Efficacy and Persistence of Tooth Bleaching Using a Diode Laser with Three Different Treatment Regimens

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Abstract

Statement of problem: Studies have measured the effectiveness of tooth bleaching, however there are very few studies that have measured the persistence in color change after a 6-month follow-up.

Purpose: This study assessed the efficacy of the laser bleaching process using different regimens, and the persistence of color change over a 6-month period.

Method and materials: Sixty patients divided into three equal groups were subjected to bleaching using a diode laser with 34% hydrogen peroxide. Group 1: patients subjected to one session of laser bleaching. Group 2: patients subjected to two sessions of laser bleaching with a 1-week interval. Group 3: the same as Group 2 but followed by home bleaching once a month for 3 months. The color was assessed four times: before bleaching, directly after bleaching, 3 months after bleaching, and 6 months after bleaching.

Results: All teeth had a significant color change at 6 months, but all teeth had regressed from the maximum value. There was significantly less regression in color for Group 3, followed by Groups 2 and 1, respectively.

Conclusion: The combined technique of in-office laser bleaching for two sessions with a 1-week interval, followed by home bleaching once a month for 3 months gave more persistence in color change. Clinical significance: In-office power bleaching using a laser assisted hydrogen peroxide system repeated after a week, combined with home bleaching once a month for 3 months, is an effective bleaching regimen with less color regression after 6 months compared to a regimen of in-office bleaching alone.

Introduction

Bleaching is the most conservative esthetic treatment for discolored teeth when compared to resin-bonded composites, porcelain veneers, or crowns. The success of any bleaching treatment is based on the ability of the bleaching agent to permeate tooth structure to the location of discoloration, and remain there long enough to oxidize the molecules containing the stain.\(^1\)

The most common agent for tooth whitening is carbamide peroxide (CH\(_4\)N\(_2\)O\(_2\)H\(_2\)O\(_2\)), which is the product of the combination of hydrogen peroxide and urea. The active molecule is hydrogen peroxide (H\(_2\)O\(_2\)). The underlying rationale for treatment is to provide a relatively high concentration of hydrogen peroxide in contact with the tooth for as long as possible without causing local peroxide burns.

This can be achieved in four ways:

- **at-home bleaching using low concentrations of carbamide peroxide in prefabricated trays for an extended period of time (3 hours)**
- **in-office bleaching using higher concentrations of carbamide peroxide or a low dose of hydrogen peroxide for short periods of time (30 min–1 h) in the dental surgery**
- **assisted bleaching using an external energy source to dissociate the carbamide peroxide and produce a high concentration of hydrogen peroxide**
- **power bleaching using relatively high concentrations of hydrogen peroxide together with an external energy source to speed up the reaction.**

These techniques became popular in 1989 when it was understood that carbamide peroxide could be applied as a gel without causing irritation to the oral mucosa.\(^2\) It was soon recognized that an unwanted side effect was sensitivity of the teeth. It has been suggested that a possible cause of this sensitivity was penetration of the peroxide through enamel and dentin into the pulp chamber,\(^3\) or an increase in temperature in the pulp chamber.\(^4\)

Home bleaching has inspired a rapid, uncontrolled proliferation of bleaching preparations, including some over-the-counter products marketed directly to the public. Some of these products were potentially harmful because of a high acid content, and others were not strong enough to be effective.\(^5\)

In-office bleaching has the advantage of being controlled by the operator, and results can normally be seen immediately. A disadvantage is the chair time, cost to the patient, and the possibility of multiple visits.\(^6\) For this reason, attempts have been made to accelerate the reaction using heat or light. At first, a hand-held heat source was use to speed up the dissociation of hydrogen peroxide.\(^7\) More recently, light-activated devices such as the plasma arc, light emitting diodes (LED), xenon-halogen lights, and various types of laser have been introduced.\(^8\) The US Food and Drug Administration has cleared the wavelengths of argon, CO\(_2\), and GaAl lasers for use as a diode laser for tooth bleaching.\(^8\)

Many papers have been published with conflicting results. Whilst there is agreement that in-office procedures produce more whitening in the short term,
there is controversy about how long the effect is maintained. Also, there are differences of opinion about the side effect of tooth sensitivity.\textsuperscript{9–14} Loss of whitening over a period of months has initiated the idea of using in-office whitening to “kick start” the process, and then maintain and even increase the whitening with a supplemental at-home regime.\textsuperscript{5,14}

So far, little research has been published in the dental literature on laser in-office power tooth bleaching. The available data comes mainly from the manufacturers of the laser devices. The purpose of this study was to compare the efficacy of power bleaching using a laser assisted hydrogen peroxide system, and to determine the stability of the color change over a 6-month period.

