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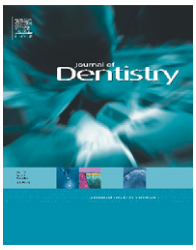

Color change of vital teeth exposed to bleaching performed with and without supplementary light

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ABSTRACT

Objectives: The aim of this clinical study was to evaluate tooth color change after exposure to 25% hydrogen peroxide in-office tooth whitening system, with and without supplementary light exposure.

Methods: Twenty subjects were treated with two separate 45-min exposures of bleach, with and without light using an opposing-arch design. Visual and instrumental color measurements were obtained from eighty teeth before bleaching and seven days after treatment using two different shade guides, Vitapan Classical (VC), Vita Bleachedguide 3D-Master (BG) and an intraoral spectrophotometer. Data were analyzed using ANOVA, paired *t*-test, and Wilcoxon signed rank tests at the 0.05 level of significance.

Results: Instrumental method revealed significant difference in color between treatment with light ($\Delta E^*_{ab} = 6.0$) and without light ($\Delta E^*_{ab} = 4.7$) after seven days ($p < 0.05$). No differences were visually detected between treatment with light and without light using the VC ($p = 0.56$). However, a significant difference was recorded using the BG ($p < 0.01$). Instrumental measurements of color change were in better accordance with visual findings using the BG guide ($R^2 = 0.60$) rather than the VC ($R^2 = 0.20$).

Conclusions: Within the limitations of this study, the treatment with supplementary light showed significantly greater bleaching-dependent changes in color compared to treatment without light when assessed using instrumental methods. The same was determined for the visual method with Vita Bleachedguide 3D-Master. No significant difference in color change with respect to light exposure was detected for the Vitapan Classical.

1. Introduction

In the context of presenting a technique for bleaching discolored teeth, the 19th century dental researcher, E.P. Wright stated, ''there is no higher glory for one who professes the healing art [of dentistry] than that of preserving the natural tissues''.[1] Aside from the obvious desire to improve the appearance of teeth, the conservative nature of in-office bleaching remains one of the primary reasons why in-office bleaching appeals to both patient and dentist alike. Hydrogen peroxide (H_2O_2) has been used to treat discolored teeth as early as 1884.[2] Throughout the 1960s and 1970s, techniques were introduced using direct or indirect heat in attempts to accelerate the oxidation process.[3–6] The direct application of heat soon fell out of favor, because of evidence suggesting that it may cause cervical resorption. Techniques using chemicals alone, such as sodium perborate and, or superoxyl followed, with some success on lightening of non-vital teeth. While these techniques are helpful for treatment of single, non-vital teeth, accelerated techniques for simultaneous lightening

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multiple vital teeth were still lacking. Improvement in bleaching products in the mid 1990s, such as light-and-chemical application, and delivery systems such as light-cured barrier materials, increased usage of in-office bleaching for multiple vital teeth.[7] Combined with the introduction of at-home bleaching trays, bleaching emerged as among the most sought after procedures in dentistry.[8]

The mechanism of bleaching by hydrogen peroxide is not fully known. The most accepted theory is that peroxide diffuses into and through enamel to reach dentin where it reacts with the organic chromophores responsible for the major color factors of teeth.[9] While it is generally accepted that the decomposition of hydrogen peroxide is influenced by *direct* heat and peroxide concentration, the influence of *indirect* heat and/or light on the decomposition rate of hydrogen peroxide and its mechanisms is not well established in the dental literature.

Many clinicians currently employ light/indirect radiation to hasten and enhance in-office vital bleaching. However, clinical studies investigating use of supplementary light on the effectiveness of vital bleaching have been equivocal. This lack of agreement may result from the variability associated with methods used to analyze bleaching efficacy, leaving the validity of using supplementary light application during vital tooth bleaching in question.

