

Effect of Four Different Opalescence Tooth-whitening Products on Enamel Microhardness

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Clinical Relevance: Enamel will be more damaged by the Opalescence products with the longer exposure period.

ABSTRACT

Objectives: The purpose was to evaluate the effect of various Opalescence tooth-whitening products on enamel.

Methods and Materials: Enamel blocks were exposed to Opalescence PF 10% Carbamide Peroxide (n=10), Opalescence PF 20% Carbamide Peroxide (n=10), Opalescence TrèswHITE Supreme 10% Hydrogen Peroxide (n=10) and Opalescence Quick PF 45% Carbamide Peroxide (n=10) according to the manufacturer's instructions. The control group was enamel blocks (n=10) kept in artificial saliva. The values were obtained before exposure and after the 14-days treatment period. Enamel blocks were kept in saliva between treatments. Indent marks on enamel blocks were examined using the scanning electron microscope for treatment effects.

Results: All four different Opalescence products damaged enamel. The most damage was done when treated for a long period (112 hours). SEM images also showed damage to enamel by all 4 products. Opalescence with 10% and with 20% Carbamide Peroxide showed the highest damage, which also differed significantly ($p < 0.05$) from the saliva control group ($p < 0.05$; Tukey-Kramer Multiple comparison test).

Conclusion: All 4 Opalescence products damaged enamel. Higher damage was done by the 10% carbamide peroxide and 20% carbamide peroxide products because of the much longer exposure period (112 hours in comparison to 7 hours).

INTRODUCTION

Vital tooth bleaching has become increasingly popular in recent years. Two commonly used methods for vital tooth bleaching include in-office or power bleaching¹ and at-home

bleaching or nightguard vital bleaching introduced by Haywood and Heyman².

The active ingredients of bleaching products are mainly hydrogen peroxide or carbamide peroxide but might also be one of a few other agents such as oxalic acid, chlorine and muriatic acid^{3,4}. Lower concentrations of peroxide are being used for at-home bleaching with a hydrogen peroxide concentration of up to 10% or a carbamide peroxide concentration of up to 10-22%. However, much higher peroxide concentrations (30-35%) are being used for in-office procedures⁵. Bleaching products with high concentrations of peroxide are claimed to ensure quicker whitening of teeth as compared to products with lower peroxide concentrations⁶.

It is stated that a 10% carbamide peroxide solution is still the most commonly used at-home bleaching concentration^{7,8}, because of its reported safety and effectiveness⁹⁻¹². Ten percent carbamide peroxide dissociates into a hydrogen peroxide concentration of 3 - 3.5%^{1,7,9}.

Bleaching of vital teeth involves direct contact with the enamel surface for an extensive period of time which differs between manufacturers. This fact increased concerns about the possible adverse effects of such a strong oxidizing agent on the enamel/dentine. Some scanning electron microscope studies have reported changes in surface morphology of enamel after bleaching with carbamide peroxide¹³⁻¹⁷ and/or hydrogen peroxide products^{13,18}, while other studies reported no alterations in the enamel morphology^{1,19,20}. Hegedüs *et al*,²¹ in an atomic force microscopy study, demonstrated that carbamide peroxide and hydrogen peroxide were capable of causing alterations in enamel surface.

In vitro studies have reported alterations in enamel microhardness after exposure to 10% carbamide peroxide²²⁻²⁴. De Oliveira *et al*,²⁵ reported a decrease in enamel microhardness when exposed to 10% carbamide peroxide containing calcium and fluoride. Some studies have reported negative effects of different carbamide peroxide^{7,13,26} and hydrogen peroxide^{13,27} concentrations on enamel microhardness. No changes in enamel microhardness were also reported by others^{28,29,30}.

This study was performed to address the enamel damage contradictions by tooth whitening agents and to evaluate the effect of various Opalescence® tooth-whitening products on enamel.

