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Clinical Evaluation of In-office Dental Bleaching Treatments With and Without the Use of Light-activation Sources

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Clinical Relevance

The use of light-activation sources did not affect the outcome of in-office bleaching with 35% hydrogen peroxide.

SUMMARY

This study clinically evaluated the alteration of color, color stability, dental sensitivity and gingival irritation on patients undergoing dental bleaching using varying bleaching methods and light-activation sources. According to pre-established criteria, 40 patients were selected and randomly divided into four groups (n=10): Group 1–35% Hydrogen Peroxide (HP); Group 2–35% HP plus Halogen Curing Light XL 3000 (3M/ESPE); Group 3–35% HP plus Demetron LED (Kerr) and Group 4–35% HP plus LED/LASER (Bio-art). For all groups, there were two sessions of bleaching with 35% HP, with a one week break between sessions. At each bleaching session, three applications of the bleaching gel were used. Two methods of shade evaluation were performed before and after the first week, second week, first month and after six months of the bleaching treatment. These methods were VITA Easyshade Spectrophotometer and Vita Classical Shade Guide. Statistical analysis using ANOVA demonstrated equality between the participating groups when evaluating the group and time variables. The In-Office dental bleaching treatments of vital teeth with 35% HP did not prove to be more effective when light sources were used. There was no difference in color stability between groups until the sixth month of evaluation.

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INTRODUCTION

Tooth whitening is one of the most requested cosmetic dental procedures asked for by patients who want a more pleasing smile. This procedure consists of carbamide or hydrogen peroxide gel applications that can be done in-office or by the patient (at-home/overnight bleaching system).[1]

Even though the at-home bleaching system is the most frequently recommended treatment for vital teeth, some patients do not adapt to the technique, because they prefer not to use a bleaching tray or do not like to wait two to three weeks to see the results of their treatment. These patients might request a method that produces more immediate results, the in-office bleaching treatment.[2]

Since the introduction of in-office bleaching treatments, the use of curing lights (including halogen curing lights, plasma arches, LED, LED plus lasers, lasers) has been recommended to accelerate the action of the bleaching gel. In the past, the clinical results obtained with the use of these lights were poor, showing an increase in tooth sensitivity and reduced long-term color stability, especially when the treatment was done in one appointment. Recent developments in in-office bleaching systems that use a chemical catalyst combined with light-cured block-out materials and compounds have resulted in decreased tooth sensitivity and enhanced treatment and have demonstrated improved results.[3]

Despite the fact that many curing lights have been introduced into the dental market for the purpose of accelerating in-office bleaching treatments, no concrete scientific study has proven their effectiveness.[4-6]

This research clinically evaluated whether using different light-activation sources would affect the outcome of in-office bleaching treatments completed with a 35% hydrogen peroxide gel.

METHODS AND MATERIALS

Based on pre-established criteria, 40 patients were selected for this study. They:

- were between the ages of 18 and 28;
- had caries-free vital anterior teeth without restorations;
- had good oral hygiene;
- were free of periodontal disease and gingival irritation;
- were non-smokers and
- were free of cervical lesions and any painful symptoms.

Patients were excluded from the study if they:

- were pregnant or nursing;
- had severely stained teeth (tetracycline stains, fluorosis, endodontic treatment) and
- had previously undergone tooth-whitening procedures.

After the dental screenings and case history check-ups, the patients were informed of the treatment procedures, including the pros and cons of in-office bleaching and the possible side effects (sensitivity and gingival irritations). The subjects gave their informed consent before the study began. Tooth sensitivity was verified with a light air jet over the labial surface of the teeth, with the degree of sensitivity recorded using the following criteria: 1-none, 2-slight, 3-moderate and 4-severe.

During bleaching treatments, the degree of gingival irritation was measured using the Loe Gingival Method[7] and was recorded using the following criteria: 1-none, 2-slight gingival irritation, 3-moderate gingival irritation and 4-severe gingival irritation.

Shade evaluation was recorded before and after the bleaching treatment using two methods of evaluation (shade guide and spectrophotometer) (Table 1).

