Clinical Efficacy & Sensitivity of In-Office Tooth Whitening With & Without Light Treatment Combined With At-Home Bleaching

Abstract
This article discusses a study that compared clinical in-office bleaching of 6% hydrogen peroxide (HP) with and without light, plus three nights of treatment with 16% carbamide peroxide (CP). Visual and instrumental color measurements were performed on 77 subjects immediately, one week, and two weeks after in-office bleaching. Data were analyzed at 0.05 level of significance using paired t-test and patient surveys. Results indicated shades were 6 to 7 shades lighter visually depending on light or no light treatment respectively, and 7.4 with respect to ΔE*. Some mild tooth or gingival sensitivity was reported. The study concluded that bleaching was significantly greater between light and no-light groups visually, but not instrumentally.

Key Words: whitening, bleaching, materials, sensitivity, esthetics
Learning Objectives

After reading this article, the participant should be able to:

1. Objectively compare in-office bleaching using 6% hydrogen peroxide with and without use of a light.

2. Evaluate compounds that can be used with bleaching to decrease tooth sensitivity and maximize bleaching effectiveness.

3. Better understand the actual mechanism of tooth bleaching and tooth sensitivity related to the bleaching process.

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Introduction

In-office whitening of discolored teeth has been performed in dentistry as early as 1884 using hydrogen peroxide (HP).\(^1\) The use of light to supplement the whitening of nonvital teeth with HP has been reported in the dental literature as early as 1918.\(^2\) Bleaching of vital teeth was introduced to the profession in 1989, utilizing 10% carbamide peroxide (CP) in a custom bleaching tray for at-home use.\(^3\) Materials and methods for at-home bleaching have become well established in the dental market over the past several decades, showing differences in efficacy related to levels of active ingredients hydrogen peroxide or carbamide peroxide.\(^4\) Improvement in bleaching products in the mid 1990s, such as light and chemical application of peroxides, increased the use of in-office vital tooth bleaching.\(^5\)

Both HP and CP compounds can be employed in the dental office, at home, or sequenced using a combined in-office/at-home technique. Compared to at-home whitening, in-office bleaching methods typically utilize higher concentrations of peroxide, which also may be used in combination with supplemental light to enhance the effect of tooth whitening.\(^6\)\(^7\) Bleaching lights in the past relied on heat or thermal decomposition of the bleaching agent, whereas contemporary bleaching lights aim to achieve photolysis of the bleaching agent or stain particles at specific wavelengths to potentiate the effects of the active bleaching agent. There also is a trend to use lower concentrations of HP with bleaching lights to minimize treatment sensitivity.

The complex chemistry of HP and stain molecules involves interaction of factors such as the bleaching agent’s pH, the presence of chemical activators, and the specificity of the light intensity spectrum. The mechanism of light and peroxide interaction is complex and its role in enhancing or accelerating the bleaching process is still not well understood.\(^8\) Manufacturers of whitening lamps in dentistry have used various light sources with different spectral outputs, making it difficult to generalize the effect of light on the bleaching outcome.\(^8\) These various light sources with different spectral distributions and efficiencies currently on the market all aim to accelerate or enhance the bleaching process. The popular consumer term for in-office bleaching with light is laser bleaching; however, most lights used for bleaching in dentistry are not lasers but rather, high-intensity discharge (HID) lamps (metal halide, xenon arc, plasma arc) or some type of blue light-emitting diode (LED) lamp. Blue LEDs generally produce less heat than HID lamps and emit a near-monochromatic light energy source, which purportedly can be optimized for embedded tooth chromogens and/or a specific bleaching formula activator. Equivocal outcomes reported in the literature on the effects of whitening lamps when used as a supplement to bleaching have led to unanswered questions about the effect of light on bleaching efficacy and tooth sensitivity.\(^10\)

The purpose of this study was to evaluate, visually and instrumentally, the efficacy of color change using 6% HP with and without a light system (Philips Zoom WhiteSpeed, Philips Oral Healthcare; Stamford, CT), as well as to evaluate the maintenance of bleach color change following an at-home regimen consisting of CP. The null hypotheses of the study were that in-office bleaching utilizing WhiteSpeed 6% HP with light would result in no greater shade change visually or instrumentally compared to treatment without light, immediately or after three nights of take-home 16% CP.

