PROFESSIONAL DENTAL BLEACHING: COMPARATIVE REVIEW OF PULP HEAT CAUSED BY DIFFERENT PHOTOACTIVATED SYSTEMS

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Resumo. *Realizou-se uma revisão comparativa dos atuais fotoativadores mais utilizados no clareamento dental de consultório e dos efeitos do aquecimento gerado sobre a polpa dental para orientar o clínico na escolha da técnica mais adequada e segura, enfocando as publicações mais recentes. A crescente demanda dos pacientes pela estética, comodidade e rapidez, tornou o clareamento dental de consultório preferido pelos pacientes em relação ao clareamento caseiro, com o uso de moldeiras. Existem várias opções para se fazer o clareamento fotoativado: LED (Ligth Emitting Diode), lâmpadas halógenas ou arco de plasma e laser de argônio, mas devido ao aquecimento provocado por estas fontes é importante respeitar o limite crítico do aumento de temperatura pulpar de 5,5ºC (Zach e Cohen, 1965) para não danificar a polpa, responsável pela vitalidade dental. De acordo com a literatura consultada, pôde-se concluir que: os LEDs têm sido a fonte fotoativadora de eleição no processo de clareamento dental de consultório por promoverem menor aumento de temperatura pulpar; tanto os LEDs como os agentes clareadores nacionais apresentam-se como uma alternativa bastante viável por oferecerem uma excelente relação custo / benefício, tanto para o dentista quanto para o paciente; o gel clareador deve ser escolhido em função da fonte fotoativadora a ser utilizada para se obter um resultado mais eficaz.*

Palavras chave*: clareamento dentário, peróxido de hidrogênio, estética dental.*

Abstract. *The aim of the study was to review literature about current photoactivated systems used in professional dental bleaching and the effects of heating dental pulp, in order to help the professional choose the best and safer technique for the patient. The increasing search for esthetics, increased patients' interest in professional dental bleaching rather than home bleaching using night time bleaching tray. As a consequence, a number of different photoactivated systems and bleaching products have appeared in the market, spreading the technique among the population once the price has decreased. There are several photoactivated systems: LED (Light Emitting Diode), halogen light, plasma arc light and argon laser light. However, these materials can cause heat and can raise the temperature of the pulp around 5.5ºC. Thus, it is important to respect to the temperature raise in order to avoid harming the pulp (Zach and Cohen, 1965). According to the literature review, we concluded that: LED is the principal photoactivated system for professional dental bleaching, because it causes less pulp temperature increase. LED and brasilian bleaching agents are alternative methods because they have a good cost-benefit for the dentist and for the patient. The bleaching gel is the best technique in order to achieve a more efficient outcome.*

Key words*: tooth bleaching, Hydrogen peroxide, esthetics, dental*

1. INTRODUCTION

The pursuit of esthetics and a pleasant smile has made the search for dental bleaching considerably increase in the dental practices recently.

The professional dental bleaching technique is preferred because it is faster than home bleaching, with the use of bleaching trays, and it is becoming popular due to cost reduction with the onset of several photoactivation systems and products meant for in-office bleaching. The combined bleaching technique is an association of the two previous ones and may be used in those cases where bleaching is not taking place as desired.

The existing techniques for dental bleaching may ser divided in intrinsic (internal) and extrinsic (external) bleaching. The intrinsic bleaching is indicated only for endodontically treated teeth, through dentinal tubules via pulp chamber (Mondelli, 1998; Navarro and Mondelli, 2002).

The most used techniques for vital tooth bleaching are: the exogenous bleaching with custom-made tray, using 10%, 15% or 16% carbamide peroxide, and the in-office exogenous bleaching technique with 35% hydrogen peroxide, which is activated by halogen, LED and laser lights (Pelino *et al*., 2001, Walverde, 2001).

The bleaching takes place within the dentin, a tissue that makes up most of the tooth's mass, once the enamel is translucid.

It is important to clarify that the photoactivation sources alone do not bleach the teeth; they enhance the action of the bleaching product, which is responsible for the bleaching process (Zanin and Brugnera Jr., 2002).

Nowadays, the advantage of bleaching in only one session is the reduction of the contact time of the product with the tooth, which from one week to 15 days, is performed in a little more than one hour. If there is any sensitivity, it will be milder and easily controlled on the same day. That reduction of the application time is due to the reaction potentialization. Zanin *et al*. (2003) stated that the hydrogen peroxide (H_2O_2) concentration used for professional bleaching is ten times greater than that for home bleaching.