Table 1: *Shade Evaluation Methods*

Shade Evaluation Method	Material Used
Color Scale	Vita Classical Shade Guide
Spectrophotometer	VITA Easyshade, (Vident, Brea, CA, USA)

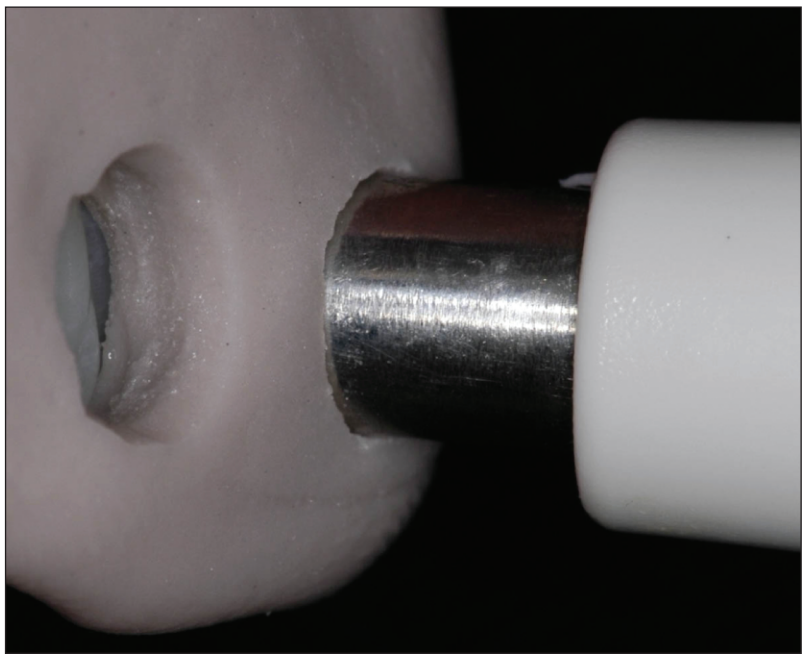

Figure 1: *Silicone Guide positioned over the labial surface of teeth with the tip of the device positioned for color measurement.*

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Before beginning the bleaching treatment, the shade of the upper anterior incisors (canine to canine) of all 40 patients was recorded by two trained volunteers, using the Vita Classic Scale (Vita, Zahnfabrik, Sackingen, Germany).

Prior to the spectrophotometer measurement, an impression of the maxillary arch was made using Zetalabor dense silicone paste (Zhermarck, Italy). The impression was extended to the upper canine and served as a standard color measurement guide for the spectrophotometer. A window was created on the labial surface of the molded silicone guide for each dental component to be evaluated (Figure 1). The window was made using a metallic device with well-formed borders, 3 mm in radius. The measurement was done on all 40 patients using Vita Easyshade (Easyshade, Vident, Brea, CA, USA) (IE) before and after the first week, second week, first month and at sixth months following treatment. The shade was determined using the parameters of the Easyshade device where it indicated the following values: L*, (c*) and (h*), in which L* indicates luminosity, (c*) value and (h*) chroma. In order to make an easy comparison with other studies, these values were converted to the CIE-Lab system, (L*, a* and b*), wherein L* represents the value from 0 (black) to 100 (white) and a* and b* represent the shade, where a* is the measurement along the red-green axis and b* is the measurement along the yellow-blue axis. This system was defined by the International Commission on Illumination in 1967[8] and is referred to as CIELab. The color comparison before and after treatment is given by the differences between the two colors (ΔE), which is calculated using the formula: $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$ (Commission Internationale de L'Eclairage, 1978).[9]

A 35% hydrogen peroxide (HP) bleaching agent was used for this study (Whiteness HP MAXX–FGM, Joinvile, Brazil). In conjunction with the bleaching gel, a halogen curing light XL3000 (3M/ESPE), Demetron LED (Kerr Dental) and LED/Laser Biolux (BioArt) were used to activate the gel (Table 2).

