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Clinical Performance of Vital Bleaching Techniques

JK Bernardon • N Sartori • A Ballarin
J Perdigão • G Lopes • LN Baratieri

Clinical Relevance

Tooth bleaching results obtained with different techniques (home bleaching, in-office bleaching with or without light source and a combination of in-office bleaching + home bleaching) were similar after a two-week period. Dentists must inform their patients about the expected outcomes of each procedure and provide an evidence-based choice.

SUMMARY

This study compared the clinical outcome of bleaching techniques in vital teeth. After IRB

*Jussara K Bernardon, DDS, MS, PhD, clinical professor, Department of Operative Dentistry, Universidade Federal de Santa Catarina, Florianópolis, SC, Brazil

Neimar Sartori, DDS, MS, graduate student, Department of Operative Dentistry, Universidade Federal de Santa Catarina, Florianópolis, SC, Brazil

Andressa Ballarin, DDS, research assistant, Department of Operative Dentistry, Universidade Federal de Santa Catarina, Florianópolis, SC, Brazil

Jorge Perdigão, DMD, MS, PhD, professor, Department of Restorative Sciences, Division of Operative Dentistry, University of Minnesota, Minneapolis, MN, USA

Guilherme Carpena Lopes, DDS, MS, PhD, clinical professor, Department of Operative Dentistry, Universidade Federal de Santa Catarina, Florianópolis, SC, Brazil

Luiz Narciso Baratieri, DDS, MS, PhD, professor, Department of Operative Dentistry, Universidade Federal de Santa Catarina, Florianópolis, SC, Brazil

*Reprint request: Amaro Antonio Viera 2489 apto 403, Florianópolis, 88034-102, Brazil; e-mail: jussara_bernardon@yahoo.com.br

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approval and informed consent, 90 subjects were selected based on the shade of their anterior teeth (A2 or darker, Vita Classic shade guide). Subjects were assigned to three treatment groups in a split-mouth study design: Group I: HB (at-home bleaching with 10% carbamide peroxide for two weeks) vs OBL (in-office bleaching with 35% hydrogen peroxide, two sessions, two-week intervals, with light irradiation); Group II: OB (in-office bleaching without light irradiation) vs OBL; Group III: HB vs combination (one session plus HB). Color change and color rebound (ΔE) were measured for a 16-week period. Color measurements were carried out with both a spectrophotometer and a shade guide at baseline, 1, 2, 4, 8 and 16 weeks. Tooth sensitivity was evaluated using a VAS scale for 15 days. Both the Student's *t*-test and Tukey-Kramer test were used to analyze the results ($p < 0.05$). After one week, one session of OBL followed by HB resulted in lower color values, compared with the other bleaching methods. Group III resulted in the least shade values at one-week evaluation, when compared with the other bleaching methods. After two weeks, HB alone resulted in similar

color changes as OB, OBL and OBL+HB. The use of light irradiation did not improve bleaching efficacy (OB = OBL). OBL and OB resulted in higher sensitivity rates than HB.

INTRODUCTION

Currently, there are a number of tooth bleaching techniques available to clinicians. Home bleaching and in-office bleaching are widely used in dental practice.^{1,2} One of the advantages of home bleaching has been reported to be its efficacy, which is readily noticed favorably by patients.^{3,4} However, home bleaching requires a longer treatment time than in-office bleaching, which may contribute to its higher incidence of tooth sensitivity during treatment.³ In spite of it being considered less effective, in-office bleaching may achieve noticeable results in one or two sessions.^{4,5} A study evaluating patients' satisfaction found that a single in-office bleaching session is not sufficient to achieve satisfactory results.⁵

Within these two main categories of bleaching techniques, there are other variables, including type of bleaching agent, concentration and application time.^{2,6-7} Carbamide peroxide (CP), in concentrations between 10% and 22%, and hydrogen peroxide (HP), in concentrations from 4% to 8%, are indicated for home bleaching for prolonged periods of time.^{2,6,8} In-office bleaching is performed using high-concentration HP (25% to 50%), which can be light-activated to accelerate the bleaching process.⁹⁻¹⁰

