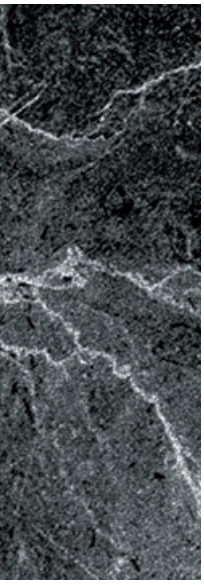

Critical Appraisal

EFFECTS OF BLEACHING ON TOOTH STRUCTURE AND RESTORATIONS, PART I: EFFECTS ON ENAMEL

Author and Associate Editor

Edward J. Swift Jr., DMD, MS

Tooth whitening has become a common treatment over the last 15 years, and much research has been reported on the effects of bleaching procedures on enamel, dentin, and restorative materials. We are presenting a series of Critical Appraisals on this topic, beginning this issue with a focus on the effects of bleaching on enamel.

HIGH LEVELS OF HYDROGEN PEROXIDE IN OVERNIGHT TOOTH-WHITENING FORMULAS: EFFECTS ON ENAMEL AND PULP

G. Pugh, L. Zaidel, N. Lin, M. Stranick, D. Bagley
Journal of Esthetic and Restorative Dentistry 2005 (17:40–7)

ABSTRACT

Objective: The purpose of this study was to evaluate the effects of peroxide tooth whiteners on enamel microhardness, enamel morphology, and pulpal penetration.

Materials and Methods: The materials tested in this study were Colgate Platinum Overnight (Colgate Oral Pharmaceuticals, Canton, MA, USA), which contains 10% carbamide peroxide (equivalent to 3.5% hydrogen peroxide), a 7% hydrogen peroxide paste, and a 12% hydrogen peroxide paste. Twenty extracted human teeth were sectioned 3 mm below the CEJ, and the pulp tissue was removed. These were coated with nail varnish from the most apical area to about 3 mm below the marginal ridges. The teeth were assigned to three experimental and one control groups. Bleaching materials were applied to the tooth crowns for 30 minutes, 4 hours, and 7 hours.

The pulp chambers were filled with an acetate buffer to stabilize any peroxide that penetrated through the teeth. Hydrogen peroxide penetration into the pulp chambers was measured using a leukocrystal violet/horseradish peroxidase colorimetric assay.

Enamel blocks were sectioned from other extracted human molars and were flattened and highly polished using a series of increasingly fine diamond pastes. These specimens were treated with the three whitening pastes for 7 hours daily for over 2 weeks. While not being bleached, they were stored in stimulated human whole saliva. The control group was stored continuously in saliva. All treatments and storage were done at 37°C. Following treatment, the specimens were analyzed

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for Knoop microhardness, surface roughness (using atomic force microscopy [AFM]), and elemental analysis (electron spectroscopy for chemical analysis).

Results: After 30 minutes, peroxide penetration of the pulp chamber was greatest with the higher peroxide gel concentrations and with longer application times. However, at 4 and 7 hours, there was no difference between the materials. The pulpal peroxide concentration for each product increases with application time.

After 98 hours of bleaching paste application, there was no significant change in microhardness in any of the treatment groups compared with the untreated saliva controls. Elemental analysis revealed no significant change in calcium or phosphorus levels, and AFM revealed no significant surface roughening or enamel etching.

Conclusions: Repeated applications of 3.5, 7, and 12% peroxide whitening pastes did not alter enamel hardness, morphology, or roughness. The concentration of peroxide recovered from pulp chambers would not be expected to affect pulpal enzymes.

COMMENTARY

Hydrogen peroxide has an acidic pH and therefore has the potential to damage enamel. (The acidity of hydrogen peroxide contributes to the external cervical resorption sometimes seen as a side effect of internal bleaching.) However, as this study showed, there is little evidence that peroxide whitening agents actually cause any damage to enamel. When not being treated, the teeth were stored in human saliva, and this might have contributed to the absence of any adverse effects.

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MICROCOMPUTERISED TOMOGRAPHY EVALUATION OF 10% CARBAMIDE PEROXIDE APPLIED TO ENAMEL

N. Efeoglu, D. Wood, C. Efeoglu

Journal of Dentistry 2005 (33:561–7)

ABSTRACT

Objective: The aim of this in vitro study was to evaluate the possible demineralization of enamel by bleaching with 10% carbamide peroxide.

Materials and Methods: Six extracted human molars were sectioned so that 12 "tooth rods" measuring 2 × 3 mm in cross section and 4 mm in length were obtained from mid-coronal areas of the buccal surfaces. A microcomputerized tomography (micro-CT) scanner was used to measure the mineral content of each specimen before and after bleaching. Bleaching was done in a humid environment by applying a measured dose of 10% carbamide peroxide bleaching gel (Opalescence, Ultradent, South Jordan, UT, USA) for 8 hours. After bleaching, the specimens were stored in artificial saliva at 37°C. This bleaching–storage cycle was repeated daily for 15 consecutive days.