Table 2: *Equipment Used for Bleaching Gel Activation*

Equipment	Type of Light	Wave Length	Manufacturer
Curing Light XL3000	Halogen Light	400 to 500 nm	3M/ESPE
Demetron	LED	450 to 500 nm	Kerr
Biolux	LED Laser	470 nm	BioArt

Table 3: *Group Divisions*

Group	N	Bleaching Treatment	Type of Photo Activation
1	10	35% HP	none
2	10	35% HP	Halogen Light
3	10	35% HP	LED
4	10	35% HP	LED/Laser

Figure 2: *Gingival isolation using light-cured gingival dam (FGM). This dam is polymerized, so that it becomes rigid and protects the gingiva from the bleaching gel.*

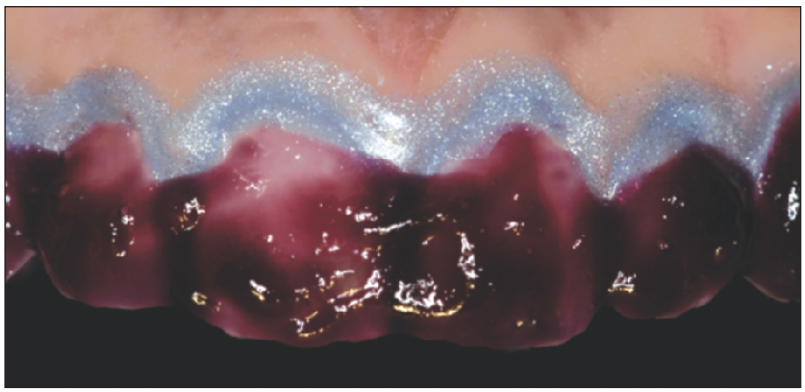

Figure 3: *Application of the 35% HP bleaching gel (Whiteness MAXX, FGM).*

The subjects were randomly divided into four groups (n=10) as shown in Table 3.

The bleaching treatment was the same for all four groups (G1, G2, G3, G4) except for altering the activation method of the bleaching agent. Before the vital teeth bleaching treatment, the gingival tissue was isolated using a light-cured resin dam (Top Dam, FGM, Joinville, Brazil) to prevent the bleaching gel from contacting the gingival tissue (Figure 2).

To aid in the bleaching process, a labial retractor, plastic suction cup with high suction power and protection glasses were used. Whiteness HP MAXX (FGM, 35% HP) was used. This bleaching gel comes in two bottles, one containing hydrogen peroxide and the other the thickening agents. The manufacturer's instructions for

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Figure 4: *Patients were submitted to two sessions of bleaching, with three applications of bleaching gel in each session.*

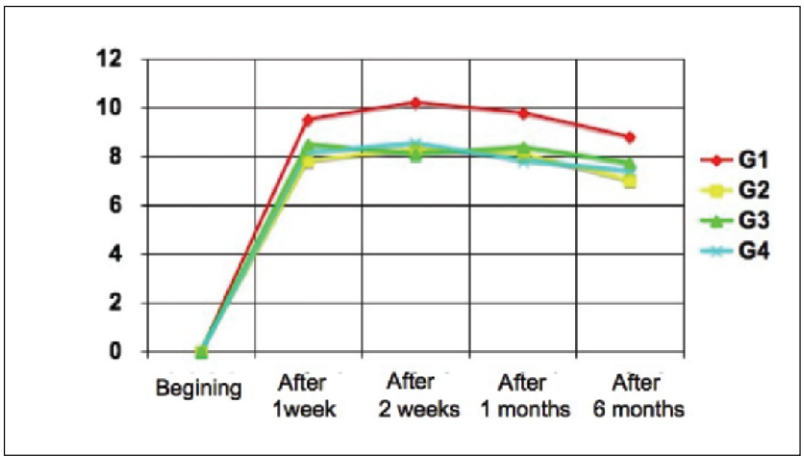

Figure 5: *ΔE in relation to time and instrumental evaluation.*

Figure 6: *Evaluation using the color scale.*

handling and applying were followed by mixing the peroxide and thickening agents using the proportion three drops of peroxide to one drop of the thickening agents. The mixture was blended using a circular motion until the gel formed and was then applied to the labial surface of the teeth to be bleached (Figures 3 and 4). To bleach one arch, approximately 12 drops of peroxide to four drops of thickening agents was required.

