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Influence of low-concentrated bleaching agents on the human enamel roughness and morphology

Influência de agentes clareadores de baixa concentração na rugosidade e morfologia do esmalte humano

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RESUMO

Este estudo avaliou a rugosidade de superfície do esmalte antes (baseline) e após o clareamento; e investigou a influência de diferentes concentrações de peróxido de carbamida (PC) na morfologia da superfície. Sessenta blocos planos de esmalte, obtidos de terceiros molares humanos, foram distribuídos aleatoriamente em 6 grupos (n = 10) e submetidos a cinco tratamentos clareadores por 14 dias: 1) sem tratamento clareador (NB-controle), 2) 10% PC – Opalescence (O10), 3) 15% PC – Opalescence (O15), 4) 20% PC- Opalescence (O20), 5) 10% PC- Whiteness (W10) e 6) 16% PC – Whiteness (W16). A topografia da superfície foi mensurada por meio de um perfilômetro e a superfície do esmalte foi examinada com o microscópio eletrônico de varredura (MEV) em aumentos de 5.000 e 20.000 vezes. A rugosidade de superfície inicial (baseline) foi semelhante para todos os grupos (P > 0.05). Todos os agentes clareadores promoveram aumento significante da rugosidade de superfície (P < 0.05). Foram observadas alterações na superfície do esmalte após o clareamento. As microscopias em MEV demonstraram que diferentes concentrações de peróxido de carbamida causaram dissolução superficial do esmalte, expondo uma superfície porosa.

PALAVRAS-CHAVE: *Esmalte dental. Branqueamento. Morfologia.*

ABSTRACT

This study examined the surface roughness of enamel before (baseline) and after bleaching; and investigated the influence of different concentrations of carbamide peroxide (CP) on the surface morphology. Sixty flat enamel blocks obtained from human third molars were randomly assigned to 6 groups (n = 10) and submitted to five carbamide peroxide treatments for 14 days: 1) without bleaching treatment (NB-control), 2) 10% CP - Opalescence (O10), 3) 15% CP - Opalescence (O15), 4) 20% CP - Opalescence (O20), 5) 10% CP - Whiteness (W10) and 6) 16% CP - Whiteness (W16). The surface topography was measured by a profilometer and the treated enamel surfaces were examined with a scanning electron microscope (SEM) at x5,000 and x20,000 magnifications. Baseline roughness average was statistically similar for all groups (P > 0.05). All bleaching agents promoted significantly increased surface roughness (P < 0.05). Enamel surface morphologic alterations were observed after bleaching treatment. SEM photographs showed that different concentrations of carbamide peroxide caused enamel surface dissolution, exposing a porous surface.

KEY WORDS: *Dental enamel. Tooth bleaching. Morphology.*

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Introduction

Carbamide peroxide is the active component in most tooth-whitening agents for home-applied bleaching [1]. This treatment protocol comprises the application of carbamide peroxide gel in a custom fabricated bleaching mouthguard, which is placed over the teeth to facilitate the contact with the bleaching agent. Tooth-whitening products are dispensed and monitored by dentists, and daily exposure to 10% carbamide peroxide for up to five weeks [2], based on clinical evaluations and researches, is a safe, conservative and effective procedure for whitening teeth [3-5].

Nevertheless, submitting the teeth and oral tissues to low concentrations of carbamide peroxide for an extended period of time may cause side effects [1]. Scanning electron microscope (SEM) evaluations have been conducted on enamel surfaces treated with carbamide peroxide and contradictory evidence of adverse effects has been related. No detectable changes in surface texture and topography were observed between unbleached control group and the bleached groups with 10% carbamide peroxide [6-9]. However, depending on the tooth-whitening product, 10% carbamide peroxide can promote varying degrees of surface porosity and structural change [10-15].

In an attempt to improve the whitening effects, bleaching agents with up to 22% carbamide peroxide are also available for at-home bleaching [16-19]. However, the possibility of increased adverse effects with higher concentrations has not been thoroughly studied and still needs to be determined.

The purpose of this study was to evaluate the influence of different concentrations of carbamide peroxide on the surface roughness of human dental enamel. In addition, enamel surface morphology of unbleached control specimens and bleached specimens were investigated using SEM. This study tested the hypothesis that increased carbamide peroxide concentrations may produce proportional adverse effects.

