Effects of Tooth Coating Material and Finishing Agent on Bleached Enamel Surfaces by KTP Laser


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Objective: The purpose of this study was to evaluate the effect of tooth coating material and finishing agent on bleached enamel surfaces after using KTP laser with 27% hydrogen peroxide.

Background data: There have been few reports on the effects of tooth coating materials and finishing agents after bleaching.

Methods: After 40 crowns of human extracted maxillary incisors were bleached by KTP laser, bleached enamels were finished with fluoride only or both of fluoride and nano-hydroxyapatite as a finishing agent. After application(s) of fluoride and/or finishing agent, the enamel surfaces were divided into 2 groups, which were covered with the coating material or without coating material. After application of coating materials, all specimens were kept for 2 weeks at 37°C of 100% humidity. After removing the coating material, color changing was measured and enamel surfaces were examined by scanning electron microscopy (SEM).

Results: SEM observation of enamel surfaces treated the fluoride gel, finishing agent and coating material showed the most flattered surface compared to other groups. By measuring the color changing, few color changing was observed on the enamel surfaces treated the fluoride gel, finishing agents and coating material.

Conclusion: These results suggested that applications of fluoride gel, finishing agent and coating material made the enamel-surfaces flattered and kept effects of bleaching, could prevent the re-coloration. After applications of fluoride gel and finishing agent, covering the bleached-enamel surfaces with the coating material enhanced the keeping whiteness. It would give the patients satisfaction of whiteness.

Key words: bleached enamel surface • coating material • finishing agent • KTP laser

Introduction

Tooth bleaching is one of the most requested cosmetic dental procedures asked for by patients. The hydrogen peroxide gel application is the most popular in office bleaching technique. In our previous study, we used KTP laser for speed up the reaction and reduced the treatment time in office bleaching and it induced the safer pulpal temperature increase when assisted with Hi-Lite bleaching gel. 1) KTP laser device was invented for in office bleaching. Its unique optional and chemical interactions make photochemical bleaching possi-
ble by promoting oxidation events in a controlled manner. 2) However, still disadvantage of bleaching remained; enamel surface roughness, less glossiness, hypersensitibity and re-coloration. 3) After bleaching, fluoride gel was applied for remineralization, but the additional supplementation of fluoride gel did not enhance the microhardness. 4) Recently the effect of finishing agent was reported, and nano-hydroxyapatite was one of the finishing agents and effectively reduced the negative effects of a bleaching agent on enamel surfaces; surface roughness and gloss values. The bleached enamel surfaces applied with fluoride gel and finishing agent are soon exposed the various matters such as saliva, food and many kinds of beverages. Recently, so-called coating resin composite materials have been introduced. The function of these materials is mainly as tooth manicure, where instantaneous esthetic improvement of teeth is a priority. It was reported that marginal leakage of coating materials was occurred after about 45 days at 1/4 from the margin. This time, it was hypothesized that covering by tooth coating material on the bleached enamel surfaces temporarily for 14 days after fluoride gel and finishing agent applications may improve these disadvantage, surface roughness and re-coloration further.

**Materials and methods**

Human studies in the article were approved by the relevant Institutional Review Board(s).

**Sample preparation of enamel**

A total of 40 human extracted maxillary incisors with intact crowns were used. After extraction, all soft tissues and debris were removed with scalers. None of the teeth had any caries, restorations, or enamel cracks. The teeth were stored in 0.2% thymol solution after extraction. The labial surfaces were cleaned with an ultrasonic device and bristle brush using a slow handpiece equipped.

**Bleaching method**

Bleaching was performed according to a previous study. A bleaching agent containing 27% hydrogen peroxide (H2O2) (Smart bleach ® kit, Herzie, België) was used in the present study, activated with KTP laser (SMARTLITE D; Deka, Firenze, Italy) operated at 532 nm with output at 1.0 W. The laser beam was delivered through an optic fiber to an aperture handpiece.