### Materials and methods

Three regimes were compared: one session of in-office laser bleaching, two sessions of laser bleaching with a 1-week interval between them, and two sessions of laser bleaching followed by at-home bleaching once a month for 3 months. Ethical approval was granted by Jordan University of Science and Technology ethical approval committee for studies on humans.

Patients over the age of 18, who requested in-office bleaching, were considered for the study. All patients were given an intraoral examination and patients with the following dental conditions were excluded: patients with active periodontal disease, gross caries, ex-
posed root surfaces, or damaged or fissured enamel. In addition, patients with known allergies to chemical products such as hydrogen peroxide and resin-based materials were excluded, as were patients who were pregnant. The study group therefore consisted of 60 patients (23 male, 37 female) with an average age of 31.5 years.

Before treatment, laser bleaching was discussed with each patient to ensure that they were aware of possible adverse effects and had a realistic expectation of the technique. The laser device used in this study was a diode laser (LaserSmile, BIOLASE Technology, Irvine, CA, USA) with an 815 nm wavelength. This can be used for soft tissue surgery as well as for tooth bleaching. The whitening gel (BIOLASE Technology) is a proprietary dental whitening gel used in conjunction with the diode laser. It contains hydrogen peroxide at a concentration of 34%, supported in a gel constituted to ensure that it did not interfere with laser transmission.

Prior to treatment, the teeth were cleaned with pumice to remove superficial stains. For the laser treatment, the maxillary and mandibular arches were divided into four sites because the application tip is designed to treat four to five teeth at a time. Each treatment site therefore consisted of the incisor, canine, and premolar units.

There were three experimental groups: Group 1 received one session of laser bleaching, Group 2 had an identical session 1 week later, and Group 3 was the same as Group 2 but was followed by home bleaching for 3 months (as recommended by Garber et al). The treatment regimens for each group is summarized in Table 1. The bleaching process was conducted in accordance with the manufacturer’s instructions.

Prior to bleaching, the gingival tissue around the teeth and exposed root surfaces were protected by applying a layer of protective gel (Liquid dam, BIOLASE Technology) as a strip about 2 mm wide by 1 mm thick, which was then light cured.

The shade was recorded at four times: immediately before bleaching, immediately after bleaching, 3 months from the first day of bleaching, and 6 months from the first day of bleaching. The shade of the patient’s teeth was measured and recorded by the same person, after polishing, using a 3D-Master VITA shade guide (VITA Zahnfabrik, Bad Säckingen, Germany). The central incisor tooth was considered as the reference for shade registration that was always taken under standard fluorescent illumination.

The 3D-Master VITA shade guide has 26 color tabs ordered into 5 groups according to lightness, with 1 being the brightest and 5 the darkest. For each group (except 1) there are 3 hues (light, middle, and red), but in this study only middle hue (M) was used. This has three levels of chroma, with 1 being the least and 3 the maximum color saturation. For the lightness group 1, there are only 2 tabs corresponding to chroma 1 and 2. A chroma score of 0 was allocated to teeth whose shade was lighter than any tab in the guide. For statistical purposes, the shades were ordered by lightness and chroma to produce a 15-point scale (1–15) (Table 2).

After in-office bleaching, patients were advised not to consume products that stain teeth for 48 hours. These
foodstuffs include coffee, tea, red wine, tomato sauces, and strongly colored fruits. Smokers were advised not to smoke. These instructions were given orally and provided in writing as advice sheets.

For patients in Group 3, alginate impressions were taken for the maxilla and mandible and sent to the laboratory to construct maxillary and mandibular night white trays (with reservoirs). A quantity of 10% hydrogen peroxide gel (Opalescence, Ultradent, South Jordan, UT, USA) was provided in standard syringes. At the end of the second visit of in-office bleaching, the fit of the trays was checked and the patients were shown how apply the gel.

