

A Single-Blind Randomized Trial About the Effect of Hydrogen Peroxide Concentration on Light-Activated Bleaching

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Clinical Relevance

The use of light-emitting diode/laser light activation could be considered for in-office dental bleaching when low concentrations of hydrogen peroxide are used. However, the conflicting results between the two instruments used to evaluate color changes deserve further study.

SUMMARY

Objective: To compare the bleaching efficacy and tooth sensitivity (TS) of two hydrogen peroxide (HP) concentrations (20% and 35%) used for in-office bleaching associated or not

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with a light-emitting diode (LED)/laser light activation.

Method: Seventy-seven patients with a right maxillary canine darker than A3 were selected for this single-blind randomized trial. The participants were distributed in four groups: bleaching with 35% HP, 35% HP + LED/laser, 20% HP, and 20% HP + LED/laser. The anterior teeth were bleached in two sessions, using a 35% or 20% HP gel with a one-week interval. Each session had three applications of 15 minutes. For the light-activated groups, the LED/laser energy (Whitening Laser Light Plus, DMC) was employed according to the manufacturer's instructions. The color change was evaluated by subjective and objective methods. Participants recorded TS with five-point verbal and visual analog scales. Color change in ΔE was evaluated by analysis of variance and Tukey tests ($\alpha=0.05$) and in ΔSGU with Kruskal-Wallis and Dunn test. The absolute risk of TS and TS intensity were evaluated by Fisher exact test and Kruskal-Wallis test, respectively ($\alpha=0.05$).

Results: All groups achieved the same level of whitening, except for the 20% HP group, which

showed the lowest degree of whitening in the subjective analysis. The use of light did not increase the absolute risk or intensity of TS. No significant difference among groups was observed when color changes were assessed with the spectrophotometer.

Conclusion: According to the value-oriented shade guide, the use of LED/laser light activation was able to increase the degree of whitening of the 20% HP group, but this association was not useful for the 35% HP gel. The spectrophotometer, however, did not detect significant differences among groups.

INTRODUCTION

In-office tooth bleaching is an effective technique that is commonly used in dental practice to improve the esthetics of discolored teeth.¹ It offers quicker whitening results with reduced applications than at-home bleaching techniques.^{1,2} It also avoids the ingestion of the whitening product, the use of bleaching trays, and the gingival irritation that frequently occurs when such a procedure is undertaken.³

Within the in-office bleaching approach, hydrogen peroxide (HP) is the active molecule that acts as a strong oxidizing agent through the formation of free radicals, reactive oxygen molecules, and HP anions.⁴ Some studies suggest that teeth are whitened by the oxidizing action of these radicals on the organic dentin matrix,^{5,6} which results in constituents that reflect less light and thus create a whitening effect.^{4,7-10}

However, tooth sensitivity (TS) is a remarkably common side effect that patients often report, mainly with in-office bleaching.¹¹⁻¹³ The mechanism that causes this painful outcome is still not fully understood,¹⁴ but it seems to be associated with the ability of HP to penetrate the dental structure and reach the pulp chamber.¹⁵⁻¹⁸ At a high concentration, HP and its related by-products can exceed the antioxidant capacity of the pulp cells and cause oxidative stress, leading to cell damage.¹⁹⁻²²

In an effort to reduce this side effect, some manufacturers have released in-office bleaching gels with lower HP concentrations. Based on the assumption that the HP diffusion through dentin is proportional to the original concentration of the bleaching agent,^{17,23} low-HP products would be less harmful to the living pulp cells. However, the whitening effect that is produced by the low-HP gels

is inferior to the traditional 35% HP concentration.^{2,24}

The association of light sources with low-HP gels may improve the bleaching outcome because light sources increase the oxygen dissociation rate and may reduce the time that is required for the bleaching protocol to occur.^{25,26} Although the benefits of this association are still controversial,²⁵⁻³¹ a recent systematic review and meta-analysis of the literature³² concluded that the advantages of light-activated bleaching with low-HP concentrations (i.e., 15%-20%) must still be investigated. Therefore, the aim of this study was to evaluate the impact of HP concentration at levels of 20% and 35% and light activation on color change and TS for in-office bleaching procedures. The null hypotheses that were tested postulated that 1) the different HP concentrations or light activation would not result in different degrees of color change and 2) the different HP concentrations or light activation would not result in various levels of the absolute risk of TS.

