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Radicular peroxide penetration from carbamide peroxide gels during intracoronal bleaching

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Abstract

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Aim To evaluate and compare radicular peroxide diffusion from different concentrations of carbamide peroxide bleaching gels.

Methodology Fifty maxillary premolar teeth were separated into five groups (n = 10). Standardized endodontic access cavities were prepared in the occlusal surfaces, and the root canals were prepared using a step back technique and filled using the lateral compaction technique. The gutta-percha filling was removed 4 mm short of the cemento-enamel junction (CEJ) and a 2-mm-thick glass–ionomer cement base was placed. Outer root surfaces were sealed with wax and nail polish, leaving the coronal third of the tooth and the CEJ exposed. All teeth were immersed in a plastic tube containing 2 mL of distilled water, and the experimental groups were treated with a bleaching agent of either 10%, 17% or 37% carbamide peroxide (CP) or a mixture of 30% hydrogen peroxide (HP) and sodium perborate (SP) placed into the coronal pulp chamber of teeth and left for 24 h. Peroxide penetration was measured using the ferrothiocyanate method. Statistical analysis of data was conducted by using the Kruskal–Wallis Analysis of Variance and Mann–Whitney U test.

Results Higher peroxide penetration occurred with the 30% HP-SP mixture than with the CP bleaching gels, and the 37% CP group also promoted greater peroxide penetration than the other CP groups ($P < 0.05$). There was no statistically significant difference between 10% and 17% CP groups ($P > 0.05$).

Conclusion Peroxide penetration of CP gels was significantly lower than that of a HP-SP mixture.

Keywords: carbamide peroxide, hydrogen peroxide, intracoronal bleaching, radicular peroxide penetration, sodium perborate.

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Introduction

Intracoronal bleaching using either the walking bleach or the thermocatalytic technique is a simple procedure for discoloured root filled teeth. The main bleaching agent used is a 30–35% concentration of hydrogen peroxide (HP), either alone or in combination with sodium perborate (SP) (Koulaouzidou *et al.* 1996). However, external root resorption has been reported as a serious complication of intracoronal bleaching with 30% HP (Harrington & Natkin 1979, Lado *et al.* 1983). Although the exact mechanism of bleaching-related root resorption is not fully understood, it has been hypothesized that bleaching agent applied inside the pulp chamber diffuses through dentine tubules to the cervical region of teeth, where it initiates an inflammatory reaction, followed by bacterial invasion and root resorption (Cvek & Lindvall 1985, Madison & Walton 1990). Other complications associated with the use of HP alone or in combination with SP include increased dentine permeability, alterations in the chemical structure of dentine and general weakening of the physical properties of dental hard tissue (Chng 2002). This has prompted a search for alternative

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bleaching agents that are as effective as the traditional ones but without the associated complications. SP moistened with water (Friedman 1997, Ari & Ungör 2002) and carbamide peroxide (CP) gels (Liebenberg 1997, Lim *et al.* 2004, Teixeira *et al.* 2004) represent two such alternatives for root filled teeth bleaching.

Aesthetic outcomes using 37% CP gel in a walking bleach technique have been found to be acceptable (Teixeira *et al.* 2004). Lim *et al.* (2004) reported that 35% CP gel used as an intracoronal bleaching agent appeared to combine the efficacy of 35% HP with the safety of SP. In addition, a 10% CP gel has also yielded similar whitening results to SP mixed with water when used intracoronally (Perrine *et al.* 2000).

Previous studies have shown peroxide from bleaching agents to penetrate into the pulp chamber from the coronal surface of teeth (Bowles & Ugwuneri 1987, Benetti *et al.* 2004, Gökay *et al.* 2004) and from the pulp chamber to the cervical region (Rotstein 1991, Rotstein *et al.* 1991, Koulaouzidou *et al.* 1996, Camps *et al.* 2007) during bleaching procedures. Radicular peroxide penetration should be as limited as possible because the biological threshold of peroxide compounds causing irreversible damage to dental hard and soft tissue is unknown (Weiger *et al.* 1994). Lee *et al.* (2004) observed that a 35% CP gel produced lower levels of radicular peroxide diffusion than 35% HP. However, there is no information available on cervical peroxide penetration from different concentrations of CP gels. If using a gel with a lower CP concentration could achieve acceptable aesthetic outcomes whilst minimizing complications related to nonvital bleaching, this would be clinically desirable. The aim of this laboratory study was to evaluate and compare radicular peroxide penetration from different concentrations of CP bleaching gels (10%,17%, 37%) and a mixture of 30% HP and SP.

