obtained with 30% hydrogen peroxide associated with sodium perborate-tetrahydrate after 14 days of measurement. However, both associations studied remained alkaline throughout the study period.

## REFERENCES

- Nutting EB, Poe GS. A new combination for bleaching teeth. *Dent Clin Nort Am* 1976;10:655-62.
- Teixeira EC, Hara AT, Serra MC. Use of 37% carbamide peroxide in the walking bleach technique: A case report. *Quintessence Int* 2004;35(2):97-102.
- Kaneko J, Inoue S, Kawakami S, Sano H. Bleaching effect of sodium percarbonate on discolored pulpless teeth in vitro. *J Endod* 2000;26(1):25-28.
- Cvek M, Lindvall AM. External root resorption following bleaching of pulpless teeth with oxygen peroxide. *Endod Dent Traumatol* 1985;1(2):56-60.
- Heithersay GS, Dahlstrom SW, Marin PD. Incidence of invasive cervical resorption in bleached root-filled teeth. *Aust Dent J* 1994;39(2):82-87.
- 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.
- Rotstein I, Friedman S. pH variation among materials used for intracoronal bleaching. *J Endod* 1991;17(8):376-79.
- Fuss Z, Szajkis S, Tagger M. Tubular permeability to calcium hydroxide and to bleaching agents. *J Endod* 1989;8(15):362-64.
- Haywood VB. History, safety and effectiveness of current bleaching techniques and applications of the nightguard vital bleaching techniques. *Quintessence Int* 1992;23:471-88.
- Ho S, Goerig AC. An in vitro comparison of different bleaching agents in the discolored tooth. *J Endod* 1989;15:106-11.
- Demarco FF, Freitas JM, Siva MP, Justino LM. Microleakage in endodontically treated teeth: influence of calcium hydroxide dressing following bleaching. *Int Endod J* 2001;34:495-500.
- Montgomery S. External cervical resorption after bleaching a pulpless tooth. *Oral Surg Oral Med Oral Pathol* 1984;57:203-06.
- Gimlin DR, Schindler WG. The management of postbleaching cervical resorption. *J Endod* 1990;16:292-97.
- Price RBT, Sedarous M, Hiltz GS. The pH of tooth whitening products. *J Can Dent Assoc* 2000;66:421-26.
- Weiger R, Kuhn A, Löst C. Effect of various types of sodium perborate on the pH of bleaching agents. *J Endod* 1993;19(5):239-41.
- Amato M, Scaravilli MS, Farella M, Riccitiello F. Bleaching teeth treated endodontically: Long-term evaluation of a case series. *J Endod* 2006;32(4):376-78.
- de 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 intracoronal bleaching agent. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2009;107(2):e43-47.
- Joiner A. The bleaching of teeth: A review of the literature. *J Dent* 2006;34(7):412-19.
- Hanosh FN, Hanosh GS. Vital bleaching: A new light-activated hydrogen peroxide system. *J Esthet Dent* 1992;4:90-95.
- Harrington GW, Natkin E. External resorption associated with bleaching of pulpless teeth. *J Endod* 1979;5(11):344-48.
- Pashley DH, Livingston MJ. Effect of molecular size on permeability coefficients in human dentine. *Arch Oral Biol* 1978;23:391-95.
- Wang JD, Hume WR. Diffusion of hydrogen ion and hydroxyl ion from various sources through dentine. *Int Endod* 1988;2:17-26.
- Friedman S, Rotstein I, Libfeld H, Stabholz A, Heling I. Incidence of external root resorption and esthetic results in 58 bleached pulpless teeth. *Endod Dent Traumatol* 1988;4:23-26.
- Vaes A. On the mechanisms of bone resorption: The action of parathyroid hormone on the excretion and synthesis of lysosomal enzymes and on extracellular release of acid by bone cells. *J Cell Biol* 1968;39:676-97.
- Rotstein I, Dankner E, Goldman A, Heling I, Stabholz A, Zalkind M. Histochemical analysis of dental hard tissues following bleaching. *J Endod* 1996;22:23-26.
- Lee GP, Lee MY, Lum SOY, Poh RSC, Lim KC. Extraradicular diffusion of hydrogen peroxide and pH changes associated with intracoronal bleaching of discoloured teeth using different bleaching agents. *Int Endod J* 2004;37:500-06.
- Carrasco LD, Froner IC, Corona SA, Pecora JD. Effect of internal bleaching agents on dentinal permeability of nonvital teeth: Quantitative assessment. *Dent Traumatol* 2003;19:85-89.

## ABOUT THE AUTHORS

### Daphne Câmara Barcellos

Postgraduate Student, São José dos Campos School of Dentistry, São Paulo State University, São Paulo, Brazil

**Alessandra Buhler Borges**

Assistant Professor, Department of Restorative Dentistry, São José dos Campos School of Dentistry, São Paulo State University, São Paulo, Brazil

**Regina Célia dos Santos Pinto Silva**

Professor, Department of Restorative Dentistry, São José dos Campos School of Dentistry, São Paulo State University, São Paulo, Brazil

**Luciana Maria Ribeiro**

Dental Surgeon and Trainee, Department of Clinical Research Academic Group (Grupo Academico de Pesquisas Clinicas-GAPEC) São José dos Campos School of Dentistry, São Paulo State University São Paulo, Brazil

**Cesar Rogério Pucci**

Assistant Professor, Department of Restorative Dentistry, São José dos Campos School of Dentistry, São Paulo State University, São Paulo, Brazil

**Carlos Rocha Gomes Torres**

Assistant Professor, Department of Restorative Dentistry, São José dos Campos School of Dentistry, São Paulo State University, São Paulo, Brazil

**CORRESPONDING AUTHOR**

Carlos Rocha Gomes Torres, Faculdade de Odontologia de São José dos Campos, Universidade do Estado de São Paulo, Avenida Engenheiro Francisco José Longo, 777, Jardim São Dimas, São José dos Campos, São Paulo, CEP: 12245-000, Brazil, Phone: (12) 39479048, Fax: (12) 39479010, e-mail: carlosrgt@fosjc.unesp.br