Evaluation of tooth color after bleaching with and without light-activation

Avaliação da coloração dental após clareamento com e sem ativação por luz

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Abstract

Purpose: The use of different light sources as an adjunct to in-office bleaching has been questioned. Thus, the aim of this study was to evaluate the color changes of teeth after application of bleaching techniques with different products, with and without activation by a LED-laser system.

Methods: Twenty-four bovine teeth surfaces were submitted to three bleaching techniques with two commercially available 35% hydrogen peroxide bleaching agents (n=8). The specimens were immersed in red wine for 48 h at 37°C and submitted to the bleaching techniques. Color changes were measured before and after staining as well as immediately after and 24 h after the bleaching treatments, with two different methods of color evaluation, software ScanWhite V1.1 and intra-oral spectrophotometer (Vita Easyshade). Data were analyzed by ANOVA and Kruskal-Wallis test.

Results: The statistical analysis showed that there was no statistically significant difference at 5% of significance level between the different groups, independently of the evaluation time, evaluation methods or the use of LED-laser systems.

Conclusion: The results suggested that the use of light in the bleaching techniques did not influence the color changes.

Key words: Tooth bleaching; curing lights, dental; esthetics, dental

Resumo

Objetivo: o uso de diferentes fontes de luz como auxiliar no clareamento de consultório tem sido descrita na literatura.Assim, o objetivo deste estudo foi avaliar as alterações da cor dos dentes após a aplicação de técnicas de clareamento com diferentes produtos, com e sem ativação por um sistema de LED-laser.

Metodologia: Vinte-quatro superfícies de dentes bovinos foram submetidas a três técnicas de clareamento com dois agentes clareadores disponíveis comercialmente à base de peróxido de carbamida a 35% (n=8). Os espécimes foram inicialmente imersos em vinho tinto por 48 h a 37°C, e submetidos às técnicas de clareamento. As alterações de cor foram mensuradas antes e após o manchamento, bem como imediatamente e 24 hs após as técnicas de clareamento, por meio de dois diferentes métodos de avaliação da cor: software ScanWhite V1.1 e espectrofotômetro intra-oral Vita Easyshade. Os dados foram analisados pelos testes de ANOVA e Kruskal-Wallis.

Resultados: A análise estatística não apontou diferenças significantes entre os diferentes grupos testados, independentemente do período de avaliação, método de avaliação ou uso do sistema LED-laser.

Conclusão: Os resultados sugeriram que o uso da luz não influenciou nas mudanças de cor.

Palavras-chave: Clareamento de dente; luzes de cura dentária; estética dentária

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Introduction

The colour of the teeth is determined by the combined effects of intrinsic and extrinsic colourations (1). Intrinsic tooth color is associated with the light scattering and absorption properties of the enamel and dentine (2). Extrinsic color is associated with the absorption of materials (e.g. tea, red wine, chlorhexidine, iron salts) onto the surface of enamel, and in particular the pellicle coating, and which ultimately cause extrinsic stain (3). The many factors associated with tooth discoloration and staining, both intrinsic and extrinsic, have recently been extensively reviewed (1). There are several techniques available for the treatment of darkened teeth and bleaching is one of the least aggressive methods. The introduction of new materials, the variety of light sources and the appearance of different protocols have allowed greater effectiveness of the tooth bleaching to be sought, operational facility for the dentist and safety for the patient.

The bleaching can be carried out in-office completely controlled by the dentist, at home by the patient, or there may be a combination of both. Besides these bleaching techniques there are other variables which include the type of bleaching agent, the concentration and application time, and more recently the presence or absence of a light source (4). For at-home bleaching, the agents used are carbamide peroxide in concentrations varying between 10% and 22%, and hydrogen peroxide between 4% and 8%. The efficacy and safety of these agents at low concentration are well documented in the literature (5,6), however, for in-office bleaching a high concentration of hydrogen peroxide is used (between 25% and 50%), which can be activated by a light source to accelerate and intensify the bleaching process (6-8). However, these high concentration hydrogen peroxide agents can lead to a significant increase in the postoperative sensitivity, or according to some authors can cause side effects in the pulp tissue, through a possible increase in the intra-pulp temperature, which should not normally exceed 5.5ºC above the physiological temperature (9).

