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In Vitro Evaluation of the Effectiveness of Bleaching Agents Activated by Different Light Sources

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Abstract

Purpose: This study evaluated the efficacy of tooth whitening and color stability at different time periods after treatment.
Materials and Methods: Blocks obtained from human molars were divided into 15 groups (n = 5) by bleaching agents: 35% hydrogen peroxide (Whiteness HP and Opalescence Xtra) and 37% carbamide peroxide (Whiteness Super); and light sources: halogen lamp and plasma arc lamp (bleach mode), LED/diode laser, argon laser, and no light source. The efficacy of bleaching was measured using a spectrophotometer. Six bleaching sessions were performed (times 1 to 6). The specimens were submitted to another reading 7, 15, and 30 days after the end of bleaching (times 7, 8, and 9). The results were submitted to ANOVA followed by Tukey test and polynomial regression ($p < 0.05$).
Results: Carbamide peroxide significantly differed from hydrogen peroxide, presenting low reflectance values. Activated versus non-activated bleaching did not differ significantly for any gel tested, except for Whiteness HP activated by argon laser, which presented the lowest mean reflectance values. The results obtained with hydrogen peroxide revealed a decrease in reflectance values one month after the end of treatment. For carbamide peroxide, this decrease was not observed.
Conclusion: The halogen lamp presented the same or higher efficacy than non-activated bleaching, which had a longer gel contact period. When hydrogen peroxide was used, a decrease in reflectance values was observed 30 days after the end of bleaching.

Color results from an interaction of three elements: a light source, an object, and the human eye. Light hitting the surface of an object can be reflected and/or absorbed; however, only the reflected wavelengths are perceived as the color of the object.[1] This color is related to the wavelength and the amount of incident light reflected. A dark tooth absorbs more light, and when it becomes whiter, its enamel will present a lower absorption and consequently, more light reflection.[2]

There are many methods used to evaluate tooth shade changes after bleaching, and the methods can be classified as subjective, such as visual analysis by comparison with a standard tooth shade guide, and objective, such as use of spectrophotometers,[2-6] colorimeters, and image analysis techniques with software.[7] Spectrophotometers differ from colorimeters in that they measure reflected light within the entire visible spectrum, whereas colorimeters measure reflected light at only three wavelengths.[1] Unfortunately, however, spectrophotometers present disadvantages, such as being relatively large units, difficult to transport, with a high manufacturing expense because of the instrument's high precision and accuracy. Moreover, in in vivo experiments, the system is limited to the anterior teeth.

Although human evaluation of tooth shade by color guide matching is a simple method to use, it is not very reliable, because it is influenced by the observer's experience, eye fatigue, and variation of the ambient light, among other factors. Horn et al[3] compared the effectiveness of visual analysis and sphere spectrophotometer analysis in assessing tooth shade. The spectrophotometer readings presented 80% agreement, whereas there was only 45% agreement by visual

analysis. The authors concluded that the sphere spectrophotometer could provide more predictable and accurate tooth shade evaluation results.

In general, whitening agents are hydrogen peroxide or products that transform into hydrogen peroxide, such as sodium perborate and carbamide peroxide. When 10% carbamide peroxide comes into contact with water or saliva, it is broken down into 3.6% hydrogen peroxide and urea. Hydrogen peroxide, the active agent of bleaching, is very unstable and undergoes dissociation, resulting in oxygen and free water radicals, while urea decomposes, resulting in ammonia and carbon dioxide.[8]

The whitening mechanism consists of an oxidation reaction with the release of free radicals. Hydrogen peroxide ionization (HOOH) can occur in different reactions and produce various types of ions:

(1) 2 hydroxyl ions (OH−);
(2) perydroxyl ions (HOO−), which are considered stronger free radicals, and hydrogen ions (H+);
(3) water molecules (H_2O) and oxygen ions (O^{-2}), weaker free radicals;
(4) water (H_2O) and oxygen molecules (O_2), in the presence of salivary peroxidase enzymes.[9]

The free oxygen radicals can react with colored organic materials found within tooth structures, leading to a reduction in color.[10,11] When bleaching intensity appears to be stabilized, the saturation point has been achieved.