Materials, Methods, and Study Design

A total of 82 subjects 18 years or older were recruited for in-office tooth whitening treatment using Philips Zoom WhiteSpeed 6% HP with and without supplemental light exposure (blue LED 456 nm, 190mW/cm\(^2\), WhiteSpeed LED Accelerator), plus three nights of at-home 16% CP (NiteWhite, Philips) based on inclusion/exclusion criteria listed in Table 1. Of the subjects recruited, 77 completed the study, comprising a total of 308 teeth (4 teeth per subject were included in the analysis). Enrolled subjects were scheduled for four visits as described below. Visual and instrumental color measurements were performed on all subjects before bleaching (visit 1), before and immediately after in-office bleaching (visit 2), one week after in-office bleaching (visit 3), and two weeks after in-office bleaching (visit 4). All subjects were treated for three nights with 16% CP in custom trays overnight starting at the third visit.

“The mechanism of light and peroxide interaction is complex and its role in enhancing or accelerating the bleaching process is still not well understood.”
Table 1: Inclusion and Exclusion Criteria for Study Participation

<table>
<thead>
<tr>
<th>Inclusion</th>
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<tr>
<td>• Be age 18 years or older.</td>
<td>• Currently report sensitivity of anterior teeth.</td>
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<tr>
<td>• Be in generally good health.</td>
<td>• Have teeth with notable intrinsic staining (tetracycline, fluorosis).</td>
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<tr>
<td>• Have no restorations on anterior teeth assessed.</td>
<td>• Have severely malposed anterior teeth.</td>
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<tr>
<td>• Have a tooth shade of 2.5M2/3M2 (16) or greater on anterior teeth</td>
<td>• Have visible supragingival calculus on the facial surfaces of</td>
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<tr>
<td>assessed using VITA Bleachedguide 3D Master.</td>
<td>maxillarily anterior teeth.</td>
</tr>
<tr>
<td>• Have a strain-free surface of teeth to be treated. (At the discretion</td>
<td>• Undergoing treatment for caries, gingivitis, or periodontitis.</td>
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<tr>
<td>of the examiner, surface can be polished with cup and standard</td>
<td>• Currently using chlorhexidine mouth rinse.</td>
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<td>prophylaxis paste.)</td>
<td>• Report to be pregnant or nursing.</td>
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<tr>
<td>• Be willing to refrain from smoking and consuming dark-staining food</td>
<td>• Pre-existing medical or dental condition considered by investigators to</td>
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<td>and drink for 30 minutes after bleaching treatment.</td>
<td>place patient at increased health risk or impact patient’s ability to</td>
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<tr>
<td>• Be willing to abstain from the use of whitening products not</td>
<td>participate in the study.</td>
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<td>associated with the study.</td>
<td>• Have previously used professionally dispensed take-home or in-office</td>
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<tr>
<td>• Be willing and physically able to carry out all study procedures and</td>
<td>bleaching products within the last year.</td>
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<tr>
<td>instructions and be available for all study visits.</td>
<td>• Be in generally good health.</td>
</tr>
<tr>
<td>• Have teeth professionally cleaned and examined within 1 year.</td>
<td>• Be age 18 years or older.</td>
</tr>
<tr>
<td>• Provide written informed consent.</td>
<td>• Have a strain-free surface of teeth.</td>
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Visit 1: Consent, Randomization, and Color Assessment

Subjects signed an informed consent that was approved by the UT-Health Internal Review Board, filled out a medical/dental history form, and eligibility was confirmed. To ensure treatment selection was free of bias, light treatment was randomized to either maxillary or mandibular arches by coin flip, while the opposite arch was assigned whitening with no supplemental light. The color examiners were blinded to which arch received the light for all color evaluations.

Visual color measurement: Visual color change was measured in shade guide units (SGU), which represent the difference in the absolute numbers of shade guide “steps” in a visual evaluation, using a commercial shade guide for monitoring bleaching (VITA Bleachedguide 3D Master, VITA Zahnfabrik; Bad Sackingen, Germany). The color assessment was performed using a hand-held color-corrected light (Rite-Lite, AdDent; Danbury, CT) with a correlated color temperature of 5500 K, and a color rendering index > 92, at a distance of approximately 25 to 35 cm (10 to 14 in).