Besides enabling the dentist to carry out the bleaching without the need of one equipment, some manufacturers have introduced onto the market bleaching gels which dispense the need to use a light source. These gels have an inorganic load in their composition which acts as a barrier and collector of heat waves. The instructions manual of these type of gels informs that these waves is being used in the gel to accelerate the bleaching, and consequently prevent them from reaching the pulp directly increasing its temperature and causing sensitivity.

The effect of light in dental bleaching is still a controversial topic, and is extensively discussed in the literature since the mechanisms of action are not well understood. In fact, there are many reports in the literature discussing the role of light in teeth whitening, but the results often contradict the existence of any effect (10).

Different bleaching techniques are described based on the concentration of hydrogen peroxide used and different methods of application. To enhance or accelerate the whitening process, heat-activation of the bleaching agent by light, heat or laser has been described in the literature (11-13). However, the use of different light sources as an adjunct to in-office bleaching has been questioned. Thus, the aim of this study was to evaluate the tooth color changes after the application of bleaching techniques with different products, activated with and without a LED-laser system.

Methods

Twenty-four (n=8) healthy bovine teeth were selected, which were stored in distilled water at room temperature, until the beginning of the experiment. Initially, the teeth were analyzed in order to confirm the absence of cracks and defects in the tooth structure. Teeth were carefully cleaned with a hand scaler and water-pumice paste with prophylaxis rubber cups. After that, the roots of the teeth were separated from the crowns with a high-speed diamond bur. The vestibular surfaces of the crowns of all teeth were delimited in a square of 3x3x3 with the bur, in order to standardize the location of insertion of the bleaching gels and the color readings.

The teeth were divided randomly into 3 groups (n=8) to be later submitted to three bleaching techniques. The initial color (M1) was measured using two different evaluation methods: a software for color evaluation of digital images (ScanWhite - Darwin V1.1, Brazil) and an intra-oral spectrophotometry (VITA Easyshade® Compact, Bad Säckingen, Germany). The specimens were then immersed in red wine and stored at 37ºC (± 1ºC) for 48 h.

After the staining, the specimens were submitted to color measurements again (M2) followed by three bleaching protocols using two bleaching agents: Whiteness HP maxx (FGM Prod. Odont, Joinville, SC, Brazil) and Whiteness HP Blue (FGM Prod. Odont. Joinville, SC, Brazil). Whitening Lase Light Plus (DMC Equipamentos Ltda, São Carlos, SP, Brazil) equipment was used in the bleaching protocol with the gel activated by light, as shown in Table 1.

Table 1. Bleaching agents and the respective bleaching techniques evaluated in the present study.

Groups	Bleaching agents	Bleaching technique
I	Whiteness HP maxx	With light activation
II	Whiteness HP maxx	Without light activation
III	Whiteness HP Blue	Without light activation

The Whitening Lase Light Plus equipment has a matrix with LED-type emitters, it generates blue light at a wavelength of 470 nm, and has three infrared laser diodes with a power of 0.2 watts which generate light at a wavelength of 830 nm.

Protocols of application

The protocols applied to groups I, II and III in the tooth bleaching sessions are described below.

Group I: Whiteness HP maxx with light activation

In the gel preparation, the peroxide phase was mixed with the thickning phase. Three drops of peroxide to one drop of thickener rate was used. This rate is sufficient for application on one tooth. In this study 18 drops of peroxide and 6 drops of thickener were used, which was sufficient for the 8 teeth corresponding to this group.

After applying the gel on the tooth surface, the protocol for the use of Whitening Lase Light Plus was applied according to the manufacturer's recommendations for the bleaching agent based on 35% hydrogen peroxide. The gel was light activated for 1 min, left to rest for 2 min, light activated again on the teeth for 1 min and left to rest for 2 min without light, this sequence was then repeated for a third time with 1 min of light activation under the teeth and 2 min without light. Lastly, the gel was left to rest for 4 min under the tooth surface. In this phase the color of the product changed from carmine red to green.

Group II: Whiteness HP Maxx without light activation

In the preparation of this gel, the peroxide phase was mixed with the thickening phase. Three drops of peroxide to one drop of thickener rate was used. This rate is sufficient for application on one tooth. In this study 18 drops of peroxide and 6 drops of thickener were used, which was sufficient for the 8 teeth corresponding to this group.