Materials and methods

Fifty fresh, intact, single-rooted human maxillary premolars extracted for orthodontic reasons from young adults were collected. All the teeth were extracted with minimal trauma without the use of elevators and with the beaks of the extraction forceps covered with gauze. Following extraction, the teeth were placed in distilled water, and soft tissue covering the root surface was gently removed using gauze soaked in 2.5% sodium hypochloride. The radicular cementum and cemento-enamel junction (CEJ) of teeth were examined stereomicroscopically, and standardized endodontic access cavities were prepared in the occlusal surfaces. Root canals were prepared to size 35 master apical file (Medin, Vlachovicka, Czech Republic), using a stepback technique and then filled with gutta-percha (Sure Dent Cor., Seongnam, Korea) and AH Plus root canal sealer (DeTrey Dentsply, Konstanz, Germany) using a lateral compaction technique. The gutta-percha filling was removed 4 mm below the CEJ using hot pluggers. Remnants of gutta-percha and sealer were removed from the access cavity with a cotton pellet soaked with alcohol and the pulp chambers of teeth were rinsed thoroughly with distilled water. A 2-mm-thick layer of glass–ionomer cement (Chemfil Superior, De Trey Dentsply) was applied as a base, and the outer root surfaces, including the apical foramina and apical third of the root, were sealed with wax and covered with two layers of nail polish. Teeth were mounted with parafilms (Parafilm-M, Neenah, WI, USA) and placed in plastic tubes (LP Italiana SPA, Milan, Italy) containing 2 mL of distilled water so that the entire root, including the CEJ, was immersed (Fig. 1). Specimens were placed in an incubator for 1 h at 37 °C.

The teeth were then separated into five groups of 10 teeth each. In Group I (control group), distilled water was placed into the pulp chambers of teeth using a micropipette (Sclavo Diagnostici, Siena, Italia). The pulp chambers of experimental groups II, III, IV and V were filled with bleaching agents consisting, respectively, of 10% CP gel (Perfect Bleach, Voco, Cuxhaven, Germany), 17% CP gel (Perfect Bleach, Voco), 37% CP gel (Whiteness Super-Endo, Sistema De Clareamento Dental, Santa Catarina, Brasil) and, a mixture of 30% HP (Merck, KGaA, Darmstadt, Germany) and SP (Merck, KGaA). Access cavities were completely sealed with a temporary filling material (Cavit, 3M-ESPE, Seefeld, Germany) and left for 24 h at 37 °C.

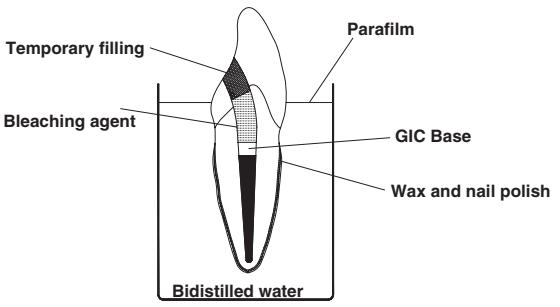

Figure 1 A schematic illustration of the experimental model.

Following the bleaching treatment, teeth were removed from plastic tubes, and the amount of peroxide in each tube was measured using the ferrothiocyanate method, in which colourless ferrothiocyanate is oxidized by peroxide to red ferrithiocyanate (Thurman *et al.* 1972), the optical density of which is measured using a UV-visible spectrophotometer (SpectraMax 190, Molecular Devices Corp., Sunnyvale, CA, USA) at a wavelength of 480 nm (at room temperature). Amounts of HP in samples were determined by comparing them to a standard calibration curve obtained using 30% HP stock solution (Merck, KGaA) diluted with distilled water.

Statistical analysis of data was conducted by using the Kruskal–Wallis Analysis of Variance and Mann–Whitney *U* test.

