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”.

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 (H₂O₂) has been used to treat discolored teeth as early as 1884.

Throughout the 1960s and 1970s, techniques were introduced using direct or indirect heat in attempts to accelerate the oxidation process. 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...
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. Combined with the introduction of at-home bleaching trays, bleaching emerged as among the most sought after procedures in dentistry.

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. 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. 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.

Color differences can also be measured using non-subjective, instrumental methods. The CIE *L*a*b* color difference (ΔEab) 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*a* (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*) would mean that the teeth became lighter and less chromatic after bleaching.

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-dispended at-home bleaching, and over the counter—OTC). 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) = 1ΔEab. The purpose of this study was to visually and instrumentally evaluate the in vivo color changes of a 25% H2O2 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 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 (H2O2) 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.

2.4. Instrumental method for color measurement

Instrumental color monitoring was performed before bleaching and seven days after bleaching using a contact-type intraoral spectrophotometer (Vita Easyshade, Vita Zahnfabrik, Bad Säckingen, Germany) with a 5 mm diameter probe excluding the specular mode. The Easyshade had a spectral range 400–700 nm (with a wavelength resolution of 25 nm), and was calibrated according to manufacturer’s instruction. A custom positioning jig was made for each subject’s arch to provide accurate repositioning and measurement on the middle third of labial tooth surface. The jig was fabricated by attaching a 5 mm diameter acrylic rod to the area to be measured, using light-cured flowable resin. For canines, the base of rod was slightly curved for better adaptation to the convex surface area. Clear silicone registration material (ClearBite, Discus Dental) was injected around the cylinder and along the incisal surface of the teeth to capture the subject’s bite. Upon setting, the rod was simultaneously dislodged from the tooth with light finger pressure while the jig was removed from the mouth. Once removed from the mouth, the rod was pushed out from the set material leaving a tunnel for placement of the spectrophotometer probe. Prior to color measurement, the jig was positioned in the patient’s mouth, and the spectrophotometer probe was inserted into the jig opening until contacting the tooth. In this manner, probe angulation was controlled thus helping to improve the repeatability of measurements (Fig. 1). The jig enabled a short-term repeatability of $\Delta E_{00}$ < 0.7. Color differences were calculated using the following equation:

$$\Delta E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}.$$

2.5. Statistical analysis

Descriptive statistics were obtained, and data were compared using t-test and Wilcoxon Signed Ranks Tests at the 0.05 level of significance. Multiple linear regression was used to analyze the influence of changes in lightness, chroma, and hue on color change.

### Table 1 - Tab arrangement and numeric order for Vitapan Classical (“Value” scale), and Vita Bleachedguide 3D-Master.

**Vitapan Classical**

<table>
<thead>
<tr>
<th>Lightest</th>
<th>Darkest</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>A1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>B2</td>
<td>A2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>D2</td>
<td>C2</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>A2</td>
<td>C1</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>D1</td>
<td>C0</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>A3</td>
<td>D3</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>D4</td>
<td>B3</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>A3.5</td>
<td>B4</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>A4.5</td>
<td>C3</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>A4</td>
<td>D4</td>
</tr>
<tr>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>A5</td>
<td>B5</td>
</tr>
<tr>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>A4.5</td>
<td>D5</td>
</tr>
<tr>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>A5</td>
<td>C4</td>
</tr>
<tr>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>A5.5</td>
<td>C5</td>
</tr>
<tr>
<td>15</td>
<td>16</td>
</tr>
</tbody>
</table>

**Vita Bleachedguide 3D-Master**

<table>
<thead>
<tr>
<th>Lightest</th>
<th>Darkest</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5M1</td>
<td>1M1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>0.5M1.5</td>
<td>1M1.5</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>0.5M2</td>
<td>1M2</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>0.5M2.5</td>
<td>1M2.5</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>1.5M2</td>
<td>2M2</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>1.5M2.5</td>
<td>2M2.5</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>2.5M2</td>
<td>3M2</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>2.5M2.5</td>
<td>3M2.5</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>3.5M2</td>
<td>4M2</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>3.5M2.5</td>
<td>4M2.5</td>
</tr>
<tr>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>5M2</td>
<td>5M2.5</td>
</tr>
<tr>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>5M2.5</td>
<td>5M3</td>
</tr>
<tr>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>5M3</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>15</td>
</tr>
</tbody>
</table>

Please cite this article in press as: Ontiveros JC, Paravina RD. Color change of vital teeth exposed to bleaching performed with and without supplementary light. Journal of Dentistry (2009). doi:10.1016/j.jdent.2009.06.015
Mean color difference values ($\Delta E_{ab}$) and differences in color coordinate values ($\Delta L^*, \Delta a^*, \Delta b^*$, $\Delta C_{ab}$, and $\Delta h^*$) with and without light are listed in Table 3. Color changes with and without light were significantly different ($p < 0.05$). Instrumental measurements of color change ($\Delta E_{ab}$) were in better accordance with visual findings (sgu) using the BG guide ($R^2 = 0.60$) rather than the VC ($R^2 = 0.20$). Overall bleaching efficacy was highly varied among patients, both visually (VC: 0–12 sgu with light and 1–10 sgu without light; and BG: 1–6 sgu with light and 0–5 sgu without light), and instrumentally ($\Delta E_{ab}: 1.2–12.1$ with light and $1.1–10.5$ without light).