Manufacturers' recommendations for using light irradiation with in-office bleaching have become more frequent in the last few years. However, use of a light source as an adjunct to in-office bleaching has been questioned in the literature.^{1,4,11-13} In fact, clinical studies show that light does not influence the degree of bleaching, while it may potentiate tooth sensitivity.¹¹⁻¹⁴ A short-term color rebound has also been described for in-office bleached teeth.¹⁵⁻¹⁶

The combination of in-office and at-home bleaching has been suggested to potentiate the bleaching effect and improve color stability.^{7,17} Many dentists perform in-office bleaching complemented with at-home bleaching. In-office bleaching with 35% HP is performed during the first session to provide an initial "jump-start" bleaching effect. Then, the patient is given a home-bleaching agent, usually CP, in a custom-made tray, which is to be used until the desired shade is obtained.¹⁷

Since clinical studies comparing these techniques are not abundant, it is necessary to evaluate the effects of the most commonly used bleaching techniques. Therefore, the current study compared the clinical performance of three bleaching strategies in terms of their effectiveness, durability of the

bleaching effect and tooth sensitivity. The null hypotheses tested in the current study were: 1) there is no difference between home bleaching and in-office bleaching with light irradiation; 2) there is no difference between in-office bleaching with light irradiation and in-office bleaching without light irradiation; 3) there is no difference between home bleaching and the combination of one session of in-office bleaching with light irradiation and home bleaching.

METHODS AND MATERIALS

After approval by the Ethics Committee and Informed Consent, 90 subjects were selected according to the inclusion and exclusion criteria cited in Table 1. For a direct comparison of the different bleaching techniques, a split-mouth design was selected, in which the same patient was randomly submitted to different treatments in the left and right sides of the maxillary arch. The side was determined by flipping a coin. The selected patients were randomly divided into three groups (n=30): Group I—at-home bleaching with 10% CP for two weeks (HB) versus in-office bleaching with 35% HP with light irradiation (OBL); Group II—OBL versus in-office bleaching without light irradiation (OB); Group III—HB versus a combination of OBL (one session) and HB.

After tooth prophylaxis and registration of the initial shade of the six maxillary anterior teeth using a shade guide (Vita Classic, Vita Zahnfabrik, Bad Säckingen, Germany) and a spectrophotometer (Vita Easysshade, Vident, Brea, CA, USA), the bleaching procedures were carried out (Figures 1-3).

Home bleaching was accomplished with 10% CP (Whiteness Perfect, FGM, Joinville, SC, Brazil). In its formulation, this bleaching agent contains 3% potassium nitrate and 0.2% sodium fluoride. The bleaching

Table 1: Inclusion and Exclusion Criteria

Inclusion Criteria
<ul style="list-style-type: none">• Absence of restorations or presenting restorations with less than ¼ of the labial surface in all anterior maxillary and mandibular teeth;• Absence of tooth sensitivity (stimulated sensitivity using air syringe);• Patients older than 18 years;• A2 shaded (or darker) teeth (Vita shade guide arranged by value).
Exclusion Criteria
<ul style="list-style-type: none">• Pregnant or breastfeeding women;• Patient with periodontal disease or to be treated for periodontal disease; patient with or to be treated for periodontal disease;• Previous bleaching treatment;• Tetracycline discoloration;• Smoker;• Tooth sensitivity;• History of treatment of tooth sensitivity;• Patient able to attend the follow-up appointments.