A common technique for measuring color change during the bleaching process utilizes a subjective, visual evaluation method based on variety types of shade guides. The Vitapan Classical (VC, Vita Zahnfabrik, Bad Säckingen, Germany) is one of the most commonly used shade guides for this purpose. This system was developed in 1956, and since that time, researchers have pointed out its inherent flaws: lack of uniformity and limited color space coverage of natural teeth.[10–16] A newer type of shade guide, Vita Bleachedguide 3D-Master (BG, Vita Zahnfabrik, Bad Säckingen, Germany) displays a greater emphasis on the extra light area of the tooth color space and is designed primarily for use with bleached teeth. When compared to the VC guide, the BG has a wider color range (almost doubled), more uniform color distribution, and a visually perceived light-to-dark value order that precisely matches the manufacturers' suggested tab arrangement. All these properties are designed to increase the reliability and validity of visual color comparisons in clinical practice, with an emphasis on monitoring tooth whitening.[17,18]

Color differences can also be measured using non-subjective, instrumental methods. The CIE[a] $L^*a^*b^*$ color difference (ΔE^*_{ab}) represents the sum of differences in L^* (lightness), a^* (green–red), and b^* (blue–yellow) coordinates, or the sum of differences in L^* (lightness), C^*_{ab} (chroma) and h° (hue). By calculating the before and after bleaching difference in absolute values of each color coordinate, the direction of the color change can be quantified. For example, a positive difference in lightness (ΔL^*) and negative corresponding difference in chroma (ΔC^*_{ab}) would mean that the teeth became lighter and less chromatic after bleaching.

[a] Commission Internationale de l'Eclairage, International Commission on Illumination.

The American Dental Association (ADA) Acceptance Program Guidelines recommends a visual method for establishing bleaching efficacy using a 16-step VC "value-ordered" shade guide for all three bleaching regimens (in-office, dentist-dispensed at-home bleaching, and over the counter—OTC).[19–21] For professional in-office tooth bleaching products, these guidelines call for documentation of color changes ≥5 color change units (ccu) to indicate efficacious bleaching treatment; where 1 ccu = 1 shade guide unit (sgu) = $1\Delta E^*_{ab}$.[19]

The purpose of this study was to visually and instrumentally evaluate the in vivo color changes of a 25% H_2O_2 in-office tooth bleaching system, with- and without the use of a supplementary chairside bleaching light. Because of the paucity of literature indicating effectiveness of enhancement of the bleaching process using light application, the research hypothesis was that chairside bleaching with light will exhibit equal bleaching efficacy compared to the same treatment without light, verified using either visual or instrumental methods.

2. Materials and methods

2.1. Patient inclusion and exclusion criteria

A total of 20 patients were enrolled for an in-office clinical tooth whitening study using an opposing-arch design, and a total of 80 teeth were analyzed (one canine and central incisor for both arches). For inclusion, each patient was required to have no caries on teeth to be bleached, similar pre-test color of maxillary and mandibular anterior teeth, eighteen years or more. The study exclusion criteria encompassed patients whose teeth had been previously bleached or where a shade lighter than A2, reported tooth sensitivity, teeth with notable intrinsic staining (tetracycline, fluorosis), existing dental restorations in teeth to be bleached, currently undergoing treatment for caries, gingivitis or periodontitis, current use of Chlorhexidine or Listerine mouth rinses, or who demonstrated any medical or dental condition (gingival inflammation) considered by investigators to place the patient at increased health risk or to impact patient's ability to participate in study. After discussing the trial, patients were required to sign an informed consent form adhering to the ethical principle stated by the World Medical Association's Declaration of Helsinki[22] in addition to agreeing to return for scheduled visits and follow up examinations. Enrolled patients were further instructed to avoid any non-study dentifrices or tooth whitening products for the duration of the study.

2.2. Study design

Study subjects were treated with two separate 45-min exposures of 25% hydrogen peroxide (H_2O_2) gel (Zoom2 kit, Discus Dental, Culver City, CA, USA). At the first appointment, the order of arch (maxillary or mandibular) and treatment type (light or no light) was randomized by flip of a coin for each patient's initial bleaching and the opposite treatment was chosen for the second appointment. Protective lip cream was applied and the six anterior teeth to be treated were isolated