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Effectiveness of LED/Laser Irradiation on In-Office Dental Bleaching after Three Years

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Clinical Relevance

Use of a hybrid light (laser/LED) for in-office dental bleaching shows the same degree of color change with lower bleaching time and sensitivity compared with conventional in-office bleaching.

SUMMARY

The present *in vivo* randomized, triple-blinded, and split-mouth clinical study evaluated the effectiveness of a hybrid light (HL) source on the color change, stability, and tooth sensitivity in patients submitted to different in-office bleaching techniques. Twenty volunteers were divided into two groups and four subgroups. A split-mouth design was conducted to compare two in-office bleaching techniques (with and without light activation): 35% Lase Peroxide Sensy (LPS) + HL: 35% hydrogen peroxide (HP) + HL; 35% LPS: 35% HP; 25% LPS + HL: 25% HP + HL; and 35% Whiteness HP (WHP): 35% HP. For the groups activated with HL, the HP was applied on the enamel surface three consecutive times using a 3 × 2-minute protocol (three HL activations for two minutes each, with a 30-second interval for a total of seven minutes and 30 seconds) for each gel application, totaling 22 minutes and 30 seconds. For the other groups, HP was applied 3 × 15 minutes, totaling 45 minutes. A spectrophotometer was used to measure the color change (ΔE) before the treatment and 24 hours, one week, and one, 12, and 36 months after. A visual analog scale was used to evaluate the tooth sensitivity before the treatment, immediately following treatment, 24 hours, and one week after. Anal-

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ysis of variance, Tukey's, Kruskall-Wallis, and Wilcoxon tests, all with $\alpha = 0.05$ were performed. Statistical analysis did not reveal any significant differences (ΔE) between the in-office bleaching techniques with or without HL in the periods evaluated; the activation with HL required 50% less time to achieve such results. The groups without HL presented statistical differences for ΔE when comparing 24 hours with the other follow-up times (inter-group) and an increase in tooth sensitivity in the initial periods. All techniques and bleaching agents were effective on bleaching during a 36-month evaluation of color stability. The groups activated with HL presented lower sensitivity and required a lower activation time.

INTRODUCTION

Tooth whitening is one of the most conservative dental treatments that can improve or enhance the smile and has gained popularity in basic oral care. Currently, tooth bleaching has been recognized as an effective and safe method to treat discolored teeth.[1-3]

Although at-home bleaching has increased dramatically in popularity, in-office bleaching products are still in demand for several reasons. Some patients do not adapt well to an at-home protocol due to the treatment time and because of the bleaching tray.[4] Another contra-indication for home bleaching consists of patients presenting sensitivity who need to be closely monitored for extensive tissue recession or deep, unrestored abfraction lesions.[5]

The use of hydrogen peroxide (HP) in high concentrations (35% and 38%) applied by a dental professional allows the patient to obtain visible results even after only one clinical session.[6] Power bleaching reduces the total in-office time by catalyzing the bleaching agent with light sources, such as lasers, light-emitting diodes (LEDs), or plasma arc light. The theoretical benefit lies in the light sources' ability to heat the HP, increasing the rate of decomposition of oxygen to form oxygen-free radicals enhancing the release of pigment-containing compounds.[6-8]

The activation of a bleaching agent by the thermocatalytic technique has been questioned due to its deleterious effects on the tooth structure.[6] Tooth sensitivity is one of the most common side effects of a bleaching treatment and its occurrence is directly dependent on the bleaching agent concentration, the application time, and the thickness of the dentin. Therefore, high-concentration agents used in in-office procedures usually generate discomfort. Tooth sensitivity can persist for up to 10 days after the conclusion of the bleaching treatment.[9-12]

Other effects such as small alterations in the enamel structure after bleaching treatments, such as surface roughness, porosity, microhardness, and ion release have also raised concerns from a few researchers.[13] These alterations can be easily reversed by polishing, remineralization of the enamel by contact with the calcium and phosphate present in the saliva and/or by the application of fluoride.[6,13]

Considering all these factors, the practitioner is faced with many treatment options. Therefore, the objective of the present *in vivo* study was to compare different in-office bleaching techniques using two concentrations of HP (25 and 35%) and the activation or not with a hybrid light (HL) source (LED/laser).