Results

Statistically significant differences between the groups were observed (Table 1).

Group V (30% HP-SP mix) had the highest peroxide penetration amongst the groups, followed by Group IV (37% CP) ($P < 0.05$). Similar amounts of peroxide penetration were found amongst Group III (17% CP) and Group II (10% CP), both of which were lower than Group IV ($P < 0.05$). No radicular peroxide was observed in Group I (control group).

Discussion

This study compared radicular peroxide penetration levels of various concentrations of CP gels and an HP-SP mixture used as intracoronal bleaching agents. Previous studies of peroxide penetration have utilized different time periods (Koulaouzidou *et al.* 1996, Lambrianidis *et al.* 2002, Benetti *et al.* 2004). This study examined penetration levels after 24 h.

Rotstein *et al.* (1992) recommended the placement of a protective base before intracoronal bleaching to prevent possible risks associated with HP. In this study, a glass–ionomer cement was applied over the canal filling.

Table 1 Radicular peroxide released (37 °C, 24 h)

Groups (*n*:10)	Absorbance (min-max)	Peroxide (mg mL^{-1}) mean ± SE
I	0	0
II	0.135–0.273	0.161 ± 0.012 A
III	0.152–0.276	0.181 ± 0.010 A
IV	0.865–1.230	0.848 ± 0.029 B
V	2.004–3.015	1.876 ± 0.094 C

*Statistically significant differences are shown by different letters ($P < 0.05$).

Some studies (Kehoe 1987, Lambrianidis *et al.* 2002, Lee *et al.* 2004) have evaluated root penetration according to pH changes of the medium surrounding the root. Other methods for HP analysis include titration, colorimetric analysis and the use of horseradish peroxidase (Gordon *et al.* 1992). The colorimetric ferrothiocyanate method used in this study is simple and precise (Vogel 1961) and has been used by a number of researchers in determining levels of HP radicular penetration (Rotstein 1991, Rotstein *et al.*1991, 1992, Koulaouzidou *et al.*1996).

The penetration of bleaching agents is affected by various factors, including dental tissue characteristics; pH, concentration, active ingredients and contact time of bleaching agents; and application of heat during the bleaching process (Rotstein 1991, Rotstein *et al.* 1991, Cooper *et al.* 1992, Hanks *et al.* 1993, Weiger *et al.* 1994, Koulaouzidou *et al.* 1996, Attin *et al.* 2003, Benetti *et al.* 2004, Gökay *et al.* 2005). Other factors include CEJ morphology, patient age and cementum defects (Gimlin & Schindler 1990, Rotstein *et al.* 1991, Camps *et al.* 2007). Koulaouzidou *et al.* (1996) reported a relationship between radicular peroxide penetration and the type of cementum-to-enamel relationship at the CEJ, which can be characterized by either edge-to-edge contact of enamel and cementum, overlap of enamel by cementum, or a gap between enamel and cementum with exposed dentine. Although bleaching is mainly performed on anterior teeth, this study was conducted using premolar teeth, due to their availability, and because the majority of earlier studies on penetration found in the literature have also used similar teeth. A study by Schroeder & Scherle (1988) found no dentine exposure at the CEJ; therefore, maxillary premolar teeth extracted from young adults were used in this study.

Rotstein (1991) and Rotstein *et al.* (1991) found peroxide diffused readily to the cervical region of teeth from 30% HP. The present study found that peroxide from CP gels and a mixture of HP and SP also penetrated to the cervical region; however, greater amounts of radicular peroxide were detected with the HP-SP mixture (1876 mL mg^{-1}) when compared to the CP gels (0.161–0.848 mL mg^{-1}). This finding is consistent with a study conducted by Lee *et al.* (2004), which observed that the use of 35% HP resulted in greater amounts of radicular peroxide when compared to 35% CP gel. The findings from the present

study pertaining to lower concentrations of CP gels could not be compared with other findings because of the lack of studies evaluating radicular peroxide penetration from lower concentrations of CP gels.