Composition	g/l
Sodium Carboxymethylcellulose	10.0
Sorbitol	30.0
Potassium Chloride	1.2
Sodium Chloride	0.844
Magnesium Chloride	0.052
Calcium Chloride	0.146
Potassium Dihydrogen Phosphate	0.342

MATERIALS AND METHODS

Specimen preparation

Freshly extracted, non-carious human molar teeth were collected and stored in water with a few crystals of thymol. The roots were removed approximately 2-3 millimetres apical to the cemento-enamel junction using a double-sided diamond saw in a low-speed motor. Enamel blocks of ~5x5 mm were sectioned longitudinally to the crowns. These enamel blocks were then examined under stereomicroscope at 25x magnification and those with stains or cracks discarded. Fifty of the selected enamel blocks (10 for each of the five treatment groups) were individually embedded in acrylic in PVC rings with a length of ~1 cm (cut from a 25mm diameter electrical tubing) with the enamel surface exposed above the acrylic and 90° to the PVC ring. The exposed enamel surfaces of the specimens were polished (Metaserv, Universal Polisher, UK) using water cooled carbide paper up to 1200 grit fineness (3M, US). The specimens were randomly divided into five treatment groups (1-5) with 10 specimens each and stored in distilled water with thymol crystals added.

For treatment of the enamel blocks, individual mouth guards were prepared (to simulate the in vivo bleaching procedure) for groups 2 to 5 using impressions of the different groups of enamel blocks which were embedded. Models were poured in yellow stone and light-cured resin block-out material (Ultradent LC Block-out Resin, Ultradent Products, South Jordan Utah) was used to create a reservoir for bleaching materials. Mouth guards were fabricated with a 0.035" thick, 5x5" soft tray material from Ultradent in a heat/vacuum tray-forming machine. The trays were trimmed to fit each specimen perfectly.

Treatments were performed as follows:

Group 1, control (n=10):

These enamel blocks were stored in the prepared artificial saliva (Table 1) at 37°C.

Group 2, Opalescence® PF 10% Carbamide Peroxide (n=10):

The formed trays (mouth guards) were filled with a layer (approx 1 mm) of 10% carbamide peroxide bleaching gel and

applied to the enamel surfaces of the blocks for 8 hours/day for 14 days, as suggested by the manufacturer. During the treatment period (bleaching) the specimens were kept in 100% relative humidity at 37 °C. After each bleaching procedure, the bleaching gel was removed gently from the enamel surfaces using a paper towel and then thoroughly rinsed and stored in the artificial saliva (Table 1) at 37 °C until the next treatment. The artificial saliva was replaced on a daily basis.

Group 3, Opalescence® PF 20% Carbamide Peroxide (n=10):

Treatment in this group was exactly as in the previous group, except that 20% carbamide peroxide was used.

Group 4, Opalescence® Trèswhite Supreme 10% Hydrogen Peroxide (n=10):

Treatment in this group was also as for group 2, except that 10% hydrogen peroxide bleaching gel was used for 30 minutes/day for 14 days, as suggested by the manufacturer.

Group 5, Opalescence® Quick PF 45% Carbamide Peroxide (n=10):

Treatment in this group was also as for group 2, except that 45% carbamide peroxide bleaching gel was used for 30 minutes/day for 14 days, as suggested by the manufacturer.

MICROHARDNESS MEASUREMENTS

Surface microhardness of the enamel blocks were measured using a digital hardness tester (Zwick Roell Indentec, ZHV; Indentec UK) with a Vicker's diamond indenter. The saliva soaked specimens were wiped gently with a tissue paper, rinsed with distilled water and tissue blot dried before each microhardness measurement. Before any treatment, four indentations were made (base-line hardness values) on the polished enamel surface of each enamel block (10 blocks) with a 300 g load applied for 15 seconds. The measurements (indents) were repeated after 14 days of active bleaching treatment close to the previous mentioned baseline indents (about 10 µm away from where the base-line indent was made). All data were saved as Vickers Hardness Values (VHN) for statistical analysis.

Three additional enamel blocks of each test group were polished, as already described. One hardness indent was then made on each block and the position of the indent was marked. The blocks were then subjected to the full 14 days treatment as described above, thoroughly rinsed under tap water, blot dried and another indent made next to the previous one (~ 10 µm away). This provided a treated as well as untreated indent mark for scanning electron microscope images (to compare the demineralization effect on the indents).