The null hypothesis was that there should not be any differences in relation to the degree of color change, sensitivity and color stability between bleaching protocols.

METHODS AND MATERIALS

Study Design and Patient Recruitment

The present interventional, triple-blinded (patient, outcomes measurements operator, and statistician), split-mouth, randomized clinical trial had as study factors the bleaching protocols in four levels (35% HP, used with HL or without HL, 25% HP with HL, and 35% HP, used without HL), assessed through the evaluation of the degree of color change and stability, as well as through postoperative sensitivity by a visual analog scale (VAS). For treatment comparisons, an $\alpha = 0.05$ and test power = 80% were set. Also considering a 30% estimate dropout rate after 36 months, a minimum of 10 patients were needed for each group.

After approval by the local Research Ethics Committee, 20 patients from a total of 38, aged 18-30 years, were selected based on the inclusion and exclusion criteria (Table 1). All patients signed the informed consent after an explanation of the nature and possible risks of their voluntary participation.

The patients were randomly divided into two groups (n=10), and all bleaching gels were used according to the manufacturer's instructions (Table 2). Following a split-mouth design, each group of patients was submitted to two bleaching treatments with a one-week interval: one on the right maxillary

Table 1: *Inclusion and exclusion criteria*

Inclusion criteria	Exclusion criteria
Sign the consent form	Presence of restorations or decay in the anterior teeth
Agree to return to scheduled follow-up sessions	Gingivitis or periodontitis
Good general health	Tobacco use
A3 or darker shade in at least four teeth	Allergic to peroxides
Tooth sensitivity lower than 2 on the VAS scale	History of oropharyngeal neoplasms
	Use of bleaching agents within one year
	Pregnant or lactating woman
	Tetracycline stained teeth

and mandibular arches and the other on the left maxillary and mandibular arches (35% Lase Peroxide Sensy [LPS] + HL, 35% LPS or 25% LPS + HL, and 35% Whiteness HP [WHP]). All the random sequences were generated by an assistant through an Excel worksheet (Microsoft, Redmond, WA, USA), which was written on a paper for each and stored in a sealed envelope until the treatment sessions.

Bleaching Procedures

All teeth were cleaned with a rubber cup at low speed using fine pumice powder and water. Next, the soft tissue was protected with a gum barrier (Lase Protect, DMC Equipamentos Ltda, São Carlos, SP, Brazil) and light-cured for 30 seconds with a 1200-mW/cm^2 LED lighting device (Radii-cal, SDI, Victoria, Bayswater, Australia).

In the 35% LPS group, the patients had their hemi-left or hemi-right upper and lower arches bleached with 35% HP (Lase Peroxide Sensy, DMC Equipamentos Ltda), without HL activation. In the 35% LPS + HL group, the patients had their contralateral upper and lower arches bleached with 35% HP and activated with HL.

For the present study, the HL was composed of six blue LEDs (470 nm and 350 mW/cm^2 each) and three infrared therapeutic diode lasers (810 nm and 200 mW/cm^2; Whitening Lase II, DMC Equipamentos Ltda).

In the 35% WHP group, the hemi-left or hemi-right upper and lower arches were bleached with 35% HP (Whiteness HP, FGM Produtos Odontológicos, Joinville, SC, Brazil), without HL activation. In the 25% LPS + HL group, the contralateral upper and lower arches were bleached with 25% HP (Lase Peroxide Sensy II, DMC Equipamentos Ltda) and activated with HL. For the groups without HL activation, HP was applied on the enamel surface for 3 × 15 minutes, totaling 45 minutes. For the other groups, HP was applied on the enamel surface three consecutive times with HL activation following a 3 × 2-minute protocol (three activations of HL for two minutes each, with a 30-second interval, for a total of 7 minutes and 30 seconds) for each gel application, totaling 22 minutes and 30 seconds.

