Effect of Diode Laser Office Bleaching on Mineral Content and Surface Topography of Enamel Surface: An SEM Study

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ABSTRACT

Aim: To assess the effects of different bleaching procedures on the mineral component and surface topography of the enamel using scanning electron microscope (SEM) and energy-dispersive X-ray spectrometry (EDX).

Materials and methods: Forty samples of approximately 3 × 3 mm size from the coronal portion of 20 extracted human anterior teeth were obtained. The samples were divided into two control groups and three experimental groups. In group I or positive control ($n = 5$), no bleaching or phosphoric acid treatment to the enamel surface was done. Group II samples or negative controls ($n = 5$) were treated with 37% phosphoric acid. In group III ($n = 10$), the tooth was treated with 35% hydrogen peroxide (HP) without any activation. Group IV ($n = 10$) was treated with 37.5% HP with LED light activation and group V ($n = 10$) was treated with 45% HP with diode laser activation. The calcium (Ca) and phosphorus (P) levels of each sample were measured using an EDX system prior to bleaching treatments. All the samples were again subjected to the EDX analysis after the bleaching treatment and two samples (after EDX analysis) from each group were subjected to the SEM analysis.

Result: No significant difference was seen in phosphorus levels before and after the bleaching. However, significant increase in calcium levels was observed after bleaching activated with LASER and LED light. The SEM observations revealed maximum surface alterations on the enamel after chemically activated bleaching.

Conclusion: The LASER-activated bleaching agent seems to be more surface-friendly and less time-consuming as compared to other bleaching systems.

Keywords: Diode laser, Energy-dispersive X-ray spectrometry system, Hydrogen peroxide, In-office bleaching, Laser, LED, Scanning electron microscopy.

International Journal of Clinical Pediatric Dentistry (2020): 10.5005/jp-journals-10005-1823

INTRODUCTION

The smile has been very essential for communication. To satisfy patients' expectations for a pleasing smile and many peoples' preference to white teeth have induced dentists to find a solution.¹ Dental bleaching treatment is one of the various esthetic treatments, which is recognized as safe, effective, nonlethal, and a nontoxic treatment.² It has been a great interest of dental professionals to research the effect of bleaching agents on the enamel surface since it is widely used.³ Regardless of introducing many curing lights into the dental market, which is used for accelerating in-office bleaching treatments, there is deficient literature regarding laser lights. Therefore, this study was conducted to determine the change in the mineral component of the enamel and to evaluate the difference in surface topography of the enamel following different bleaching materials and activating methods.

MATERIALS AND METHODS

Twenty intact, noncarious, human permanent anterior teeth that were extracted for periodontal reasons were collected and stored in distilled water at room temperature prior to the procedure. The removal of calculus and extrinsic stains was done approximately 2 mm below the cemento-enamel junction with ultrasonic scaler and then polished with slurry of pumice. Horizontal cross-cut sections were performed separating the crown and the root using the diamond disc bur mounted on a micromotor straight handpiece. Each crown was then sectioned vertically to obtain two samples of size approximately 3 × 3 mm with the diamond disk. Thus creating a sample of 40 specimens from 20 crowns and these were stored in distilled water. The samples were then randomly assigned to

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How to cite this article: Suresh S, Navit S, Khan SA, *et al.* Effect of Diode Laser Office Bleaching on Mineral Content and Surface Topography of Enamel Surface: An SEM Study. *Int J Clin Pediatr Dent* 2020;13(5): 481–485.

Source of support: Nil

Conflict of interest: None

three experimental groups ($n = 10$) and two control groups ($n = 5$). In group I, the samples were kept in distilled water until the time of analysis and no bleaching procedure was performed. In group II, the samples were treated with 37% phosphoric acid (DPI Tooth conditioner gel, India) for 30 seconds. In group III, the bleaching agent consisting of 35% hydrogen peroxide (Pola Office, SDI, Australia) was applied to the enamel surface for 8 minutes as per to the manufacturer's instructions. The specimens were washed and then fresh gel was again applied. This procedure was repeated two more times and then kept in distilled water. Total contact time of gel to enamel was $8 \times 3 = 24$ minutes. In group IV, the bleaching agent consisting of 37.5% hydrogen peroxide (Pola Office+, SDI, Australia)

was applied to the enamel surface. The gel was applied for 8 minutes and activated with LED light (C-Bright-I, United Kingdom) at 1200 mW/cm² for 8 minutes. This process was repeated for another two times and each time fresh gel was prepared and then kept in distilled water. Total contact time of gel to enamel was $8 \times 3 = 24$ minutes and total time of LED light activation was $8 \times 3 = 24$ minutes. In group V, the samples were bleached with 45% hydrogen peroxide (LaserWhite20, BIOLASE, USA). The gel was activated with the 940 nm diode LASER system (Epic10, BIOLASE, USA) using the whitening program (7 W) as per the manufacturer's instructions. The gel was then washed and fresh gel was applied and the whole process was repeated three times. The teeth were then rinsed, dried, and kept in distilled water. Total contact time of gel to enamel was 17 minutes, and total time of LASER light activation was 3 minutes. Postbleaching EDX was performed on all the samples of each group for the mineral analysis. The scanning electron microscope (SEM) analysis, for surface topography, was performed on two samples of each group.

