Clinical Efficacy of 5% Sodium Hypochlorite for Removal of Stains Caused by Dental Fluorosis

Aurora Cárdenas Flores* / Héctor Flores Reyes ** / Antonio Gordillo Moscoso*** / Juan Pablo Castanedo Cázares**** / Amaury de J. Pozos Guillén*****

The objective of this study was to evaluate the clinical efficacy of 5% sodium hypochlorite solution for removal of stains caused by dental fluorosis in young patients. A clinical trial involved 33 patients with diffuse opacities on the enamel surfaces of maxillary incisors due to effects of dental fluorosis. The protocol of treatment 3 steps:(1) cleaning and enamel etching with 37% phosphoric acid in order to eliminate the layer that covers the fluorotic enamel surface and allow better penetration of the bleaching agent,(2) application of 5% sodium hypochlorite to remove stains caused by organic material, and (3) filling the opened microcavities with a light-cured, composite surface sealant to prevent restaining. The whiteness of the enamel lesions before and after treatment were expressed in L, a*, and b* color space measurements using a Minolta Chroma Meter CR300. Analysis of parameters of ¢E (L*, a*, b*) showed that changes were observed in the L* (brightness) and a* (redness), which paralleled the ¢E differences. There was no significant difference in the b* (yellow) parameter. The technique described in this study appears to have advantages over other methods for improving the appearance of fluorotic lesions. It is simple, low cost, non invasive so the enamel keeps its structure, relatively rapid, and safe; it requires no special materials, and it can be used with safety on young permanent teeth.*

Keywords: *bleaching, sodium hypochlorite, dental fluorosis.*
J Clin Pediatr Dent 33(3): 187–192, 2009

INTRODUCTION

There has been a decline in dental caries in developed countries over the last 2 decades because of the widespread use of fluoride. Concurrent with the decline in caries, an increase in the prevalence of dental fluorosis has been reported.[1]

* Aurora Cárdenas Flores, DDS Resident, Pediatric Dentistry Posgraduate Program, Facultad de Estomatología, Universidad Autónoma de San Luis Potosí, México

** Héctor Flores Reyes, DDS, PhD Associate professor, Endodontics Posgraduate Program, Facultad de Estomatología, Universidad Autónoma de San Luis Potosí, México

*** Antonio Gordillo Moscoso, MD, PhD Associate professor, Department of Clinical Epidemiology, Facultad de Medicina, Universidad Autónoma de San Luis Potosí, México

**** Juan Pablo Castanedo Cázares, MD, MS Associate professor, Department of Dermatology, Hospital Central "Dr. Ignacio Morones Prieto," Universidad Autónoma de San Luis Potosí, México

***** Amaury de J. Pozos Guillén DDS, PhD, Associate professor, Pediatric Dentistry Posgraduate Program, Facultad de Estomatología, Universidad Autónoma de San Luis Potosí, México

Send all correspondence to: Amaury de Jesús Pozos Guillén, Facultad de Estomatología, Universidad Autónoma de San Luis Potosí. Av. Dr. Manuel Nava #2, Zona Universitaria, C.P. 78290; San Luis Potosí, S.L.P. México.

Tel: 52 (444)8262357 ext 106

E-mail: apozos@uaslp.mx

Dental fluorosis is a specific disturbance in tooth formation, and is defined as a chronic, fluoride-induced condition in which enamel development is disrupted and the enamel is hypomineralized. Clinically, dental fluorosis is seen as white spots or opaque white lines (striations), or the tooth surface may have a white, parchment-like appearance. The brown stains sometimes seen in moderate-to-severe fluorosis are due to the uptake of extrinsic stains, mainly from the diet. At higher concentrations of fluoride, discrete or confluent pitting of the enamel surface is seen, accompanied by extrinsic stains.[2] Dental fluorosis is distributed symmetrically, affecting mainly anterior teeth, and the severity varies among the different types of teeth. Teeth that develop and mineralize later in life have a higher prevalence of dental fluorosis.[3]