The purpose of the present study was to carry out a comparative review of the different photoactivated systems used in professional dental bleaching and the effects of the heat produced on the dental pulp to guide the clinician in the selection of the most adequate and safest technique, focusing the most recent publications.

LITERATURE REVIEW

Kirk (1989) was one of the first worker to describe the probable mechanisms of dental bleaching. He stated that the success of dental bleaching is in the destruction of the pigments that affects dental structures by a chemical agent with enough strength to achieve that purpose. He classified the whitening substances in two classes: the oxidant ones that destroy the pigments by removing the hydrogen, and the reducing ones that do it by removing the oxygen. Among the oxidant substances, he cited hydrogen peroxide, chlorine and potassium permanganate reduced by oxalic acid, because, in failure of which, its final product would be brown and would stain the dental tissues. In professional bleaching, the whitening agent usually is hydrogen peroxide (30-35%), activated with some kind of photoactivation source. When photoactivated, the hydrogen peroxide decomposes into water and nascent oxygen quickly penetrating the enamel pores, running through the enamel and dentin organic matrix. The nascent oxygen promptly reacts with the pigments rupturing the weak links between the chromatogenous molecules and the organic matrix; the molecules continue to be oxidized by the nascent oxygen ions, becoming smaller, less complex and colorless. Depending on the contact time and the bleaching agent concentration, the effervescence of the bleaching reaction would eventually drag the pigment molecular remainder, totally or partially oxidized, out of the dental structure (Riehl, 2002).

$$H_2O_2 \longrightarrow OH^- + OH^- \longrightarrow H_20 \quad + \quad O^-$$

Hydrogen peroxide	Hydroxyl ions	Water	Nascent oxygen

Regardless the technique and the bleaching agent used, the action mechanism of the whitening agents consist in an oxidation reaction, with the release of free radicals. When there is no difference in the bleaching intensity, the saturation point has been reached (Navarro and Mondelli, 2002).

The bleaching indications for vital teeth, regardless of the technique used, usually encompass the darker teeth or those with a yellowish color from the tooth shade itself or those presenting post-eruptive pigmentations (exogenous) caused by alimentary habits from food dyes like coffee, black tea, beetroot and other pigments like nicotine, chromogen bacteria, bacterial plaque, among others. In cases of mechanical or orthodontic traumas the dystrophic calcification of the root coronal pulp may occur, and through the formation of reactional dentin in the entire lumen of the pulp chamber, tooth color change also occurs, usually with a tendency to the yellow color, with these teeth responding well to the bleaching treatment (Mondelli, 1998; Mondelli, Oltrami, D´Alpino, 2002; Navarro e Mondelli, 2002).

According to Ten Cate (1994) and Touati (2000) the color of the dentin tends to become more saturated due the continuous deposition of secondary dentin and the reduction of both the diameter and the number of dentinal tubules, producing an anti-esthetic and aging aspect of the teeth.

Before beginning the treatment, it is necessary to look for the origin of tooth color changes that may have pre-eruptive factors, which incorporate to the dental structure during its formation (tetracycline, fluorosis, hypoplasia), or post-eruptive factors (Zanin *et al*., 2003).

There are several photoactived bleaching options: LED (*Ligth Emitting Diode*), halogen or plasma arc lights and argon laser, but because these sources produce heat, it is important to approach the study by Zack e Cohen (1965) that set safe parameters for pulpal temperature increase. Both the efficacy of the photoactivation source and the safety in terms of pulpal heating should be considered.

Zach and Cohen (1965) developed the first *in vivo* study in rhesus monkeys' teeth *(macaca rhesus)*, because of their similarity with human teeth, to determine intrapulpal temperature increase and its effects on the pulp tissue. The authors have assessed the degree of histological changes that occurs as a function of the different parameters in order to establish safety standards and a correlation between the amount of heat emitted according to the application time and heat transmission to the pulp chamber. Heat production was the main responsible for pulpal changes when the teeth were prepared. The results of the study have demonstrated that the healthy pulps had not recovered from an intrapulpal temperature increase of 20^oF (11.1^oC) in about 60% of the cases. Fifteen percent of the teeth heated to 10^oF ($5.5\ ^oC$) failed to recover. Temperature increases, below this critical level, produced severe reactions related to the heat degree - almost invariably led to pulpal recovery, but left histological sequels. Temperature increases above 20^oF almost invariably destroyed the pulp. Thus, according to this study, pulpal temperature increase must stay below 10^oF (5.5ºC), so the pulp, which is responsible for tooth vitality, is not damaged.