RESULTS

After bleaching, the calcium levels significantly increased in the group IV ($p = 0.002$) and group V ($p < 0.001$) and significantly decreased in group II ($p = 0.001$). The phosphorus levels decreased significantly in group II ($p = 0.007$) after bleaching. However, no significant difference in calcium levels in groups I and III and phosphorus levels in groups I, III, IV, and V were found. Results are summarized in Tables 1 and 2. The graphical comparison is also shown in Figs 1 and 2. The SEM observations were recorded to compare the differences among the groups at magnification of 500x and 10,000x (Figs 3A and B) and the correlated SEM analysis results showed the partial removal of the aprismatic layer with shallow

erosions in group III (Figs 4A and B) and severe surface alterations with complete removal of the aprismatic layer and presence of increased depth of enamel grooves in group II (Figs 5A and B). There were mild surface alterations seen in group IV (Figs 6A and B) and group V (Figs 7A and B).

DISCUSSION

In the present study, the enamel surface was treated by different bleaching methods using similar hydrogen peroxide concentrations, i.e., 35% (SDI-PolaOffice, Australia), 37.5% (SDI-PolaOffice+, Australia), and 35% (LaserWhite20, BIOLASE, USA). It is pertinent to note that the LaserWhite20 whitening gel kit is supplied as a two-syringe system. Base syringe contains 45% hydrogen peroxide and activator syringe is formulated with a propriety dye that activates by absorbing laser energy. When the components of both the syringes are mixed prior to the application, on the tooth surface, it results in 35% hydrogen peroxide.

In group III (35% hydrogen peroxide without any light activation), the SEM analysis of the specimen showed partial removal of the aprismatic layer leading to surface roughness. There were also shallow erosions seen on the enamel surface. The alteration of the enamel surface seen may be due to the acidic pH of the bleaching agent. Similar results were reported by the study conducted by Freire et al.⁵ They used the same bleaching agent (SDI-PolaOffice, Australia) as of the present study and found its pH to be ranging between 2.4 and 2.6. The result of the present study is also in accordance with the study conducted by Fatima⁶ who evaluated the effect of in-office bleaching agent containing similar concentration of hydrogen peroxide and found that bleaching with hydrogen peroxide resulted in mild changes in

Table 1: Mean and standard deviation values of calcium levels of enamel before and after bleaching

Groups	Before bleaching	After bleaching	Difference	p value
Group I	62.647 ± 4.937	62.661 ± 4.947	-0.014 ± 0.035	0.238
Group II	60.259 ± 4.165	53.776 ± 3.686	6.483 ± 3.938	0.001
Group III	63.302 ± 5.409	66.278 ± 5.375	-2.976 ± 4.589	0.071
Group IV	65.313 ± 4.144	68.539 ± 4.683	-3.226 ± 2.394	0.002
Group V	67.539 ± 1.694	70.664 ± 0.681	-3.125 ± 1.697	0.001

Table 2: Mean and standard deviation values of phosphorus levels of enamel before and after bleaching

Groups	Before bleaching	After bleaching	Difference	p value
Group I	28.524 ± 4.565	28.481 ± 4.756	0.043 ± 0.498	0.791
Group II	29.584 ± 3.613	25.882 ± 1.890	3.702 ± 3.344	0.007
Group III	30.196 ± 3.799	28.51 ± 2.253	1.686 ± 3.799	0.194
Group IV	30.592 ± 4.140	28.15 ± 3.068	2.442 ± 4.534	0.123
Group V	29.534 ± 1.013	29.216 ± 0.916	0.318 ± 0.468	0.06

Fig. 1: Comparison of calcium levels before and after bleaching

Fig. 2: Comparison of phosphorus levels before and after bleaching

Figs 3A and B: Unbleached enamel (control) at (A) 500x and (B) 10,000x magnification

Figs 4A and B: Enamel surface after application of chemically activated office bleaching system at (A) 500x and (B) 10,000x magnification