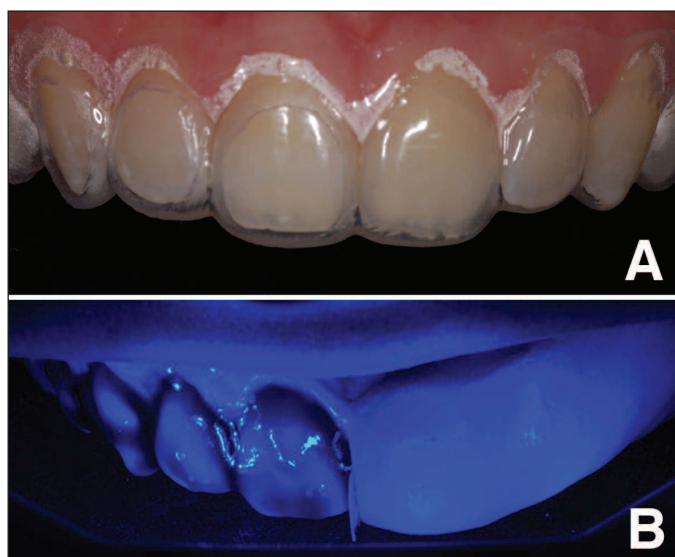


Figure 1. Illustration of the bleaching techniques used in Group I: Home bleaching (Figure 1A) vs In-office bleaching with light irradiation (Figure 1B).

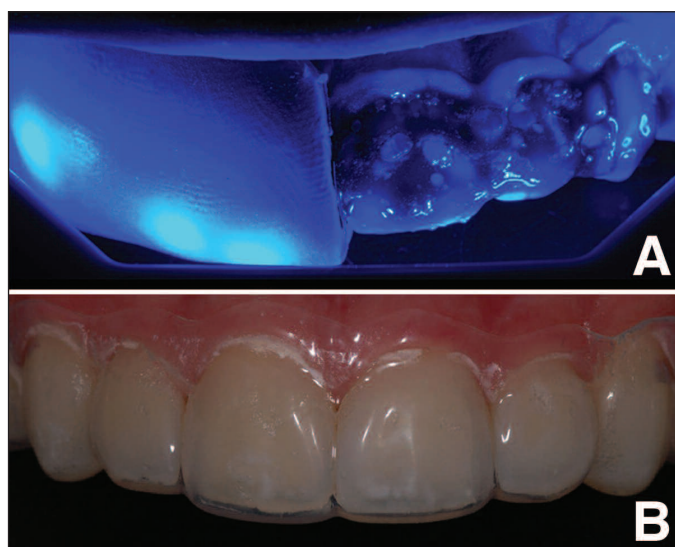


Figure 3. Illustration of the bleaching techniques used in Group III: a combination of one session of in-office bleaching with light irradiation (Figure 3A) vs home bleaching (Figure 3B).

gel was inserted in the internal facial aspect of the tray, which was used for two weeks in an eight-hour daily regimen. The tray did not have reservoirs and was trimmed 2 mm beyond the gingival margin. Facial perforations were made in the region of the tray that corresponded to the teeth that would not be treated in order to prevent the gel from being applied on those teeth.

For in-office bleaching, 35% HP (Whiteness HPmaxx, FGM) was used (two sessions, three applications for each session, 15 minutes per application, 15-day intervals) according to the manufacturer's instructions. A 2-

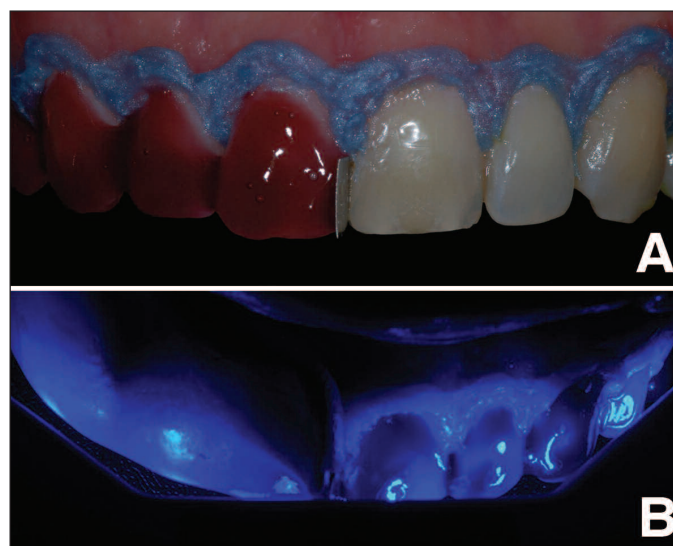


Figure 2. Illustration of bleaching techniques used in Group II: In-office bleaching without light irradiation (Figure 2A) vs in-office bleaching with light irradiation. Notice that the teeth of the hemi-arches that were not irradiated with light were protected with silicone during the light irradiation (Figure 2B).