The color evaluators assigned to the study tested superior for color discrimination competency according to guidelines on color measurement in dentistry (ISO/TR 28642). The competency test consisted of matching pairs of shade tabs from two identical shade guides (with original markings blinded). Data from the literature on visual thresholds were used in result interpretation: ΔE* ≤ 2.7 for 50:50% acceptability threshold, and ΔE* ≤ 1.2 for 50:50% perceptibility threshold.

Instrumental color measurements: Instrumental color measurements were obtained with a contact-type intraoral spectrophotometer (VITA Easyshade) and expressed in ΔE* units of the CIELAB color notation system, calculated and compared for each visit as follows:

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ΔE^* = [(ΔL^*)^2 + (Δa^*)^2 + (Δb^*)^2]^{1/2}
\]

where ΔL*, Δa*, and Δb* are differences in lightness (achromatic coordinate), green-red coordinate, and blue-yellow coordinate, respectively.

The spectrophotometer was used with a custom positioning jig. The custom jig was made for both arches by attaching a 5-mm diameter acrylic rod, which corresponds to the probe diameter of the Easyshade device, to the middle third of the teeth to be evaluated (central and cuspid of maxillary and mandibular arches) using a flowable light-cured resin. The acrylic rod was slightly curved at one end when used on the cuspids for better adaptation. A clear silicone registration material (Clear-Bite, DenMat; Lompoc, CA) was then rolled in a horseshoe shape and adapted to cover facial and occlusal surfaces of each subject’s stone cast. Upon setting, the jig assembly was removed with light pressure and the acrylic rods were pushed out. The jig was tried in the mouth for accuracy and used for repeat instrumental measurements.

Custom shield and take-home trays: Maxillary and mandibular impressions were made for fabrication of take-home bleaching trays and a protective shield, using alginate replacement impression material (Silgemix; Sultan Healthcare; York, PA). After pouring the impressions in micro stone, a custom-made protective shield was fabricated for the arch that was randomly selected to have no light as follows: A vinyl sheet was heated with a vacuum former and adapted to a 3- to 4-mm labial spacer modified cast. This served as a reservoir for the bleach material and ensured adequate space and no contact between bleach material and protective shield during treatment. Polyvinyl siloxane material (Exaflex, GC America; Alsip, IL) was then rolled in a horseshoe shape and adapted to cover facial and occlusal surfaces of each subject’s stone cast. After setting, the protective shield was removed from the cast and trimmed (Figs 2a & 2b).

Custom bleach trays for the maxillary and mandibular arches were fabricated by heating .9 mm, 5” x 5” vinyl sheet material with a vacuum former unit and scalloped around the facial gingival crest. All subjects were given an ADA-recommended manual toothbrush and toothpaste (True White, Sensodyne; Brentford, UK) to use for the duration of the study.
Visit 2: In-Office Treatment

A limited oral examination was performed and baseline shade was confirmed visually and instrumentally. Protective lip cream was applied and soft tissue isolation using a light-cured resin barrier (Liquidam, Philips) was carried out for gingival protection of the maxillary and mandibular arches. The custom protective shield was tried in the patient's mouth for fit (Fig 3). The upper and lower teeth to be bleached (from second premolar to second premolar) were treated with pH booster solution (Whitening Accelerator, Philips) to increase enamel surface pH as whitening gel was applied. All materials were supplied in the bleaching kit. The pretreatment solution and the bleaching agent (6% HP) were repeated 4 times for 15 minutes each, for a total of 60 minutes.

Light-protective eyewear was provided to each patient during treatment. After applying the bleaching agent on both arches, the protective shield was placed on the previously selected arch before light treatment began. Between light cycles, the bleaching material was removed from both arches using surgical suction and gauze. Ten to 15 minutes after the last cycle (to allow for tooth rehydration), visual and instrumental color measurements were completed on the selected teeth. Subjects completed a log to document levels of tooth and gingival sensitivity: mild, moderate, or severe, immediately after bleaching (day 1). Subjects kept this log to record sensitivity for the remainder of the study.
Visit 3: One Week Post In-Office Treatment
Subjects returned for the third visit one week after in-office bleaching for visual and instrumental color measurements, and for sensitivity reporting. Subjects were given maxillary and mandibular custom trays to use with 16% CP (NiteWhite, Philips) for three nights. Subjects were instructed to continue sensitivity documentation on days 8-14.

Visit 4: Two Weeks Post In-Office Treatment
Subjects returned for visit 4 two weeks after in-office bleaching. Visual and instrumental color measurements were documented and the final sensitivity data were collected.