The gel remained under the tooth surface for 15 min and during this time a microapplicator was used to move the gel and release any bubbles of oxygen generated. In this phase the color of the product changed from carmine red to green.

Group III: Whiteness HP BLUE

For the preparation of this gel, the syringes containing the peroxide phase and the thickening phase were connected, pushing the plungers alternately for up to 8 times, and then the mixed content was pushed into one of the syringes, and then it was ready for use. The gel was applied under the tooth surface to be bleached, on which it remained for 40 min, with a single application during the session. With the aid of the microapplicator the gel was moved frequently to eliminate any bubbles of oxygen generated and renew the contact of the gel with the teeth.

A diagram of the sequence of application can be seen in Figure 1. The gels were placed on the enamel surface, corresponding to the first, second and third bleaching session, and for groups I and II, in each session, the gel application was repeated three times, while for group III the application was repeated only once. Between one application and the next, the bleaching gel was removed using a suction system and between each session the tooth was washed with water, which corresponds to the end of the bleaching process. After the last session, the color was measured (M3) immediately after bleaching. The specimens were then stored in artificial saliva at 37 ºC (±1 ºC) for 24 h, when a new color measurement wasregistered (M4).

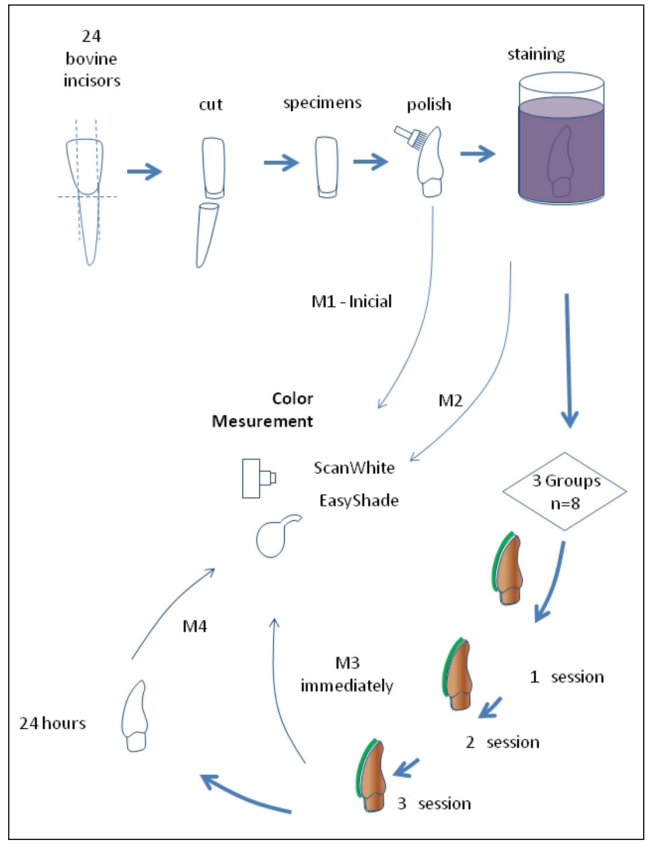

Fig. 1. Experimental setup for the different experimental protocols.

Method of bleaching measurement

ScanWhite – Darwin (V 1.1)

ScanWhite is a software created for helping clinicians in the evaluation of the level of tooth whitening and supporting decision. Digital photographs were obtained with a digital camera Sony DSC F828 Cybershoot, which was attached to the tablet to control the distance of obtaining photographs. The following photographic parameters were used: opening f6, 3, speed 640, ISO 100, Macro on, Flash on medium intensity and resolution of 3 MP.

To reduce possible variations inherent in the formation of images on the CCD, each experimental group (specimens fixed on slides with wax) were photographed 5 times. All images were obtained with the ceramic block calibration positioned alongside the specimens. The images obtained were opened in ScanWhite full evaluation mode.

Following the routine evaluation of ScanWhite, the images were first calibrated in order to correct possible variations inherent to obtain the images, such as variation in brightness and color deviations registration.

For a better benchmark for evaluating the effectiveness of tooth bleaching, it was decided to adopt the ceramic block calibration ScanWhite as color reference, from which both the initial level of staining as the effectiveness of each stage of bleaching can be compared.