In groups G2, G3 and G4, light curing was used at a distance of 1 cm from the bleaching gel, while G1 did not use any activator sources. All groups were submitted to two sessions of bleaching with 35% HP, with three applications of the bleaching gel at each session. Each bleach application lasted for 15 minutes, totaling 45 minutes for each appointment. To prevent tooth sensitivity, a gel of low viscosity with potassium nitrate and 2% sodium fluoride (Desenbilize KF 2%, FGM) was applied for 10 minutes immediately after the clinical session. There was a one-week break between sessions.

The patients were monitored so that no bleaching gel came in contact with the gingiva, and patients were questioned about any discomfort or sensitivity. The groups were evaluated based on the difference in color change before and after the bleaching session, then after seven days, two weeks, one month and six months from completion of the bleaching treatment.

At the clinical evaluations before, during and after bleaching treatment, the degree of shade changes, tooth sensitivity and gingival irritation was established for all patients. After seven days, upon completion of the bleaching treatment, patients received a questionnaire asking them to evaluate the bleaching treatment. Using the scale: none, slight, moderate or a lot, patients were asked how much they felt the procedure whitened their teeth. They were also asked if they would recommend the bleaching treatment to others, using the criteria: yes, maybe and no.

RESULTS

1. Instrumental Evaluation—Spectrophotometer

The results of the instrumental method (spectrophotometer) that evaluated the variables (group and time) through the ANOVA tests in all groups (G1, G2, G3 and G4) matched the hypothesis of equality between the values of ΔE for the group and time variables where p=0.999993. The averages of the results are shown in Figures 5 and 6.

2. Visual Evaluation—Color Scale

The results of the visual method (shade evaluation) that evaluated the variable (group and time) through the ANOVA tests in groups G1, G2, G3 and G4 matched

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the hypothesis of equality between the values of ΔE for the group and time variables where p=1.00000.

3. Dental Sensitivity and Gingival Irritation

The clinical evaluation results are shown in Tables 4 and 5. Due to the low molecular weight of the peroxide and elevated usage, some patients presented with brief dental sensitivity (Table 4), but there was no significant difference between the groups. Sensitivity and gingival irritation were recorded as: none, slight, moderate or severe.

Sixty-seven percent of the patients recorded having side effects, of those, 63% recorded dental sensitivity and 4% gingival irritation. Of the 56% of patients who confirmed having tooth sensitivity, 92% recorded having slight and moderate sensitivity. Tooth sensitivity was recorded immediately following the initial bleaching application and was greater after the second appointment for all participating groups. No sensitivity was recorded 24 hours after treatment.

Gingival irritation was recorded on patients where the bleaching gel came in contact with the gingiva due to a gingival dam not being used.

Table 4: *Dental Sensitivity During Bleaching Treatment*

Group	Patients	None	Slight	Moderate	Severe
G1	10	4	2	4	0
G2	10	5	3	1	1
G3	10	2	3	4	1
G4	10	4	3	2	1

Table 5: *Gingival Irritation During Bleaching Treatment*

Group	Aux Sources	None	Slight	Moderate	Severe
G1	–	9	1	0	0
G2	Halogen	9	1	0	0
G3	LED	8	1	1	0
G4	LED + Laser	8	1	1	0

Table 6: *Patient Evaluation After Treatment*

Group	Patients	None	Slight	Moderate	A Lot
G1	10	0	0	3	7
G2	10	0	0	4	6
G3	10	0	2	2	6
G4	10	0	1	5	4

Table 7: *Patients Answers in Regard to Recommending the Treatment to Others*

Group	Active Source	Yes	Maybe	No
G1	–	10	0	0
G2	Halogen	9	1	0
G3	LED	9	1	0
G4	LED + Laser	9	1	0

4. Patients Satisfaction

Seven days after completion of the bleaching treatment, a questionnaire was given to all subjects, asking them to evaluate the treatment. Thirty-six of the 40 patients (92.5%) recorded that the treatment whitened their teeth "moderately" and "a lot," and just three patients (7.5%) who belonged to groups G3 and G4 recorded "a slight" difference (Table 6).

