



Clinical Efficacy of a Bleaching System Based on Hydrogen Peroxide with or without Light Activation

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Abstract

The objective of the present study was to assess the clinical efficacy of a dental bleaching system based on hydrogen peroxide with or without light activation. This randomized controlled trial evaluated the effect of the light when applied to the hydrogen peroxide by using a split-mouth design with 21 patients, with light activation in one hemi-arch but not in the other. The bleaching agent was QuickWhite 35% hydrogen peroxide and activation was conducted with a diode lamp (Luma Cool®). The Classic Vita Guide was used to score tooth shades. Two consecutive applications of hydrogen peroxide were made to one hemi-arch, each light-activated for 10 min. The other hemi-arch was then identically treated but without light activation. After removal of the bleaching agent, the

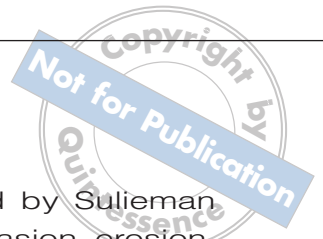
shade was re-scored and the Wilcoxon signed ranks test was used to compare differences in tooth shade values.

The bleaching treatment produced significant shade changes ($P < 0.01$) in both hemi-arches. After treatment, there were no statistically significant differences between light-treated and non-light-treated tooth types (central incisors, lateral incisors, and canines). However, taking central incisor, lateral incisor, and canine as a group, comparison between each hemi-arch showed a significant effect in the hemi-arch with light activation ($P < 0.05$).

The use of diode light with a 35% hydrogen peroxide gel slightly improved the dental bleaching.

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Introduction

Patients seek esthetic dental treatment for a variety of reasons, from personal gratification to work needs. The bleaching of dark-shaded teeth is widely considered desirable and can be achieved with a simple and conservative therapeutic procedure that reduces or eliminates dental discoloration and also acts as a preservative treatment to maintain tooth integrity, with few and reversible side effects.¹

In 1970, with the objective of reducing the treatment time of dental bleaching, practitioners began to use devices that generated light and heat to activate the hydrogen peroxide and accelerate the release of oxygen, increasing the tooth bleaching capacity.² Early techniques used light and heat together, leading to an increase in temperature of teeth³ and post-treatment heat sensitivity due to intrapulpal vasodilatation, with extravasation of blood and a mild inflammatory response.^{4,5} Consequently, new systems that use light to accelerate bleaching but do not generate heat have been developed.⁶

In 1995, visible light-emitting diodes (VLEDs) were introduced, which produce light from semiconductors rather than the filaments used in halogen lamps. VLED lamps produce visible light from semiconductor materials that can be polarized by the passage of electric current and emit visible light (electroluminescence). The color of this light depends on the type and the design of the LED lamp.⁷ The chemical compound most widely used for light-activated bleaching is 35% hydrogen peroxide.⁸ The effectiveness and safety of this

agent was demonstrated by Sulieman et al⁹ in a study of the abrasion, erosion, hardness, and structural changes that it produced in enamel and dentin. Nevertheless, 35% hydrogen peroxide can produce lesions in soft tissues, which need to be protected during treatment.

Many “power bleaching” techniques use 35% hydrogen peroxide without light activation and are clinically very effective.^{10,11} Therefore, the degree of bleaching obtained with systems that use light to accelerate the action of peroxide may be due to the peroxide itself and not to the action of the light.¹² Consequently, bleaching systems that use light to activate the hydrogen peroxide should perform the bleaching treatment faster than systems that do not use light. The objective of the present study was to address this question through a randomized controlled trial comparing the clinical effectiveness of hydrogen peroxide in dental bleaching with and without light activation.

Materials and methods

The study included adults with intact maxillary anterior teeth from one canine to the canine on the contralateral hemiarch and had tooth shade A2 or darker. Exclusion criteria were previous orthodontic treatment or the presence of caries or restorations in maxillary anterior teeth; pregnancy; previous bleaching treatment; or presence of gingivitis, periodontal disease, or known systemic disease. The final study sample comprised 21 patients aged 18 to 38 years. All patients signed a detailed informed consent form that outlined all procedures



and defined alternatives. All subjects were offered a supplemental bleaching treatment after the study was finished.