As these relationships have been defined, the algorithm automatically ScanWhite presented a comparison of the variation in hue in the results bar, allowing the export of results of R, G, B and L*, a*, b*, for a specific worksheet using Microsoft Excel software, and generating the graphics for the analysis of specimens in the experimental groups.

The effectiveness of tooth bleaching, indicated by the color difference between the initial condition and the other conditions evaluated, was determined by the values of ΔE.

The magnitude of this variation was determined from the average values of L* a* b* obtained automatically by the algorithm of ScanWhite from the computational interpretation of each selected area in the photographs.

The calculation used for this determination was proposed in 1976 by Commission Internationale d'Eclairage and represents a color space closer to clinical reality.

$$\Delta e_{CIELAB} = \sqrt{(L^*_1 - L^*_2)^2 + (a^*_1 - a^*_2)^2 + (b^*_1 - b^*_2)^2}$$

Where: L* = lightness (0-100)
a* = change the color of the axis red/green
b* = color variation axis yellow/blue

The results were expressed in number of bleached tones (T), with a measurement scale proposed by the creators of ScanWhite. This number represents the color difference between two digital images, where negative numbers mean darkening and positive numbers mean lightening.

EasyShade Spectrophotometry

For each sample three readings were made using the parameters CIELAB system (L* indicates lightness, a* represents the color saturation and red-green axis b* means color and saturation in blue-yellow axis). The reading for the determination of color parameters was always performed at the central point of the crowns in the same environment with the same lighting conditions.

The effectiveness of tooth bleaching was directly expressed by ΔE values that indicate the color difference between an initial condition and the other evaluated conditions.

Data were analyzed by Analysis of Variance (ANOVA) and Kruskal-Wallis test using the statistics software program Statgraphics Plus Professional.

Results

The results obtained with the two evaluation methods (spectrophotometer and digital image analysis) were similar. Differences between the groups tested by the spectrophotometer Easyshade method (*P*=0.571) and by digital image analysis with the software ScanWhite (*P*=0.157) were not observed. All of the bleaching protocols tested were shown to be effective in tooth color change. The mean values obtained for each bleaching protocol using the spectrophotometer method and image analysis are represented in Figures 2 and 3, respectively. All test groups exhibited minimal color change between bleaching (M3) and after 24 hours (M4) of storage in artificial saliva.

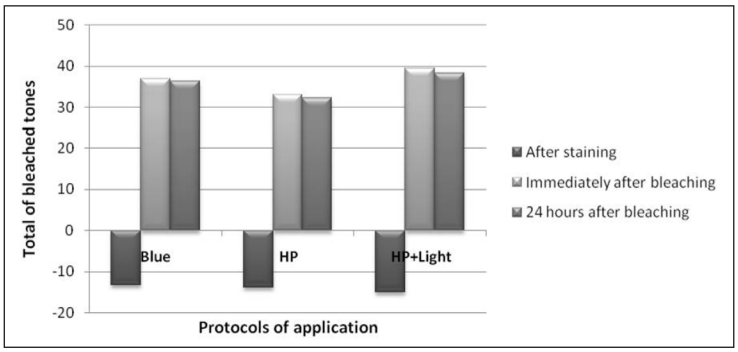

Fig. 2. Graphic representation of the mean values of the bleached tones for each bleaching protocol using the digital image analysis.

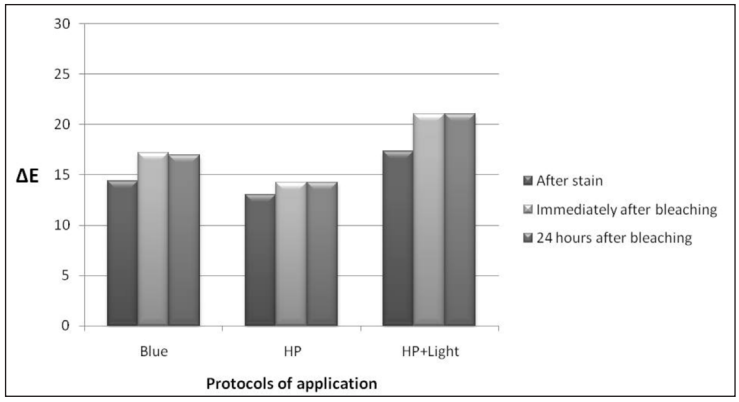

Fig. 3. Graphic representation of the mean values of ΔE obtained for each bleaching protocol using the spectrophotometer analysis.