Materials and methods

Thirty extracted sound erupted third molars stored in 2% buffered formalin solution were used within one month of extraction. The teeth were obtained after approval of the Ethical Research Committee of Piracicaba School of Dentistry/Unicamp, Brazil. The roots were separated from the crowns, which were sectioned mesiodistally using a water-cooled slow speed diamond saw (Isomet - Buehler Ltd., Lake Bluf, IL, EUA). Sixty dental fragments from buccal and lingual enamel surfaces (3.5 x 3.5 x 2.5 mm) were obtained and individually embedded in self-curing polyestyrene resin in a ring mold. Enamel surfaces were flattened with wet 600-, 1000- and 1200-grit aluminum oxide abrasive papers and polished with 6, 3, ½, and ¼ μm–grit diamond pastes on a polishing machine (APL-4 – Arotec, Cotia, SP, Brazil).

Before bleaching treatments, a profilometer (Surf test 211 – Mitutoyo, Tokyo, Japan) was used to measure the initial surface roughness (baseline). Three measurements in different directions were recorded and the mean Ra value (μm) was determined for each specimen. Two commercially available bleaching agents, containing different low concentrations of carbamide peroxide (CP) Opalescence (Ultradent Products Inc., South Jordan, UT, USA) and Whiteness (FGM Produtos Odontológicos, Joinville, SC, Brazil) were used in this study.

Specimens were randomly divided into six groups (n = 10): Group 1- Control, no bleaching treatment; Group 2- 10% CP - Opalescence (O10); Group 3- 15% CP Opalescence (O15); Group 4- 20% CP - Opalescence (O20); Group 5- 10% CP – Whiteness (W10) and Group 6- 16% CP – Whiteness (W10). Control group was kept in artificial saliva at 37°C for 14 days and was not bleached. For bleaching groups (2, 3, 4, 5 and 6), enamel was exposed to one daily application of carbamide peroxide for 8 hours during 14 consecutive days.

In each specimen, approximately 0.1 mL of bleaching agent and 0.05 mL of artificial saliva was applied on the enamel surface and covered with an individual tray. During bleaching, the specimens were placed in 100% relative humidity at 37° C, and after daily bleaching; the specimens were thoroughly rinsed with an air/water spray for 10 seconds and stored in artificial saliva [20] at 37° C. After 14 days, surface roughness was recorded for each specimen again. Profilometric analysis data were statistically analyzed by two-way analysis of variance (ANOVA) and Tukey test at 0.05 level of significance.

Specimens were removed from the acrylic blocks and prepared for the scanning electron microscope (DSM 940A – Zeiss, Jena, Berlin, Berlin, Germany). Then, specimens were sputter coated with gold in a vacuum evaporator (MED 010 – Balzers Union, Liechtenstein) and SEM photomicrographs of a representative area of the surfaces were taken at 5,000X and 20,000X.

Results

The average surface roughness of experimental groups are displayed in Table 1. Two-way ANOVA showed significant influence of both factors (treatment and time) on surface roughness. Baseline data were performed in order to verify the similar initial surface smoothness ($P > 0.05$) and to contrast differences between untreated and treated enamel in the same group. Specimens from control group stored in artificial saliva for 14 days presented no increase of surface roughness mean values ($P > 0.05$). However, all bleaching agents produced significant increased on the surface roughness (P < 0.05). After 14 days of tooth-bleaching, O15, W10 and W16 bleaching agents promoted higher surface roughness (P < 0.05) than unbleached control group, which was similar to O10 and O20 (P > 0.05).

Table 1- Mean values (±SD) of surface roughness (μm) of unbleached and bleached enamel surfaces (n=10)

Groups	Control	O10	O15	O20	W10	W16
Baseline	0.12±0.0 Aa	0.11±0.02 Aa	0.11±0.0 Aa	0.12±0.02 Aa	0.12±0.0 Aa	0.12±0.0Aa
14 days	0.12±0.0 Aa	0.20±0.08 Bab	0.27±0.0 Bb	0.21±0.06 Bab	0.24±0.0 Bb	0.21±0.0 Bb

Means followed by different letters (lower case - horizontal and capital letter - vertical) differ among them by Tukey test (P<0.05).

Representative photomicrographs of polished enamel surface and enamel stored in saliva for 14 days (control group) are shown in Figures 1a and 1b. No surface morphologic alterations are noted on unbleached enamel surfaces. The surface morphology of enamel following exposure to 10%, 15%, 16% and 20% carbamide peroxide revealed alterations in surface topography when compared to unbleached control group. Morphologic alterations were more evident for O15, O20, W10 and W16 than O10, which presented porosities, irregularities and pits at some sites of the bleached enamel surface (Figures 2a and 2b). Irregular pattern of enamel etching or erosion is noted for others bleached enamel photomicrographs (Figures 3a, 3b, 4a, 4b, 5a, 5b, 6a and 6b).