The in-office bleaching procedure makes use of high concentrations of carbamide or hydrogen peroxide agents, in order to provide faster and more effective treatment.[12-15] For this purpose, bleaching agents have been used in association with an energy source with the goal of accelerating the whitening gel oxi-reduction reaction. In early systems, a heated spatula or a heat lamp were recommended as catalyst.[16] The temperature achieved by these instruments was very high, increasing the risk of cracks on the enamel surface and pulp irritation. Therefore, other methods, such as curing lights and photosensitive agents, have been used to accelerate the chemical reaction. Photosensitive agents are present in some whitening agent compositions and contain components designed to absorb additional energy from the light source.[17,18]

For many years, heat or light has been used to speed the breakdown of hydrogen peroxide for a faster whitening result. Many devices, such as halogen curing lights, LEDs, diode lasers, argon lasers and plasma arc lamps, have been used; however, there are questions in the literature about the benefits brought by these curing lights on whitening results.[19-26] Thus, by means of photoreflectance spectroscopy, this study evaluated the efficacy of tooth whitening and color stability at time periods after treatment. The null hypothesis for this study was that change in reflectance values and bleach regression would not depend on hydrogen peroxide concentration and type of energy source used.

Materials and methods

One week after extraction, 100 sound third human molars were cleaned, polished, and examined under a light microscope (×4) to exclude those with cracks and caries lesions. They were also examined for the presence of tetracycline and fluorosis stains; any having these characteristics were rejected and substituted. Very dark or light teeth, standing out from the others, were also excluded. The specimens remained immersed in distilled water during the entire experiment.

One hundred and eighty cubic blocks were obtained from the buccal/lingual surfaces. The crown of each tooth was set in an acrylic plaque, which was fixed to a precision slow-speed water-cooled diamond saw (Imptech PC10, Equilam Lab Equip., Diadema-SP, Brazil, 09960-500), with two parallel disks, distanced 4 mm from each other and perpendicular to the buccal/lingual surface of the tooth. Each tooth was cut in the incisal-gingival and in the mesial-distal direction, resulting in 3-mm thick blocks with an area of 16 mm^2.

The 75 blocks with the flattest surfaces were selected. The superficial enamel was wet-polished with silicon carbide (SiC) paper, #600 and 1200 grit. The enamel of every block was polished until the surface was completely flattened. During this procedure the blocks that had their dentin exposed or had a very thin enamel layer left were replaced by others. The approximate range of remaining enamel thickness was 1 mm. To standardize the specimen position in the spectrophotometer, one of the lateral faces of each specimen was demarcated with a diamond bur (#1014, KG Sorensen Ind. e Com. Ltda., Barueri, Brazil), using a high-speed handpiece (Extra-Torque 605, Kavo do Brasil S.A., Joinville, Brazil) and a copious air-water spray.

The blocks were divided into 15 groups in accordance with the bleaching agent (n = 5): 35% hydrogen peroxide (Opalescence Xtra, Ultradent Inc., Salt Lake City, UT), 35% hydrogen peroxide (Whiteness HP, FGM Produtos Odontológicos, Joinville, Brazil), and 37% carbamide peroxide (Whiteness Super, FGM Produtos Odontológicos); and light source: halogen lamp used in bleach mode (Optilux 501C, Demetron/Kerr, Danbury, CT), LED associated with a diode laser (Ultrablue IV, DMC, São Carlos, Brazil), argon laser (Spectra Physics, Stabilite 2071, Mountain View, CA), and Plasma Arc lamp—bleach mode (Apollo 95E, DMD, Woodland Hills, CA).

The efficacy of bleaching was measured using a spectrophotometer (77702 model, Oriel Instruments, Mountain View, CA) in reflectance mode. For the reflectance analysis, a Teflon sphere in the reflectance configuration was used. The reflectance is the luminous radiation portion that is reflected by the material under study. Before the bleaching procedure, the specimens were placed in the sample carrier, which is part of the spectrometer sphere, and were irradiated by fiber optics at a distance of 2 mm to obtain the initial reading (baseline). The potency of the white light source was 5 mW. For each reading, 100 signal accumulations were obtained during 50 seconds of exposure time. The reflectance signal was confined inside the integrating sphere, and from this, a proportional signal fraction was collected for analysis in the spectrometer. The dispersed signal was reflected to a charge couple device camera that converted the optical signal to a digital signal, which was interpreted by the computer and exhibited as intensity x wavelength signal.