Immediately after each bleaching session, all groups were polished with impregnated polishing felt discs (Lase Peroxide, DMC Equipamentos Ltda) to reestablish the enamel smoothness. After polishing, a desensitizing gel (Lase Sensy, DMC Equipamentos Ltda) composed of 2% sodium fluoride and 5% potassium nitrate was applied for four minutes. To follow and standardize the manufacturer's recommendation for avoiding and controlling postoperative sensitivity, the groups activated with HL were laser irradiated (25 J for 30 seconds).

All patients were instructed to avoid any staining substances in the first 48 hours following the treatment, such as coffee, black tea, cola, mustard, ketchup, red wine, soy sauce, chocolate, red lipstick, consumption of tobacco products, as well as food and acidic beverages.

Instrumental Method for Color Measurement

A contact-type intraoral spectrophotometer (Vita Easyshade, Vita-Zahnfabrik, Bad Säckingen, Germany) was used for the color assessment during the different

Table 2: *Groups and treatment descriptions*

Groups	Bleaching gels	Commercial brands	Manufacturer	Modality
25% LPS + HL	HP (25%)	Lase Peroxide Sensy II (25% HP)	DMC Equipamentos Ltda., São Carlos, SP, Brazil	In office with chemical and/or physical activation
35% LPS and 35% LPS + HL	HP (35%)	Lase Peroxide Sensy (35% HP)	DMC Equipamentos Ltda., São Carlos, SP, Brazil	In office with chemical and/or physical activation
35% WHP	HP (35%) (35% WHP)	Whiteness HP (35% HP)	FGM Produtos Odontológicos Ltda., Joinville, SC, Brazil	In office with chemical and/or physical activation

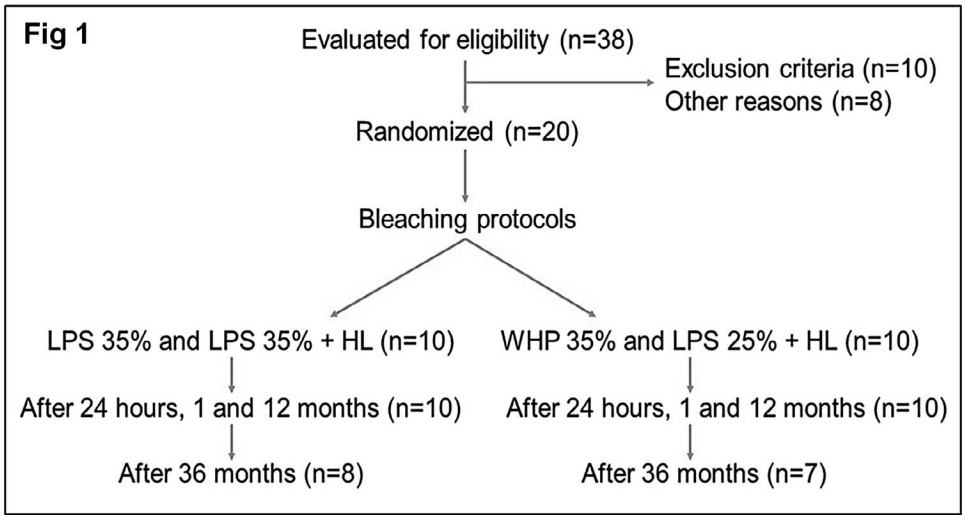

Figure 1. *Study flowchart.*

evaluation times (baseline and after 24 hours, one week, and one, 12, and 36 months). The color assessment was based on the CIELAB system, and color differences were calculated using the following equation: $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$.[14] The measurements were performed by a blinded operator. First, the spectrophotometer was calibrated, and after that, the measurements were taken from the median third of each tooth, two times consecutively.[6]

Tooth Sensitivity Assessment

Each patient was submitted to two different bleaching protocols with a one-week interval. The VAS questionnaire was used to measure the initial tooth sensitivity (baseline), immediately after bleaching, and 24 hours and one week after. The patients had to indicate any tooth or oral sensitivity by marking the level of sensitivity on a horizontal line, which ranged from 0 to 10.

The range of sensitivity scores used were as follows: 0-1, no pain; 2-3, mild pain; 4-6, moderate pain; 7-8, severe pain; 9-10, intolerable pain.