DISCUSSION

Previous tooth-whitening protocols employed caustic chemical agents [21-23], which were capable of causing enamel surface alterations [12,24,9]. When hydrogen peroxide-containing bleaching agent was associated with preoperative etching and heat application, extensive structural changes in enamel were observed [14,25]. Mouthguard bleaching using 10% carbamide peroxide was developed to substitute the use of high concentrations of hydrogen peroxide in order to minimize their adverse effects [2].

In the present experiment, specimens treated with bleaching agents revealed significant increased on surface roughness, demonstrating that alterations on enamel surface may occur. Storage in artificial saliva did not affect the surface roughness of unbleached control group specimens. SEM observation showed that superficial morphological alterations or pattern of enamel etching were not evident after 14 days of artificial saliva storage for unbleached specimens (Figures 1a and 1b).

Differences were noted between unbleached and bleached enamel surfaces under SEM observations. Different concentrations of carbamide peroxide in contact with enamel surface provide morphological changes, causing increased surface roughness and erosion or etching-like appearance. Alterations were not uniform throughout the surfaces, thus, some areas showed little effect of the bleaching process, whereas other areas showed decalcification and increased porosity of the enamel surface.

A lower extensively altered surface was observed for O10 (Figures 2a and 2b). Pits and irregularities were noted for O10, which produced surface roughness that was similar to control group after 14 days of bleaching (O10) or artificial saliva storage treatment (control), respectively. O20 was also similar to O10 and control group, however, a more altered surface was noted (Figures 4a and 4b). O15, W10 and W16 bleaching agents also promoted morphological alterations, leading to increased surface roughness after bleaching (Figures 3a, 3b, 5a, 5b, 6a and 6b, respectively).

The oxidative process on enamel surface and pH of tooth-whitening products have been considered the main cause of adverse effects of bleaching on mineralized tissues. Inquiries have been raised if oxidative process will create porosity in enamel [1]. Studies have reported that enamel treated with a low-pH carbamide peroxide agent show slight surface erosion under SEM [15] and that the greater peroxide concentration, the more acidic the pH of the bleaching product [26]. The dentist-supervised home-bleaching products have a mean pH of 6.48 [19]. Despite the close to neutral pH level of the bleaching agents, changes on bleached surfaces were presented after bleaching treatments.

Carbamide peroxide (10%) degrades into 3% hydrogen peroxide and 7% urea, which is capable of penetrating into the enamel and affecting the interprismatic regions [27], as observed in bleached specimens of this study (Figures 3a, 3b, 4a, 4b, 5a, 5b, 6a and 6b). Thus, urea may contribute to the structural changes and roughness of enamel. However, beneficial side effects can be promoted by alkaline property of urea that decreases the hydrogen ion concentration of the bleaching solution and reduces the whitening adverse effects [28,3].