METHODS AND MATERIALS

This clinical study was approved (protocol 07943/10) by the Ethics Committee of the State University of Ponta Grossa. The protocol of this study was registered at clinicaltrials.gov under registration number NCT01231243. The experimental design followed the CONSORT statement.³³ Based on pre-established criteria, 76 volunteers from the cities of Ponta Grossa (Paraná, Brazil) and São Paulo (São Paulo, Brazil), were selected for this study. Two weeks before the bleaching procedures, all of the volunteers received a dental screening and a dental prophylaxis with pumice and water in a rubber cup, and they signed an informed consent form.

Study Design

This was a single-blind randomized clinical trial with an equal allocation rate. The study took place in the clinics of the schools at the State University of Ponta Grossa, Paraná, and the University of São Paulo, São Paulo, from June 2010 to June 2012.

Inclusion and Exclusion Criteria

The patients who were included in this clinical trial were men and women of any age who were in good general and oral health. These participants were recruited by wall announcements at both universities. The participants were required to have six maxillary and mandibular anterior teeth without caries lesions or restorations. The right maxillary

canine was shade A3 or darker, as judged by comparison with a value-oriented shade guide (VITA Classical Shade Guide, Vita Zahnfabrik, Bad Säckingen, Germany). Pregnant or lactating women and smokers were not included in this trial. Participants with anterior restorations, bruxism habits, severe internal tooth discoloration (tetracycline stains, fluorosis, pulpless teeth), and recessed or exposed dentin were also excluded. In addition, participants who took anti-inflammatories, analgesics, or antioxidants were not included in the study.

Sample Size Calculation

The primary outcome of this study was color change of the participants' teeth. A previous study³⁴ reported that two bleaching sessions with the product Whiteness HP Maxx 35% (FGM Dental Products, Joinville, SC, Brazil) without light activation produced a whitening effect of about 7 ± 2 SGUs. To detect a difference of 2 SGUs between the means of any pair of the study groups, with a power of 80% and an alpha of 5%, a minimum sample size of 17 patients per group was required. This threshold of perceptibility was based on the fact that "untrained" people, such as the patients, do not detect easily changes of one shade guide unit at the lighter end of the classical guide.

Random Sequence Generation and Allocation Concealment

Participants were randomly divided into four groups according to the combination of the main factors: HP (20% or 35%) and light activation (with or without). A third person who was not involved in the research protocol performed the randomization procedure by using computer-generated tables. We used blocked randomization (block sizes of 2 and 4) with an equal allocation ratio (www.sealedenvelope.com). Opaque and sealed envelopes containing the identification of the groups were prepared by a third person not involved in the study intervention.

Study Intervention

The participants and the operator were not blinded to the procedure, as the use of light could not be masked. However, the examiners who evaluated the color changes with the value-oriented shade guide (VITA Classical Shade Guide, Vita Zahnfabrik) were not aware of the allocation of the participants within the study groups.

This study employed the 35% HP Whiteness HP Maxx (FGM Dental Products). Its manufacturer also

produced specifically for this study a 20% HP bleaching product that shares the same features as the 35% HP Whiteness HP Maxx. The light activation source used was light-emitting diode (LED)/laser equipment (Whitening Lase Light Plus, DMC Odontologica, São Carlos SP, Brazil). This light source is composed of a matrix of LEDs with a wavelength of 470 nm, three infrared laser diodes with a wavelength 830 nm, and a light intensity of 200 mW/cm².

Bleaching Procedure

We isolated the gingival tissue of the teeth to be bleached by using a light-cured resin dam (Top Dam, FGM Dental Products). In compliance with the manufacturer's directions, we applied the HP gels (20% and 35%) during three 15-minute applications for both groups. The products were refreshed every 15 minutes during the 45-minute application period. We performed two bleaching sessions with a one-week interval. The light-activated groups received an LED/laser energy (Whitening Lase Light Plus) according to the manufacturer's directions. The buccal surfaces were activated for 1 minute, and then the device was turned off for 2 minutes. This procedure was repeated three times for each 15-minute gel application. All of the participants were instructed to brush their teeth regularly (i.e., four times a day) with a fluoridated toothpaste (Sorriso Fresh, Colgate-Palmolive, São Paulo, SP, Brazil) that was provided by the study investigators.