The 10% and 17% CP gels used in this study are recommended by their manufacturers as suitable for both vital and nonvital bleaching, whereas the 37% CP gel is marketed as an intracoronal bleaching agent. In the present study, all the bleaching agents were used intracoronally. It is generally argued that greater HP concentrations of bleaching products result in higher levels of peroxide penetration (Cooper *et al.* 1992, Benetti *et al.* 2004, Gökay *et al.* 2005). This study also found a correlation between concentration and peroxide penetration, with lower peroxide penetration levels found with 10% and 17% CP gels compared to the 37% CP gel.

The walking bleach technique is probably the most popular option for bleaching of root filled teeth. In this technique, SP is frequently used in combination with HP, which breaks down into free radicals that eventually combine to form water and molecular oxygen, which oxidizes the stained areas. In addition, the decomposition of SP with the formation of HP upon contact with water may release active oxygen that initiates the bleaching process (Haywood 1992). Amounts of radicular penetration of HP have been shown to be dependent upon the form of SP (mono-tri-tetra hydrate) used in intracoronal bleaching (Weiger *et al.* 1994). Despite reports and recommendations that SP mixed with water is the safest alternative (Weiger *et al.* 1994, Lambrianidis *et al.* 2002), Weiger *et al.* (1994) observed no significant differences in radicular peroxide penetration between a SP trihydrate-30% HP mixture and a SP tetrahydrate-water mixture. For this reason, this study evaluated an SP trihydrate-30% HP mixture, which is still widely utilized in clinical practice.

In this study, the amount of radicular peroxide detected in the 37% CP gel group was less than half of that detected in the 30% HP-SP group, and the amounts detected in the 10–17% CP groups were approximately one-tenth of that detected in the 30% HP-SP group. These results could appear to be clinically significant. Although the bleaching efficacy of these agents was not evaluated, considering the low levels of extra-radicular diffusion found in this study and the successful whitening effects reported in the literature (Perrine *et al.* 2000), 10% or 17% CP gels may prove to be the intracoronal bleaching agents of choice.

Conclusion

Both HP and CP bleaching agents penetrate to the extra-radicular region of teeth; however, the level of peroxide penetration from CP gels was significantly lower than that of an HP-SP mixture. CP gels may carry less risk of post-bleaching external root resorption than HP-SP bleaching agents.

References

Ari H, Ungör M (2002) *In vitro* comparison of different types of sodium perborate used for intracoronal bleaching of discoloured teeth. *International Endodontic Journal* **35**, 433–6.

Attin T, Paque F, Ajam F, Lennon AM (2003) Review of the current status of tooth whitening with the walking bleach technique. *International Endodontic Journal* **36**, 313–29.

Benetti AR, Valera MC, Mancini MN, Miranda CB, Balducci I (2004) In vitro penetration of bleaching agents into the pulp chamber. *International Endodontic Journal* **37**, 120–4.

Bowles WH, Ugwuneri Z (1987) Pulp chamber penetration by hydrogen peroxide following vital bleaching procedures. *Journal of Endodontics* **13**, 375–7.

Camps J, de Franceschi H, Idir F, Roland C, About I (2007) Time-course diffusion of hydrogen peroxide through human dentin: clinical significance for young tooth internal bleaching. *Journal of Endodontics* **33**, 455–9.

Chng HK (2002) Update on materials used in intracoronal bleaching. *Annals of the Royal Australasian College of Dental Surgeons* **16**, 147–50.

Cooper JS, Bokmeyer TJ, Bowles WH (1992) Penetration of the pulp chamber by carbamide peroxide bleaching agents. *Journal of Endodontics* **18**, 315–7.

Cvek M, Lindvall AM (1985) External root resorption following bleaching of pulpless teeth with oxygen peroxide. *Dental Traumatology* **1**, 56–60.

Friedman S (1997) Internal bleaching: long-term outcomes and complications. *Journal of American Dental Association* **128**, 51S–5S.

Gimlin DR, Schindler WG (1990) The management of postbleaching cervical resorption. *Journal of Endodontics* **16**, 292–7.

Gökay O, Müjdeci A, Algin E (2004) Peroxide penetration into the pulp from whitening strips. *Journal of Endodontics* **30**, 887–9.

Gökay O, Müjdeci A, Algin E (2005) In vitro peroxide penetration into the pulp chamber from newer bleaching products. *International Endodontic Journal* **38**, 516–20.