For the bleaching procedure, 0.04 ml of the whitening agent was applied to the enamel surface (the manufacturer recommended gel thickness of approximately 1 mm). Because the whitening agents were in gel form, bleaching agent contact was limited to the surface only, and did not flow onto the cut surfaces

Table 1 Information about light sources and activation times

Light source	Potency and wavelength	Activation time
Halogen lamp (bleach mode)	480 mW and 350 to 500 nm	4 × 30-second applications, spaced by 2 minute intervals
LED/Diode laser	200 mW and 450 to 500 nm for LED and 830 nm for diode laser	3 minute activation
Argon laser	200 mW and 488 nm	30-second activation
Plasma arc lamp (bleach mode)	320 mW and 440 to 500 nm	3 × 3-second applications, spaced by 30-second intervals
No light source		Gel remained on enamel surface for 30 minutes

of the blocks. The tip of each catalytic source was positioned 2 mm from the specimen surface. The light source activation times, in accordance with the manufacturer's instructions, are listed in Table 1.

Three gel applications were made in each session, and the activation protocol was repeated each time. The intervals between the sessions were 7 days. Gel was removed 6 minutes after source activation. All bleaching treatments were performed at a controlled atmospheric temperature (23.0 ± 1°C) and humidity (58 ± 2%).

Six bleaching sessions were performed for all groups in this study. At the end of each session, there was a waiting period of 24 hours for the specimens to rehydrate before spectrometer readings were taken. The specimens were submitted to another reading 7, 15, and 30 days after the end of the bleaching procedure.

A spectrophotometer measures and records the amount of visible radiant energy for each hue present in the entire visible spectrum. The wavelength pattern of each color is called spectral data. The reflectance analysis data reading was done with the aid of a microcomputer. For this, spectra data were recorded every 10 nm and plotted against the percentage of reflectance to create a spectral curve of an object. The area given by the curve was calculated with the software Origin 6.0, and numeric data were obtained. Figure 1 is an example of the spectral reflectance curve obtained (LED/diode laser, Opalescence Xtra).

The results were submitted to a repeated measures ANOVA for comparisons between the source and gel factors, followed by the Tukey test ($p < 0.05$). For the time factor, polynomial regression was used ($p < 0.05$).

Results

The results of the reflectance analysis are presented in Figures 2–4 and Table 2. The higher the reflectance values (%), the higher the bleaching results achieved by the specimens.

ANOVA revealed significant differences among sources, whitening gels, and time, and a triple interaction among these factors. The Tukey test was applied for individual comparisons (Table 2).

Carbamide peroxide differed significantly from hydrogen peroxide, presenting low reflectance values. Activated versus non-activated bleaching did not differ significantly for all the gels tested, except for Whiteness HP activated by argon laser, which presented the lowest mean reflectance values.

In general, when comparing the light sources: for Opalescence Xtra, the halogen lamp differed significantly from other sources presenting higher reflectance values; for Whiteness HP, all sources did not differ significantly, except the argon laser, which presented lower reflectance values than the halogen lamp; for Whiteness Super, the plasma arc differed significantly from the halogen lamp for three of the nine times tested and the other sources did not differ significantly among them. For time 9, all light sources did not differ significantly for all gels, except the plasma arc, which presented the lowest reflectance values for Whiteness Super.

A regression analysis graph was drawn for the time factor analysis. The times 7 to 9 indicate the readings taken at 7, 15, and 30 days after the end of the treatment. In Figures 2–4, a variation in reflectance was observed as a result of time. In Figures 2 and 3 this variation could be represented by a quadratic function; in other words, there was increased reflectance between times 1 and 5, stabilization between times 5 and 6 and afterwards, regression between times 7 and 9. In Figure 4, increased reflectance was observed between times 1 and 5. Stability was observed after time 5, although no regression of reflectance was observed after this period. The coefficient of determination (R^2) varies from 0 to 1, and the higher the R^2 value, the higher the regression curve adjustment. In this study, R^2 varied from 0.78 to 0.97, showing that the estimated curves were well adjusted to the observed data.