The effects of fluoride on enamel formation in man are cumulative, rather than requiring a specific threshold dose. These effects depend on the total fluoride intake from all sources. The principal source of fluoride is drinking water; many cities have large amounts of natural fluoride in their drinking water, putting the population at risk for developing dental fluorosis. In central and northern Mexico there are extensive areas of endemic fluorosis. Such a city is San Luis Potosi (SLP). Because it is located in an area where the drinking water contains excessive quantities of natural fluoride, its inhabitants are at risk for developing dental fluorosis.[4] Also, the high prevalence of dental fluorosis in SLP cannot be attributed only to the levels of fluoride in drinking water; other risk factors must be considered.[5-7]

The unesthetic discoloration of dental fluorosis is the most prominent feature, frequently causing psychological problems. A variety of treatment approaches have been proposed for discoloration caused by dental fluorosis in young patients, including microabrasion,[8-11] direct and indirect restorations,[12] whitening toothpastes,[13,14] and bleaching using products such as acids,[15-17] calcium sucrose phosphate,[18] carbamide peroxide, hydrogen peroxide,[19-21] and sodium hypochlorite (NaOCl).[18,22-24] NaOCl has been used in different concentrations in endodontic treatment as an irrigant to support the mechanical preparation of root canals. Studies have demonstrated that irrigation with NaOCl is an effective means of faciliting the removal of pulp tissue and dentinal shavings; it also has been shown to have antimicrobial properties.[25] The etch/bleach/seal technique using NaOCl as a bleaching agent has recently been proposed as a conservative alternative treatment, and it has shown good clinical success.[23] This study aimed to evaluate the clinical efficacy of sodium hypochlorite 5% solution for the removal of stains caused by dental fluorosis in young patients.

MATERIALS AND METHODS

Study subjects were recruited from the Clinic for Pediatric Dentistry Posgraduate Program, Facultad de Estomatología, Universidad Autónoma de San Luis Potosí, México. A clinical trial involved 33 patients with diffuse opacities on enamel surfaces of maxillary incisors due to the effects of dental fluorosis. The study was approved by the Ethics Committee. Indications, contraindications, risks, benefits, and alternatives of bleaching were explained to the parents or legal guardians, and written informed consent was obtained.

Inclusion criteria were as follows: Dental fluorosis of degrees 1 to 4 according to the Tooth Surface Index of Fluorosis (TSIF); 4 maxillary incisors completely erupted; all teeth free of caries and restorations, and aged between 8 and 12 years. Exclusion criteria were: Previous bleaching treatment, tooth sensitivity, periodontal disease, nonvital teeth, history of dental trauma, and hypersensitivity to sodium hypochlorite.

Studies were done to assess the reproducibility of recording the TSIF, and the Kappa value was calculated. Fifty full-arch tooth blocks were examined by the main examiner and another examiner to assess interexaminer agreement. The kappa value for interexaminer agreement was 0.90 for the.

We applied NaOCl 5% solution in this study, according to Wright´s protocol. Briefly, the teeth were cleaned with flour of pumice, using a rubber cup to remove all plaque, and rinsed with water. The teeth were then isolated with a rubber dam and each tooth was ligated to protect the soft tissues from the bleaching agent. To allow better penetration, the enamel surface was etched for 15 seconds with 37% phosphoric acid and rinsed. The NaOCl was applied to the entire tooth surface using a cotton applicator, repeating the application as the solution evaporated. The teeth were bleached at one appointment in 15 to 20 minutes. To prevent organic material from reentering the porous and hypomineralized enamel, the teeth was sealed after achieving the optimal bleach result using a light-cured, composite surface sealant (Fortify, Bisco, Lombard, IL).

Whiteness of the enamel lesions were expressed in L*, a*, and b* color space measurements using a Minolta Chroma Meter CR300 (Chromameter, Minolta, Osaka, Japan). We then calculated tooth color by averaging L*, a*, and b* color parameters using the delta equation, $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]/2$, where ΔE is the difference in color (the more positive the value, the whiter the color), ΔL* is the change in lightness (the greater the ΔL*, the whiter the teeth), and Δa* and Δb* are chromacity values (the amount of redness and the amount of yellowness).[26,27] Color parameters and the delta equation were registered before and after treatment. For the statistical analysis, the data were analyzed by Wilcoxon and Student *t* tests when appropriate. A probability value of <.05 was considered statistically significant. The JMP IN v. 4.0.1 statistical program was used to analyze the data.[28]