Statistical analysis: A paired t-test at the 0.05 alpha level was performed for subjects at each time point for instrumental and visual data comparisons between the light and no-light treatment groups. The mean color change outcomes were ΔE* values and SGU by bleaching guide, tested separately, with Bonferroni adjustment for multiple comparisons. A power of 90% to detect an effect size of 1 SD comparing the posttreatment outcomes was determined after Bonferroni adjustments. Descriptive statistics and scales were plotted for posttreatment visits to show tooth and gingival sensitivity.

Results

Mean Reduction in SGU
Immediately following in-office bleaching the mean reduction in SGU for 6% HP with supplemental light was 6.9, compared to 5.3 for the no-light group. The difference was statistically significant (P = 0.0001). For ΔE*, the mean color change for 6% HP plus light group was 7.3, and 6.8 without light (P = 0.315).

At one week following 6% HP in-office bleaching, the mean reduction in SGU with supplemental light was 4.4, and 3.6 without light. The difference was statistically significant (P = 0.009). For ΔE*, the mean color change for 6% HP with light was 7.7, and 6.7 without light (P = 0.057).

At two weeks following in-office bleaching plus three treatments of NiteWhite 16% CP, the mean reduction in SGU for the 6% HP with supplemental light was 6.9, and 6.2 without light. The difference was statistically significant (P = 0.015). For ΔE*, the value for 6% HP with light was 7.4, and also 7.4 without light (P = 0.97).

The results showed that there were significant differences between the light and no-light groups at each time point compared to baseline (P = 0.0001, 0.0089, 0.0148, respectively). These differences were still significant even after Bonferroni correction for the three tests.

With respect to ΔE*, the outcomes did not show any significant difference at any time point, nor before Bonferroni correction. Figures 4 and 5 provide bar chart comparisons of the two efficacy endpoints at each time point.

Sensitivity
Some mild tooth and gingival sensitivity was reported during the at-home whitening period with 16% CP, while the great majority of subjects reported no tooth or gingival sensitivity during or immediately after chairside whitening with 6% HP. The number of subjects reporting tooth or gingival sensitivity for both in-office and at-home phases of the study is shown in Figures 6a and 6b.

“A wide range of HP concentrations (from 6% to 40%) has been used for professional in-office whitening.”
Figure 4: Visual color measurements (SGU = shade guide units). Mean for each time point compared to baseline (T1 = immediate, T2 = one week, and T3 = two weeks); p < 0.05 between light and no-light groups at each time point.

Figure 5: Instrumental color measurements (ΔE* = total color difference) for each time point compared to baseline (T1 = immediate, T2 = one week, and T3 = two weeks); p > 0.05 between light and no-light groups at each time point.

Figure 6: a) In-office 6% HP sensitivity. b) At-home 16% CP sensitivity.
Discussion

SGU and ΔE* Analysis
Past recommendations for measuring bleaching efficacy include use of the 16-step shade guide (Vita Classical) arranged according to the so-called “value scale.” Studies using this scale often set the tooth shade threshold as A3 or darker. More recently, the ADA Council on Scientific Affairs recommended adoption of a 29-step shade guide, as used in the present study (Vita Bleachedguide), for the evaluation of bleaching efficacy. The later standard allows for monitoring of subjects with lighter teeth than previously captured visually (lighter than shade B1 on the Vita Classical scale). Shade #16 or darker on the Bleachedguide scale was adopted as the threshold for the present study. The tab order for this shade guide is known to better correspond to the manufacturer’s visual light-to-dark suggested order, which was not the case for the classical value scale. The same is true for tab order and whiteness, and tab order and yellowness, with the latter corresponding largely to the uniform increase in chroma (predominant change during tooth whitening).

The results of this study showed 6% HP was effective in achieving an average 4 to 6.5 shades visually. The shade changes were statistically significant for visual comparisons (SGU) of light versus no light at each time point, and mean differences were above the 50:50 perceptibility threshold. Instrumentally, average ΔE* values ranged from 7.1 to 7.4. This is greater than two times the 50:50 acceptability threshold of 2.7, documenting the efficacy of the evaluated whitening procedures. Both SGU and ΔE* values in this study correspond to the ADA recommended efficacy level for in-office tooth whitening products of at least 5 color change units.