Color Evaluation

The examiners recorded the color prior to the commencement of the study and at periods of one week and 30 days after the bleaching treatment by using subjective (value-oriented shade guide VITA Classical Shade Guide, Vita Zahnfabrik) and objective evaluation tools (Easyshade spectrophotometer, Vident, Brea, CA, USA).

For the subjective examination, the shade guide's 16 tabs were arranged from highest (B1) to lowest (C4) value, thus denoting the color A3 as number 9. The measurement area of interest for shade matching was the middle one-third of the buccal surface of the right maxillary canine. For calibration purposes, five participants whom we did not include in the study sample participated in the training phase. The two examiners, who were blinded to the allocation assignment, scheduled these patients for bleaching and evaluated their teeth against the shade guide at the baseline at one week and again 30 days after the procedure. The two evaluators presented superior

color-matching competency according to the ISO/TR 28642.³⁵ This means that they have an agreement of at least 85% (Kappa statistic) before beginning the study evaluation (85% of correctly matched pairs of tabs in shade guides). If disagreements occurred during the evaluation, they needed to reach a consensus before the participant was dismissed.

For the objective evaluation, a dense silicone Speedex (Coltène Whaledent AG, Altstaetten, Switzerland) was used to make a preliminary impression of the maxillary arch of the patients. The impression, which was extended to the maxillary canine, served as a standard color measurement guide for the spectrophotometer. A window was created on the labial surface of the silicone guide so that the right maxillary canine could be evaluated. The window was made by using a metallic device with well-formed borders as a radius of 3 mm.²⁸ Only one of the operators conducted the assessment on all of the participants by using Vita Easyshade before the procedure and one week and 30 days after the bleaching process.

The shade was determined by using the following parameters that were detected by the Easyshade device: L*, a*, and b*, in which L* represents the value from 0 (black) to 100 (white) and a* and b* represent the shade, where a* is the dimension along the red-green axis and b* is the dimension along the yellow-blue axis. The color comparison before and after the treatment was assessed through the differences (ΔE) that were observed between the two colors. Such differences were calculated with the formula $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$.^{2,28}

Tooth Sensitivity Assessment

The patients recorded their perception of TS during the first and second bleaching sessions according to two pain scales. A five-point rating scale (0 = *none*, 1 = *mild*, 2 = *moderate*, 3 = *considerable*, and 4 = *severe*)^{28,34,36} and a visual analogue scale (VAS)³⁷⁻³⁹ were employed in this study. The VAS scale is a 10-cm horizontal line that denotes the words *no pain* at one end and *worst pain* at the opposite end. We asked the subjects to indicate whether they experienced TS in the intervals: during the treatment up to 30 minutes and from 30 minutes up to 48 hours after the bleaching process. The worst score/numerical value that was obtained in both bleaching sessions was considered for statistical purposes.

If the patient scored zero (no sensitivity) in all time assessments from both bleaching sessions, this patient was considered to be insensitive to the bleaching protocol. In all other circumstances, the

patients were considered to have sensitivity to the bleaching procedure. This dichotomization allowed us to calculate the absolute risk of TS, which represented the percentage of patients who reported TS at least once during treatment. We also calculated the overall TS intensity. In addition, the participants were instructed to record the painful tooth on an appropriate form.

Statistical Analysis

The analysis followed the intention-to-treat protocol and involved all of the participants who were randomly assigned. The statistician was blinded to study groups. The color change (primary outcome) was used to determine the efficacy of the bleaching treatment. The color change (ΔSGU and ΔE) between the baseline vs one week and baseline vs 30 days was calculated for each group. The ΔE were subjected to two-way repeated-measures analysis of variance (groups vs time as the main factors) and Tukey test. The ΔSGU data were subjected to Kruskal-Wallis and Dunn test.

We compared the study group's absolute risk of TS by using the Fisher exact test. The confidence interval for the effect size was calculated. The study groups' TS intensity at each assessment period (for both scales) was statistically analyzed with the Kruskal-Wallis test. Comparisons between assessment points (during and following the bleaching process), within each group, were performed by applying the Wilcoxon signed-rank test. The type of tooth that was reported to be the most painful was analyzed by Fisher exact test or the chi-square test. In all of the statistical tests, the alpha was preset at 0.05.