Significant interactions existed between $\Delta E_{ab}$ and $\Delta L^*$ ($p < 0.001$), and between $\Delta E_{ab}$ and $\Delta C_{ab}$ ($p < 0.001$), while no significant interaction existed between $\Delta E_{ab}$ and $\Delta h^*$. Based on standardized coefficients, which allow for relative comparison of the extent of influences of different independent variables on the dependent variable, the effect of change in chroma was nearly three times more influential (0.78) than that of lightness (0.28) (standardized coefficients in Table 4). The predictive multiple logistic regression correlation between overall color change and the individual color parameters derived based on the recorded results was as follows: $\Delta E_{ab} = 0.51 \times \Delta L^* + (0.98 \times \Delta C_{ab}) + 0.02 \times \Delta h^*$. Multiple linear regression showed that bleaching-dependent color differences can be very well estimated based on changes in lightness, chroma, and hue ($R^2 = 0.95$).

Patient tooth sensitivity was higher immediately after bleaching (with the typical peak within 24 h after bleaching) as compared to 1-week time period after bleaching and the difference was not statistically significant ($p > 0.05$). Higher sensitivity was recorded for bleaching with light (2.8/3.0) as compared to bleaching without light (1.4/1.6) ($p < 0.05$).

4. Discussion

4.1. Opposing-arch design and timing of color measurements

An opposing-arch design was chosen over a split-arch method, as a means to eliminate the potential influence of radiation on the no light segment. The opposing-arch design...
developed in this research is preferred over the thin, vacuum-
State University showed the precision of the Vita Easyshade to
a high degree of variation in the data, while a fixed position
showed that slight changes in probe angulation would lead to
investigation with the instrument used in the current study
cular position (angulation) of the instrument probe. A pilot
controlled in bleaching studies. Not only the repeatability of
was introduced in this study. Repositioning of the color
intraoral contact spectrophotometer and custom apparatus
A novel method for obtaining color measurements with an

4.3. Repositioning of the probe for repeatability

In order to facilitate comparison of test results among other
studies, the Vitapan Classical (VC) shade guide, arranged by
“value-order,” was included. However, because of the prior
noted problems associated with this shade guide, the Vita
Bleachedguide 3D-Master (BG) system was also included. The
evaluators agreed that it was easier to discern shade and reach a
consensus using the BG system compared to the VC.

4.4.  ADA recommendations and visual judgments of color
differences

The VC shade guide changes and $\Delta E_{ab}$ values corresponded to
the ADA recommended efficacy level for professional in-
office tooth bleaching products of at least 5 ccu.19 Longevity of
changes after 3 and 6 months was not evaluated in this study.
The nature of changes also corresponded to the ADA
guidelines and literature: teeth became lighter (increase in
$\Delta L^*$) and less chromatic (decrease in $\Delta C_{ab}$) after bleaching.19–
21,25 In addition, mean change in shade guide units for the VC
system were the same as the instrumental findings, which
supports the ADA recommendation that 1 ccu = $\Delta E_{ab}$ =
1 sgu.28,29 The $\Delta E_{ab}$ values recorded for both with- and
without light exceeded the 50:50% acceptability thresholds
reported in other studies ($\Delta E_{ab} = 2.76$ and $\Delta E_{ab} = 3.37$). This
indicates very obvious changes in color after bleaching as
compared to baseline, pre-treatment condition. On the other
hand, the mean difference in bleaching efficacy of $\Delta E_{ab} = 1.3$
(6.0 with light minus 4.7 without light) was slightly above the
perceptibility threshold of $\Delta E_{ab} = 1$ obtained under controlled
conditions with trained evaluators28 and well below the
perceptibility threshold of $\Delta E_{ab} = 2.6$ recorded in less con-
trolled clinical setting and using evaluators that were not
specifically trained for color matching.29 This study was
performed by trained evaluators and under controlled
clinical conditions, but a distinction should be made
between the statistical significance and clinical perceptibil-
ity. Further studies are needed to determine whether
the effect of light would be perceivable for non-trained
evaluators in the routine clinical practice, the influence of
the peroxide dose on color change, and sensitivity with-
without the light.

also allows the patient to discern the location of sensitivity
more easily compared to a split-arch design. Balancing the
groups with an equal number of maxillary and mandibular
teeth allowed for control of any color change influenced by
tooth size. The effect of immediate dehydration that accom-
panies tooth isolation during a long session of chairside
bleaching, and potential effect of exposure to the supplemen-
tary light, must be taken into account when considering the
timing of post-treatment shade evaluation. The purpose of
waiting seven days before the final shade comparisons and
instrumental measurements was to avoid these influences.