The patients were asked if they would recommend this treatment to others. Thirty-seven patients (94%) answered "yes" and three patients (6%) responded "maybe" (Table 7).

Their major concerns during treatment were its duration, which was approximately one hour per appointment, the labial retractor and tooth sensitivity after the bleaching sessions.

DISCUSSION

In this clinical study, the in-office treatment with 35% hydrogen peroxide was used. These bleaching agents were used despite some *in vitro* and *in situ* studies that demonstrated alterations in the dental structure.[10-12]

Other authors provided evidence that these bleaching agents do not cause any type of alteration to the dental structure.[13-18] This divergence is justified by the different methods of study (time of evaluation, bleaching agents used, time of application, immersion of the specimens in artificial saliva between treatments, type of storage, bleaching agent pH, usage of fluoride, etc). When these studies are done under *in vivo* and *in situ* conditions, no alteration of the dental structure was recorded, as saliva prevents demineralization of bleached dental enamel.[19]

The various side effects verified in the *in vitro* studies were not recorded when these same studies were done under *in situ* conditions.[20] This study was performed *in vivo* for the purpose of testing the bleaching treatment in a clinical scenario.

This evaluation was done specifically on six maxillary anterior teeth (canine to canine). The duration of the applications during the bleaching treatment was standardized. The in-office treatment with 35% HP was used in two in-office sessions, with six applications of the bleaching gel (three applications at each appoint-

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ment) conducted in all four groups. This standardized application technique simplified comparison of the results to other studies,[17,21-23] while it differed from other studies where the number of sessions and applications depended on patients' will and their consent.[24-25]

Tooth sensitivity and gingival irritation were measured and recorded using the following criteria: none, slight, moderate and severe, to simplify the evaluation. This differed from the study by Zekonis and others,[26] in which the evaluation was done in five categories: none, slight, moderate, considerable and severe.

The color scale was used for the visual evaluation. This method is the most common, as it is a quick, simple procedure and has been used successfully in many studies.[19,24-25,27-30] The shade selection process depends on numerous factors, such as source of light, tooth to be evaluated, evaluator experience and standardization and many other factors.[31] The current study was done in a single room with artificial lighting and two experienced, qualified evaluators, for the purpose of preventing any discrepancy in choosing the correct shade.

The instrumental evaluation has been preferred over the visual evaluation, because it makes the process more practical and statistically more reliable. The instrumental evaluation consisted of a spectrophotometer, colorimeter and image analysis techniques using software programs.[18]

The Easyshade spectrophotometer (Vita-Zanhnfabrik, Germany) was used in the current study to compare and standardize shade evaluation. This method has become more popular in recent studies, because of its ease of use and it being lightweight, with precise measurement that allows analysis in small areas.[29]

A silicon guide was used, with openings in the middle third of each evaluated tooth, to standardize the shade measurement region by using the spectrophotometer before and after the bleaching treatment and to prevent light contamination during the evaluation, contrary to other studies that did not standardize the measurement region[17,26] or to conduct numerous measurements in various regions of the labial surface.[30] The non-standardization of the measurement region could interfere with the final results.

The auxiliary lights used in the in-office bleaching treatment were used to accelerate the action of the bleaching gel (35% HP) and are recommended by some manufacturers[3,24,32] for the in-office bleaching of vital teeth. Some manufacturers question whether the use of curing lights is necessary.[4-5] In the current study, no curing lights were used in group G1, only the bleaching gel with 35% HP was applied for posterior group comparisons (G2, G3 and G4).