Peroxide Concentration and pH
A wide range of HP concentrations (from 6% to 40%) has been used for professional in-office whitening. For example, current EU regulations limit application of HP in concentrations no higher than 6% (approximately 18% CP), while in the U.S. higher concentrations of HP may be used. Studies have looked at the effect of lowering HP concentration on whitening efficacy. Rezende and colleagues showed that reducing the concentration from 40% HP to 20% HP did not affect the overall whitening efficacy in a single in-office bleaching treatment when combined with 10% HP at-home for two weeks. Another recent clinical trial compared effectiveness and tooth sensitivity when using 4% HP or 10% HP in custom trays for 2 weeks, twice a day, for 30 minutes. The results showed no significant difference in tooth whitening efficacy between the two concentrations, while the frequency and intensity of tooth sensitivity was shown to be lower with the lower 4% HP concentration.

Hydrogen peroxide is stored at an acidic pH to maintain a stable shelf life. The protocol used in this study involved the use of an alkaline solution (pH = 9; whitening accelerator pH booster) swabbed on the enamel surface immediately prior to in-office application of 6% HP. The HP formula is supplied in a dual-barrel syringe containing the peroxide in one compartment and sodium hydroxide (pH = 10) in the other. This solution application and activator-mixed formula is designed to elevate the pH at tooth contact. Previous investigations have reported that increasing the alkalinity of HP to approximately pH = 9 can increase its dissociation rate and increase the effectiveness of bleaching.

Light and Efficacy
Several studies have reported no difference in whitening efficacy with supplemental light during the bleaching process, while others have shown a difference. Martin and colleagues demonstrated that 6% HP with nitrogen-doped titanium dioxide light-activated agent was as effective as 35% HP alone when activated with an LED/laser hybrid light. Bleaching agents used with supplemental light have worked by adding activators such as metal oxides (e.g., titanium, iron) or highly conjugated compounds of the complement color, such as beta carotene, to accentuate photolysis of HP. Some of the confounding variables in many of these studies may be related to the use of different light spectra; the concentration, contact time, and form of the bleaching agent used; as well as the instruments and methods used for color measurements.

The system used in the present study works on the theory that blue light energy is absorbed by, and interacts with, the conjugated organic chromophores embedded in the natural tooth substrate. Although this mechanism may contribute to these results, more research is needed to explain the reasons why the addition of LED light may improve tooth-bleaching outcomes with low-concentration HP.

Sensitivity
Sensitivity is a known concern when prescribing at-home or in-office bleaching. The exact mechanism of sensitivity is not fully understood, but it is believed to be caused by peroxide passing through enamel and dentin to the pulp chamber. Higher concentrations of bleaching agent have been previously observed to be associated with greater tooth sensitivity compared to peroxides of lower concentration. The low-concentration 6% HP utilized for in-office treatment in the present study was shown to provoke minimal levels of tooth sensitivity (Fig 6a). It is noted that the HP formula used in this study includes the active ingredients of potassium nitrate and amorphous calcium phosphate. The addition of compounds such as potassium nitrate, fluoride, and amorphous calcium phosphate to bleaching agents has been shown to reduce sensitivity, which may account for the low levels of tooth and gingival sensitivity observed in this study. A previous two-week study demonstrated that subjects experienced minimal tooth sensitivity (mean score of 2 on a 10-point scale) with nightly use of a high-concentration (22%) CP gel in a formulation that contained potassium nitrate.
In a clinical study using an earlier-generation Zoom whitening lamp (Zoom AP) and 25% HP, treatment with supplemental light showed greater tooth sensitivity than the no-light treatment group. The light source in the same study was a high-intensity xenon-arch whitening lamp, which is associated with emitted extraneous heat and high power. It has been reported that, as the power output from the light increases, the potential for generating damaging temperatures in the pulp and oral tissues also increases. In the present study, however, a blue LED lamp (Zoom WhiteSpeed), which included an adjustable multi-intensity control setting, was utilized. The intensity was maintained on the high setting (190 W/cm²).

**Combination Technique**

Subjects in the present study followed a protocol of 6% HP in-office treatment with an additional three nights of treatment with 16% CP. A combination technique of in-office bleaching plus home bleaching has been shown to be more effective than in-office bleaching alone. Seven days of at-home bleaching with 10% CP has been shown to be equivalent to three 15-minute applications of in-office 38% HP, or five days of at-home bleach and 1-hour treatment with 28% HP with supplemental light.