4.2. Shade guides used

In order to facilitate comparison of test results among other
studies, the Vitapan Classical (VC) shade guide, arranged by
“value-order,” was included. However, because of the prior
noted problems associated with this shade guide, the Vita
Bleachedguide 3D-Master (BG) system was also included. The
evaluators agreed that it was easier to discern shade and reach a
consensus using the BG system compared to the VC.

4.3. Repositioning of the probe for repeatability

A novel method for obtaining color measurements with an
intraoral contact spectrophotometer and custom apparatus
was introduced in this study. Repositioning of the color
measuring instrument is an important variable that must be
controlled in bleaching studies. Not only the repeatability of
measuring area should be ensured, but also a fixed perpen-
dicular position (angulation) of the instrument probe. A pilot
investigation with the instrument used in the current study
showed that slight changes in probe angulation would lead to
a high degree of variation in the data, while a fixed position
resulted in a higher repeatability. An in vitro study out of Ohio
State University showed the precision of the Vita Easyshade to
be better that a laboratory spectrophotometer when various
color measuring instruments were compared.24 The apparatus
developed in this research is preferred over the thin, vacuum-

Table 3 – Means (s.d.) for bleaching-dependent changes in color ($\Delta E_{ab}$), and changes in lightness ($\Delta L^*$), chroma ($\Delta C_{ab}$), and hue ($\Delta h^*$), recorded in with- and without light procedures.

<table>
<thead>
<tr>
<th>Light</th>
<th>$\Delta E_{ab}$</th>
<th>$\Delta L^*$</th>
<th>$\Delta a^*$</th>
<th>$\Delta b^*$</th>
<th>$\Delta C_{ab}$</th>
<th>$\Delta h^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>With</td>
<td>6.0 (2.6)</td>
<td>2.3 (2.6)</td>
<td>-0.9 (0.9)</td>
<td>-4.6 (2.7)</td>
<td>-4.4 (2.8)</td>
<td>3.2 (2.6)</td>
</tr>
<tr>
<td>Without</td>
<td>4.7 (2.2)</td>
<td>1.8 (2.3)</td>
<td>-0.9 (0.9)</td>
<td>-3.3 (2.4)</td>
<td>-3.3 (2.4)</td>
<td>2.9 (3.0)</td>
</tr>
</tbody>
</table>

$^*$ p < 0.05.

Table 4 – Multiple regression coefficients for color parameters ($\Delta L^*$, $\Delta C_{ab}$, and $\Delta h^*$), dependent variable being $\Delta E_{ab}$,
irrespective of bleaching light exposure.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Non-standardized coefficients</th>
<th>Standardized coefficients</th>
<th>T</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta L^*$</td>
<td>0.51</td>
<td>0.06</td>
<td>0.28</td>
<td>8.71</td>
</tr>
<tr>
<td>$\Delta C_{ab}$</td>
<td>-0.98</td>
<td>0.07</td>
<td>-0.78</td>
<td>13.66</td>
</tr>
<tr>
<td>$\Delta h^*$</td>
<td>0.02</td>
<td>0.08</td>
<td>0.01</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Please cite this article in press as: Ontiveros JC, Paravina RD, Color change of vital teeth exposed to bleaching performed with and without supplementary light. Journal of Dentistry (2009), doi:10.1016/j.jdent.2009.06.015
4.5. VC–BG conversion and result validity

Color changes noted using the BG shade guide exhibited smaller variation compared to those using the VC system, and were in better agreement with the instrumental findings. It is likely that the inconsistent color distribution of the VC influenced the accuracy of findings in this study and could have also influenced previously reported work. The sgu conversion factor for BG–VC comparisons was 1 BG sgu = 1.6 VC sgu, which closely corresponds to the conversion factor reported in an in vitro study (1 BG sgu = 1.9 VC sgu). Instrumental color change as measured showed that application of supplemental light exposure during the chairside bleaching treatment significantly influenced the results. Therefore the research hypothesis was rejected for both instrumental findings and visual evaluation using BG. The instrumental measurements are more sensitive, as they provide objective color parameter values. The visual method relies on visual perception in determining the best before- and after matches. However, one should be aware that the best visual matches are rarely exact matches.