Statistical Analysis

For the color change (ΔE) analysis, all groups were submitted to two-way analysis of variance (ANOVA) (bleaching agents and HL activation) and the Tukey's test to identify and individually compare the groups. One-way ANOVA was used for intragroup comparison (ΔE over time).

The differences in degree of sensitivity were determined using Kruskal-Wallis and Wilcoxon tests for individual comparisons, both with a 5% significance level.

RESULTS

In the present study, 20 volunteers were chosen in accordance with the inclusion and exclusion criteria to participate in the clinical research, and a decrease in participation was observed from the initial to the 36-month period (Figure 1).

The intragroup analysis, for ΔE, showed statistically significant differences only for the groups without HL activation ($p \leq 0.05$). The differences were observed between the 24-hour and the other (one-, 12-, and 36-months) evaluations. The comparison between the groups (intergroups) for all periods evaluated did not present any statistically significant difference during the 36 months evaluated (Table 3).

Considering the evaluation of the sensitivity (VAS), a lower degree of sensitivity in the groups in which the HL was used (35% LPS + HL and 25% LPS + HL) in the period immediately after bleaching ($p < 0.034$) was observed. The sensitivity decreased after 24 hours for all groups, without statistical differences between groups after 24 hours and one week (Figure 2).

DISCUSSION

The purpose of the present *in vivo* study was to compare the effectiveness and stability of in-office bleaching techniques, with or without HL activation, regarding degree of color change (ΔE) up to 36 months and tooth sensitivity up to one week after bleaching.

The null hypothesis was partially verified because the degree of color change in the different assessed times was similar for all groups. Nevertheless, the

Table 3: *Mean, SD, and statistical analysis of ΔE for bleaching groups evaluated during 36 months*[a]

Groups	24 Hours (mean ± SD)	One Month (mean ± SD)	12 Months (mean ± SD)	36 Months (mean ± SD)
35% LPS (3 × 15 minutes: 45 minutes)	4.64 ± 1.21 Aa	6.78 ± 2.11 Ab	6.61 ± 2.05 Ab	6.03 ± 1.88 Ab
35% LPS + HL (3 × 7 minutes, 30 seconds: 22 minutes, 30 seconds)	4.88 ± 1.06 Aa	5.43 ± 1.09 Aa	5.45 ± 1.35 Aa	5.49 ± 1.40 Aa
35% WHP (3 × 15 minutes: 45 minutes)	4.59 ± 1.04 Aa	6.51 ± 1.79 Ab	6.56 ± 1.33 Ab	6.15 ± 1.97 Ab
25% LPS +HL (3 × 7 minutes, 30 seconds: 22 minutes, 30 seconds)	4.70 ± 1.38 Aa	5.10 ± 1.04 Aa	5.07 ± 1.46 Aa	5.28 ± 1.06 Aa

[a] *Lowercase letters show analysis between columns in the same line; capital letters show analysis between lines in the same column.*

groups with HL produced lower sensitivity in the first days compared with the groups without HL.

Two different HP gel concentrations (25% and 35%) were used for the chemical and physical activations. In the groups with physical activation (HL), the bleaching gel time was 22 minutes and 30 seconds, which corresponds to half of the gel application time for groups without light activation (45 minutes). This is the main advantage of using a light source to activate the bleaching gel, allowing lower working time for each bleaching appointment, resulting in lower cost and more convenience for both the patient and professional.[6]

Tooth sensitivity is caused by the passage of HP molecules through the enamel and dentin into the pulp chamber. Therefore, tooth sensitivity may vary with the different factors that affect this passage, such as presence of dental cracks, dentin exposure, and/or pulp chamber dimensions.[5,12] Nevertheless, tooth sensitivity is a temporary side effect that disappears after four days of treatment in most patients, but in some cases can persist for up to 10 days.[6,9-12,15]

The results of sensitivity in the present study indicated that the use of hybrid light activation, allowing a 50% lower bleaching time, promoted lower sensitivity for the patients immediately after the bleaching procedure (Figure 2). The lower gel application time in the groups with HL, associated with the laser therapy during and right after the bleaching procedure, may have contributed to the lower postoperative sensitivity observed. These results are in accordance with Bartolotto and others.[16]

Some studies reported no difference between degree of tooth sensitivity using both LED and HL activation devices, with a greater percentage of patients reporting pain within 12 hours after bleaching.[12,15] The results of the present clinical trial disagree with these results, and this may be due to the higher gel application time in the above related articles (30 minutes per session, about 50% higher than that used in the present study).