Discussion

The specimens were submitted to six bleaching episodes with 7-day intervals between the sessions. This is more often than recommended by manufacturers; however, the large number of sessions was used to analyze the time required for the treatment to achieve saturation. It was observed that all groups stopped whitening practically at the same time, between the 5th and 6th weeks of bleaching; however, the degree of reflectance reached was lower for some of these groups, even when extending treatment time with subsequent sessions.

Hydrogen peroxide can form several types of active oxygen, depending on the temperature, pH, light, and co-catalysts, among others.[9] Probably, certain combinations of gel and light sources were more effective because stronger free radicals were produced. Kashima-Tanaka et al[22] showed that the amounts of OH- generated from H_2O_2 were higher when the peroxide was activated by light sources (plasma arc lamp and halogen lamp) than laser irradiation (He–Ne laser and yellow He–Ne laser).

During longer activation periods, more energy is deposited on the dental tissue, and consequently more heat is generated. As is known, heat acts to accelerate peroxide breakdown. In this study, the activation time used for each source was different. Nevertheless, the objective was to test the manufacturers'

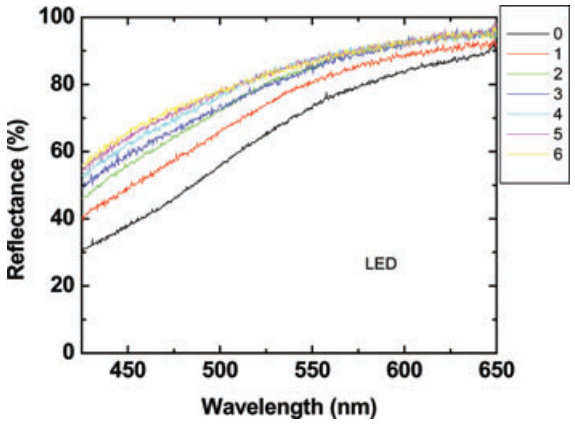

Figure 1 Plotting the reflectance analysis data. 0 = baseline, 1 = 1st bleaching session, 2 = 2nd bleaching session, and so on.

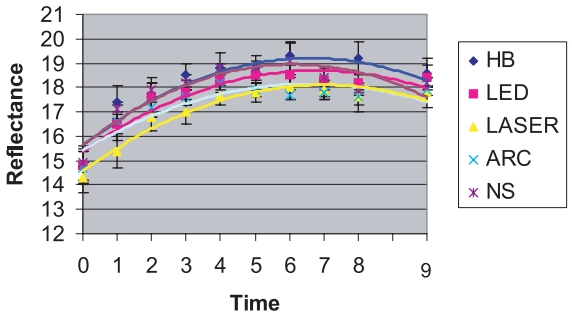

Figure 3 Reflectance as a result of time for the Whiteness HP whitening agent (1 to 6 means the number of beaching sessions; 7, 8, and 9 mean 7 days, 15 days, and 30 days after the end of the bleaching). HB = halogen lamp ($R^2 = 0.81$); LED = LED/diode laser ($R^2 = 0.87$); Laser = argon laser ($R^2 = 0.93$); ARC = plasma arc ($R^2 = 0.78$); NS = no source ($R^2 = 0.82$).

established protocols for the tested appliances, and compare them with regard to treatment efficacy. For the non-activated bleaching group, the gel contact period was extended, since the objective was to have maximum efficacy of the peroxide agent to serve as a control group.

In general, activated versus non-activated treatment did not differ significantly for all the gels tested, except for Whiteness HP activated by argon laser, which presented the lowest reflectance values differing for half of the tested times. Laser light is distinguishable from conventional light because it is monochromatic, coherent, and collimated. These properties make the laser beam a differentiated source of energy.[23] In spite of all these characteristics, Jones et al,[24] evaluating the shade change of dental elements in vitro, concluded that the one-session bleaching treatment potentiated by argon laser was not enough to obtain a perceptible shade change. In the present study, argon laser did not differ significantly from LED/laser and plasma arc; however, for Opalescence Xtra and Whiteness HP, the reflectance means of the argon laser group were inferior to those of the halogen lamp. This can be attributed to the lower potency of the argon laser compared with the halogen lamp in the bleach mode and the short activation time.

