Effects of 10% carbamide peroxide treatment and sodium fluoride therapies on human enamel surface microhardness

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This study sought to evaluate the microhardness of enamel submitted to 10% carbamide peroxide treatment and different methods of remineralization involving sodium fluoride (NaF). Non-erupted third molars were used and 75 enamel blocks with standardized dimensions (4.0 x 4.0 x 2.0 mm) were obtained. Enamel blocks were randomly divided into five groups (n = 15): one control (no bleaching and no fluoride treatment), one receiving a 10% carbamide peroxide treatment, one receiving 10% carbamide peroxide plus acidulated phosphate fluoride, one receiving 10% carbamide peroxide with 0.2% NaF, and one receiving 10% carbamide peroxide and 0.05% NaF. There were no differences among four of the groups (p > 0.05); the group receiving 10% carbamide peroxide only was different from all other groups (p < 0.05). Based on these results, NaF therapies are recommended during carbamide peroxide bleaching treatments.

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Discolored teeth can be treated successfully through non-invasive techniques such as at-home bleaching treatments.1,2 Carbamide peroxide is universally accepted as an effective method for lightening discolored teeth.3,4 However, the widespread use of carbamide peroxide among dentists and patients is concerning, since there is no agreement about bleaching’s effects on enamel.5 Some studies have reported little or no topographic alterations, while others have reported increases in porosity, pitting, erosion, and demineralization of enamel prisms in addition to decreased enamel microhardness.6-13

Bleaching with 10% carbamide peroxide may decrease the calcium and fluoride content of enamel and increase the enamel’s susceptibility to demineralization.14-17 Reduced hardness indicates the dissolution and degradation of treated enamel, which suggests that bleaching agents could cause enamel alterations. Because fluoride enhances remineralization and inhibits demineralization, different sodium fluoride (NaF)-based treatments have been indicated to control enamel mineral loss and minimize carbamide peroxide’s adverse effects on enamel surfaces.18-22 It has been reported that fluoride can remineralize the surface of bleached enamel.14,16,18,19 Professionally applied 1.23% acidulated phosphate fluoride gel (APF) and NaF mouthwashes (0.02% or 0.5%) are recommended post-bleaching.18,19

Due to the possible adverse effects of 10% carbamide peroxide bleaching, this experiment tested the null hypothesis that professional fluoride application and self-administered NaF mouthwash solutions are unable to remineralize bleached enamel surfaces.

Materials and methods
This study was approved by the Ethical Committee Guidelines of the University of Taubate in accordance with the National Health Council.

Experimental design
Experimental units consisted of 75 enamel slabs. Five groups were created to study enamel treatment that involved no treatment, bleaching, and fluoride treatment. Four repeated measurements of Vickers microhardness were made on the surface of each specimen.

Specimen preparation
Forty non-erupted third molars that were free of defects were stored in a sodium chloride solution (0.9%) at 10°C for no more than 30 days. Immediately after extraction, the samples were completely cleaned of gross debris and autoclaved (Autoclave MK3000 12L III, Odontobras, Ribeirao Preto, SP, Brazil; 55.16.2102.6700) in individual plastic vials with distilled water for 15 minutes at 121°C.23 The root was divided from the coronal portion with double-faced diamond discs (No. 7020, KG Sorensen, Barueri, SP, Brazil; 55.11.4197.1700) in a
low-speed handpiece (Intramatic 2068, Kavo, Joinville, SC, Brazil; 55.47.3451.0100) and the crown was sectioned to obtain dental blocks (4.0 x 4.0 x 2.0 mm). The dental blocks were not allowed to dehydrate for longer periods. Enamel blocks with surface defects were discarded after stereomicroscope loupe visual analysis (magnification 30x).24

The 75 enamel blocks were embedded individually in a self-curing polyester resin in a polyvinylchloride ring mold (with a diameter of 2.0 cm); the external surface of the enamel was exposed. The molds were removed and the external surfaces of dental blocks were leveled using a water-cooled mechanical grinder (Aropol 2Vm Arotec, Cotia, SP, Brazil; 55.11.4613.8600), ground flat with water-cooled aluminum oxide grit papers (No. 600, 800, 1000, and 1200, 3M ESPE, St. Paul, MN; 888.364.3577), and polished with diamond pastes (Arotec); four different pastes (6.0 µm, 3.0 µm, 1.0 µm, and 0.25 µm) were used.22 Samples were immersed in an ultrasonic bath after each paste was used to remove any impurities from the previous paste.

Polished and flat dental slabs were divided into five experimental groups (n = 15) and submitted to one of the following treatments: Group 1, the control group; Group 2, treated with 10% carbamide peroxide (Whiteness 10%, FGM Dental Products, Joinville, SC, Brazil); Group 3, treated with Whiteness 10% and 1.23% APF (Proctor and Gamble, Cincinnati, OH; 800.543.2577); Group 4, treated with Whiteness 10% and 0.2% NaF; and Group 5, treated with Whiteness 10% and 0.05% NaF.