Some visual color rebound was observed at visit 3 in the present study (one week after in-office treatment with 6% HP). However, combining the additional three nights of treatment with 16% CP was successful in restoring the original whitening effect and thus preventing the rebound effect, independent of supplemental light.

Visual color changes, as indicated by SGU outcome, showed significant differences between the light and no-light groups at each time period. On the other hand, ΔE* data did not show any significant difference at any time period. Therefore, the null hypothesis was not rejected for instrumental results, but was rejected for visual evaluation.

**Summary**

In-office tooth whitening with 6% HP and the Zoom WhiteSpeed LED acceleration lamp exceeded the ISO/TR 28642-defined ΔE* visual thresholds (AT and PT) at all time points. The addition of three take-home treatments with 16% CP (Philips NiteWhite) was similarly effective and helped prevent color rebound. In-office tooth bleaching with 6% HP and WhiteSpeed LED acceleration was superior to in-office bleaching without LED acceleration, as measured by the VITA Bleachedguide 3D Master shade guide, but not instrumentally.

**Acknowledgments**

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**References**


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“Some of the confounding variables in many of these studies may be related to the use of different light spectra; the concentration, contact time, and form of the bleaching agent used; as well as the instruments and methods used for color measurements.”
This Continuing Education (CE) self-instruction exam is based on the article Clinical Efficacy and Sensitivity of In-Office Tooth Whitening With and Without Light Treatment Combined With At-Home Bleaching by Dr. Joe C. Ontiveros, Dr. Magda S. Eldiwany, Dr. Dianna M. Arriaga, Dr. Rose-Marie Fay, Dr. Maria D. Gonzalez, Dr. Natalie A. Pereira Sanchez, Dr. Marilia M. Sly, and Dr. Rade Paravina. This article appears on pages 70-80.

The examination is free of charge and available to AACD members only. AACD members must log onto www.aacd.com to take the exam. Note that only Questions 1 through 5 appear in the printed and digital versions of the JCD; they are for readers’ information only.

1. Which of the following is correct regarding tooth bleaching with and without a light?
   a. Light was used to supplement the whitening of nonvital teeth approximately 70 years before bleaching of vital teeth was introduced to the dental profession.
   b. Light was used to supplement the whitening of vital teeth approximately 70 years before bleaching of nonvital teeth was introduced to the dental profession.
   c. Light was used to supplement the whitening of both vital and nonvital teeth many years after bleaching without a light began.
   d. Light can be used only to supplement the whitening of nonvital teeth. This technique is never used for bleaching of vital teeth.

2. How does the concentration of peroxide in in-office bleaching methods compare to that in at-home whitening?
   a. The concentration of peroxide in at-home methods typically is higher.
   b. The concentration of peroxide in in-office methods is the same as in in-office bleaching.
   c. In-office methods typically utilize a higher concentration of peroxide.
   d. The main difference between in-office and at-home bleaching methods is the use of supplemental light to enhance the effect of tooth whitening.

3. How have bleaching lights changed since they were introduced to the dental profession?
   a. Bleaching lights in the past relied on photolysis of the bleaching agent or stain particles at specific wavelengths to potentiate the effects of the active bleaching agent.
   b. Bleaching lights in the past relied on heat or thermal decomposition of the bleaching agent.
   c. Contemporary bleaching lights rely on photolysis of the bleaching agent or stain particles at specific wavelengths to improve the bleaching effect.
   d. Contemporary bleaching lights rely on heat or thermal decomposition of the bleaching agent for an optimal result.

4. How did evaluators in this study visually compare the change in tooth shade following bleaching?
   a. Shade was evaluated with a standard 3D VITA shade guide under fluorescent light.
   b. Shade was evaluated by matching pairs of shade tabs from an unmarked VITA shade guide using a hand-held color-corrected light.
   c. Shade was evaluated with a spectrophotometer under fluorescent light.
   d. Shade was evaluated visually under natural light (5500K) with the VITA Bleachedguide and instrumentally with a spectrophotometer.

5. How did the evaluators in this study compare bleaching with and without a light?
   a. Half the participants bleached with the addition of a light, half without.
   b. During in-office bleaching, the participants’ right side received light, the left no light.
   c. During in-office bleaching, participants had a protective cover over one arch to prevent light from affecting the bleaching material.
   d. The participants bleached first without the light and evaluated the color change, then they bleached with a bleaching light to compare their results.

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