Micro-CT scans were evaluated on a computer, with each tooth specimen being divided into 50-µm "regions of interest," from the enamel surface down through the deepest enamel. Image gray values were measured along a scale ranging from –1,000 to +1,000, with the higher gray values indicating greater mineralization. The median

gray scale values for each region were converted to g/cm^2 of calcium hydroxyapatite.

Results: After bleaching, the outer 50 µm of enamel had a significantly reduced mineral content. In each of the deeper areas of enamel, the mineral content was not significantly affected by bleaching.

Conclusions: A 2-week in vitro bleaching regimen with 10% carbamide peroxide demineralized enamel to a depth of about 50 µm.

COMMENTARY

This is an interesting study because it used sophisticated technology to evaluate the effects of an at-home bleaching material on the mineral content of enamel. The results are interesting as well because they showed a clear demineralization effect by 10% carbamide peroxide gel despite storage of the tooth specimens in artificial saliva. The demineralization effect was confined to the outer 50-µm layer of enamel. An earlier study reported that the amount of mineral loss caused by bleaching was similar to that caused by drinking cola beverages.

The authors recommend that the use of bleaching agents should be carefully considered in patients who are susceptible to caries or tooth wear. Surface demineralization could exacerbate the abrasive effects of bruxism or overzealous toothbrushing. Even in patients without unusual caries or wear problems, the judicious use of tooth bleaching products is advisable simply because there is almost no information about the potential problems with prolonged use of the products.

However, it must be noted that there is no clinical evidence that bleaching causes demineralization of enamel or that it contributes to any problems with caries or wear. It is possible that any demineralization that does occur is reversed by the action of natural saliva during the bleaching regimen or after it is finished. The present study did use artificial saliva rather than plain water or saline solution, but it is not clear whether artificial saliva would have the same effect as natural saliva.

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Yeh ST, Su Y, Lu YC, Lee SY. Surface changes and acid dissolution of enamel after carbamide peroxide bleach treatment. Oper Dent 2005;30:507–15.

EFFECT OF PEROXIDE-BASED BLEACHING AGENTS ON ENAMEL ULTIMATE TENSILE STRENGTH

A.P. Silva, R. Oliveira, V. Cavalli, C.A.G. Arrais, M. Giannini, R.M. Carvalho

Operative Dentistry 2005 (30:318–24)

ABSTRACT

Objective: The purpose of this study was to evaluate the ultimate tensile strength of human enamel bleached with three concentrations of peroxide.

Materials and Methods: Composite was bonded to acid-etched occlusal surfaces of 14 extracted third molars. From these bonded specimens, 70 hourglass-shaped enamel-composite slabs of the type used for microtensile bond strength testing were sectioned and assigned to seven groups. One group was stored in artificial saliva and was not bleached, serving as the control. The other groups were bleached according to manufacturers' directions using the following materials: Colgate Platinum Overnight (10% carbamide peroxide), a Brazilian product also containing 10% carbamide peroxide, Day White 2Z (7.5% hydrogen peroxide; Discus Dental, Culver City, CA, USA),

Opalescence Quick (35% carbamide peroxide; Ultradent Products), and two Brazilian products containing 37% carbamide peroxide and 35% hydrogen peroxide. The carbamide peroxide products intended for at-home use were applied for 6 hours daily for 14 days, and the hydrogen peroxide product was applied for 30 minutes daily. The products intended for in-office use were used with much shorter application times. All specimens were stored in artificial saliva when they were not being treated. At the end of the bleaching regimen, they were stored in deionized water for 24 hours before tensile testing.

The specimens, which were trimmed such that fractures would occur in enamel, were tested to failure using an Instron universal testing machine (Instron Corporation, Canton, MA, USA). The cross-sectional area of the fracture sites was measured with digital calipers for the calculation of ultimate tensile strength in MPa units. The fracture sites were examined with scanning electron microscopy (SEM).

Results: The control group had the highest mean ultimate tensile strength, 51.3 MPa. The means for the experimental groups were significantly lower, with most in the range of 30 to 35 MPa. The mean of the enamel treated with 35% hydrogen peroxide was only 22 MPa. SEM evaluation revealed the possible loss of interprismatic enamel, especially in the latter group.

Conclusions: Peroxide bleaching treatments can reduce the ultimate tensile strength of enamel and increase its porosity.