RESULTS

Thirty-three patients participated in this study (19 males and 14 females), ranging in age from 8 to 12 years, with mean age of 10.9. Table 1 shows the minimum, the maximum, the median, the mean, the SD, and values corresponding to L* (brightness) color parameter before and after treatment. L* is the main parameter and represents the lightness of the teeth (the greater value of L*, the whiter the tooth). Results after treatment with NaOCl indicated a clinically and statistically significant difference ($P < .05$, Wilcoxon test). The teeth after treatment were lighter (whiter), with the mean difference (ΔL*) being 3.35.

Table 1. L* Color Parameter before and after Treatment

L* color parameter	Mean ± S.D.	Median	Range
Before treatment	68.95 ± 5.01	69.56	56.50–80.35
After treatment	72.30 ± 3.74	72.88	63.63–78.89

$P < .05$, Wilcoxon test.

Table 2. a* and b* Color Parameters before and after Treatment

Color parameter	Mean ± S.D.	Median	Range
Before treatment a*	1.65 ± 2.43	2.05	-3.21–8.93
After treatment a*	-0.04 ± 2.14	-0.85	-3.49–4.58
Before treatment b*	12.80 ± 3.95	12.86	3.70–20.97
After treatment b*	12.31 ± 2.83	12.50	4.73–18.05

$P < .05$, Wilcoxon test (a* parameter).
$P > .05$, Student *t* test (b* parameter).

Table 3. Delta Equation (ΔE) before and after Treatment

Delta equation (ΔE)	Mean ± S.D.	Median	Range
Before treatment	70.32 ± 4.61	71.27	59.32–80.54
After treatment	73.42 ± 3.70	73.87	64.03–80.03

$P < .05$, Wilcoxon test.

Figure 1. Initial aspect of maxillary central incisors. Accentuated, irregular brown stains localized in incisal third of teeth 11 and 21 diagnosed as dental fluorosis.

Figure 2. Final aspect of maxillary central incisors after bleaching with NaOCl.

With respect to a* and b* color parameters (chromacity values, the amount of redness and yellowness, respectively), Table 2 show the results corresponding to each parameter both before and after treatment. For the* value, a statistically significant difference ($P < .05$, Wilcoxon) was found; however, such was not the case for b*: the mean values were similar before (12.80) and after treatment (12.31).

Tooth color was calculated by averaging the L*, a*, b* color parameters for each tooth before and after treatment and calculating the differences using the delta equation (¢E). Table 3 shows the color comparison before and after treatment, which indicate a clinically and statistically significant difference ($P < .05$, Wilcoxon). The teeth after treatment were whiter, with the mean difference (ΔE) being 3.10.

Figures 1 and 2 show enamel conditions before and after treatment in a patient. Before treatment, irregular brown stains localized in the incisal third of both maxillary central incisors were observed. After treatment, a satisfactory esthetic result was observed.

DISCUSSION

Widespread use of fluoride in many forms and vehicles has been responsible for the decline in dental caries; however, excessive quantities of fluoride consumption during enamel formation results in structural and compositional changes in enamel known as dental fluorosis. It can be characterized by white spots or striations on the teeth. More severe cases exhibit brown staining due to the uptake of extrinsic stains, mainly from the diet. Studies suggest that the early maturation stage of enamel development is the most critical for the development of dental fluorosis.[29,30]

Tooth discoloration, including dental fluorosis, creates a wide range of cosmetic problems for which the dental profession and the public expend considerable time and money in attempting to correct.[31] Owing to the psychological impact of unaesthetic maxillary anterior teeth, dental fluorosis has attracted considerable attention.