mm thick gingival barrier was applied on the soft tissues from canine to canine prior to application of the bleaching gel using a light-curing resin (Top Dam, FGM). The right and left quadrants were separated by a metallic matrix band inserted in the midline to confine placement of the corresponding bleaching gel (Figure 1). An LED/laser unit was used for four minutes (Whitening Lase, DMC, São Carlos, SP, Brazil) to irradiate the HP bleaching gel.

The bleaching outcome was evaluated qualitatively using a visual method with the aid of a Vita Classical shade guide and quantitatively using a Vita Easyshade spectrophotometer after 1, 2, 4, 8 and 16 weeks from the start of the treatment. Two blinded, previously calibrated examiners participated in the visual evaluation. They selected the tooth color using the Vita Classic shade guide arranged in decreasing order of value: B1, A1, B2, D2, A2, C1, C2, D4, A3, D3, B3, A3.5, B4, C3, A4 and C4.

To standardize the lighting conditions during shade determination, a 500° Kelvin hand-held lamp was used (Color-I-dent, Waldmann, Germany) as recommended by the manufacturer. In case of disagreement, the differences were discussed between the evaluators until a final consensus was obtained. The selected tab in the shade guide was converted to previously established numeric values (Table 2),^{4,12} ranging from 1 (B1) to 16 (C4). The smaller the numeric value, the lighter the tooth.

For the spectrophotometric evaluation, the device used was the Vita Easyshade (Vident, Brea, CA, USA) to obtain L*, a* and b* values of the CIELab system for

Table 2: Representation of Conversion of Vita Classical Shade Guide Tabs to Numeric Values							
Tab	Value	Tab	Value	Tab	Value	Tab	Value
B1	1	A2	5	A3	9	B4	13
A1	2	C1	6	D3	10	C3	14
B2	3	C2	7	B3	11	A4	15
D2	4	D4	8	A3,5	12	C4	16

each tooth. L* indicates the brightness, and a* and b* represent hue. The a* axis represents saturation in the red-green axis and b* is the saturation in the blue-yellow axis. For each period, color was compared before and after the bleaching procedure using the color difference or ΔE, according to the formula:^{2,18} $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$, with ΔL = final L–initial L; Δa = final a–initial a, and Δb = final b–initial b. To standardize the area of the tooth for shade taking, a silicon index extending from canine to canine was fabricated with a VPS impression material (Express Putty, 3M ESPE, St Paul, MN, USA). A perforation compatible with the size of the spectrophotometer tip was made in the middle-third of the facial surface (6 mm diameter) with a scalpel blade (Figure 4).¹² Standardized photographs

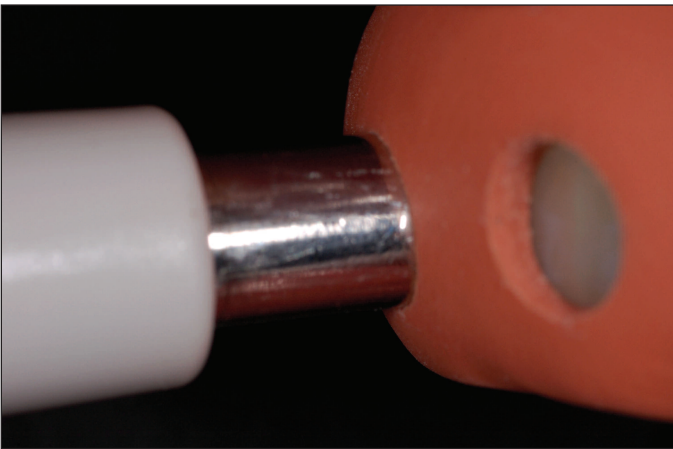


Figure 4. Tip of the spectrophotometer placed in the labial perforation of the silicone matrix. The matrix was used for individual evaluation of the six maxillary anterior teeth.