The data were analysed with one way analysis of variance followed by a Tukey-Kramer multiple comparison test for differences amongst the different groups (significance level was 5%).

Table 2 gives general information about the bleaching products according to the manufacturer.³¹

The general composition of the Opalescence bleaching products investigated in this study is given (Table 2). Opalescence® PF 10% (group 2), 20% (group 3) and 45% (group 5) carbamide peroxide gels (pH ~6.5) are sticky with high viscosity and contain potassium nitrate and 1100 ppm fluoride. They are all dentist-controlled, dentist-supervised, take-home bleaching systems, as referred to by the manufacturer³¹. Opalescence® Trèswite Supreme (group 4) contained 10% hydrogen peroxide, filler and flavour but without nitrate and fluoride (Table 2). All Opalescence products were supposed to have adhesive properties and sustained release of peroxide. It is reported that 10% of carbamide peroxide released 3.35% hydrogen peroxide.¹ Therefore, a new and strong oxidizing product (group 5) which contained 45% carbamide peroxide released 15.08% hydrogen peroxide (Table 2).

The control group (Figure 1) comprised enamel blocks stored in artificial saliva (Table 1; group 1) for the whole period of the experiment (14 days) and showed almost no hardness change over 14 days (median difference between the start and the end was only 1.0). This finding showed that our artificial saliva solution did not alter the hardness of sound enamel either positively or negatively and could be rightfully used as a soaking medium in the experiment.

The difference in hardness has a negative value when bleaching resulted in a softer enamel surface (Figure 1). All four peroxide treatments resulted in lower hardness values which indicated damage to enamel. Statistical results showed no significant differences amongst any of the four treatment groups (Tukey-Kramer), although the total treatment times and peroxide concentrations differed (Table 2). Groups 2 and 3 (Table 2) had the same treatment time of 112 hours but different hydrogen peroxide concentrations (3.35% and 6.7%), which gave almost the same hardness values (Figure 1; medians of -19.5 and -18.0). It appeared that a shorter treatment period of seven hours (groups 4 and 5) with higher peroxide concentrations (10% and 15%) gave rise to a softer enamel when compared to lower concentration treatments (3.35% and 6.7%) but for a much longer period (112 hours). Although there was no significant difference amongst the two seven hour treatment groups and the saliva control, these seven hour groups showed half the softness inflicted by the two 112 hour treatment groups. This effect was further supported by SEM images taken of indent marks before and after the bleaching process (Figure 2; images 1 and 2). SEM images were done on indentation marks for all four of the products but only one image (obtained from the least destructive Opalescence Trèswite Supreme, group 4) was shown because similar images were found for all of the four products. The indent marked 1 was done on unbleached enamel and the indent marked 2 was subjected for the full treatment period to Opalescence Trèswite Supreme. Comparing these two images, it can clearly be seen that the indent mark which was subjected to the bleaching process (image 2) almost disappeared because of enamel demineralization (dissolution). Although some studies have reported no significant changes in enamel microhardness after

bleaching with Opalescence 10% carbamide peroxide^{3,14,28,36}, or 15% carbamide peroxide³⁷, other studies have found a decrease in enamel microhardness after treatment with Opalescence 10%,^{7,8} 20% carbamide peroxide⁷ and 35% carbamide peroxide¹³. To the knowledge of the authors no results were published on Opalescence® Trèswite Supreme and Opalescence® 45% PF as these were new products which had not been investigated.

CONCLUSION

1. All four Opalescence groups decreased enamel microhardness.
2. Reduced microhardness occurred with 10% and 20% carbamide peroxide whitening groups.
3. Softer enamel resulted from a longer exposure period (112 hours) than the higher hydrogen peroxide concentrations.

RECOMMENDATIONS

Therefore, of the four Opalescence products tested, the least damage could be expected from Opalescence® Trèswite Supreme and Opalescence® Quick PF 45%.

Declaration: No conflict of interest was declared.

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