A split-mouth design was used for the study, treating both hemi-arches with hydrogen peroxide but light-activating only one of them. Two groups were formed: in one group hydrogen peroxide 35% and light were applied (Group I), and in the other group only hydrogen peroxide 35% was applied (Group II). The bleaching agent was QuickWhite 35% hydrogen peroxide (DMDS House, Canterbury, UK), supplied as a liquid to be mixed with a powder that increases the density and contains photoinitiators. A diode lamp (Luma Cool®, LumaLite, Spring Valley, CA, USA) was used at 380 to 530 nm for the light activation.

Before starting the bleaching procedure, initial numerical shade values were obtained for central mandibular incisors, lateral incisors, and canines, in accordance with the Vita Classic Shade Guide (Vident, Brea, CA, USA). The shade tabs were arranged in a sequence suggested by the manufacturer and each shade tab was assigned a numerical value ranging from 1 to 16 (B1, A1, B2, D2, A2, C1, C2, D4, A3, D3, B3, A3.5, B4, C3, A4, and C4). The Demetron Shade Light System® (KerrHawe, Bioggio, Switzerland) was used to provide the same light conditions (5500 K) for the shade scoring of all teeth. The score was considered valid when two out of three blindfolded independent examiners agreed on the shade value, which always proved possible (Fig 1).

Hemi-arches were selected by a randomly generated numbers table. Before application of the hydrogen peroxide, soft tissues of the mouth, lips, and



Fig 1 Shading value before bleaching.

cheeks were protected by using the Optragate system (Ivoclar Vivadent, Schaan, Liechtenstein). A 1 mm layer of photopolymerizable resin was then applied at the dentogingival junction on the vestibular surface of the teeth, from the first premolar of one hemi-arch to the first premolar of the contralateral hemi-arch, in order to prevent contact between peroxide and gingiva.

Both patient and operator wore special glasses to protect their eyes from the light, and the hydrogen peroxide gel was then applied in 2-mm-thick layers to the vestibular surface of the central incisor, lateral incisor, and canine of a randomly selected hemi-arch. During the time the gel was in contact with the tooth, it was agitated every 2 minutes to refresh the contact surface. The other hemi-arch was protected from being dried by the light by application of an opaque blue resin (LC Block-Out Resin, Ultradent Products, South Jordan, UT, USA).

The diode light was applied for 10 min and the gel was then removed. The



Fig 2 Application of light over 35% hydrogen peroxide in one hemi-arch.



Fig 3 Application of 35% hydrogen peroxide in the hemi-arch without light.

entire procedure was then repeated on the same hemi-arch, applying fresh hydrogen peroxide followed by light for another 10 min (Fig 2). After this second application, the hydrogen peroxide was removed by using an aspirator and water. The hydrogen peroxide containing product was then applied to the contralateral hemi-arch without light for 10 min, removed, and then reapplied for a further 10 min without light (Fig 3). The teeth were subsequently cleaned with cotton wads and abundant water, and the gingiva and soft tissue protection was removed.

After the bleaching procedure, the shade of the treated teeth was scored again, following the same procedure as the initial shade assessment (Fig 4).

Statistical analysis

The Wilcoxon signed-rank test was used to compare differences in tooth shade values between before and after the bleaching and to compare mean post-treatment values between test and control hemi-arches. The SAS (9.1) soft-

ware package was used for the statistical analyses. The statistical significance level P was considered to be 0.05 (5% significance level).

Results

Both light-treated and non-light-treated groups showed significant differences (Wilcoxon signed-rank test, $P < 0.05$) between pre-treatment and post-treatment scores for all tooth types studied (Table 1). The overall mean shade after bleaching was 2.9 units for the side

Table 1 P value (Wilcoxon test) of differences in values before and after treatment with or without light according to tooth type.

Initial/end	Light (Group I)	No light (Group II)
Central incisor	$p = 0.0001$	$p = 0.0005$
Lateral incisor	$p = 0.0001$	$p = 0.0001$
Canine	$p = 0.0001$	$p = 0.0002$

Significance: $P < 0.05$



Fig 4 Shading value after bleaching.