Several authors are unanimous in stating that the small temperature increase that the use of the LED produces in the internal and external tooth structures during the activation of dental resins or whitening agents is its main advantage (Carvalho Filho *et al*., 2006; De Michelli, 2004; Ferreira, 2006; Kabbach *et al*., 2006; Knezevic *et al*., 2002; Ozturk *et* *al*., 2004; Weerakoon *et al*., 2002). LEDs do not produce visible light by heating metal filaments, but through especial characteristics of a semiconductor. The LED is a combination of two different semiconductors, an n-type one, which has electrons in excess and a p-type one, which lacks electrons, but it is rich in gaps or electron “receptor holes”. When a given voltage is applied across these two semiconductors, the electrons will move from the *n*-region to the *p*-region, resulting in an electron and hole flow (Kurachi *et al*., 2001; Medeiros, 2001). All this movement produces photons in a narrow wavelength band, that is, around 470 nanometers. Therefore, LEDs produce a divergent and incoherent light, like the halogen light, concentrating within a narrow spectrum of visible light (Franco e Lopes, 2003).

The light emitted by the LED presents a narrow band emission spectrum (450 – 490nm), with a maximum peak around 470nm (Fig. 1).

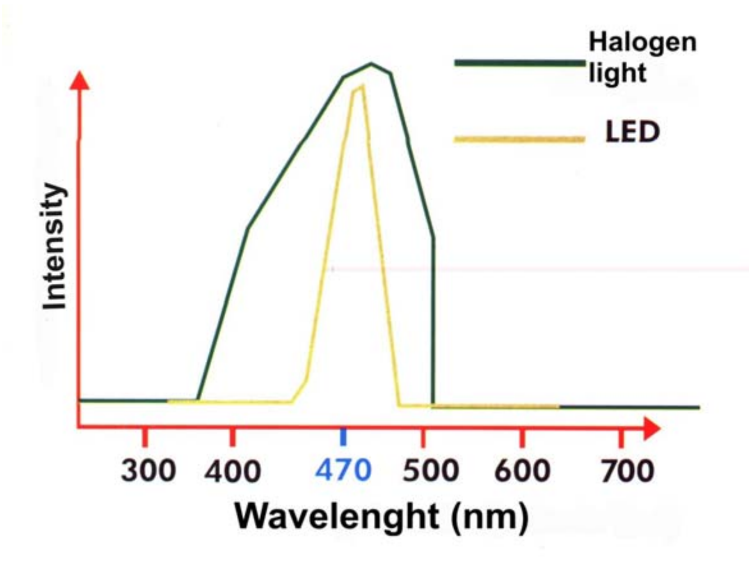

Figure 1. Representation of the light spectrum emitted by the LED in comparison to conventional halogen light
Source: Franco e Lopes, 2003, p.23

It may be observed that the energy produced by an LED has a narrow band, with a maximum peak coinciding with the region of greater camphoroquinone absorption, a photo-initiator found in most of the composite resins. The following are some advantages of LEDs: a) they are assembled in small apparatuses; b) they do not have a cooling system, which reduces their size and noise production; c) they do not need a filter system, which is one of the most expensive parts of the light curing units (Rueggeberg, 1999); d) low energy consumption, which is an inherent semiconductor characteristic; e) they may be operated by batteries, making them more portable; f) they are more resistant to vibrations and/or shocks; g) low heat emission (Franco and Lopes, 2003).

Desensitizing agents may be used to minimize, ou even avoid post-therapy sensitivity; among them, there are 2% potassium nitrate-based ones, which acts on nervous endings preventing depolarization. Two percent or 0.2% potassium fluoride-based desensitizers are different from the previous product; they try to occlude the dentinal tubules due to the formation of obliterating crystals that prevent fluid movement, consequently producing pain (Baratieri *et al*., 2004).

