Light-activated Bleaching: Effects on Surface Mineral change on Enamel

ABSTRACT

Aim: This study evaluated the in vitro effect of 35% hydrogen peroxide (HP) on surface enamel change when activated with different light curing units (LCUs).

Materials and methods: Enamel blocks (4 × 4 × 2 mm) were obtained from bovine incisors. The initial microhardness of the enamel was determined for each specimen. After this enamel blocks were randomly divided into four groups (n = 10) and treated as follows: Control, no bleaching procedure performed; HP – LCU, application of 35% HP gel without light activation; HP + QTH, application of 35% HP gel and light activation with a Quartz Tungsten-Halogen (QTH); and HP + Light Emitting Diode, application of 35% HP gel and light-activation with a LED. New microhardness measurements were obtained, immediately, 7 and 14 days after treatment. The percentage of surface mineral change was calculated according to the baseline and post-treatment microhardness values. Additionally, six samples from each group were randomly selected and prepared for scanning electron microscopy (SEM) characterization. The data were analyzed using an analysis of variance (ANOVA) to detect differences between the three time periods, and an ANOVA and Tukey’s test with a confidence level of 95%.

Results: There was no significant difference between the initial hardness values and hardness values after treatment in any of the groups or time periods (p > 0.05). No major surface alterations were detected with SEM when comparing control groups to those undergoing bleaching treatments.

Conclusion: The use of 35% HP in combination to QTH or LED light curing units LCU does not have detrimental effect on the enamel surface topography or in the mineral content, when compared with unbleached enamel or enamel submitted to 35% HP treatment alone.

Keywords: Tooth bleaching, Dental enamel, in vitro, Light source, Hydrogen peroxide, Hardness, Enamel morphology.


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Conflict of interest: None declared

INTRODUCTION

The most popular vital bleaching technique is the at-home treatment with trays using 10% carbamide peroxide, because this treatment is the only treatment that has received acceptance from the American Dental Association (ADA), and this technique can provide results for up to 2 years. However, in some situations, patients are unwilling or unable to be enrolled in long-term treatment (2-3 weeks for mouthguard bleaching) or they are not willing to wear a tray. In these situations, a high-concentration bleaching agent, such as 35% HP or carbamide peroxide can be used in the dental office. This in-office treatment has been suggested to provide a faster and stronger bleaching effect.

In addition, this high concentration of bleaching agents may be associated with light sources. Activation of the bleaching gel may be performed with different light-curing units: Quartz Tungsten-Halogen (QTH), Light emitting diode (LED) and lasers, and the combination of bleaching agents plus a light source has been indicated to improve the effect of treatment and produce faster results. Despite the alleged advantage, clinical studies have questioned the improvement in bleaching effects. In addition, other adverse effects have been related to bleaching technique, it independent of the concentration used, such as mineral tissue removal, causing increased porosity and permeability. However, such alterations were hardly observed, when the dental structure was stored in artificial saliva. The increase in tooth permeability can also produce deeper HP penetration that could reach the dental pulp, leading to adverse pulpal responses, because such responses are more prone to occur when in-office treatments are conducted, especially with an additional light source as adjunctive treatment.

A recent in situ study analyzed the influence of different light activation sources and 35% HP on the microhardness of human enamel subjected to in-office dental bleaching. The authors observed that the light sources did not significantly alter the microhardness of human enamel after 14 days, but the use of HP together with a halogen light reduced microhardness after 1 and 7 days. Another in vitro study observed a significant decrease in hardness when combining
the application of a high-concentration peroxide agent with a light source,\textsuperscript{13} but the authors used distilled water as the storage condition during the experiment. It is already known that the storage solution and study design will influence the effect of bleaching on dental structures.\textsuperscript{10} Because, there is a lack of information in the scientific literature regarding the safety of bleaching using light sources,\textsuperscript{4} and some of the results observed are contradictory, new studies are needed to investigate the potential adverse effects associated with this treatment.

Therefore, the purpose of the present study was to investigate the effects of 35% HP activated using different curing units on surface mineral change (SMC).