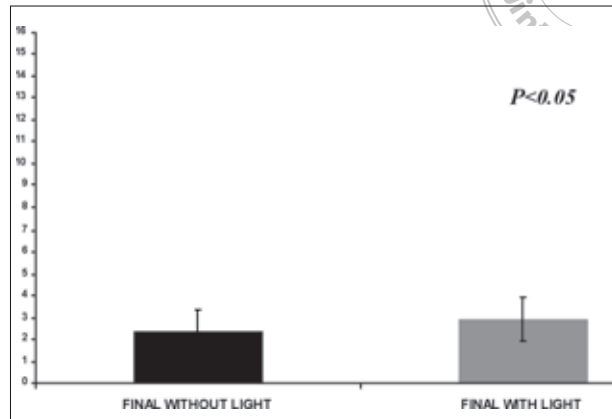


Fig 5 Mean values for each hemi-arch (with and without light treatment) at the end of treatment.

Table 2 Mean tooth shade values before and after treatment with or without light.

	n	Pre-treatment		Light (Group I)		No light (Group II)	
		Mean	SD	Mean	SD	Mean	SD
Central incisors	42	6.5	3.8	3.9	2.8	4.3	3.4
Lateral incisors	42	6.7	4.2	3.9	2.4	4.6	3.4
Canines	42	10.3	2.8	6.9	3.2	7.4	3.2

treated with light activation (Group I) and 2.4 units for the side treated without light (Group II) (Fig 5).

Shade score results for each individual tooth are listed in Table 2. Central incisors (IC), lateral incisors (IL), and canines (C) showed mean reductions of 2.2, 2.1, and 2.9 units after bleaching treatment without light, respectively. There were significant results for each tooth (IC $P = 0.0005$, IL $P = 0.0001$, and C $P = 0.0002$). Results in light-treated hemi-arches were slightly higher: 2.6 units for IC ($P = 0.0001$), 2.8 units for IL ($P = 0.0001$), and 3.4 units for C ($P = 0.0001$).

Differences between overall means were significant for both groups (Group I and Group II) at the end of treatment

($P = 0.0479$), but there was no significant effect of light when each tooth type (IC, IL, C) was considered separately (Table 3).

Table 3 P value (Wilcoxon test) of difference between mean values for each tooth type (with versus without light) at the end of treatment.

With/without light	P value
Central incisor	0.19
Lateral incisor	0.14
Canine	0.19

Significance: $P < 0.05$



Discussion

The results of the present study, which used a split-mouth design, confirm the clinical effectiveness of tooth bleaching with 35% hydrogen peroxide, which achieved a significant improvement in tooth shade both with and without light activation. However, in 7 out of the 21 patients treated, the use of the LED lamp improved the action of the bleaching product. In two patients, on only one tooth, bleaching was greater on the side without light activation.

Comparing the mean shade scores after treatment, there were no differences between individual tooth types as a result of light activation. However, when the overall mean for whole hemi-arches exposed to light was compared with the mean for those that were not, a significant difference was found. These findings may indicate that a greater sample size would probably have yielded more significant differences. According to these results, the bleaching process was found to be accelerated by the application of an LED light on the hydrogen peroxide. However, in some cases, the difference between treatment with and without light was only 1 to 3 units, and patients were unable to discern this difference when asked about their degree of satisfaction.

One of the problems found in this kind of study is the visually subjective method to assess the color of the tooth. Many studies use the Vita Classic Guide to measure color¹³⁻¹⁵ and more objective techniques as spectrophotometric guides (Vita Easy Shade),¹⁶⁻¹⁸ but both techniques are considered acceptable. As the spectrophotometric guides are

very sensitive to holding position, ambient light, and mouth aperture, the best option was considered to be to measure color with the Vita Classic Guide reordered by value and three different operators.

The present study was performed following a split-mouth design,^{14,19} and the effect of dehydration was equal on both sides. The immediate effect after treatment was evaluated when performing the bleaching with and without light. Many studies have evaluated shade values immediately after bleaching, 1 or 2 weeks after termination of bleaching, and 3 to 6 months post-bleaching to see the stabilization of color.^{13,15-17,19}

In some studies that evaluate bleaching in patients who are involved in different groups and receive different kinds of bleaching treatments,¹⁵⁻¹⁸ the effect of dehydration would be more strong in those who were applied light and heat instead of those who were only applied gel, and therefore it would be necessary to wait at least a few days for the teeth to rehydrate and then obtain shade values.