Lima (2005) quantitatively assessed the color change of the dental element, following the vital bleaching technique, varying the bleaching agent type and a catalyst light source. He also analyzed bleaching stability during 30 days after bleaching treatment, and temperature variation of the enamel and dentin opposite to the surface to be bleached produced by the light sources. Fifteen groups (n=5) were studied according to the bleaching agent from different manufacturers: 35% Hydrogen peroxide (Opalescence Xtra, Ultradent), and 37% Carbamide Peroxide (Whiteness Super, FGM). The analyzed photoactivators were: high intensity halogen light, argon laser and plasma arc. After each bleaching session, a photoreflectance reading was carried out by a photoreflectance spectroscopy apparatus. Reflectance is the portion of light radiation reflected by study material; the higher the reflectance value, the more effective was the experimental dental fragment bleaching. The temperature variations of the enamel and the opposite dentin were measured with a laser digital thermometer and a K-type thermocouple attached to a digital thermometer, respectively. The results have demonstrated that 37% carbamide peroxide bleaching gel presented the lower reflectance mean value compared to 35% hydrogen peroxide. For the bleaching agent Opalescence Xtra, the high-intensity halogen source has presented the higher reflectance mean values. For the Whiteness HP bleaching agent, the laser has presented the lowest reflectance mean values, and differed for the high intensity halogen source, and not for the nonuse of the source. The color regression for 35% hydrogen peroxide bleaching agent was observed, however, that regression was not observed for 37% carbamide peroxide. The author’s conclusion was that the performance of the catalyst source was dependent on the bleaching agent used, as well as the behavior of the bleaching agent was dependent on the catalyst source employed.

Bispo (2006) carried out a literature review with the purpose of elucidating the real perspectives and the adverse effects that the indiscriminate use of bleaching agents could bring forth. According to the author, 35% hydrogen peroxide gel is still used associated to the xenon plasma, argon laser, LED and light curing units with halogen light. In 2001 and 2002, the manufacturers of bleaching agents and equipment started to market products with the purpose of making dental bleaching accessible to a large portion of population. Among the new high concentration hydrogen peroxide-based bleaching agents, which are physically and/or chemically activated, we can name: Whiteness HP (FGM *Produtos Odontológicos*), Opalescence Xtra (Ultradent) or Polaoffice (SDI). For the activation of these photosensitivity agents there are the options of using high power halogen light devices like, for instance, the Optilux device (Demetron/Kerr), the plasma arc device with xenon lamp, Apollo 95E (Apollo Elite DMD) or Sapphire (Dent Mat). Devices that emit two light systems, LED and diode laser, such as the Ultrablue IV (DMC *Equipamentos*) and Whitening Laser (DMC *Equipamentos*) or only the diode laser like the Lasering L808 (New Image), and finally argon laser activation, Accure 3000 – Elite Model (Laser Med Inc – USA) (Mondelli, 2003). LEDs have an operating life 100.000 times greater than the conventional photopolymerization units, since it is a cold light, which does not produce excessive heating of the structure to be bleached. Photoactivation acts on components that are commercial secrets, however, it is believed that the carotene present in the color is the main responsible for triggering the oxidation reaction.

Ferreira (2006) studied the analysis of the thermal and optical behavior of two dental FGM bleaching agents irradiated at different wavelengths in the visible spectrum: Whiteness HP and Whiteness HP Maxx. He developed a test bench that showed itself effective both for the assessment of gel influence, wavelength, light transmission time inside the gel, and the analysis of the thermal behavior of both gels. He found significant differences among those assessed factors. He reported that most of the commercial equipment for dental bleaching have LED emitting blue light between 450nm and 480nm, and that it would be interesting that the bleaching agents possessed a photoabsorber pigment with the same spectral band to produce a greater absorption of the incident radiation, gel temperature increase, and consequently reduction of radiation transmission on the dental pulp. The author concluded that Whiteness HP Maxx, which has in its composition an inert load (silica crystals), with the purpose of retaining heat, was the one that presented the least temperature variation when irradiated with red or green LEDs.

CONCLUSION

According to literature, it could be concluded that:

a. LEDs have been the photoactivation source of choice for the professional dental bleaching procedure because they produce lower increases in pulpal temperature, though other photoactivation sources are also used;
b. both LEDs and Brazilian bleaching agents are very viable alternative methods because they present an excellent cost/benefit ratio, both for the dentist and the patient;
c. The bleaching gel should be selected according to the photoactivation source to be used in order to obtain an effective result.

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