Diode Laser-Activated Bleaching

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This study describes a preclinical investigation with laser-activated bleaching agent for discolored teeth. Bleaching techniques involve a broad-spectrum approach utilizing hydrogen peroxide (3-38%) with or without heat or laser, carbamide peroxide (10-30%), or a mixture of sodium perborate and hydrogen peroxide. Extracted human maxillary central incisors were selected. In the bleaching experiment, 38% hydrogen peroxide was used. Two different laser systems and light emission diodes for activation of the bleaching agent were used: diode laser, wavelength 970 nm, and infra-red diode laser, wavelength 790 nm, with eight blue light emission diodes, wavelength 467 nm. The enamel surface was evaluated with the scanning electron microscope. The method of chemical oxidation resulted in a 2-3 shade change in one treatment (15 min). Shorter time (5 min) was not effective. The diode laser, wavelength 970 nm, and the bleaching agent produced the same effect but with a shorter time of bleaching process (5 min – 1 W, 2.5 min – 2 W). Infra-red diode laser, wavelength 790 nm with eight blue light emission diodes, wavelength 467 nm, and the bleaching agent reached the desired color shade also after a shorter time (5 min – 40 mW). Slight surface modification after the bleaching process was detected with scanning electron microscopy. Currently, the laser has been proven the most valuable energy source for power bleaching with simple and short application in the dental office.

Key Words: dentistry, laser, bleaching.

INTRODUCTION

The desire to have whiter teeth and the bleaching technique have been documented since the mid-nineteenth century. Patients’ awareness of options available for changing the color of natural dentition has created an increase in public demand. Bleaching corrects or improves the color of teeth, and is also the least expensive esthetic treatment option. The indications are acquired superficial stains, penetration and absorbed stains, age-related stains, patients who desire conservative treatment to improve appearance, color change related to pulp trauma and necrosis, and interproximal discolorations (1,2).

The current techniques involve a broad-spectrum approach utilizing hydrogen peroxide (3-38%) with or without heat or laser, carbamide peroxide (10-30%), or a mixture of sodium perborate and hydrogen peroxide (3). The methods can be used in-office or at home. Severely discolored teeth or difficult bleaching cases are treated initially in the office, followed by bleaching at home.

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Some patients cannot complete the home bleaching process for various reasons, such as the time required, discomfort or irritation from wearing the trays, or the unpleasant taste, and gingival or stomach irritation from the bleaching gel. For such patients, power bleaching or in-office bleaching produces the whitening results quickly, without the long-term commitment of wearing trays. To have this procedure performed, the patient visits the dentist only once.

The history of power bleaching goes back to Abbots’ use of high-intensity light to raise the temperature of hydrogen peroxide, accelerating the chemical process of bleaching. Since the early 1980’s, the heat lamp and heated spatula have been used as a heat source to accelerate the bleaching process of concentrated hydrogen peroxide. This has been shown to be effective, but it also causes pulp irritation. The process of controlling the caustic 35% hydrogen peroxide liquid has been challenging (4).

The latest development of power bleaching has resulted in easy-to-use bleaching agents, essentially using highly concentrated hydrogen peroxide mixed with thickening agents or additional buffering agents, catalysts, or coloring agents. The energy source can be derived from blue-colored halogen curing lamps, infrared CO₂ lasers, and blue-colored plasma arc lamps as well as the cool blue argon laser and 980-nm GaAlAs lasers (4,5). These studies showed that tissue ablation requires a high-energy-density beam. This irradiation condition could increase the temperature in the adjacent tissue, which can cause thermal damage, i.e., carbonization and the creation of fissures and cracks in the surrounding tissues. Laser irradiation of dental hard tissue can cause morphological and chemical changes (6). The extent of these changes is affected by the absorption characteristics of the tissues, so that the changes can be varied according to the type of laser and dental tissues. Compositional changes were also confirmed to decrease or increase the solubility of irradiated enamel or dentin (CO₂, Nd:YAG laser) (7).

The goal of this study was to compare diode laser systems, and chemical action agents to control the time and quality of the bleaching process. The effect of various laser techniques for bleaching teeth using in-office vital whitening was evaluated. The ultrastructural changes in enamel caused by a laser-activated bleaching agent for treating discolored teeth were also determined.

**MATERIAL AND METHODS**

**Tooth Material**

For the study, twenty healthy human maxillary central and lateral incisors, extracted from adult males and females for various reasons, were selected. The teeth were kept hydrated in saline solution. For the experiment, they were cleaned with pumice in the laboratory, and tooth surface was divided into two symmetrical parts in the sagittal (lengthwise) plane. The left control part was covered by wax before bleaching to protect the surface. The right part was used for treatment.