RESULTS

A total of 263 participants were examined; 77 participants were selected (Figure 1). The mean age (years) of the participants, the percentage of women vs men, and the baseline SGU are described in Table 1. One can observe comparable data among treatment groups by ensuring the comparability of baseline features. None of the patients discontinued the intervention or presented adverse effects during the intervention. No medication and/or desensitizer were necessary to be prescribed/applied in the participants from this study for the relief of bleaching-induced TS.

Color Change

Significant whitening was observed in the study groups under the subjective and objective evaluation

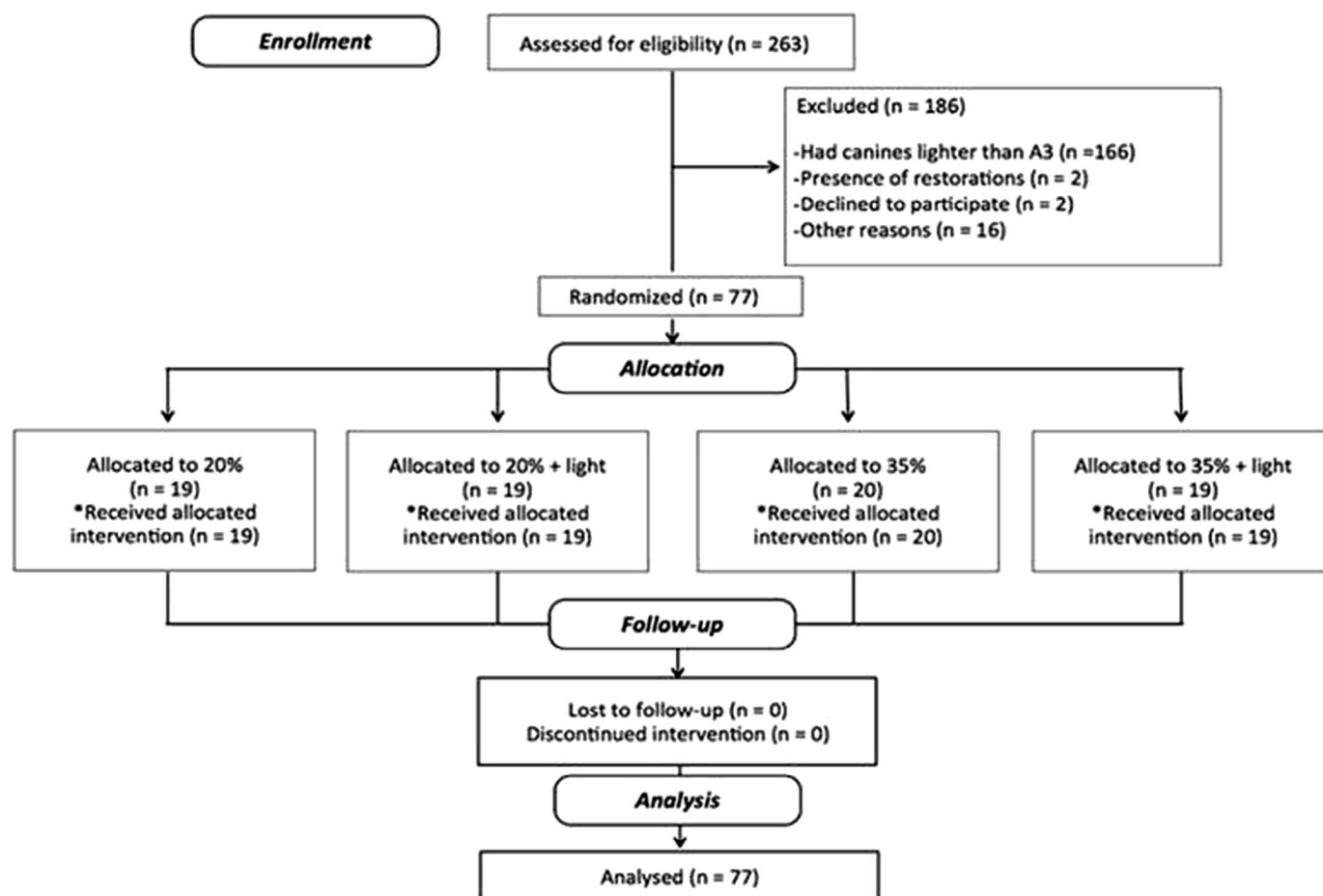


Figure 1. Flow diagram of the trial including detailed information on the excluded participants.

methods. A whitening of approximately 6 to 8 SGU and a ΔE of 12 to 14.5 was detected for the groups (Table 2). A lower amount of whitening was observed for the group 20% under subjective evaluation (Table 2; $p=0.006$). No significant difference among groups was detected under the objective evaluation (Table 2; $p>0.05$).