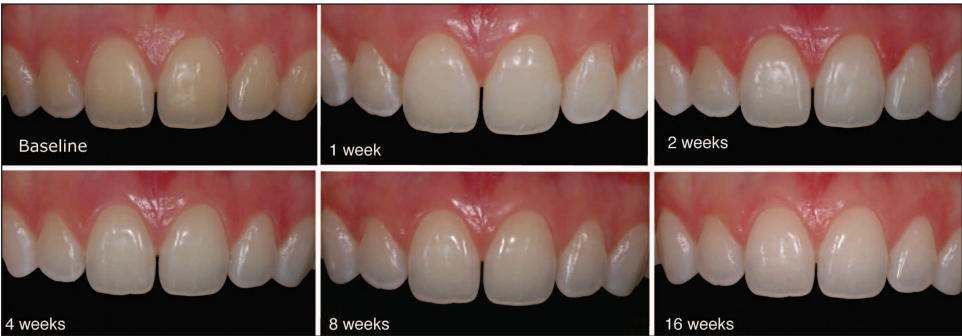


Figure 5. Color change observed in a patient in Group III (right side: home bleaching, left side: 1 session of in-office bleaching + home bleaching) at different evaluation periods.

(Figure 5) were taken at each evaluation period to allow for observation of the results obtained by the different techniques up to the 16-week period.

Tooth sensitivity for each hemi-arch was evaluated on a daily basis by the patient for two weeks (period of bleaching) and recorded on a clinical form. Pain intensity was classified in a 0-10 scale ranging from “without any discomfort” to “extremely unpleasant or uncomfortable” using the 10-cm VAS scale as the reference and recorded on the form.¹⁹

Statistical analyses were carried out with ANOVA for repeated measures using statistical package software (Statistical Analysis System, SAS Institute, Cary, NC, USA). The Student's *t*-test was used for comparison between the bleaching techniques and the Tukey-Kramer test for comparison of bleaching techniques with time ($p \leq 0.05$).

RESULTS

The results obtained with visual and spectrophotometric analyses are displayed in Tables 3 and 4, respectively. Means and standard deviations for each group are presented for comparison of the bleaching techniques and evaluation periods. All the techniques evaluated were effective for tooth bleaching, resulting in a statistically similar degree of bleaching at two weeks, and color stability was acceptable over a 16-week period. The degree of bleaching obtained with the in-office bleaching technique was statistically higher than that obtained with the home-bleaching technique only at the one-week evaluation period. The degree of bleaching was similar at the second week for both techniques. Evaluation of the results for tooth sensitivity was not subjected to statistical analysis. The comparison of pain intensity for the different bleaching techniques was extrapolated from the analysis of Figure 6.

DISCUSSION

This *in vitro* study applied a split-mouth design in order to compare different bleaching techniques. This design allows for simultaneously comparing two bleaching techniques in the same patient, reducing the influence of tooth-related and patient-habit variables commonly observed in the bleaching treatment.^{7,20}

Table 3: Means and Standard Deviations of Subjective Evaluation (shade guide)