Bleaching techniques involve the use different substances, the most popular being the use of dentist-prescribed peroxide and related products in different concentrations, including home bleaching, assisted bleaching, and power bleaching. Tooth-whitening systems are based primarily on hydrogen peroxide or on carbamide peroxide, one of its precursors. Also, these products have been shown to improve the clinical appearance of teeth affected by dental fluorosis.[20] Side effects have been reported: tooth sensitivity and soft tissue irritation being the most common adverse events. In various studies assessing the occurrence of sensitivity, 11% to 93% of patients reported this as a problem.[32-35] Tooth sensitivity normally persists for up to 4 days after cessation of bleaching treatment.[36] High concentrations are caustic to the mucosa and can cause burns of gingival tissue.[37] It has been reported that carbamide peroxide agents in different concentrations affect the bond strength of composites to enamel and may increase the solubility of glass ionomer and other cements,[38,39] produce changes in morphometry of gingival ephitelium,[40] penetrate into the pulp chamber to cause cytotoxicity,[41] increase the level of DNA damage,[42] and increase the risk of carcinoma.[43]

Microabrasion is another alternative in the treatment of fluorosis stains.[17] This technique involves the removal of a small amount of surface enamel and incorporates both abrasion with dental instruments and erosion with an acid mixture. It can be successful for mild and relatively superficial stains that do not extend into the deeper enamel layers.

In young permanent teeth that are partially erupted and have large pulp chambers, bleaching with 5% NaOCl is an excellent alternative for the treatment of fluorosis stains. NaOCl is a commonly used irrigating solution that has been shown to have both antimicrobial properties and the ability to dissolve organic material.[44,45]

The efficacy of NaOCl to dissolve of organic tissue is related to its concentration; dilution of 5.25% has been shown to cause a significant decrease in its ability to dissolve necrotic tissue.[46] Its effectiveness is attributed to its ability to neutralize amino acids to form water and salt (neutralization reaction). With the exit of the hydroxyl ions, there is a reduction of pH. Hypochlorous acid, a substance present in NaOCl solution, releases chlorine when in contact with organic tissue as a solvent that combines with the protein amino group, forming chloramines (chloramination reaction). Hypochlorous acid and hypochlorite ions lead to amino acid degradation and hydrolysis.[47] When NaOCl contacts hypomineralized and discolored enamel, it degrades and removes the chromogenic organic material located on the enamel surface.[22]

In this technique, the first critical step is the etching of the enamel surface, which in this study took 15 seconds with 37% phosphoric acid, as opposed to the 60 seconds described in Wright´s protocol.[23] The use of phosphoric acid denudes the microcavities containing the organic elements, facilitating their dissolution and removal by NaOCl. The use of 37% phosphoric acid is preferred over 16% because it removes less enamel, and it is highly effective in etching the enamel surface; this increases porosity and allows better penetration of the bleaching agent. The second step is the application of NaOCl. Care must be exercised during this step to reduce the risk of mucosal irritation, skin injury, eye splashes, clothing damage, and hypersensitivity and allergic reactions.[48-51] Third, the final application of sealant fills the opened microcavities and prevents the penetration of new organic material and restaining of the hypomineralized lesions.[22,23]

Several indices have been proposed for assessing the prevalence and severity of dental fluorosis. Each system is used to evaluate clinical effects, and each scoring system incorporates an ordinal measurement scale, identifying fluorotic conditions ranging from very mild to severe. These indices include Dean's Index, Thylstrup-Fejerskov Index, Fluorosis Risk Index, and the TSIF.[52] In this study we used the TSIF for selecting patients; this index was developed in part to allow for the separate assessment of cosmetic fluorosis (fluorotic discoloration, staining, or pitting on surfaces visible to others.[53]

To evaluate changes of color after bleaching, it is necessary to use a method that is sensitive to small changes in color, and is consistent and accurate because traditional methods of evaluation require subjective visual grading. Different methods have been used to evaluate changes after tooth whitening, including indices for dental fluorosis, standard shade guides, digitized photographs, and electronic and computer-aided systems. These indices and shade guides require subjective visual grading, and the eye's color perception is affected by various factors such as ambient lighting, duration of viewing, fatigue of operator, surrounding colors, and individual interpretation.[54] Other problems in assessing stain removal and tooth color after bleaching include observer bias and variations in the illumination and dryness of the dental surface, in recording opacities. Some of these problems have been solved by using a method that gives a consistent and accurate evaluation of tooth color, particularly important in the evaluation of a system intended to enhance tooth whiteness in clinical trials.[55,56]