Evaluating shade changes using the Easyshade spectrophotometer (Vita-Zahnfabrik, Germany) and the Classical Vita Shade Guide (Vita-Zahnfabrik, Germany) over a six-month period revealed no significant difference between groups in which instrumental evaluation (p=0.281394) and visual evaluation (color guide) (p>0.3895787) was used. These results are similar to those by Auschill and others[24] but differ from the clinical study of Zekonis and others,[26] in which the bleaching agent was used for a total of 60 minutes. In the current study, the bleaching agent was used for 90 minutes, which could be a contributing factor towards the superior results from this in-office bleaching treatment.

When comparing the two methods of shade evaluation (color guide and spectrophotometer), there were differences in the results, which correspond with other studies.[2,17,30,33] The authors of this study believe that similarities between the evaluating methods are the result of the spectrophotometer possessing the same measurement scale as the Vita Shade Guide and because both methods are standardized.[34]

There were no statistically significant differences observed with or without the use of curing light in relation to color change after the bleaching treatment. The use of activator sources (Halogen Light, LED and LED/Laser) for the purpose of accelerating the process of the bleaching gel and getting better results was not confirmed clinically.

Color stability was observed up to the sixth month after treatment. There was a slight color relapse after six months, but there were no statistically significant differences between the groups (Figures 5 and 6). However, a prolonged clinical study observed color descent to the original tooth shade.[34] Rosenstiel and others[36] monitored, *in vitro*, the color modification and its stability after one session of in-office bleaching with 35% HP activated with light for 30 minutes. That study observed a color relapse seven days after treatment, which differed from the current study. This discrepancy might be due to the lower number of bleaching sessions, the duration of the bleaching gel application, being an *in vitro* study and the introduction of new bleaching agents and techniques. The inclusion of light-cured gingival dams, chemical activators and the use of compounds that decrease tooth sensitivity have simplified treatment and demonstrated better results.[23]

To promote better color stability, the use of both in-office and at-home treatments has been recommended. This claim was not evaluated in the current study. With that method, the first bleaching session is done using 35% HP (in-office), followed by at-home bleaching.[37] This combination of bleaching treatments for vital teeth provides better results, because it reduces the length of treatment and lowers irritation of the gingival tissues and tooth sensitivity.[23] Another method for achieving better results is by using two application sessions (35%

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HP) and three applications of the bleaching gel for each session, as was utilized in the current study.

The groups (G1, G2, G3, G4) were bleached in two clinical sessions, with a seven-day break between each session. Each session utilized a bleaching gel application lasting 45 minutes, totaling 90 minutes for the entire treatment to promote higher shade alteration and color stability.

The recorded tooth sensitivity was similar in both the number of patients and intensity. Sensitivity is strongly related to concentration, time and rate of usage of the bleaching gel.[21,23,38]

Tooth sensitivity probably occurred due to a high concentration of the bleaching gel and the length of application (35% HP, 45 minutes). Another factor that contributed to the increase in tooth sensitivity during the in-office bleaching treatment was the use of light and heat sources, which led to higher pulpal temperature.[3]

Tooth sensitivity occurred immediately following bleaching, but a higher degree of sensitivity was recorded after the second bleaching session, independent of the group evaluated. Tooth sensitivity that occurred immediately following bleaching was probably due to the high concentration of peroxide associated with a light source, increasing tooth temperature and the patient's sensitivity.[33]

A recent study observed that the bleaching treatment caused a therapeutic effect combined with an increase or decrease in oral bleeding and dental plaque and healthier gingival tissues, because certain hydrogen peroxide byproducts are antibacterial.[39] A low concentration of bleaching agent in contact with gingival tissues causes no noticeable clinical lesion. Local inflammation can occur in gingival tissues that are exposed to high concentrations of peroxide, but that inflammation is easily treated.[39]

In the current study, patients reported low gingival irritation probably because it was possible to safely control contact of the bleaching gel with the gingival margin by using light-cured gingival dams.

CONCLUSIONS

1. The in-office bleaching agent used was effective for the whitening of vital teeth.
2. The in-office bleaching treatment of vital teeth with 35% hydrogen peroxide did not show improvement with the use of any auxiliary sources tested (halogen light, LED, LED/Laser).
3. There were no color stability differences up until the sixth month after the evaluation between the study groups.

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