		Period (weeks)				
Groups	Treatment	1	2	4	8	16
G I	HB	3.95 ± 2.46 aA	3.00 ± 2.14 aB	2.64 ± 1.86 aB	2.69 ± 1.91 aB	3.10 ± 1.87 aB
	OBL	3.58 ± 2.15 aA	3.26 ± 2.07 aA	2.64 ± 1.76 aB	2.63 ± 1.70 aB	2.88 ± 1.57 aB
G II	OB	3.06 ± 1.69 aA	3.30 ± 1.98 aA	2.26 ± 1.30 aB	2.35 ± 1.38 aB	2.59 ± 1.45 aAB
	OBL	3.13 ± 1.84 aA	3.06 ± 1.79 aA	2.26 ± 1.37 aB	2.32 ± 1.38 aB	2.45 ± 1.34 aAB
G III	HB	2.72 ± 1.80 aA	2.17 ± 1.33 aAB	2.00 ± 1.18 aB	2.42 ± 1.45 aAB	1.99 ± 1.34 aB
	HB + 1 session OBL	2.20 ± 1.49 bA	1.79 ± 1.38 bA	1.71 ± 1.16 aA	2.18 ± 1.45 aA	1.75 ± 1.08 aA

Means with identical lowercase letters in the same columns for each group are not statistically different (Student's t-test, $p > 0.05$).
Means with identical capital letters for each group within the same rows are not statistically different (Tukey-Kramer test, $p > 0.05$).

Table 4: Means and Standard Deviation of Objective Evaluation (spectrophotometric analyses: ΔE)

		Period (weeks)				
Groups	Treatment	1	2	4	8	16
G I	HB	6.33 ± 2.94 aA	8.40 ± 3.59 aB	8.91 ± 3.42 aB	9.08 ± 3.39 aB	8.82 ± 3.76 aB
	OBL	7.53 ± 3.63 bA	7.41 ± 3.33 bA	9.18 ± 3.76 aB	9.39 ± 3.72 aB	8.98 ± 3.84 aB
G II	OB	6.65 ± 2.73 aA	6.17 ± 2.62 aA	8.41 ± 3.14 aB	7.96 ± 3.26 aB	8.03 ± 3.08 aB
	OBL	6.86 ± 2.80 aA	6.64 ± 3.08 aA	8.76 ± 3.40 aB	8.61 ± 3.48 aB	8.37 ± 3.08 aB
G III	HB	7.74 ± 3.18 bA	9.30 ± 3.56 aB	10.00 ± 3.62 aB	9.50 ± 3.46 aB	9.70 ± 3.37 aB
	HB + 1 session OBL	8.87 ± 3.51 aA	10.07 ± 3.52 aB	10.82 ± 3.62 aB	10.09 ± 3.54 aB	10.32 ± 3.62 aB

Means with identical lowercase letters in the same columns for each group are not statistically different (Student's t-test, $p > 0.05$).
Means with identical capital letters for each group within the same rows are not statistically different (Tukey-Kramer test, $p > 0.05$).

The color change obtained by the different bleaching techniques was evaluated with a subjective method (visual examination, with the aid of the shade guide) and an objective method (spectrophotometer). The similar outcome regarding color change observed with both evaluation methods corroborates the reliability and precision of the results obtained.^{4,21-23}

The mean ΔE values obtained at the end of the

bleaching treatment for both home bleaching ($\Delta E \approx 9$) and in-office bleaching ($\Delta E \approx 8.7$) were comparable to the mean ΔE values reported in the literature for these techniques.^{4,24} It has been suggested that a variation ΔE from 3.3 to 3.7 produces clinically perceptible color changes.²⁵

Considering the statistical analysis, it was observed that all evaluated techniques were effective for bleaching vital teeth in general, showing the effectiveness of HP as a bleaching agent, regardless of the concentration and application regimen.^{4,12,26}

Different from home bleaching, which produced significantly increased bleaching at one week, a far greater bleaching effect (higher ΔE) was observed only after the two-week evaluation in teeth bleached exclusively with the in-office technique. This was expected, because the second bleaching session was performed on the day of the two-week evaluation and only after color registration. Therefore, the final color obtained by the in-office technique was taken only at the four-week evaluation. It should be emphasized that this difference in the degree of bleaching between the in-office technique and at-home was clinically noticeable according to the results of the visual evaluation (Table 3). A possible explanation is that the teeth were dehydrated to some extent by the 500°K lamp and the teeth appeared lighter. However, all the teeth were subjected to the same conditions.