**Chemical Action Bleaching Techniques**

In the experiment, 38% hydrogen peroxide (Ultradent Opalescence X Extra Boost; Ultradent Products, South Jordan, UT, USA) was used. The agent was provided in a red gel form. The bleaching procedure had the following steps:

1. preoperative photographic record;
2. mechanical plaque removal – pumice, cleansing with alcohol and drying;
3. covering of control half of the incisor with wax;
4. mixing the product;
5. immediate application of 1-2 mm layer to uncovered part of labial surface;
6. time measurement of bleaching process;
7. rinsing gel with water.

The chemical action process only was completed in 15 minutes.

**Laser Equipment**

Two different diode laser systems for activation of the bleaching agent were used:

1. infra-red diode laser, wavelength 790 nm; power 40 mW, and eight blue light emission diodes, wavelength 467 nm, P = 4000 milicandelas each (Kondortech, São Carlos, SP, Brazil; a set of blue LEDs with associated therapeutic laser), 5 min.
2. infra-red diode laser, wavelength 790 nm; power 40 mW, and eight light emission diodes, wavelength 467 nm P = 4000 milicandelas each (Kondortech,) 10 min.
3. diode laser, wavelength 970 nm (university proto-
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The pre- and postoperative photographic records were made. The color shade was checked to compare both halves of the tooth. The enamel surface was analyzed with the scanning electron microscope (SEM) JSM 5500 LV (Jeol, Japan).

**RESULTS**

The results of laser-assisted bleaching in-office procedure are summarized in Table 1. The method of chemical oxidation resulted in a 2-3 shade change in one treatment (Figure 1). The time of application had to be sufficient – the minimum was 15 min for chemical activation only (Figure 2). Slight surface modification after bleaching was detected in SEM (Figures 3 and 4).

The blue light diode laser radiation, wavelength 970 nm and bleaching agent caused the same effect and shorter time of bleaching process (5 min) (Figure 5). The power had a direct influence on activation time (power 1 W – 5 min (Figure 7), 2 W – 2.5 min (Figure 6). No changes of enamel morphology were found (Figures 7 and 8).

Infra-red diode laser, wavelength 790 nm (red light); power 40 mW, and eight light emission diodes (blue light), wavelength 467 nm and
Figure 3. SEM of enamel of left control part (magnification 2000X).

Figure 4. Slight surface modification (right part of tooth) after bleaching was detected in SEM (magnification 2000X).

Figure 5. The blue light diode laser radiation, wavelength 970 nm and bleaching agent activated process of bleaching for 5 min.

Figure 6. Results of bleaching process - diode laser radiation, wavelength 970 nm and bleaching agent, 2 W, 2.5 min.

Figure 7. SEM of enamel of left control part (magnification 2000X).

Figure 8. No changes of enamel morphology after diode laser radiation, wavelength 970 nm and bleaching agent process of bleaching activation 2 W, 2.5 min (magnification 2000X).
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Figure 9. Infra-red diode laser, wavelength 790 nm (red light); power 40 mW, and eight light emission diodes (blue light), wavelength 467 nm and bleaching agent helped to reach the desired color shade after shorter time (5 min) (Fig. 9). The surface was smoother, and the relief of hydroxylapatite prisms was well formed (see Figs. 10, 11).

Figure 10. SEM of enamel of left control part (magnification 2000X).

DISCUSSION

The objective of laser bleaching is to achieve the ultimate power bleaching process using the most efficient energy source, while avoiding any adverse effect. The following three dental laser wavelengths have been cleared by the FDA (Food and Drugs Administration) for tooth whitening: argon, CO2 and 980 nm GaAlAs diode, but also other laser radiation systems have been tested for this purpose (4,6). In a previous investigation, it was confirmed that the Alexandrite (wavelength 750 nm) and Er:YAG lasers (2940 nm) can activate the process of bleaching (8).

The goal of power bleaching is to whiten the tooth efficiently by obtaining controlled temperature elevation (9,10), but with no morphological and chemical changes of enamel (5). The heat element is favorable for accelerating the rate of reaction but unfavorable for maintaining pulp health. Zach and Cohen (11) showed that an intrapulpal temperature increase of 10°F, 20°F, and 30°F caused a 15%, 60%, and 100% irreversible pulp damage in monkeys, respectively. In another study, Cohen (12) attempted to measure incidental discomfort relative to vital bleaching procedures and to identify pulp changes that would explain the sensitivity and pain phenomenon. White et al. (6) found that since lasers and high intensity lamps produce higher temperatures than conventional lights the treatment time can be regulated to receive greater surface temperature increases than the pulp temperature increases.

It was found that selective laser radiation can decrease the time of bleaching without any surface modification.
process (all used methods) was detected with SEM (13,14). In this study, it was found that selective diode laser radiation can decrease the time of bleaching without surface modification. No differences between enamel surfaces were observed.

Dental lasers contribute to the field of tooth bleaching. Currently, the laser has been proven to be the most valuable energy source for power bleaching with simple and short application in the office.

ACKNOWLEDGMENTS

This research was supported by the Grant Agency of the Ministry of Health of the Czech Republic No.6823-3, and Monbusho International Scientific Research program Joint Research No.09044122 of Japan.

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