Opalescence Xtra activated by halogen lamp presented higher reflectance values than LED/diode laser, argon laser, and plasma arc for times 1 to 8. This was probably due to the high potency of the halogen lamp, extended activation time, and the photosensitive agent, named beta-carotene, present in its composition. According to the manufacturer, the addition of beta-carotene improves the ability of the product to absorb blue light, since the maximum absorbance of beta-carotene occurs at 450 nm; however, Baik et al[17] showed that this compound presents a broad absorption profile between 350 and 500 nm. According to the authors, the larger the coincidence between the spectral emission curve of the source and the spectral absorbance curve of the colorant, the greater the potential for light absorption presented by the gel.

The halogen lamp is a broadband unit (375 to 500 nm) whose emitted light matches the absorbance spectrum of beta-carotene. Although the plasma arc source presents a high broadband emission (425 to 500 nm) and high-energy intensity, the activation time in this study was only 9 seconds, leading to a significantly lower result than with the halogen lamp. LED units

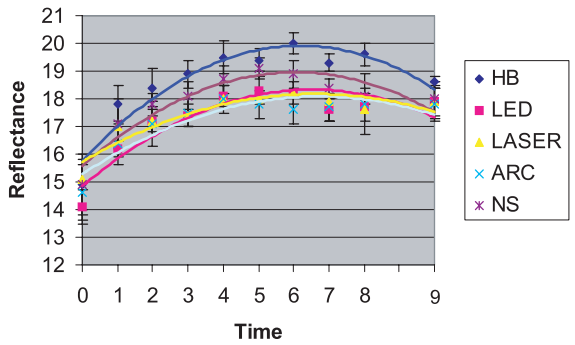

Figure 2 Reflectance as a result of time for the Opalescence Xtra whitening agent (1 to 6 means the number of beaching sessions; 7, 8, and 9 mean 7 days, 15 days, and 30 days after the end of bleaching). HB = halogen lamp ($R^2 = 0.87$); LED = LED/diode laser ($R^2 = 0.82$); Laser = argon laser ($R^2 = 0.90$); ARC = plasma arc ($R^2 = 0.81$); NS = no source ($R^2 = 0.84$).

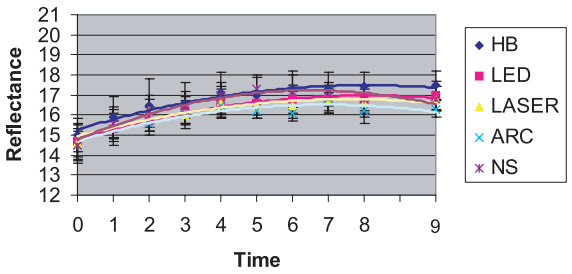

Figure 4 Reflectance as a result of time for the Whiteness Super whitening agent (1 to 6 means the number of beaching sessions; 7, 8, and 9 mean 7 days, 15 days, and 30 days after the end of bleaching). HB = halogen lamp, ($R^2 = 0.94$); LED = LED/diode laser ($R^2 = 0.97$); Laser = argon laser ($R^2 = 0.86$); ARC = plasma arc ($R^2 = 0.84$); NS = no source ($R^2 = 0.92$).