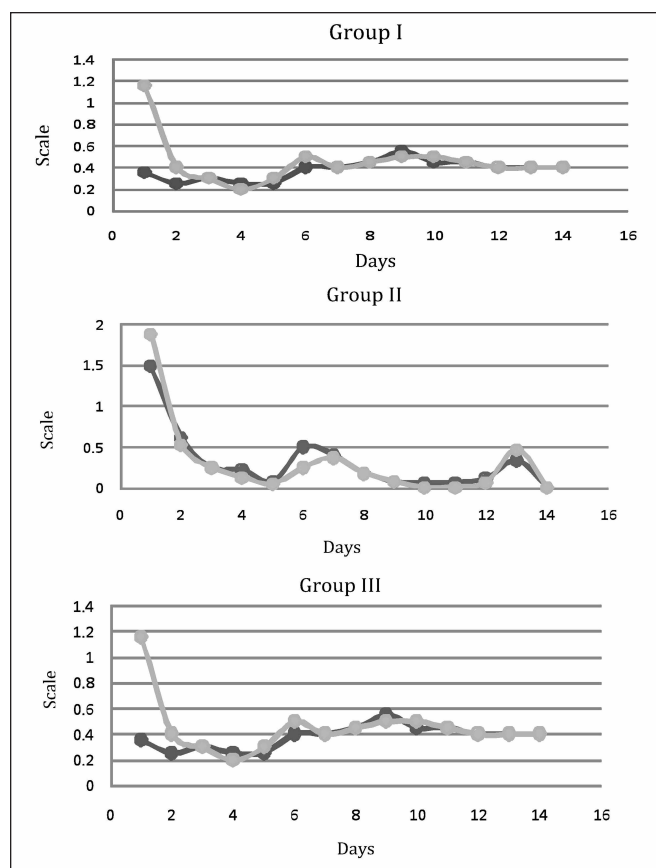


Figure 6. Representation of tooth sensitivity reported during the bleaching treatment period.

Group I: Comparison of Home Bleaching vs In-office Bleaching with Light Irradiation

In order to obtain lighter teeth in less time, in-office bleaching using a high concentration HP associated or not associated with a light source has been recommended.^{9-10,27}

In the current study, the degree of bleaching obtained via the in-office technique with light irradiation (35% HP, six applications for 15 minutes each) was higher than that obtained by the home bleaching technique (10% CP/8 hours/14 days) only after the first week. In all other evaluation periods, the bleaching obtained by the home bleaching technique was similar to that obtained by the in-office technique, regardless of the use of a light source. This result corroborates the *in vitro* findings of Sulieman and others,⁹ who found that a high-concentration gel produced similar bleaching to a low-concentration gel, and it reaches the final results more rapidly. On the other hand, these findings were different from Auschill and others¹ and Zekonis and others,⁴ where both obtained significantly lighter teeth with the home bleaching technique ($\Delta E \approx 10.3$) compared with the in-office technique without light irradiation ($\Delta E \approx 4.05$).

None of the techniques evaluated in the current study resulted in color rebound at the 16-week evaluation. The bleaching obtained with the home bleaching technique ($\Delta E \approx 9$) and the in-office technique ($\Delta E \approx 8.7$) did not relapse with time. Regarding the home bleaching technique, this behavior corroborates the findings of Meireles (2008), who observed maintenance of the bleaching effect using 10% and 16% CP for up to six months. Conversely, Zekonis and others⁴ reported color rebound for teeth bleached with 10% CP after 12 weeks ($\Delta E \approx 6.39$). For the in-office technique, the findings of the current study were opposite the other studies, which found short-term color rebound.^{5,12,16,20,28}

Group II: Comparison of In-office Bleaching With and Without Light Irradiation

Because there have been claims that use of a light source accelerates the bleaching process,^{9,29} the current study evaluated the influence of light irradiation on the effectiveness and durability of an in-office bleaching technique.