Kugel et al,¹⁹ in a study using a split-mouth design, stated that the use of light activation and 15% hydrogen peroxide (BriteSmile® system) resulted in increased bleaching at the immediate post-bleaching evaluation compared with 38% hydrogen peroxide (Opalescence® Xtra Boost). However, this increase was temporary; after 2 weeks no differences were recorded between the two systems. This is believed to be the result of temporary dehydration of the tooth.

The shade value achieved in the present study using light was 2.9. This result is similar to de Silva et al,¹³ where



they obtained values from 2.1 to 2.9 after four sessions at a 2-week interval between appointments. Out of 20 patients that received the treatment in one session with xenon-halogen light (LumaArch) and hydrogen peroxide 35% (Luma White), only 12 of the patients were satisfied with the results.

Papathanasiou et al¹⁴ found no significant effect of light activation in a 2002 study of 20 patients using 35% hydrogen peroxide gel (Opalescence Xtra), which contained carotene that theoretically absorbs light and increases bleaching effects, and unspecified halogen light source in a split-mouth design. In contrast, Tavares et al¹⁶ used a plasma arc lamp (BriteSmile 2000) and reported a mean increase in bleaching of 2 units using 15% hydrogen peroxide compared to that without activation. Interestingly, they also found a mean increase in bleaching of 1 unit using a placebo gel and the BriteSmile® lamp, possibly due to the dehydration of teeth during this treatment. Discrepancies between the present findings and those of Tavares et al¹⁶ are probably due to the different study conditions, notably the distinct light source, study teeth composition, and duration of the light application to the bleaching gel. In 2005, Sulieman et al²⁰ obtained an increase in bleaching of 12 to 14 units in an *in vitro* study using various lamps (LumaArch, Apolite, Optilux 501, and Velopex®) and types of bleaching agent with hydrogen peroxide 25% (QuickWhite, Opus mix, and Pola Office). Only teeth with an initial shade of C4 on the Vita Shade Guide were selected, equivalent to the numerical value of 16 in Table 1. The best results were obtained by Sulieman et al²⁰ with xenon-halogen lamps and QuickWhite bleaching agent. When

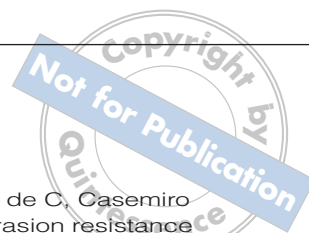
no light was used, the average bleaching obtained was 9.5 units. These *in vitro* results cannot be compared directly with the present findings, because when the initial shade is C4, there is a higher range of shade values, and more shade units can be obtained after bleaching.

The present results are also similar to Wetter et al¹⁷ when each tooth group is considered separately. When Wetter et al used LED light (Bright LEC 11) and 35% hydrogen peroxide (Whiteness HP FGM), they also found better results in the canine group than the central incisor group.

Marson et al¹⁸ found that when using three applications over 15 minutes with a 35% hydrogen peroxide gel (Whiteness HP MAXX-FGM) and three different bleaching lamps (Halogen Curing Light XL 3000, Demetron LED, and LED/LASER Bioart), no significant differences were found between the three different lamps, and no differences were found when the gel was applied without light.

The differences in the present study are significant though slightly small between the light and no-light groups. The Marson et al¹⁸ study sample may be small (n = 10) compared to the present study. Also, the present study is a split-mouth design, while the Marson study had a patient group with gel and light, and a control group using only gel.

Another similar study performed by Ziembra et al,¹⁵ using ultraviolet light, obtained better results (evaluated immediately after bleaching) in those patients treated with 20% hydrogen peroxide and light (Zoom2 system, average = 7.7 unit shade change) compared to those only treated with 20% hydrogen peroxide (average = 6.1 unit shade change),



although the kind of light used was different and it was not a split-mouth study.

The main purpose of the present study was to clinically evaluate the different bleaching systems immediately after bleaching. Further bleaching effects could have been achieved if more than one session was conducted. Additional independent research studies evaluating more than one session and color stabilization are recommended. Advantages and disadvantages of light-activated bleaching systems also should be considered in other research.

Conclusions

The present study shows that the action of hydrogen peroxide alone is capable of lightening tooth shade by 1 to 3 units in a single 20-min session. An LED lamp can increase this bleaching effect by 0.4 units, but this difference is barely discernible by the patients or by some professionals.

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