Gordon G, Cooper WJ, Rice RG, Pacey GE (1992) *Disinfectant Residual Measurement Methods*, 2nd edn. Denver, CO: AWWARF and AWWA.

Hanks CT, Fat JC, Wataha JC, Corcoran JF (1993) Cytotoxicity and dentin permeability of carbamide peroxide and

hydrogen peroxide vital bleaching materials, in vitro. *Journal of Dental Research* **72**, 931–8.

Harrington GW, Natkin E (1979) External resorption associated with bleaching of pulpless teeth. *Journal of Endodontics* **5**, 344–8.

Haywood VB (1992) History, safety, and effectiveness of current bleaching techniques and applications of the night-guard vital bleaching technique. *Quintessence International* **23**, 471–88.

Kehoe JC (1987) pH reversal following in vitro bleaching of pulpless teeth. *Journal of Endodontics* **13**, 6–9.

Koulaouzidou E, Lambrianidis T, Beltes P, Lyroudia K, Papadopoulos C (1996) Role of cemento enamel junction on the radicular penetration of 30% hydrogen peroxide during intracoronal bleaching in vitro. *Endodontics and Dental Traumatology* **12**, 146–50.

Lado EA, Stanley HR, Weisman MI (1983) Cervical resorption in bleached teeth. *Oral Surgery Oral Medicine Oral Pathology* **55**, 78–80.

Lambrianidis T, Kapalas A, Mazinis M (2002) Effect of calcium hydroxide as a supplementary barrier in the radicular penetration of hydrogen peroxide during intracoronal bleaching in vitro. *International Endodontic Journal* **35**, 985–90.

Lee GP, Lee MY, Lum SO, Poh RS, Lim KC (2004) Extraradicular diffusion of hydrogen peroxide and pH changes associated with intracoronal bleaching of discoloured teeth using different bleaching agents. *International Endodontic Journal* **37**, 500–6.

Liebenberg WH (1997) Intracoronal lightening of discolored pulpless teeth: a modified walking bleach technique. *Quintessence International* **28**, 771–7.

Lim MY, Lum SO, Poh RS, Lee GP, Lim KC (2004) An in vitro comparison of the bleaching efficacy of 35% carbamide peroxide with established intracoronal bleaching agents. *International Endodontic Journal* **37**, 483–8.

Madison S, Walton R (1990) Cervical root resorption following bleaching of endodontically treated teeth. *Journal of Endodontics* **16**, 570–4.

Perrine GA, Reichl RB, Baisden MK, Hondrum SO (2000) Comparison of 10% carbamide peroxide and sodium perborate for intracoronal bleaching. *General Dentistry* **48**, 264–70.

Rotstein I (1991) In vitro determination and quantification of 30% hydrogen peroxide penetration through dentin and cementum during bleaching. *Oral Surgery Oral Medicine Oral Pathology* **72**, 602–6.

Rotstein I, Torek Y, Misgav R (1991) Effect of cementum defects on radicular penetration of 30% H_2O_2 during intracoronal bleaching. *Journal of Endodontics* **17**, 230–3.

Rotstein I, Zyskind D, Lewinstein I, Bamberger N (1992) Effect of different protective base materials on hydrogen peroxide leakage during intracoronal bleaching in vitro. *Journal of Endodontics* **18**, 114–7.

Schroeder HE, Scherle WF (1988) Cemento-enamel junction–revisited. *Journal of Periodontal Research* **23**, 53–9.

Teixeira EC, Hara AT, Serra MC (2004) Use of 37% carbamide peroxide in the walking bleach technique: a case report. *Quintessence International* **35**, 97–102.

Thurman RG, Ley HG, Scholz R (1972) Hepatic microsomal ethanol oxidation. Hydrogen peroxide formation and the role of catalase. *European Journal of Biochemistry* **25**, 420–30.

Vogel AI (1961) *A Textbook of Quantitative Inorganic Analysis*, 3rd ed. London: Longmans, 785.

Weiger R, Kuhn A, Löst C (1994) Radicular penetration of hydrogen peroxide during intra-coronal bleaching with various forms of sodium perborate. *International Endodontic Journal* **27**, 313–7.