Table 2 Mean (%) and standard deviation of reflectance

Period	Gel	Light source				
		Halogen	LED/diode laser	Argon laser	Plasma arc	No light source
0 (Baseline)	Xtra	14.9 (1.1) A a	14.1 (0.6) A a	15.1 (0.5) A a	14.6 (1.0) A a	14.9 (0.9) A a
	HP	14.8 (0.7) A a	14.8 (0.6) A a	14.3 (0.6) A a	14.7 (0.7) A a	14.9 (0.7) A a
	Super	15.0 (0.8) A a	14.7 (0.8) A a	14.6 (1.0) A a	14.5 (0.7) A a	14.5 (0.8) A a
1 (1st bleaching session)	Xtra	17.8 (0.7) A a	16.2 (0.3) BC a	17.0 (0.4) C a	16.4 (0.8) BC a	17.1 (0.9) AB a
	HP	17.4 (0.7) A a	16.5 (0.5) A ab	15.4 (0.7) B a	16.6 (0.8) A a	17.1 (0.2) A a
	Super	15.9 (1.0) A b	15.3 (0.8) A b	15.5 (0.8) A a	15.3 (0.4) A b	15.6 (0.8) A b
2 (2nd bleaching session)	Xtra	18.4 (0.7) A a	17.2 (0.4) B a	17.2 (0.6) B a	17.1 (0.8) B a	17.8 (0.4) AB a
	HP	17.6 (0.6) AB a	17.6 (0.8) AB a	16.8 (0.6) B ab	17.2 (0.4) ABa	17.9 (0.3) A a
	Super	16.5 (1.3) A b	15.7 (0.7) A b	16.2 (0.8) A b	15.6 (0.4) A b	16.2 (0.6) A b
3 (3rd bleaching session)	Xtra	18.9 (0.5) A a	17.4 (0.4) B a	17.4 (0.5) B a	17.5 (0.5) B a	18.1 (0.5) AB a
	HP	18.5 (0.5) Aa	17.8 (0.5) AB a	17.0 (0.5) B a	17.6 (0.3) AB a	18.2 (0.3) A a
	Super	16.6 (1.0) A b	16.2 (0.7) A b	16.0 (0.7) A b	16.1 (0.5) A b	16.5 (0.7) A b
4 (4th bleaching session)	Xtra	19.5 (0.6) A a	18.1 (0.4) B a	18.0 (0.5) B a	18.0 (0.5) B a	18.7 (0.5) AB a
	HP	18.8 (0.6) A a	18.3 (0.5) AB a	17.7 (0.4) B a	18.2 (0.3) AB a	18.8 (0.2) A a
	Super	17.1 (1.0) A b	16.6 (0.7) A b	16.6 (0.8) A b	16.5 (0.5) A b	17.0 (0.6) A b
5 (5th bleaching session)	Xtra	19.4 (0.4) A a	18.3 (0.5) BC a	18.0 (0.5) C a	17.8 (0.5) C a	19.1 (0.4) AB a
	HP	18.8 (0.5) A a	18.5 (0.6) A a	17.8 (0.4) A a	17.9 (0.3) A a	18.8 (0.2) A a
	Super	17.0 (1.0) AB b	16.6 (0.6) AB b	16.5 (0.7) AB b	16.2 (0.4) B b	17.3 (0.6) A b
6 (6th bleaching session)	Xtra	20.0 (0.4) A a	18.2 (0.4) BC a	18.2 (0.4) BC a	17.6 (0.5) C a	18.9 (0.5) B a
	HP	19.3 (0.6) A a	18.5 (0.4) AB a	18.0 (0.5) B a	17.7 (0.2) B a	19.1 (0.7) A a
	Super	17.3 (0.9) A b	16.8 (0.7) AB b	16.5 (0.7) AB b	16.1 (0.4) B b	17.2 (0.8) AB b
7 (7 days post-bleaching)	Xtra	19.3 (0.3) A a	17.6 (0.4) B a	17.9 (0.3) B a	17.7 (0.5) B a	18.4 (0.3) AB a
	HP	18.2 (0.6) A b	18.3 (0.4) A ab	17.9 (0.4) A a	17.8 (0.3) A a	18.4 (0.3) A a
	Super	17.3 (0.8) A c	16.8 (0.7) A b	16.7 (0.6) A b	16.8 (0.3) A b	16.9 (0.7) A b
8 (15 days post-bleaching)	Xtra	19.6 (0.4) A a	17.7 (0.5) B a	17.6 (0.3) B a	17.8 (1.1) B a	18.1 (0.3) B a
	HP	19.2 (0.7) A a	18.2 (0.4) AB a	17.6 (0.6) B a	17.6 (0.3) B a	17.9 (0.2) B a
	Super	17.4 (0.7) A b	16.8 (0.6) AB b	16.6 (0.7) AB b	16.2 (0.6) B b	16.8 (0.7) AB b
9 (30 days post-bleaching)	Xtra	18.6 (0.2) A a	17.9 (0.6) A a	17.9 (0.4) A a	17.8 (0.6) A a	18.0 (0.6) A a
	HP	18.6 (0.6) A ab	18.4 (0.5) A a	17.8 (0.6) A a	17.9 (0.2) A a	18.2 (0.2) A a
	Super	17.5 (0.7) A b	17.0 (0.7) AB b	16.8 (0.6) AB b	16.3 (0.4) B b	16.8 (0.6) AB b