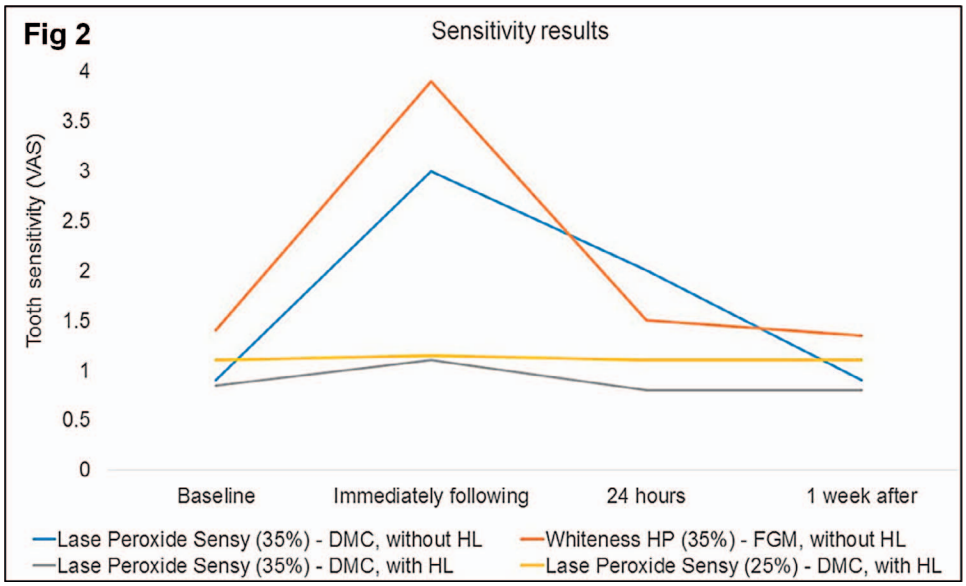

Figure 2. *Mean sensitivity values (VAS) of the groups evaluated for the different periods.*

Nevertheless, the pain was transitory, and the values of color change were similar among all protocols.

The use of CIELAB-based spectrophotometers is the most effective method used for assessment of the color and color changes over time because it is more objective and accurate than using a visual scale and photographs.[6,7,10,11,17]

The results presented in the present three-year study justified the use of HL for similar degrees of color change (ΔE) and stability with in-office bleaching compared with groups without light irradiation, independent of the bleach gel concentration (25% and 35%). Despite this, some researchers present conflicting results regarding the effectiveness of the use of light activation with in-office bleaching.[6,9,18-21] The differences between the light devices, such as the lamp type, wavelength, irradiation, tip design, time used for gel irradiation, and HP gel concentration are some of the reasons for the conflicting results presented in the literature.

All bleaching protocols were similar considering all the evaluation periods. Despite this, the groups with HL produced the same color change results, both immediately after bleaching and over time, but with 50% less bleaching time (22 minutes and 30 seconds versus 45 minutes; Table 3). These results are in agreement with Mondelli and others, who used the same HL device.[6]

The use of HL allows a greater number of gel changes (four to five gel applications) during an appointment and can promote the desired results in a single session.[6] Some clinical studies used the same HL source but left the bleaching gel on the tooth surface for as long as 15 minutes per gel application, increasing the clinical time and tooth sensitivity.[9]

The present study results showed great color change stability with a single bleaching session. The use of the HL should be further explored, using different gels concentrations (such as 10% and 15%) and application times. Such protocols could reduce the risks of tooth sensitivity while promoting the same bleaching effect and could be used in younger patients.

CONCLUSION

The use of HL produced the same bleaching results as the other protocols without HL, immediately and after 36 months, with 50% gel application time and lower immediate postoperative sensitivity.

Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the Research Ethic Committee of the Bauru School of Dentistry, University of São Paulo. The approval code for this study is 105/2008.

Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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