Tooth Sensitivity

With regard to the absolute risk of TS, no significant difference was observed between groups (Table 3; $p=0.4229$). With regard to the TS intensity, the statistical analysis of both pain scales detected no significant difference among the groups for the two

assessment points (Table 4; $p>0.05$). Regarding the TS intensity of each group in the two assessment points, the pain during bleaching was statistically lower than that observed in the post-bleaching period for the 35% + light group in the five-point verbal scale and for the 35% group in the VAS (Table 4; $p<0.05$). Table 5 demonstrates that pain was rarely experienced in the premolars, while the anterior teeth experienced that symptom most often in the 35% groups ($p<0.03$).

DISCUSSION

Bleaching procedures have become the most conservative and popular techniques that are used to solve

Table 1: Demographic Features of the Participants in Each Study Group

Feature	20%	20% + Light	35%	35% + Light
Age, mean $\pm$ SD	22.9 $\pm$ 4.0	22.0 $\pm$ 4.4	23.0 $\pm$ 3.4	22.0 $\pm$ 3.6
Female, n (%)	13 (68)	12 (63)	13 (65)	12 (63)
Baseline SGU, median (25-75 percentile)	12 (11-14)	12 (11-12)	12 (10.5-15)	11 (9-12)

Table 2: Means and Standard Deviations of ΔSGU and ΔE at the Different Assessment Points for the Treatment Groups ^a					
Color Evaluation	Assessment Time	Group			
		20%	20% + Light	35%	35% + Light
ΔSGU ^b	Baseline vs one week	6.7 ± 2.6 B	7.9 ± 1.8 A	8.0 ± 2.2 A	8.2 ± 1.2 A
	Baseline vs 30 days	6.1 ± 2.6 B	8.2 ± 1.3 A	8.2 ± 2.5 A	8.4 ± 1.4 A
ΔE ^c	Baseline vs one week	12.0 ± 4.9 a	11.8 ± 4.0 a	13.5 ± 2.3 a	14.5 ± 3.5 a
	Baseline vs 30 days	13.2 ± 4.1 a	11.8 ± 4.0 a	12.4 ± 3.7 a	14.1 ± 2.9 a
^a Comparisons are valid only within each color evaluation scale.					
^b Identical uppercase letters indicate statistically similar means (Kruskall-Wallis and Mann-Whitney test, α=0.05).					
^c Identical lowercase letters indicate statistically similar means (two-way repeated-measures analysis of variance and Tukey test, α=0.05).					

tooth discoloration. Consequently, many authors have focused their studies on determining the best clinical approach that produces the fewest side effects.^{1,11,13,24,31,39,40} Although only a 10% carbamide peroxide product has the American Dental Association’s seal of acceptance,⁴¹ there are some other commercially available bleaching products (i.e., over-the-counter, at-home, and in-office bleaching) that have yielded successful outcomes.^{1,12,31,42-44}

In the present investigation, color changes were evaluated in the canines instead of the incisors, as commonly done in bleaching studies. This procedure was already done in other studies in the literature.^{45,46} A significantly stronger overall increase in whitening was observed in canines than in incisors,^{45,46} which was 1.4 to 1.6 times more pronounced than incisors, probably because of their darker baseline color.⁴⁷⁻⁴⁹ By measuring the color in canines, the recruitment of patients became easier as patients with baseline incisors A3 or darker is not common, while this is more frequent for canines.