COMMENTARY

Bleaching has proved to be both safe and effective not only in routine clinical use but also in numerous controlled clinical trials. However, at least one study has reported that bleaching can cause a reduction in the fracture toughness of enamel. The present study raises further concerns about the possibility of enamel weakening. However, if decreased fracture toughness and tensile strength were actually occurring, why are we apparently not seeing more fractured teeth, incisal edge chipping, etc.? The answer may be that the changes observed in the laboratory—despite the use of artificial saliva—are occurring clinically as well but are being reversed by saliva. Nevertheless, the prolonged use of bleaching materials could have some unforeseen adverse effect on teeth.

The present study might have been more relevant if the teeth had been bleached before specimen formation, rather than after. It is possible that the bleaching of intact enamel may have had different results than the bleaching of the already prepared microtensile specimens. Also, it would have been interesting to see the enamel tensile strength following immersion in artificial saliva for a few days or weeks after bleaching.

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IN SITU AND IN VITRO EFFECTS OF BLEACHING WITH CARBAMIDE PEROXIDE ON HUMAN ENAMEL

L.M. Justino, D.R. Tames, F.F. Demarco
Operative Dentistry 2004 (29:219–25)

ABSTRACT

Objective: The purpose of this study was to evaluate whether the effects of bleaching gels on enamel are less pronounced in a clinical simulation (in situ) than in a laboratory model (in vitro).

Materials and Methods: Twenty-four 4-mm^2 square enamel slabs were taken from extracted human premolars, sterilized, embedded in

polystyrene resin with one surface exposed, and polished to 1,200 grit. Two of the 24 specimens were reserved as controls and were not bleached. The others were divided into in vitro and in situ test groups.

Removable oral appliances with enamel slabs embedded in them were fabricated and worn by human subjects for 16 hours daily, allowing saliva to contact the enamel slabs. The actual bleaching procedures were accomplished outside the mouth. For 8 hours each day, a 10% carbamide peroxide gel was applied to the enamel and covered with a PVC film.

Similarly, the in vitro enamel specimens were bleached in the laboratory for 8 hours each day, and immersed in deionized water for the other 16 hours. Vickers microhardness was measured before and after the 14 days of treatment. Bleaching gel from both conditions was collected each day and analyzed for calcium content using a spectrophotometer. The surface morphology of several specimens, including the unbleached controls, was evaluated using SEM.

Results: Hardness of the in vitro enamel specimens declined significantly after bleaching, from a Vickers hardness number of 341.7 to 206.0. In contrast, the hardness of the in situ specimens was essentially unchanged, with values of 333.9 and 321.7 before and after treatment, respectively.

A much higher amount of calcium was lost from the in vitro than from the in situ specimens. Over the entire treatment period, the calcium recovered from the in vitro group was 1,516 mg/mL but was only 611 mg/mL for the in situ group. Under SEM, the in situ bleached specimens looked much like the controls, but the in vitro specimens contained obvious surface depressions indicative of mineral loss.

Conclusion: In the oral cavity, the remineralization effect of saliva could prevent the demineralizing effects of bleaching on human enamel.

COMMENTARY

Some laboratory studies have reported that peroxide bleaching agents can demineralize enamel, even when bleached enamel was immersed in artificial saliva after bleaching. Using a novel experimental design, the present study showed that the demineralization effects observed in the laboratory might be very different from what happens clinically. In the laboratory, all measures of enamel mineralization—including microhardness, calcium loss, and surface characteristics—clearly were affected by application of 10% carbamide peroxide in the laboratory setting. However, when the enamel was bleached under those same laboratory conditions but exposed to natural saliva in the oral cavity, no adverse effects on enamel mineralization were detected. Because of its unique experimental design, this is a very clinically relevant study that helps to confirm the safety of tooth whitening with 10% carbamide peroxide.

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THE BOTTOM LINE

A number of in vitro studies have reported that peroxide bleaching procedures can roughen, demineralize, or even weaken enamel. However, there is essentially no evidence that any of these adverse effects occurs clinically. The protective action of saliva probably accounts for the discrepancies between the laboratory and clinical settings, as illustrated so well by the Justino et al. study.

As Silva and colleagues mentioned in their article, bleaching agents might be prescribed cautiously in some specific patients, such as those with poor salivary flow or other factors that might contribute to the erosion or abrasion of tooth structure. Also, it should be noted that the established safety of bleaching is based on the observation of reasonable, relatively short-term usage. Long-term use (or abuse) of the products might cause unforeseen problems.

Editor's Note: We welcome readers' suggestions for topics and contributors to Critical Appraisal. Please address your suggestions to the section editor:

Critical Appraisal—Dr. Edward J. Swift Jr.
Department of Operative Dentistry
University of North Carolina
CB#7450, Brauer Hall
Chapel Hill, NC 27599-7450
Telephone: 919-966-2773; Fax: 919-966-5660
E-mail: Ed_Swift@dentistry.unc.edu