Discussion

In order to obtain a greater whitening of teeth in a reduced time, in-office bleaching technique using hydrogen peroxide gel in high concentration, associated or not with a light source, has been recommended (9,12,13). Some studies affirm that a light source can be used to catalyze the hydrogen peroxide composition, thus accelerating the bleaching process (14,15) although this issue is still controversial in the literature. Also, the true contribution of light in the acceleration of the process and the action mechanisms of visible radiation in terms of increasing the chemical reaction rate are not yet completely understood.

Currently, the hypothesis that the light/pigment interaction increases the molecular freedom of the system, increasing the probability of the meeting of reactive oxygen and specific sites of the pigmented molecules, is accepted as one of the possible mechanisms responsible for the photonic catalysis of the reaction (16). Regard of this, one of the factors which influence the interaction of the light with the crystalline structure of the tooth is the presence and color of the gel. According to Florez et al. 2009 (17) with the use of green colored bleaching gel it is possible to verify that the light emitted is intensely dispersed by the gel pigment, reducing the efficiency of the process. This dispersion could explain the results obtained in this study, since the color of the gel used in the protocols with and without light is green.

The Commission International de l'Eclariage (CIE) L* a* b* color order system uses a mathematical system to describe the three dimensions of color within a color space of equally perceived gradations (8,18,19). The color value is described by the L* axis, where high L* values are obtained for bright or white specimens, whereas lower L* values represent dark or black ones. Hue-chroma is measured by a* axis in the red-green direction. When positive a* values are found, the specimen has a great amount of red and if a* values are negative green predominates. The b* axis represents the hue-chroma in the blue-yellow direction and it is considered that positive b* values are yellow while negative values are blue (8,18). ΔE number is the total color difference (19) and its value has been correlated with limits of human detection whereby 50% of the population can perceive a color difference unit greater than one (20) while some papers have reported that color difference values less than 3.3 can be considered clinically insignificant (21).

A great variety of methods to evaluate the efficacy of tooth bleaching can be used such as: color scales, photographs, spectrophotometer and digital image analysis using specific software programs. One of the most used methods is the simultaneous comparison of the tooth with standardized color scales (22-24). However, this method is subjective, not predictably reproducible, and is influenced by factors such as ambient lighting and operator fatigue (25). Thus, in this *in vitro* study, the color change obtained using the different in-office bleaching protocols with 35% hydrogen peroxide, with or without activation by LED-laser was evaluated through two objective methods, in order to provide more reliable results in the colorimetric evaluation. Both methods are based on CIE L* a* b* values, despite the ScanWhite final results are given in a specific scale. Although the methods used are not comparable since they employ different measurements in the evaluation of the level of bleaching, they show similar tendencies toward a greater effectiveness of the bleaching agent Whiteness HP maxx under activation by LED-laser, however, the differences between the treatments were not statistically significant.

In this study, it was observed that all of the products and protocols tested were effective in the tooth bleaching in general, regardless of the application regime, since total color difference (ΔE) between baseline (M2) and after bleach (M3) application was obtained for each specimen and the values were greater than 3.3 for all test groups. For evaluations between bleaching applications (M3) and after 24 hours (M4) of storage in artificial saliva, all groups exhibited minimal color change that could not be clinically perceived. When the teeth bleached by the in-office technique associated with irradiation by light were compared to teeth bleached without irradiation by light, statistically similar results were observed for the two evaluation methods. These finding are corroborated by other studies (20-22).

Considering the experimental findings, the use of LED-laser light source as the beaching reaction activator was not found to be advantageous in relation to the protocols without light activation and they should thus be considered optional in the in-office bleaching technique when using hydrogen peroxide in high concentration as the bleaching agent. However, new studies are required in order to elucidate the effectiveness of the activation by different light sources combined with different bleaching agents available on the market.

Conclusions

Within the limitation of this study it was concluded that:

- In-office bleaching systems tested, with or without light source, were effective and showed similar results in teeth whitening.
- The use of a LED-laser system in association with the bleaching gel did not increased the teeth whitening compared to protocols without light activation, and concluded that, in this case, the use of light can be considered optional.
- The methods used in the measurements, although not comparable, showed similar trends for all groups.

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