Bleaching treatment and fluoride application
Carbamide peroxide was applied to samples according to manufacturers’ instructions, except for Group 1, which was not bleached and remained in a remineralizing solution during bleaching. Groups 2–5 were bleached for six hours a day over 28 days. After bleaching, samples were stored in remineralizing solution (artificial saliva, Bioformula, Sao Jose dos Campos, SP, Brazil; 55.11.6165.6936) at 37°C until the next bleaching application. Groups 2–5 were submitted to bleaching and fluoride application, which respected protocols for the fluoride gels’ respective concentrations. In Group 3, a 1.0 mm pellicle of NaF gel (1.23%) was applied to the enamel surface for one minute after 7, 14, 21, and 28 days of bleaching. Samples in Group 4 were immersed in 3.0 mL of 0.2% NaF solution for one minute after 7, 14, 21, and 28 days of bleaching. Samples in Group 5 were immersed in 3.0 mL of 0.05% NaF for five minutes every day after bleaching. After each fluoride application, samples in Groups 2–5 were washed thoroughly in distilled water and stored in artificial saliva at 37°C.

Microhardness measurement and statistical analysis
Surface microhardness was assessed directly after carbamide peroxide treatment. Microhardness was determined using a Vickers diamond (Microhardness Tester...
FM-700, Future Tech, Troy, MI; 248.743.0958), at a load of 50 g, applied for ten seconds. Four indentations were made (100 µm from each other) and mean values were analyzed by one-way ANOVA and Tukey test ($p < 0.05$).

**Results**

Mean values and standard deviations are displayed in Chart 1 and the table. The enamel surface microhardness of Group 1 was statistically similar to that found in Groups 3, 4, and 5 ($p > 0.05$) but different from that of Group 2 ($p < 0.05$). There were no differences among Groups 3, 4, and 5 ($p > 0.05$); however, Group 2 was different from all other groups ($p < 0.05$).

**Discussion**

Overnight treatment with 10% carbamide peroxide may decrease microhardness and increase the porosity of enamel.9-11,25-29 Polishing and fluoridating teeth after whitening therapy has been recommended to reverse the adverse effects of bleaching agents on enamel.14 Fluoride’s role concerning caries prevention and reduction of demineralization due to erosion has been well-examined; however, there are insufficient scientific data concerning the influence of fluoride on bleached enamel.21,30 This study verified the effects of 10% carbamide peroxide on enamel and the ability of different fluoride therapies to reverse the possible adverse effects of 10% carbamide peroxide. Surface hardness was used as a criterion to determine mineral loss, since it is an established technique for evaluating the mineralization rate of enamel.31

The results of the present study are similar to those from a 2002 study, which reported that 10% carbamide peroxide used alone was able to reduce enamel microhardness.14 Enamel mineral loss after bleaching is explained by the composition and oxidation mechanism of the whitening agent.24 Hydrogen peroxide breaks down into free radicals, which are unspecific, unstable, and highly reactive.24 It is believed that these free radicals decompose the organic and inorganic enamel matrix to achieve stability.32 These uncontrollable characteristics of free radicals may alter the chemical and morphological enamel structure.5,9-11,25-26,32

The neutral pH is attributed to urea, which also is present in the bleaching agent.33 Although urea raises the pH of the reaction, it may denature proteins, thus affecting the surface and the interprismatic regions of enamel.9-34 It also has been reported that carbopol, the thickening agent present in most bleaching agents, can decrease enamel microhardness during bleaching, even when pH is neutral.35 This decrease may be due to carbopol’s high calcium-binding capacity, which inhibits hydroxyapatite crystal growth.24,28,36 The oxidizing whitening process and the presence of urea and carbopol may be responsible for enamel demineralization.

The present study also demonstrated that Group 1 (the control) was similar to the groups that received bleaching and/or fluoridation. There were no differences among the bleaching/fluoridation groups, which indicates that all fluoride therapies were effective.

NaF’s efficacy in terms of remineralizing enamel has been established; fluoride treatments prevent enamel softening and increase enamel acid resistance.20,37 Several studies have been conducted to define the optimal fluoride therapy for preventing dental caries.30,38-41

Acidulated fluoride leads to a higher fluoride deposition in enamel and is more effective than a neutral gel in reducing the demineralization of enamel submitted to a cariogenic challenge.42 The low pH and the high fluoride concentration are responsible for the high fluoride uptake into dental hard tissues and the formation of a calcium fluoride-like layer found after acidulated fluoride gel is applied.43,44 The precipitation of products (the process by which a substance is separated from a solution as a solid) is relevant to caries development, since loosely bound fluoride can act as reservoir sources.45,46 Others have considered high-frequency use and low concentrations of fluoride agents the most beneficial therapy for patients with a high risk of demineralization.22 Because the present study found no differences among the bleach and fluoride groups, the authors recommend APF gel and NaF mouthrinse solutions during bleaching therapy.

**Conclusion**

Based on the results of this study, 10% carbamide peroxide agents can reduce enamel surface microhardness. The null hypothesis is rejected. Professional fluoride application and self-administered NaF mouthwash solutions were able to remineralize bleached enamel; fluoride therapy during supervised 10% carbamide peroxide treatment is advised.

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