In this study, changes in color were evaluated using a Minolta Chroma Meter CR300 (Chromameter, Minolta, Osaka, Japan). This device is an excellent tool in assessing gradual changes in shade of discolored teeth by tooth whitening because evaluations are not affected by the above factors and they can accurately, quantitatively, and reliably express color changes.[57,58] Light-surface reflectance is expressed in L*, a*, and b* color space measurements established by the Comission Internationale de L'Eclairage,[59] and they are related to human color perception in all 3 color dimensions: L* values represent color gradients from white to black; a* values represent green to red; and b* values, blue to yellow. For all color measurements in this study, a Chroma Meter was used; we observed a quantitative interpretation of changes of color. The changes of L*, a* parameters, and ΔE were clinically and statistically significant after treatment.

CONCLUSIONS

The technique described in this study appears to have advantages over other methods for improving the appearance of fluorotic lesions. It is simple, low cost, noninvasive so the enamel keeps its structure, relatively rapid, and safe; it requires no special materials, and it can be used with safety on young permanent teeth.

ACKNOWLEDGMENTS

Special thanks to Miguel Guerra, and Gabriela Torre for their time and effort in assisting this study. We would like to thank Norman Wahl, for his assistance in editing this manuscript.

REFERENCES

1. Mascarenhas AK. Risk factors for dental fluorosis: A review of the recent literature. Pediatr Dent, 22: 269–77, 2000.
2. Thylstrup A, Fejerskov O. Clinical appearance of dental fluorosis in permanent teeth in relation to histological changes. Community Dent Oral Epidemiol, 6: 315–28, 1978.
3. Larsen MJ, Richards A, Fejerskov O. Development of dental fluorosis according to age at start of fluoride administration. Caries Res, 19: 519–27, 1985.
4. Grimaldo M, Borja-Aburto V, Ramírez A, Ponce M, Rosas M, Díaz-Barriga F. Endemic fluorosis in San Luis Potosí, México. I. Identification of risk factors associated with human exposure to fluoride. Environ Res, 68: 25–30, 1995.
5. Díaz-Barriga F, Leyva R, Quistián J, Loyola-Rodríguez JP, Pozos A, Grimaldo M. Endemic fluorosis in San Luis Potosi, Mexico. IV. Sources of fluoride exposure. Fluoride, 30: 219–22, 1997.
6. Loyola-Rodríguez JP, Pozos-Guillén A, Hernández-Guerrero JC. Bebidas embotelladas como fuentes adicionales de exposición a flúor. Salud Publica Mex, 40: 438–41, 1998.
7. Loyola-Rodríguez JP, Pozos-Guillén A, Hernández-Guerrero JC, Hernández-Sierra JF. Fluorosis en dentición temporal en un área con hidrofluorosis endémica, Salud Publica Mex, 42: 194–200, 2000.
8. McCloskey RJ. A technique for removal of fluorosis stains, J Am Dent Assoc, 109: 63–4, 1984.
9. Croll TP, Cavanaugh RR. Enamel color modification by controlled hydrochloric acid-pumice abrasion. I. Technique and examples. Quintessence Int, 17: 81–7, 1986.
10. Train TE, McWhorter G, Seale NS, Wilson CF, Guo IY. Examination of esthetic improvement and surface alteration following microabrasion in fluorotic human incisors in vivo. Pediatr Dent, 18: 353–62, 1996.