**MATERIALS AND METHODS**

**Preparation of the Enamel Blocks**

This study used 64 recently extracted bovine incisors. The pulp tissue was removed, and the crowns were sectioned longitudinally to obtain 4 × 4 × 2 mm enamel blocks. The blocks underwent steam sterilization to avoid bacterial contamination. Each slab was included in a polyvinyl chloride (PVC) with only one side unsealed: buccal enamel. The samples were sequentially polished in decreasing order of disk granulation (400, 600, 800 and 1,200) with a polishing solution MetaDi Supreme\textsuperscript{®} (Buehler, Dusseldorf, Germany) to obtain flat. About forty blocks were used for the microhardness tests, and 24 were used for the SEM evaluation. The specimens were stored in an artificial saliva solution at 37ºC according to previously reported methods.\textsuperscript{14} The artificial saliva was changed daily.

**Bleaching Treatment Protocol**

The samples were treated with a 35% HP gel Whiteness HP Maxx\textsuperscript{®} (FGM, Joinville, Brazil) and these were randomly allocated into four different groups (n = 10), as shown in Table 1. In the experimental groups, the bleaching agent was mixed at a rate of three drops of peroxide to one drop of thickening agent. Soon after enamel drying, the prepared gel was applied with a microbrush to form a 1 mm layer, corresponding to approximately 0.05 ml of the bleaching agent on each specimen. The gel remained on the enamel buccal surface for 15 minutes. When light activation was used, the light unit remained parallel to the surface and was applied twice for 20 seconds, with 2 minutes intervals between each light application and a standard distance of 5 mm. A detailed description of the light-curing units, including the light type, energy power and wavelength, (Table 1).

Following the bleaching treatment, the gel was washed off with an air-water spray. The bleaching procedures were repeated three times in each treatment session, resulting in 45 minutes of bleaching agent contact with the enamel surface. To simulate the manufacturer’s clinical recommendations, three bleaching treatments were performed: initially, after 7 and 14 days, using the same bleaching protocols. Throughout the experiment, the specimens were maintained in artificial saliva\textsuperscript{14} (changed daily) at 37ºC.

**Percentage of Surface Mineral Change**

To determine the percentage of surface mineral change (SMC), the initial microhardness (baseline) was measured using a Knoop hardness indenter in a microhardness tester (FM-700, Future Tech Corp., Tokyo, Japan). Following a pilot study, a 25 gm load for 5 seconds was set as the parameter for producing indentations. In each specimen, 10 hardness readings were conducted at distances of 100 μm from each other in the center of the enamel blocks before treatment (baseline) (Fig. 1). After each bleaching protocol, new indentations were conducted, with 10 readings per sample: 5 indentations were located 100 μm above and 5 were located 100 μm below the baseline indentations (Fig. 1). The mean values for the experimental groups at different time periods were obtained using these 10 measurements, from which the percentage of SMC was determined in relation to the baseline measurement using the following equation: percentage of SMC = SMH after the treatment – baseline × 100/baseline.\textsuperscript{15} The SMC was determined at three time periods: initially, at 7 and 14 days.

**Statistical Analysis**

The data within each group were subjected to statistical analysis using repeated measured one-way ANOVA to detect differences.
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Differences between the three time periods. Comparisons between the treatments independent of time were conducted with one-way ANOVA and Tukey’s test, with a confidence level of 95%.

Surface Morphology Analysis using Scanning Electron Microscopy

Six enamel blocks (2 × 2 × 2 mm) from bovine incisors were obtained from each group (control and experimental), with two specimens allocated for each time period. The specimens were embedded in epoxy resin (Buehler, Lake Bluff, IL, USA) and drystored in lightproof containers at 37°C. The samples were ultrasonically cleaned using distilled water and then dried at 37°C for 2 hours. Thereafter, the specimens were coated with gold and examined by SEM (JSM-5600 LV; Jeol Inc., Tokyo, Japan) at 18 kV to analyze the etching morphology provided by the different treatments. The analyses focused on the integrity, homogeneity, and continuity of the enamel surface using different magnifications.

RESULTS

The percentage of SMC values for the different groups during the evaluation periods are shown in Graph 1. Despite some differences, there were no statistically significant differences among the groups (p > 0.05), indicating that neither HP usage nor the application of a light source significantly altered the mineral content of the enamel blocks at any period (Fig. 2).

No significant surface alterations in surface morphology under SEM were observed when comparing the baseline values of the groups with the values after the bleaching protocols (Figs 3A to D). The enamel surfaces treated with a bleaching agent, with (Figs 3C and D) or without (Fig. 3B) a catalyst source, were very similar in appearance to the control group (Fig. 3A); the enamel surface did not show any evidence of porosities, but intact enamel crystallites were present.