Figs 5A and B: Enamel surface etched with 37% phosphoric acid at (A) 500x and (B) 10,000x magnification

surface micro-morphology of enamel. A study conducted by Bistey et al.⁶ found severe alterations in the enamel surface. However, no morphological alterations on the enamel with similar concentration of hydrogen peroxide were produced in the research conducted

by Cakir et al.² The difference in this study can be attributed to the different bleaching agents since in the study conducted by Cakir et al., the bleaching agent used was Opalescence Xtra Boost whereas in the present study, SDI- Pola Office bleaching agent was used. The

Figs 6A and B: Enamel surface after application of LED-activated office bleaching system at (A) 500x and (B) 10,000x magnification

Figs 7A and B: Enamel surface after application of LASER-activated office bleaching system at (A) 500x and (B) 10,000x magnification

difference could also be due to the longer contact time (30 minutes) of the gel to the enamel surface in the study conducted by Cakir et al. as compared to the present study (24 minutes).

In the present study, in the fourth group (37.5% hydrogen peroxide with LED activation) slight surface alteration was seen on the enamel surface.⁷ There was an increased depth of enamel grooves and an increase in the porosity all over the enamel. However, the alterations seen in the enamel surface of group IV were less when compared to group III, although the time of application of the bleaching gel remained same (24 minutes) for both the groups. This difference can be attributed to the different pH of the bleaching material as the bleaching agent (SDI PolaOffice+, Australia) used for the LED-activated bleaching had a neutral pH as claimed by the manufacturer. Although the concentration of hydrogen peroxide used was slightly higher in this group, it can be considered that the lower pH of the bleaching agents is more detrimental to the tooth rather than the concentration of hydrogen peroxide. Similar results were reported by Loguerio et al.⁸ when they compared the effect of acidity of in-bleaching gels on tooth sensitivity and whitening. However, the effects of bleaching on the tooth sensitivity were not considered in this study as it was an *in vitro* study.

The fifth group of the present study was treated with LASER-activated bleaching. The LASER used in this study was a diode

LASER using the whitening program (7 W for 30 seconds) at a wavelength of 940 nm. When the SEM images of LASER-activated bleaching group were compared with that of the positive control group, there were only mild alterations seen on the enamel surface involving very slight increase in number of porosity. The enamel surface was almost similar to the positive control group. The reason for this result may be the less exposure time of the bleaching gel to the tooth (17 minutes) as compared to other group (24 minutes). It is supported by the study conducted by Souza et al.⁹ that the increase in surface alterations is directly proportional to the period of exposure to the bleaching agent to the enamel surface. Dostalova et al.¹⁰ investigated various laser-activated bleaching agents for discolored teeth and concluded the diode laser to be simple and less time-taking procedure.

In the present study, for comparing the surface characteristics of bleached and etched enamel surfaces, the samples of negative control were treated with 37% phosphoric acid. Severe alterations of the prismatic structure of the enamel including loss of the aprismatic layer and increased depth of enamel grooves were seen after etching.

Also, in this study, the calcium and phosphorus levels were examined before and after treatment with different in-office bleaching agents using EDX. The postbleach enamel calcium level

was found to be significantly higher in LED-activated and LASER-activated bleaching while in chemical bleaching, no significant difference was found in calcium levels before and after the bleaching. None of the bleaching procedure significantly affected the phosphorus level in the enamel.

Cakir et al.² determined the change in the mineral component of enamel and reported a slight increase in the calcium levels of the enamel after treatment with different bleaching agents. Poorni et al.¹¹ also revealed a slight increase in the calcium ion levels after bleaching with 35% hydrogen peroxide. Contrary to this, Souza et al.⁹ reported a decrease in the calcium levels of the enamel after treatment. The reason may be because of the high exposure time of bleaching agent to the surface (45 minutes). A significant reduction in the calcium and phosphorus ion levels was observed in negative control group samples, which were treated with 37% phosphoric acid.

Many studies are in agreement with findings reported in the present study, which detected changes in mineral composition and surface topography of the enamel surface after bleaching with hydrogen peroxide. Therefore, while performing in-office bleaching, caution is required. Also, to completely understand the effects of bleaching agents on dental tissues, further studies are necessary.

CONCLUSION

The use of LASER- and LED-activated in-office bleaching system causes very slight morphological alteration in the enamel surface of the tooth. The added advantage of the LASER-activated bleaching is that it seems to be surface friendly and less time-consuming as compared to other bleaching systems. Chemically activated in-office bleaching agent causes maximum surface alteration and erosion. Factors like time of contact and pH of the bleaching agents also play a role in its effect.

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