**Colorimetric measurements**

After cleaning, 40 teeth were evaluated the color variable before bleaching by ShadeEye NCC (Shofu. Inc. Kyoto, Japan) at the 1/3 labial enamel surfaces from the cervical lines. The measured teeth were divided into 4 groups which average of L-value was almost equal. Color measurements were taken immediately after bleaching and after removing the applied coating material. Five readings were recorded for each specimen after it was rinsed with distilled water. Color changes were calculated from the following:

\[
\Delta L^* = L^*(\text{post}) - L^*(\text{0})
\]

\[
\Delta a^* = a^*(\text{post}) - a^*(\text{0})
\]

\[
\Delta b^* = b^*(\text{post}) - b^*(\text{0})
\]

where post is the value post-treatment and 0 is the value at baseline. This time baseline was after bleaching and post-treatment was after removing the applied coating materials. For staining test, baseline was after removing the applied coating materials and post-treatment was after staining. Total color difference values (\(\Delta E_{ab}\)) between baseline and subsequent measurements were expressed as a distance between two points in space and calculated according to the following formula:

\[
\Delta E_{ab} = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}
\]

**Fluoride gel and finishing agent application**

After bleaching, enamel surfaces of teeth were treated with fluoride gel or finishing agent (Renamel®, Sangi Co., LTD., Tokyo, Japan) or both. The enamel surfaces of teeth treated without any application were used as a negative control.

**Covering by tooth coating material**

After the fluoride gel and/or finishing agent application(s), enamel surfaces of the incisors were divided into 2 from the center (Fig. 1). A half of the enamel surfaces was coated by the coating material (White coatTM, Kurare Medical Inc., Tokyo, Japan). After coating, teeth were soaked into the artificial saliva (Salivate®, Teijin Pharma LTD, Tokyo, Japan) for 2 weeks at 37°C.

**Scanning electron microscopic (SEM) observation and staining test**

After 2 weeks the coating material was removed and 5 teeth in each group were subjected to SEM observation and the staining test. For SEM observation, the crowns were removed at the cervical line. The crowns were dehydrated through a graded series of aqueous ethanol solutions (70, 80, 90, 95, and 100 %) for 24 h at each concentration. The samples were dried by liquid CO2
using a critical point dryer device (JCPD-3, JEOL, Tokyo, Japan) and then sputter-coated using a platinum ion sputter device (E-1030, HITACHI, Tokyo, Japan). The crowns were then observed by SEM (PC-SEM) (JSE-5500, JEOL, Tokyo, Japan) at an accelerating voltage of 20 kV.

The color changing was examined and the staining test using coffee as the liquid was performed. The coffee powder of 6 g (Nestlé Japan LTD., Kobe, Japan) was dissolved in the 80 ml boiled water. The teeth were soaked in coffee liquid for 7 days. After 7 days, the teeth were rinsed with distilled water and the color changing was examined.

The procedure of each step of this study is shown in Fig. 1. Finally the teeth were divided into 7 groups for each application (Table 1). Statistical analysis was performed using Mann-Whitney U test between two groups at significant level of 5%.

Results

After staining, the color difference values ($\Delta E_{abl}$) of each group are shown in Fig. 2. The values of group D, that is, fluoride gel and finishing agent applications, and coating were lowest. After coating, the values were decreased compared to those without coating after the applications of fluoride gel and finishing agent in groups D and F. The values were increased compared to those without fluoride gel application in group B. Statistical analysis showed a significant difference between groups A and B, C and D, and group E and F, respectively ($p < 0.05$).

SEM photographs are shown in Fig. 3. The small particles were observed on the enamel surfaces without any applications and the coating in the control group G. After fluoride gel application, the surfaces were flattered compared to the control (A). After coating, the surfaces were more flattered than those of only fluoride gel application, but the hollows were become more wider than those of without coating (B). After fluoride gel and finishing agent applications, the small particles were observed on the surfaces and the surface roughness was slightly increased than control (C). After coating, the surfaces were more flattered than those of only fluoride gel and finishing agent applications (D). After finishing agent application, there were small particles on the surfaces, though the particles were flattered (E). After coating, the surfaces were more flattered than those of only finishing agent application (F).