11. Limeback H, Vieira AP, Lawrence H. Improving esthetically objectionable human enamel fluorosis with a simple microabrasion technique. Eur J Oral Sci, 114 Suppl 1: 123–6, 2006.
12. Rodd HD, Davisodson LE. The aesthetic management of severe dental fluorosis in the young patient. Dent Update, 24: 408–11, 1997.
13. Sharif N, MacDonald E, Hughes J, Newcombe RG, Andy M. The chemical stain removal properties of whitening toothpaste products: studies *in vitro*. Br Dent J, 188: 620–4, 2000.
14. Joiner A. Review of the extrinsic stain removal and enamel/dentine abrasion by a calcium carbonate and perlite containing whitening toothpaste. Int Dent J, 56: 175–80, 2006.
15. Wong M. A clinical comparison of treatments for endemic dental fluorosis. J Endodon, 17: 343–5, 1991.
16. Barreto AC, Coelho S, Moraes SA, Lamas DB, Nogueira VR, Ayrton O. Enamel opacities removal using two different acids: an *in vivo* comparison. J Clin Pediatr Dent, 29: 147–50, 2005.
17. Allen K, Agosta C, Estafan D. Using microabrasive material to remove fluorosis stains. J Am Dent Assoc, 135: 319–23, 2004.
18. DenBesten P, Giambro N. Treatment of fluorosed and white-spot human enamel with calcium sucrose phosphate in vitro. Pediatr Dent, 17: 340–5, 1995.
19. Kalil S, Augusto M, Eberson P, Mendes M, Guedes AC. Esthetic alternative for fluorosis blemishes with the usage of a dual bleaching system based on hydrogen peroxide at 35%. J Clin Pediatr Dent, 28: 143–6, 2004.
20. Loyola-Rodriguez JP, Pozos-Guillen AJ, Hernandez-Hernandez F, Berumen-Maldonado R, Patiño-Marin N. Effectiveness of treatment with carbamide peroxide and hydrogen peroxide in subjects affected by dental fluorosis: a clinical trial. J Clin Pediatr Dent, 28: 63–8, 2003.
21. Berga-Caballero A, Forner-Navarro L, Amengual-Lorenzo J. At-home vital bleaching: a comparison of hydrogen peroxide and carbamide peroxide treatments. Med Oral Patol Oral Cir Bucal, 11: E94–9, 2006.
22. Belkhir MS, Douki N. A new concept for removal of dental fluorosis stains. J Endodon, 17: 288–92, 1991.
23. Wright JT. The etch-bleach-seal technique for managing stained enamel defects in young permanent incisors. Pediatr Dent, 24: 249–52, 2002.
24. Zantner C, Derdilopoulou F, Martus P, Kielbassa AM. Randomized clinical trial on the efficacy of 2 over-the-counter whitening systems. Quintessence Int, 37: 695–706, 2006.
25. Baumgartner JC, Cuenin PR. Efficacy of several concentrations of sodium hypochlorite for root canal irrigation. J Endodon, 18: 35–40, 1985.
26. Gegauff AG, Rosenstiel SF, Lnghout KJ, Johnson WM. Evaluating tooth color change from carbamide peroxide gel. J Am Dent Assoc, 124: 65–72, 1993.
27. Nathoo SA, Gaffar A. Studies on dental stains induced by antibacterial agents and rational approaches for bleaching dental stains. Adv Dent Res, 9: 462–70, 1995.
28. JMP-IN Version 4.0.1 (Academic) Copyright © 1989-2000 SAS Institute Inc. Cary, NC.
29. Larsen MJ, Richards A, Fejerskov O. Development of dental fluorosis according to age at start of fluoride administration. Caries Res, 19: 519–27, 1985.
30. DenBesten P. Mechanism and timing of fluoride effects on developing enamel. J Public Health Dent, 59: 247–51, 1999.
31. Sulieman M. An overview of tooth discoloration: Extrinsic, intrinsic and internalized stains. Dent Update, 32: 463–71, 2005.
32. Tam L. The safety of home bleaching techniques. J Can Dent Assoc, 1999; 65: 453–5.
33. Jorgensen MG, Carroll WB. Incidence of tooth sensitivity after home whitening treatment. J Am Dent Assoc, 133: 1076–82, 2002.
34. Leonard RH Jr, Garland GE, Eagle JC, Caplan DJ. Safety issues when using a 16% carbamide peroxide whitening solution. J Esthet Restor Dent, 14: 358–67, 2002.
35. Dahl JE, Pallesen U. Tooth bleaching – a critical review of the biological aspects. Crit Rev Oral Biol Med, 14: 292–304, 2003.