Data were analyzed using the Statistical Package for Social Sciences (SPSS V.14, Chicago, II USA). One-way ANOVA tests were used to assess the null hypothesis that there was no difference between groups at the four time intervals. In the case of significant F values, a Fisher's Least Significant Difference (LSD) test was used to determine homogeneous subsets (level 0.05). t tests were used to determine if the before and after values were significantly different.

**Results**

Fifty-nine patients attended the 3-month recall and 60 attended the 6-month recall. The results are given in Table 3 and shown in Figure 1. ANOVA tests indicated that there was no difference between the groups before and after the office bleach, but a significant difference
Table 3  Results. Figure in parentheses = standard deviation. NS = not significant. NA = not applicable. Letter A-C = homogeneous subsets at 3 and 6 months.

<table>
<thead>
<tr>
<th></th>
<th>Pre-Bleach</th>
<th>Post-Bleach</th>
<th>3 months</th>
<th>6 months</th>
<th>Pre vs. 6 months</th>
<th>Post vs. 3 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>One session</td>
<td>8.60 (2.26)</td>
<td>3.65 (1.84)</td>
<td>5.58 (2.25) A</td>
<td>7.25 (1.94) A</td>
<td>$t = 2.03$ $P &lt; 0.05$</td>
<td>NA</td>
</tr>
<tr>
<td>Two sessions</td>
<td>9.35 (1.87)</td>
<td>3.65 (1.50)</td>
<td>4.63 (1.74) A</td>
<td>5.96 (2.04) B</td>
<td>$t = 5.48$ $P &lt; 0.001$</td>
<td>NA</td>
</tr>
<tr>
<td>Two + at home</td>
<td>8.40 (1.88)</td>
<td>4.30 (1.78)</td>
<td>2.70 (1.66) B</td>
<td>4.05 (1.67) C</td>
<td>$t = 4.36$ $P &lt; 0.001$</td>
<td>$t = 2.94$ $P &lt; 0.01$</td>
</tr>
<tr>
<td>ANOVA * F</td>
<td>NS</td>
<td>NS</td>
<td>11.914 ($P = 0.00$)</td>
<td>14.516 ($P = 0.00$)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

at 3 months ($F = 11.914, P = 0.000$) and 6 months ($F = 14.516, P = 0.000$) was observed. LSD tests showed that there were two homogenous subsets at 3 months and all the groups were significantly different at 6 months. There was a significant difference between pre-bleach and 6-month values for all groups ($t > 2.02$, $P < 0.05$). Figure 1 indicates that color regression commenced as soon as the bleaching regime ceased. Whereas two sessions of power bleaching did not make a significant difference in the shade over one session, it is apparent that the color regression in this group was slower. Home bleaching allowed a continuation of the lightening process, as there was a significant difference between the post-bleach and the 3-month values ($t = 2.94$, $P < 0.01$). Once home bleaching ceased, the color regression was the same rate as the other two groups.

Discussion

The present study indicates that in the absence of complications, two sessions of power bleaching will decrease the rate of color regression over one session and that home bleaching will cause further whitening after two in-office sessions. The results of this study generally agree with other studies on laser bleaching, which showed that laser bleaching was very efficient.4,10,11,16,17 These studies, however, measured the bleaching efficacy for only 1 or 2 weeks after bleaching, while this study measured the efficacy over 6 months. The manufacturers of the laser whitening kits claim that teeth whitening remains for up to 2 years. If the rate of color regression seen in Figure 1 continues, then this would seem questionable. Many studies, however, indicate that the whitening can be “topped up,” either with in-office whitening or home bleaching.5,15,18

Although the patients in this study reported that they recognized the need to avoid staining foodstuffs immediately after bleaching, it is unreasonable to expect that they would continue to do this for any period of time. The most common foodstuffs causing tooth discoloration include, coffee, tea, red wine, heavily dyed curry, and sodas. Nicotine is clearly a
staining agent.\textsuperscript{19} It is unlikely that smokers in this study abstained for 24 hours, but it seems reasonable to include this in the preoperative instructions.

The advantage of in-office bleaching is that normally a noticeable shade change occurs, although some clinicians have found that some teeth are resistant to rapid whitening.\textsuperscript{2} In these cases, at-home bleaching also takes longer before the patients start to see a change.