Similar results were observed when teeth bleached using the in-office technique and light irradiation were compared to teeth bleached without light irradiation, either for spectrophotometric or shade guide evaluation. ΔE values obtained in the hemi-arch bleached with the in-office technique with light irradiation ($\Delta E = 8.41$) were not statistically different from those obtained in the hemi-arch, where the gel was not irradiated with light ($\Delta E = 8.76$), in spite of a subtle decrease in ΔE . This corroborates the findings of other research projects.^{4,11,13-14} Considering that no color rebound was observed for up

to 16 weeks in teeth bleached using the in-office technique, the use of a light source should be considered optional for this technique when using high-concentration HP. These findings contradict other studies that have reported color rebound with time for in-office bleaching associated^{12,29} or not⁴⁻⁵ associated with light irradiation.

Group III: Comparison of Home Bleaching vs a Combination of In-office and Home Bleaching Techniques

Another treatment option is a combination of two bleaching techniques. According to the literature, this combination may accelerate the bleaching process and promote color stability with time.^{2,13,15}

In the current study, the technique associating one session of in-office bleaching to the home bleaching technique obtained higher ΔE values and lower values after conversion from the visual evaluation at the one-week period. Clinically, this means lighter teeth in less time. Therefore, the mixed technique accelerated the bleaching process. However, after the second week, ΔE obtained for the hemi-arches bleached with this combination were not statistically different from ΔE obtained from teeth bleached using custom trays with 10% CP. This suggests that both techniques were similarly effective after the second week.

Both techniques in this group presented color stability for up to 16 weeks. It has been shown that one session of in-office bleaching associated with home bleaching does not influence the maintenance of color with time.

Tooth Sensitivity

Tooth sensitivity is a side effect commonly reported in the literature after vital tooth bleaching.^{1,2,12,30} *In vitro* studies have shown that the peroxide diffuses into enamel and dentin and reaches the pulp. The peroxide concentration within the tissues is related to the concentration of the bleaching agent.³⁰⁻³¹ Notwithstanding, the mechanism responsible for bleaching-related tooth sensitivity has not been established; in the current study, the hemi-arches bleached with the in-office technique (35% HP) resulted in a higher degree of tooth sensitivity when compared to the hemi-arches treated with the home-bleaching technique. This might be associated with the high concentration of bleaching agent used in the in-office bleaching technique. The reported sensitivity was moderate and was more severe on the day of the gel application, and it virtually disappeared after four days for most patients, similar to a study by Marson and others. Tooth sensitivity has been associated with heating produced by light irradiation of the bleaching agent.^{11-12,22,29} In the current study, the use of a light source did not influence the intensity of sensitivity reported by patients, and this was similar for the

hemi-arches bleached with and without light irradiation.

Regarding the home-bleaching technique, the value ascribed to pain intensity was as low as 0.5 (0-5 scale), that is, sensitivity was virtually non-existent throughout the evaluation period. It should be emphasized that, according to the manufacturer, the bleaching agent used contains a combination of potassium nitrate and sodium fluoride as desensitizing agents, which may reduce tooth sensitivity.³² This finding did not corroborate with the findings of Zekonis and others, who found higher sensitivity for home bleaching (10% CP) when compared to in-office bleaching (35% HP).⁴ The reason could be the absence of a desensitizing agent in the formulation of the bleaching agent used in their research.

CONCLUSIONS

Within the limitations of the current study, it can be concluded that.

- The degree of bleaching obtained with the home-bleaching technique was similar to that obtained with the in-office technique, regardless of light irradiation or the combination of home/in-office techniques.
- The use of a light source for in-office bleaching did not influence the rate of bleaching, the intensity of tooth sensitivity and the durability of the bleaching effect; therefore, light irradiation is not recommended.
- The combination of in-office and home-bleaching techniques increased the rate of bleaching only in the first week. However, the same combination did not influence the results after the first week.
- Higher sensitivity was observed with the in-office technique immediately after treatment, regardless of light irradiation.

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