All of the in-office bleaching techniques that were investigated in this clinical trial showed significant whitening after two bleaching sessions. Both the 35% and 35%+ light groups showed a color change of approximately eight SGU, which supports the outcome of previous studies that evaluated two bleaching sessions that each consisted of three 15-minute applications.^{11,12,30}

Color matching is a complex issue because of the color discrimination ability that differs from individual to individual. The visual color selection depends on several factors, such as the shape, size, position, surrounding illumination, and background color. A variation in any factor may result in an altered perception of color.⁵⁰⁻⁵³ To eliminate the subjective variables for shade analysis, improve the communication and reproduction of color, and increase the efficiency of esthetic restorative works, an instrumental color assessment has been developed. Some studies demonstrated that this equip-

ment can be more accurate than human shade assessment.⁵³⁻⁵⁵ Other studies explain that previous training in shade matching and clinical experience in dentistry play a more significant role in demonstrating shade-matching accuracy⁵⁶ and that clinical education and professional experience has a positive impact on the participants’ ability to match correctly tooth shades.^{50,52,57}

In the present study, a lack of agreement between the color evaluation tools was observed. Significant differences were observed with the subjective tool, while the objective color evaluation was not capable to detect such differences. Usually, the opposite is more common (i.e., differences in color change are not detected with the subjective tool), but it is when an instrumental method is employed.^{26,58} When this occurs in a clinical study, authors are put in a dilemma about which data to discuss. Although the spectrophotometer gives accurate results, this instrument is yet not currently used in clinical practice. On the other hand, shade guide units are the most used tools for color evaluation in the clinicians’ armamentarium. This controversy between these two instruments, however, should not be interpreted as a flaw of the present study. One should look at this as a need for future randomized clinical trials on this topic, and researchers should be encouraged to run further studies with this aim.

Irrespective of the instrument for color change, the results of this study are consistent with previous

Table 3: Absolute Risk of Tooth Sensitivity (%) for the Treatment Groups Along With the 95% Confidence Interval (CI) for the Arch ^a		
Group	Tooth Sensitivity, %	95% Confidence Interval
20%	63 A	41-80
20% + light	73 A	51-88
35%	80 A	58-92
35% + light	85 A	64-95
^a Fisher exact test, p=0.4229.		

Table 4: Medians and Interquartile Ranges of Tooth Sensitivity Intensity Reported by Patients at Different Assessment Times for the Treatment Groups in the Upper Arch Using the Five-Point Verbal Scale and the Visual Analog Scale^a

Assessment Time	Five-Point Verbal Scale				Visual Analog Scale			
	20%	20% + Light	35%	35% + Light	20%	20% + Light	35%	35% + Light
During bleaching up to 30 minutes	0 (0-1) aA	0 (0-1) aA	1 (0-2) aA	0 (0-1) aA	7 (0-22) aA	16 (0-56) aA	0 (0-27.5) aA	20 (0-52) aA
30 minutes up to 48 hours	0 (0-1.75) aA	0 (0-1.75) aA	1 (0-2) aA	2 (0-3) bA	0 (0-30) aA	17 (0-52) aA	36.5 (0-71) bA	45 (0-57) aA

^a Each pain scale was individually analyzed. At each treatment, the two periods were compared with Wilcoxon signed rank ($\alpha=0.05$), and differences are represented by different lowercase letters. For each assessment time, the treatments were compared with Kruskal-Wallis and Mann-Whitney U test, and the differences are represented by different uppercase letters.

studies that revealed that the use of light irradiation did not improve the bleaching efficacy of 35% HP.^{27-32,59} At first glance, this result seems to contradict the well-known finding that light can heat and photo-activate the HP, thereby increasing the rate of the oxygen decomposition to produce oxygen-free radicals.⁶⁰ In fact, from chemical theories, one knows that, in simplest chemical reactions, the highest concentration of reactants raises collisions per unit time. Hence, the reaction rate increases. However, if the reaction is complex and involves a series of consecutive steps, there might be a limit to which the increased concentration leads to faster reaction rates. We hypothesize that 35% HP alone already produces enough free radicals to oxidize the organic component of dentin, and thus, the increase in free radicals that are produced by the light activation might be useless. Consequently, the further increases in HP radicals that are produced by light activation do not lead to faster bleaching because of the presence of unknown rate-determining steps in the oxidizing mechanism of tooth bleaching.

This concept is strengthened by the findings of the 20% group observed in the subjective evaluation. On average, the use of 20% HP yielded a whitening of six SGUs, which was statistically lower than the mean eight SGUs detected in the other groups that led us to partially reject the first null hypothesis. In this case (20% group), it seems that the limiting factor of the oxidizing reaction rate was the amount of free radicals; thus, the association with light, which likely increases the amount of free radicals, produced a faster reaction rate and a whitening degree that was similar to that of the 35% HP gel associated or not with light.