Fig. 1: Schematic of the experimental procedure. Surface of the enamel was divided into two parts along the center line.

Fig. 2: The color difference values ($\Delta E_{abl}$) between C1 and C2. The color variable of tooth was evaluated using a digital tooth colorimeter, ShadeEye NCC, at the labial enamel surface one-third from the cervical line. Data are the mean ± SEM from five experiments. *Values of $p<0.05$ were considered statistically significant.
Discussion

After tooth bleaching, the demineralization of the enamel and the small reductions of the enamel micro-hardness were occurred. The structure of the apatite crystal of the enamel surfaces was changed for bleaching. The factors of staining in the relapse after bleaching were reported. For keeping whiteness, the staining beverages; Oolong tea (Suntory oolong tea®, product of Suntory Food), coffee solution (extracted from 17 g of coffee powder; MJB Army Green®) with 720 ml of boiling water and Coca Cola (Diet Cola®; product of Coca Cola International Sales) etc. were recommended to be restricted. Due to the disadvantage of bleaching, the fluoride gel and finishing agent were applied on the surfaces of enamel.

Fig. 3: Representative SEM photographs of the enamel surface. (A) fluoride gel, (B) fluoride gel and coating material, (C) fluoride gel and finishing agent, (D) fluoride gel, finishing agent and coating material, (E) finishing agent, (F) finishing agent and coating material, (G) control. Original magnification ×4,500; bar represents 10 µm.
However, the bleached enamel surfaces applied with fluoride gel and finishing agent were soon exposed to various matters such as saliva, food and many kinds of beverages containing staining which were color development materials.

After bleaching, fluoride and nano-hydroxyapatite adsorbed the surface of the enamel. The fluoride ion bound hydroxyapatite and it formed fluoroapatite, which was more stable structure \(^\text{18}\). The nano-hydroxyapatite deposited the micro defective parts of enamel \(^\text{5}\). At the same time, the color development materials adsorbed to the surface of the hydroxyapatite crystal and it’s supposed that the adsorbed color development materials with other organic substrate embedded into the insert of the hydroxyapatite crystal \(^\text{19}\).

This time, we hypothesize that covering by tooth coating material soon the bleached enamel surfaces temporarily after fluoride gel and finishing agent applications may improve these disadvantage, surface roughness and re-coloration further.

The staining was the lowest in the all treatments (fluoride gel, finishing agent and then, coating material) after coating. This means that after bleaching, applications of fluoride gel, finishing agent and coating material most effective for keeping whiteness. The staining was decreased after removing the coating material compared to those without coating material. It may be results from the exclusion of the color development materials by the coating materials and the reactions with fluoride and nano-hydroxyapatite on the enamel surface were protected until finishing.

The only application of fluoride gel after removing the coating materials, the staining was increased. Removing the coating materials caused to peel off the part of the enamel surfaces. After only fluoride gel, we supposed that it is easy to peel off the part of the enamel than the other treatment and then staining proceeded. The results of SEM observation consist with this result. After removing the coating material followed by only application of fluoride gel, the surfaces were more flatter than without coating, but the hollows were become more wider than those of without coating. It was supposed that the hollows were caused by removing the coating material with peeling off the enamel. It has been suggested that wider-hollows cause the easy-staining.

After only application of fluoride gel, the staining was decreased compared to the additional application groups without coating material. It means that the additional application caused staining easily. The results were different from after all treatment with or without coating materials. It was considered that the coating might influence on the reaction of all treatment effectively. We need the further investigation to make it clear.

**Conclusion**

After removing the coating material, followed by the applications of fluoride gel and finishing agent, the enamel surfaces were more flatter and staining was prevented most effectively. For reduction of the disadvantage of bleaching such as surface roughness and re-coloration, coating material followed by the applications of fluoride gel and finishing agent was thought to be one of the most efficient applications. After applications of fluoride gel and finishing agent, covering the bleached-enamel surfaces with the coating materials enhanced the keeping whiteness. It would give the patients satisfaction of whiteness.

**Disclosure statement**

No competing financial interests exist.

**References**