36. Schulte JR, Morrissette DB, Gasior EJ, Czajewski MV. The effects of bleaching application time on the dental pulp. J Am Dent Assoc, 125: 1330–5, 1994.
37. Pretty IA, Ellwood R, Brunton PA, Aminian A. Vital tooth bleaching in dental practice: 1. Professional bleaching. Dent Update, 33: 288–304, 2006.
38. Miles PG, Pontier JP, Bahiraeli D, Close J. The effect of carbamide peroxide bleach on the tensile bond strength of ceramic brackets: an *in vitro* study. Am J Orthod Dentofacial Orthop 1994; 106: 371–5, 1994.
39. Sung EC, Chan SM, Mito R, Caputo AA. Effect of carbamide peroxide bleaching on the sear bond strength of composite to dental bonding agent enhanced enamel. J Prosthet Dent, 1999; 82: 595–9, 1999.
40. Da Costa Filho LC, Covolo Da Costa C, Lara Soria M, Taga R. Effect of home bleaching and smoking on marginal gingival epithelium proliferation: a histologic study in women. J Oral Pathol Med, 31: 473–80, 2002.
41. Gokay O, Mujdeci A, Algin E. Peroxide penetration into the pulp from whitening strips. J Endodon, 30: 887–9, 2004.
42. Araki D, Alencar ME, Fávero DM. Study of DNA damage induced by dental bleaching agents *in vitro*. Braz Oral Res, 20: 47–51, 2006.
43. Weitzman SA, Weitberg AB, Stossel TP, Schwartz J, Shklar G. Effects of hydrogen peroxide on oral carcinogenesis in hamsters. J Periodontol, 1986; 57: 685–8, 1986.
44. Carson KR, Goodell GG, McClanahan SB. Comparison of the antimicrobial activity of six irrogants on primary endodontic pathogens. J Endodon, 31: 471–3, 2005.
45. Hand RE, Smith ML, Harrison JW. Analysis of the effect of dilution on the necrotic tissue dissolution property of sodium hypochlorite. J Endodon, 4: 60–4, 1978.
46. Harrison JW, Hand RE. The effect of dilution and organic matter on the antibacterial property of 5.25% sodium hypochlorite. J Endodon, 7: 128–32, 1981.
47. Estrela C, Estrela CRA, Barbin EL, Spano JC, Marchesan MA, Pécora JD. Mechanism of action of sodium hypochlorite. Braz Dent J, 13: 113–7, 2002.
48. Serper A, Özbek M, Calt S. Accidental sodium hypochlorite-induced skin injury during endodontic treatment. J Endodon, 30: 180–1, 2004.
49. Hülsmann M, Hahn W. Complications during root canal irrigation: literature review and case reports. Int Endod J, 33: 186–93, 2000.
50. Ingram TA. Response of the human eye to accidental exposure to sodium hypochlorite. J Endodon, 16: 235–8, 1990.
51. Kaufman AY, Keila S. Hypersensitivity to sodium hypochlorite. J Endodon, 15: 224–6, 1989.
52. Kingman A. Current techniques for measuring dental fluorosis: Issues in data analysis. Adv Dent Res, 8: 56–65, 1994.
53. Horowitz HS, Driscoll WS, Meyers RJ, Heifetz SB, Kingman A. A new method for assessing the prevalence of dental fluorosis: the Tooth Surface Index of Fluorosis. J Am Dent Assoc, 109: 37–41, 1984.
54. Reno EA, Sunberg RJ, Block RP, Bush RD. The influence of lip/gum colour on subject perception of tooth colour. J Dent Res, 79: 381, 2000.
55. Rustogi KN, Kowitz GM, Wong R, Curtis JP, Weickowski SE. Use of chroma meter to assess changes in tooth coloration (abstract). J Dent Res, 70(Spec Iss): 778, 1991.
56. Li Y. Tooth color measurement using Chroma Meter: Techniques, advantages, and disadvantages. J Esthet Restor Dent, 15(Suppl 1): S33–41, 2003.
57. Amaechi BT, Higham SM. Development of a quantitative method to monitor the effect of a tooth whitening agent. J Clin Dent, 13: 100–3, 2002.
58. Gallagher A, Maggio B, Bowman J, Borden L, Mason S, Felix H. Clinical study to compare two in-office (chairside) whitening systems. J Clin Dent, 13: 219–24, 2002.
59. Commission Internationale de L'Eclairage. Recommendations on uniform color spaces. Color difference equations. Psychometric color terms. Suppl.2 to CIE publication 15 (E-13.1) 1971/(TC-1.3), 1978. Paris, France: Bureau Central de la CIE.