Mean values followed by different letters differ among them for the Tukey test ($p < 0.05$). Capital letters are to be read horizontally and lower cases vertically.

produce a narrow band of blue light, around 450 to 500 nm.[25] As regards Opalescence Xtra activation, the spectral emission of the light produced by LED is narrow, covering only a small portion of the carotene absorption. This may explain why, when Opalescence Xtra was activated by LED/diode laser, the reflectance values were lower than Opalescence Xtra activated by the halogen lamp. When Whiteness HP was used, the results obtained by these two sources did not differ significantly. This may have happened because this whitening agent presents a specific red color, which absorbs blue light.

The bleaching agent concentration is also a relevant factor in successful treatment.[10,23] Thirty seven percent carbamide peroxide, which is equivalent to 13.4% hydrogen peroxide, presented lower efficacy than 35% hydrogen peroxide. Sulieman et al[14] compared the in vitro efficacy of various concentrations of hydrogen peroxide (5% to 35%) and found that the higher the concentration, the lower the number of gel applications required to produce a bleaching effect. When high concentrations of hydrogen peroxide (35% and 50%) were compared, Lee et al[15] demonstrated that after 1 or 2 hours of treatment, the whitening effect was the same.

Evaluating color stability, no change in reflectance values was seen for Whiteness Super, at 7, 15, and 30 days after the end of the bleaching treatment. When Whiteness HP and Opalescence Xtra bleaching agents were used, it was possible to note a decrease in reflectance values after 1 month of the procedure. This result is in agreement with Rosenstiel et al[16] who monitored, in vivo, the shade differences over time after a single in-office bleaching session using 37% hydrogen peroxide and observed great shade regression obtained after 7 days. In

the present study, at 30 days after the end of the bleaching procedure, the decrease in reflectance values did not reach the values obtained before the bleaching treatment.

A number of light sources are available for activating whitening agents during bleaching procedures. The results of this study showed that when using the bleaching gel Opalescence Xtra, the application of halogen lamp (bleach mode) resulted in the highest reflectance values when compared with the other sources tested. For the sources that presented the same efficacy for activating the whitening agent, the recommendation is to use the one that causes a minimum rise in temperature, to avoid undesired pulpal responses.[26]

Further in vivo studies must been conducted to confirm the relationship of bleaching efficacy and light sources. It is difficult to establish a direct relation between an in vitro and an in vivo result. Many in vivo factors should be considered, such as the etiology of the discoloration, dietary habits, and others; however, in vitro studies may guide one to conclusions that can later be confirmed in vivo and then improve the clinical activity.

The null hypothesis for this study was not accepted, since change in reflectance values and bleach regression depended on hydrogen peroxide concentration and type of energy source used. It is important to point out that during the shade stability evaluation, the test specimens remained in distilled water and did not come into contact with the pigments usually present in the diet. Further research is needed to determine the effect of shade reversal in vivo after in-office bleaching treatment.

Conclusion

(1) Hydrogen peroxide gels had significantly higher reflectance values than the carbamide peroxide gel.
(2) Opalescence Xtra with the halogen lamp had significantly higher reflectance values than any other gel and light combination.
(3) Activated versus non-activated gels did not differ significantly, except for Whiteness HP activated by argon laser, which presented the lowest reflectance values.
(4) The results obtained with hydrogen peroxide revealed a decrease in reflectance values after one month at the end of the treatment. For carbamide peroxide, this decrease was not observed.

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