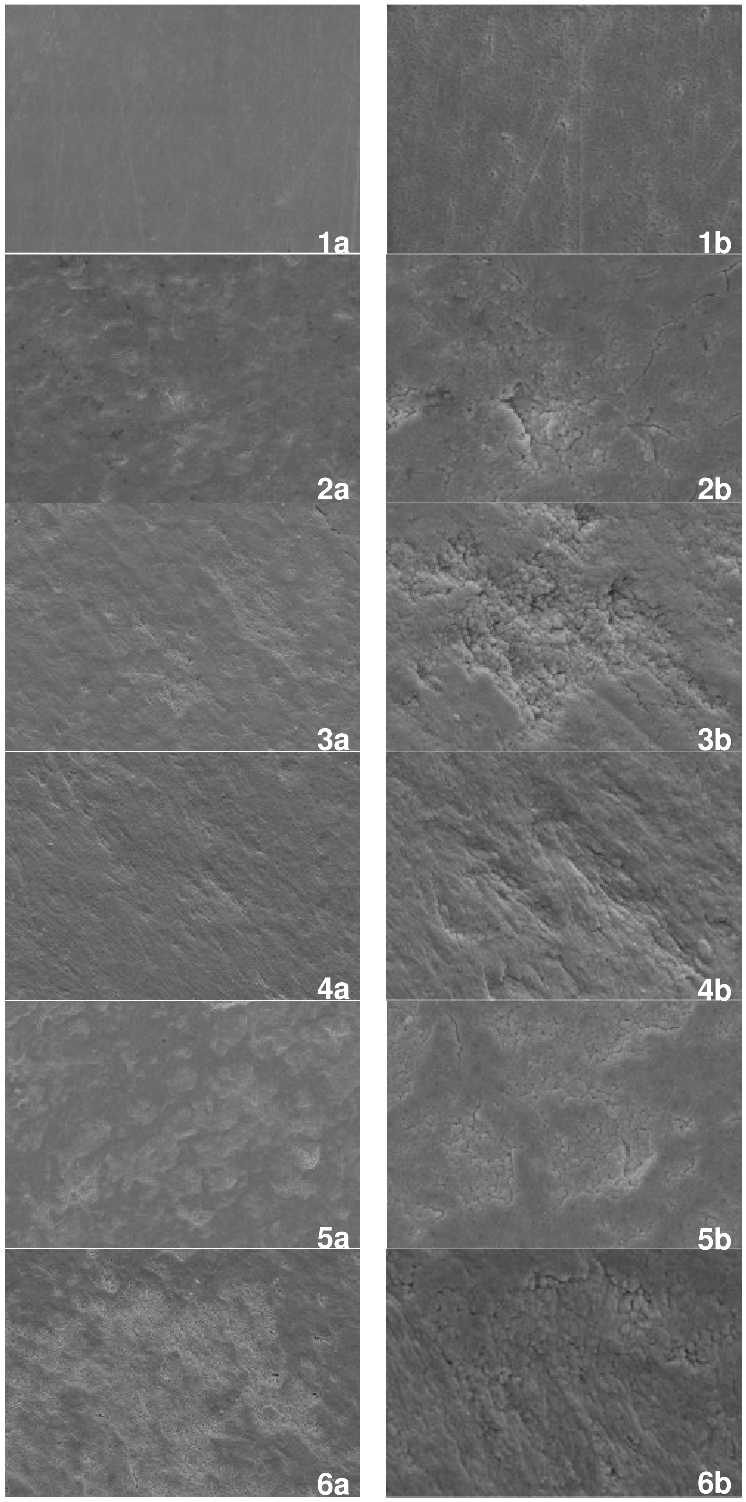

Figure 1- Enamel surface morphology from unbleached control group. No alterations or pattern of enamel etching are noted. Figure 2- Enamel surface exposed to O10. Pits (arrow), porosities and irregularities are noted. Figure 3- Enamel surface exposed to O15. Irregular patterns of enamel etching and affected interprismatic structures (arrows) can be seen (C - enamel prism core). Figure 4- Enamel surface exposed to O20. Irregular patterns of enamel etching and affected interprismatic structures (arrows) can be seen (C - enamel prism core). Figure 5- Enamel surface exposed to W10. Erosion or mild demineralized areas showing irregular patterns of enamel etching (arrows). Figure 6- Enamel surface exposed to W16. Erosion or mild demineralized areas showing irregular patterns of enamel etching (arrows). A- original magnification x5,000. B- original magnification x20,000

CONCLUSIONS

This investigation showed that in vitro use of different low concentrations of carbamide peroxide resulted in significant increased surface roughness and SEM evaluations revealed that tooth-whitening products tested have a potential demineralizing effect on the enamel surface.