4.6. Comparison with other studies

Although it is more appropriate to report polar coordinates \((C_a,\ h)\) than rectangular coordinates \((a'\ b')\) in studies on color in dentistry, changes in \(a'\) and \(b'\) values were included in Table 3 for easier comparison with former bleaching studies. However, indicative comparisons between \(L'\ C'\ h'\) and \(L'\ a'b'\) findings can be easily made: \(C_a\) values of human teeth are almost identical to \(b'\) values, and the decrease in \(a'\) coordinate values corresponds to the increase in \(h'\) values.

There are many factors that can attribute to findings contrary to those reported in the current study. Commercial bleaching lights emit a wide variety of radiant energy to teeth, which partially originates from the variability of the light-to-tooth distances. A few studies concluded that application of light during the bleaching process did not have any effect on bleaching efficacy. Papathanasiou et al. used a dental polymerizing unit as a supplementary light in that study. Photolysis of the chromophoric organic matter found in dentin. Photolysis of hydrogen peroxide has been shown to be independent of temperature. However, in 1957 it was reported in the Transactions of the Faraday Society that photolysis of hydrogen peroxide can occur by light of wavelengths of 365 nm or less, which is within the range of the light used in the current study. Tavares et al. reported using short-arc gas plasma light in combination with a 15% \(\text{H}_2\text{O}_2\). They reported significantly lighter teeth when using the light/bleach combination compared to bleach alone. Their protocol included the use of sun-block to protect the lips from UV radiation. It has been shown that chromophoric dissolved organic matter (CDOM) present in natural waters can undergo photolysis by exposure to UV radiation leading to the formation of hydrogen peroxide. It is plausible that endogenous dentinal water exposed to UV radiation can lead to the formation of additional hydrogen peroxide and thus potentiate the bleaching effect. While photolysis of hydrogen peroxide and chromophoric organic matter within the dentinal matrix may play an important role in the mechanisms responsible for the current results, further investigation is required on this topic to expound the many possible reasons why supplemental light increases the bleaching results of hydrogen peroxide.

4.7. “Bleaching” or “desaturation”: the influence of chroma

The standardized coefficients for \(\Delta L',\ \Delta C_a,\) and \(\Delta h'\) enabled an objective comparison of the influence of each color parameter on total color difference. Based on the ratio derived from the standardized coefficients reported in Table 4, \(\Delta E_{ab}^*\) values were influenced by changes in chroma nearly three times more than by changes in lightness, while hue changes had almost no influence on color change. These findings are in accordance with the literature. Thus the recorded change in color appearance during bleaching treatment would more accurately be described as desaturation than bleaching/whitening. This finding suggests that a “chroma scale” of dental shade guides would be more appropriate than a “value scale” for monitoring bleaching results. Furthermore, this result also underscores the importance of using a progressive and uniform increase in chroma/yellowness, from the lightest to the darkest tab, which is probably one of the most pronounced advantages of BG shade guide as compared to VC.

4.8. Additional considerations

The mechanistic details accounting for the recorded differences between the light and no light group are related not only to photolysis of hydrogen peroxide but also to the photolysis of the chromophoric organic matter found in dentin. Photolysis of hydrogen peroxide has been shown to be independent of temperature. However, in 1957 it was reported in the Transactions of the Faraday Society that photolysis of hydrogen peroxide can occur by light of wavelengths of 365 nm or less, which is within the range of the light used in the current study. Tavares et al. reported using short-arc gas plasma light in combination with a 15% \(\text{H}_2\text{O}_2\). They reported significantly lighter teeth when using the light/bleach combination compared to bleach alone. Their protocol included the use of sun-block to protect the lips from UV radiation. It has been shown that chromophoric dissolved organic matter (CDOM) present in natural waters can undergo photolysis by exposure to UV radiation leading to the formation of hydrogen peroxide. It is plausible that endogenous dentinal water exposed to UV radiation can lead to the formation of additional hydrogen peroxide and thus potentiate the bleaching effect. While photolysis of hydrogen peroxide and chromophoric organic matter within the dentinal matrix may play an important role in the mechanisms responsible for the current results, further investigation is required on this topic to expound the many possible reasons why supplemental light increases the bleaching results of hydrogen peroxide.

5. 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. Future research might reveal weather recorded differences can be perceivable by untrained evaluators in a typical clinical setting with uncontrolled lighting conditions.

Acknowledgement

This study was funded in part by Discus Dental, Culver City, CA, USA.

Conflict of interest

Vita Bleachedguide 3D-Master was jointly developed by Dr. Rade D. Paravina and Vita Zahnfabrik. The University of Texas Health Science Center has executed a licensing agreement with VITA Zahnfabrik, dealing with commercialization of Vita Bleachedguide 3D-Master. Dr. Paravina is a paid consultant for Vita Zahnfabrik.

References