DISCUSSION

The overall results of our study have demonstrated that neither the application of 35% HP nor the application of this bleaching agent coupled with a light source had a significant detrimental effect on the enamel surface. Studies have investigated the enamel microhardness before and after bleaching.6,17-20 The results of these studies are controversial; some have observed a decrease in microhardness,9,16,17,19 while these changes were not observed in other studies.6,18,20 These conflicting results are due to a wide variety of differing factors, including different methods of investigation, bleaching agents, gel concentrations, application times, the use of catalyst sources and storage models. Therefore, the results of our study are more appropriate to the clinical situation, and in the presence of artificial saliva, the light-curing units combined with the 35% HP agent were not harmful to the enamel surface.

In our study, we used artificial saliva as the storage solution throughout the study, and no significant alterations in enamel topography and mineral content were observed. Artificial saliva closely resembles the composition and viscosity of natural human saliva,14 and it is able to prevent the demineralization effect of bleaching agents, as previously reported.10,21 Artificial saliva contains calcium and phosphate ions, which ensures ionic changes on tooth surfaces,15 increasing surface hardness, decreasing permeability and increasing enamel resistance.17,22 Consequently, it is extremely important to use artificial saliva as the storage solution when performing studies on the effect of bleaching on enamel; otherwise, the detrimental effects observed could be more related to the experimental design than the bleaching agent.20

The use of a light source for vital bleaching follows the same process, because the light is transformed into heat, and this heat could accelerate the process of color recovery.4 The use of light sources to catalyze the immediate bleaching treatment is a relatively new approach, and few studies have investigated this technique. Some studies have reported tooth sensitivity during the in-office bleaching treatment with light,23-25 and these observations were closely associated with the type of source used23,24 and the time of enamel application.25 Thus, patients who undergo bleaching with high concentrations of peroxide (35%) with application of a light
source should not undergo the prolonged application time of an in-office bleaching gel.

We used two light sources as catalyst agents: QTH and LED. Both units have different energy outputs and wavelengths (Table 1), and LED is considered to produce a lower level of temperature increase compared with QTH. If an increase in temperature accelerates the bleaching reaction, the QTH unit should provide an improved bleaching effect compared with the LED unit. However, this assumption has not been proven to occur in clinical trials, where neither QTH nor LED units were able to improve the bleaching effect. It is also noteworthy that the increase in temperature produced by the light curing units during bleaching procedures could be harmful to the dental pulp, because high intensity light sources, such as plasma arc and lasers, may be able to significantly increase the intrapulpal temperature. The increase in intrapulpal temperature and penetration of HP throughout the dental pulp may lead to serious pulp damage. Therefore, high-concentration peroxide agents and light sources should be used with caution to prevent potential detrimental effects.

Another mechanism to explain the pain experienced during bleaching treatment is the increase in enamel permeability with mineral loss and production of microcracks, which could facilitate the penetration of peroxide inside the tubules, causing fluid movement (hydrodynamic theory). However, the SEM images from our study did not show significant surface alterations with the use of 35% HP: HP plus light sources. In all samples, the enamel surface was essentially unchanged, and this finding could be the result of using artificial saliva, which prevented the potential erosive effect of bleaching agents.
Bovine teeth were used in this study due to their advantages over human teeth; they are easily obtained in a frigorific and have large surfaces, unlike, human teeth are becoming seldom available for research purposes. Moreover, bovine enamel and dentin also have similar microstructures and hardness to human teeth.

We used the percent of SMC instead of microhardness values. This methodology has been used in different studies for different purposes. The main advantage of this method is that it provides a graph displaying the loses and gains in mineral structure over time. The percentage of SMC indicates some changes in the mineral content between groups at the different time periods; however, as stated in the statistical analysis, these alterations were not statistically significant. In addition, the graph produced for percentage of SMC with the SEM images suggests that the surface alterations were not clinically relevant.

CONCLUSION

Within the limitations of this study, we conclude that the use of 35% HP in combination to QTH and LED does not have detrimental effect on the enamel surface topography or in the mineral content, when compared with unbleached enamel or enamel submitted to 35% HP treatment alone.

CLINICAL SIGNIFICANCE

The use of 35% HP in combination with a light source does not have detrimental effect on the enamel surface.

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REFERENCES