This study indicated that when the manufacturer’s instructions were followed carefully, one session of laser treatment may be enough to achieve a noticeable degree of whitening. Patients should be encouraged to accept some degree of whitening rather than trying to achieve an unnatural level of whiteness.

Studies on laser bleaching are limited and conflicting. Dostolova et al\textsuperscript{9} have demonstrated \textit{in vitro} that lasers are the most valuable energy source for power bleaching, with simple and short application in the dental office. They also showed that selective diode laser irradiation can decrease the time of bleaching without surface modification, as no differences between enamel surfaces were observed under scanning electron microscopy. Wetter et al\textsuperscript{16} conducted an \textit{in vitro} study to examine the bleaching efficacy of whitening agents activated by a xenon lamp and 960 nm diode radiation. They found that both the xenon arc lamp and diode lasers were effective in providing brighter teeth. Niklaus et al\textsuperscript{17} conducted an \textit{in vitro} study and concluded that the best overall bleaching results were obtained with laser association. Karen et al\textsuperscript{10} examined the effect of light energy on peroxide tooth bleaching, and found that the application of an external light source significantly improved the whitening efficacy of certain bleaching gels, but it caused significant temperature increases in the outer and inner tooth surfaces. However, this study examined CO\textsubscript{2} and argon lasers, which are no longer used for tooth bleaching. Baik et al\textsuperscript{20} found that the use of intense light does elevate intrapulpal temperature, which may have a further impact on patient sensitivity. Sulieman et al\textsuperscript{4} concluded that the laser gel acts as an effective insulator, helping prevent large increases in temperatures within the oral cavity. Thus, teeth should never be irradiated with laser energy without the laser gel, which should not be replaced by any other gel. Sulieman et al\textsuperscript{4} however, stated that temperature rises within the pulp chamber return to baseline levels very quickly after removal of the laser source. Wetter et al\textsuperscript{20} compared the effectiveness of laser and light on tooth bleaching. They found that the association of laser and hydrogen peroxide showed significantly better results than when the same agent was used alone with light.

The key factors that affect tooth whitening efficacy by peroxide-containing agents are concentration and time.\textsuperscript{21} Laser manufacturers argue that the time of contact between the gel and teeth for several hours over a number of days were more harmful than using 35% hydrogen peroxide for 10 minutes. However, further studies are needed to assess which have more adverse effects.

A CRA report published in 2003 addressing the use of lights and lasers during in-office bleaching, evaluated four currently available light-activated
bleaching systems: Zoom (metal halide light), LumaArch (halogen light), BriteSmile (plasma arc or LED) and LaserSmile (Al-Ga-As diode laser). They showed that the amount of tooth lightening achieved depends on three variables: patient variation, the chemistry and concentration of the active ingredient, and the time of bleach application. This study only measured the color change for 1 week after the bleaching process. Papathanasiou et al\textsuperscript{18} stated that statistically there was no significant difference between the light-activated side, when compared to a non-light activated side. Both the CRA report\textsuperscript{22} and Papathanasiou et al\textsuperscript{18} contradict other studies\textsuperscript{11,19}, which have indicated that light activation causes increased whitening when used with hydrogen peroxide. Hasson et al\textsuperscript{14} reviewed all the articles on teeth bleaching from 1966 to 2005. A total of 416 articles were identified. All the studies were short term, measuring the effectiveness immediately or after 1 and 2 weeks of product application, and were either conducted or sponsored by the manufacturer.

In this study, shade evaluation was by subjective comparison to the VITA 3D-Master shade guide. Any subjective shade assessment can be criticized, as there are differences in individuals’ color perception. Appearance, however, is subjective and patients are more likely to be pleased by a visual difference than printouts of CIE values from a machine. In this study it was decided that the middle value (M) on the VITA 3D-Master shade guide should be used to compare shades. This approach has now been adopted in the new VITA Bleachedguide 3D-Master\textsuperscript{®} that also has 15 shade tabs.

Conclusions

Within the limitations of this study it was concluded that:
- the diode laser system is an effective aid for tooth bleaching
- the combined technique (laser bleaching followed by home bleaching) allowed the lightening to continue
- as soon as bleaching ceases there is color regression regardless of the bleaching regime.
References