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REFERENCES

1. Heymann HO. Tooth bleaching: facts and fallacies. Br Dent J. 2005;23;198(8):514.
2. Haywood VB, Heymann HO. Nightguard vital bleaching. Quintessence Int. 1989;20(3):173-6.
3. Haywood VB. History, safety, and effectiveness of current bleaching techniques and applications of the nightguard vital bleaching technique. Quintessence Int. 1992;23(7):471-88.
4. Metz MJ, Cochran MA, Matis BA, Gonzalez C, Platt JA, Lund MR. Clinical evaluation of 15% carbamide peroxide on the surface microhardness and shear bond strength of human enamel. Oper Dent. 2007;32(5):427-36.
5. Hannig C, Lindner D, Attin T. Efficacy and tolerability of two home bleaching systems having different peroxide delivery. Clin Oral Investig. 2007;11(4):321-9.
6. Ernst CP, Marroquin BB, Willershausen-Zönnchen B. Effects of hydrogen peroxide-containing bleaching agents on the morphology of human enamel. Quintessence Int. 1996;27(1):53-6.
7. Haywood VB, Leech T, Heymann HO, Crumpler D, Bruggers K. Nightguard vital bleaching: effects on enamel surface texture and diffusion Quintessence Int. 1990;21(10):801-4.
8. Oltu Ü, Gürgan S. Effects of three concentrations of carbamide peroxide on the structure of enamel. J Oral Rehabil. 2000;27(4):332-40.
9. Zalkind M, Arwas JR, Goldman A, Rotstein I. Surface morphology changes in human enamel, dentin and cementum, following bleaching: A scanning electron microscopy study Endod Dent Traumatol. 1996;12(2):82-8.
10. Faraoni-Romano JJ, Turssi CP, Serra MC. Effect of a 10% carbamide peroxide on wear resistance of enamel and dentine: in situ study. J Dent. 2009;37(4):273-8
11. Faraoni-Romano JJ, Da Silveira AG, Turssi CP, Serra MC. Bleaching agents with varying concentrations of carbamide and/or hydrogen peroxides: effect on dental microhardness and roughness. J Esthet Restor Dent. 2008;20(6):395-402
12. Faraoni-Romano JJ, Turssi CP, Serra MC. Concentration-dependent effect of bleaching agents on microhardness and roughness of enamel and dentin. Am J Dent. 2007;20(1):31
13. Pinto CF, Paes Leme AF, Cavalli V, Giannini M. Effect of 10% carbamide peroxide bleaching on sound and artificial enamel carious lesions. Braz Dent J. 2009;20(1):48-53..
14. Leandro GA, Attia ML, Cavalli V, do Rego MA, Liporoni PC. Effects of 10% carbamide peroxide treatment and sodium fluoride therapies on human enamel surface microhardness. Gen Dent. 2008;56(3):274-7.
15. Pinto CF, Oliveira R, Cavalli V, Giannini M. Peroxide bleaching agent effects on enamel surface microhardness, roughness and morphology. Braz Oral Res. 2004;18(4):306-11.
16. Leonard RH, Sharma A, Haywood VB. Use of different concentrations of carbamide peroxide for bleaching teeth: an in vitro study. Quintessence Int. 1998;29(8):503-7
17. Matis BA, Mousa HN, Cochran MA, Eckert GJ. Clinical evaluation of bleaching agents of different concentrations. Quintessence Int. 2000;31(5):303-10.
18. Mokhlis GR, Matis BA, Cochran MA, Eckert GJ. A clinical evaluation of carbamide peroxide and hydrogen peroxide whitening agents during daytime use. J Am Dent Assoc. 2000;131(9):1269-77.
19. Price RBT, Sedarous M, Hiltz GS. The pH of tooth-whitening products. J Can Dent Assoc. 2000;66(8):421-6.
20. Cavalli V, Reis AF, Giannini M, Ambrosano GMB. Bond strength to enamel relative to the elapsed time from bleaching with various concentrations of carbamide peroxide. Oper Dent. 2001; 26(6):597-602.
21. Arens DE, Rich JJ, Healey HJ. A practical method of bleaching tetracycline-stained teeth. Oral Surg Oral Med Oral Pathol. 1972;34(5):812-7
22. Cohen SC, Parkins FM. Bleaching tetracycline-stained vital teeth. Oral Surg Oral Med Oral Pathol. 1970;29(3):465-71.
23. McEvoy SA. Chemical agents for removing intrinsic stains from vital teeth. II. Current techniques and their clinical application. Quintessence Int. 1989;20(6):379-84.
24. Ledoux WR, Malloy RB, Hurst RVV, Mcinnes-Ledoux P, Weinberg R. Structural effects of bleaching on tetracycline-stained vital rat teeth. J Prosthet Dent.1985;54(1):55-9.
25. Titley K, Torneck CD, Smith D. The effect of concentrated hydrogen peroxide solutions on the surface morphology of human tooth enamel. J Endod.1988;14(2):69-74.

26. Weiger R, Kuhn A, Lost C. Effect of various types of sodium perborate on the pH of bleaching agents. J Endod. 1993;19(5):239-41.
27. Arends J, Jongebloed WL, Goldberg M, Schuthof, J. Interaction of urea and human enamel. Caries Res. 1984;18(1):17-24.
28. Haywood VB, Heymann HO. Nightguard vital bleaching: how safe is it? Quintessence Int. 1991;22(7):515-23.