These results corroborate previous clinical studies.^{25,26} A detailed analysis of the literature reveals that when the association of light effectively increased the bleaching rate, low-HP concentrations were employed. For instance, Tavares and others²⁵

showed favorable results for the use of a light source associated with a 15% HP gel applied in a single one-hour session. Similarly, Ontiveros and Paravina²⁶ observed improved whitening when a 25% HP was irradiated with a light source during two 45-minute in-office bleaching sessions.

One should not interpret, however, that the use of low-HP concentrations could not achieve the same level of whitening that is produced by the other techniques investigated in this study. In an *in vitro* study, Sulieman and others² established a direct correlation between the concentration of the HP gel and the number of applications needed to achieve a satisfactory whitening effect. Thus, another clinical session of 20% HP alone would probably produce a similar outcome to the other in-office bleaching techniques, but requires further study.

Bleaching-induced TS is a common side effect that occurs during bleaching treatments,¹¹⁻¹³ and the present study is in agreement with such observations from the previous literature. The risk of TS in this study varied from 63% to 85%, and it is within the range reported in the literature. Although the reported risk of TS is variable in clinical trials, it very often exceeds 50%. A recent study that

Table 5: Number of Patients (%) Who Reported Tooth Sensitivity at Least Once in the Different Tooth Types, in the Maxillary Arch^a

Tooth Type	Group			
	20%	20% + Light	35%	35% + Light
Central incisors	7 (37) a	7 (37) a	6 (32) a	9 (45) a
Lateral incisors	6 (32) a	11 (56) a	11 (56) a	7 (35) a
Canines	6 (32) a	8 (42) a	8 (42) a	10 (50) a
Premolars	2 (11) a	4 (21) a	2 (11) b	2 (10) b
p-value ^a	0.274	0.1382	0.002	0.03

^a Fisher exact or chi-square tests ($\alpha=0.05$). Comparisons are valid only within columns. The same lowercase letters indicate statistically similar groups.

evaluated the individual patient data of 11 clinical trials on bleaching produced a more accurate estimate of these risks. For in-office bleaching, the risk of TS was reported to be 62.9% (95% confidence interval [CI] 56.9-67.3), which was not very different from that reported for at-home bleaching (51% [95% CI = 41.4-60.6]).⁴⁹ Although the risk of TS was reported to be similar between in-office and at-home bleaching, the intensity of TS was very different between these bleaching protocols. On a 0 to 4 pain scale, the overall mean intensity of bleaching-induced TS for in-office bleaching was 2.8 ± 2.9 , while that for at-home bleaching was 0.5 ± 0.9 .⁴⁹

In the present study, we could not detect, however, a difference between bleaching protocols. As a result, we did not reject the second null hypothesis. Although some studies reveal that light activation produces more persistent bleaching-induced TS,^{11,61,62} this study failed to show such a trend. However, this finding should be interpreted with caution, as we have not calculated the sample size of the present study to detect clinical and relevant changes in the bleaching-induced TS but rather on color change. Thus, we cannot rule out the fact that a true difference between the study groups may exist.

A few studies in the literature have attempted to investigate what tooth type is the most sensitive to the bleaching protocol.^{31,63} In this study, anterior teeth (incisors and canines) were reported to be more painful than premolars, which is in agreement with previous studies.^{31,63} In a review of the literature, Haywood⁶⁴ reported that bleaching-induced TS usually affects the smaller teeth, such as the maxillary laterals and the mandibular incisors. These reports are in agreement with a recent histological study of pulp tissue after in-office bleaching.²² Notable damage of the pulp tissue was observed in the incisors but not in premolars.²² The thinner enamel and dentin layers of the incisors, in comparison with premolars, may allow the easy passage of HP to the pulp; thus, there is less time for the production and release of protective enzymes against damage by HP.²²

Lastly, we should mention the limitations of the present study. Most of the participants who participated in this study were young, which prevents us from generalizing the results of this study to older patients. The conflicting results between the two instruments used for color change evaluation highlight the need for further research on this topic.

CONCLUSION

Within the limitations of the present study, the treatment with supplementary light only showed significantly higher degree of whitening when used with 20% HP gel when evaluated with the value-oriented shade guide unit. No significant difference in color change was reported when this outcome was evaluated with the spectrophotometer.

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Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects' oversight committee guidelines and policies of State University of Ponta Grossa. The approval code for this study is: 07943/10.

Conflict of Interest

The authors 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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