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AVALIAÇÃO DE DIFERENTES CATALISADORES NO CLAREAMENTO DENTAL. ESTUDO *IN VITRO*.

Tese apresentada à Faculdade de Odontologia de Piracicaba, da Universidade Estadual de Campinas, para obtenção do Título de Doutora em Clínica Odontológica – Área de Dentística.

Orientador: Prof. Dr. José Roberto Lovadino

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RESUMO

O objetivo deste estudo “in vitro” foi avaliar a eficácia do clareamento dental através da utilização de um gel contendo peróxido de hidrogênio em alta concentração associado a diferentes agentes catalisadores físicos e químicos. Para isso, o estudo foi dividido em 2 experimentos. Experimento 1- avaliou a eficácia do clareamento após tratamento com peróxido de hidrogênio 35 % (Whiteness HP Maxx) ativado por diferentes fontes de luz: Lâmpada halógena (no modo convencional e clareamento) (Optilux 501C, Demetron/Kerr), LED 1° geração (Ultrablue IV, DMC), LED/ laser de diodo (Ultrablue IV, DMC), LED 2° geração (no modo alta potência) (Bluephase 16i, Ivoclar Vivadent) e nenhuma fonte de luz (grupo controle); Experimento 2- avaliou a eficácia do clareamento em consultório ativado com catalisadores químicos e/ou físico: G1- peróxido de hidrogênio 35 % (Whiteness HP Maxx) + 20 % hidróxido de sódio; G2- peróxido de hidrogênio 35 % + 7 % bicarbonato de sódio; G3- peróxido de hidrogênio 38 % (Opalescence Xtra Boost); G4: peróxido de hidrogênio 35 % + lâmpada halógena; G5: peróxido de hidrogênio 35 % + 20 % hidróxido de sódio + lâmpada halógena; G6: peróxido de hidrogênio 35 % + 7 % bicarbonato de sódio + lâmpada halógena; G7: peróxido de hidrogênio 38 % + lâmpada halógena e G8: peróxido de hidrogênio 35 %. Para tanto, fragmentos dentais foram obtidos de terceiros molares humanos e aleatoriamente distribuídos em grupos (n=5) de acordo com o tratamento estipulado. A eficácia do clareamento foi avaliada através de um espectrofotômetro. Para tratar os fragmentos, foram realizadas três sessões de clareamento (sessões 1 a 3). Os resultados foram submetidos à Análise de Variância, seguido do Teste de Tukey ($p<0,05$). Verificou-se que, para ambas as fases, os grupos ativados e não ativados pelos diferentes sistemas catalisadores não diferiram significativamente entre si. Dessa forma, os sistemas catalisadores não melhoraram a efetividade do tratamento clareador de alta concentração.

Palavras-Chave: Espectrofotometria, Dentes - Clareamento, Catalisador.

ABSTRACT

The aim of this *in vitro* study was to evaluate the bleaching efficacy of high concentration bleaching agents activated by chemical or physical catalysts. For this, this study was divided in two parts: Experiment 1- evaluated the efficacy of tooth whitening after treatment with 35 % hydrogen peroxide (Whiteness HP Maxx) activated by different light-curing units: Halogen lamp (Conventional and Bleach mode) (Optilux 501C, Demetron/Kerr), LED 1st generation (Ultrablue IV, DMC), LED/ diode laser (Ultrablue IV, DMC), LED 2nd generation (Bluephase 16i, Ivoclar Vivadent) , and no light source (control group); Experiment 2- analysis of chemical and physical catalysts: G1- 35 % hydrogen peroxide (Whiteness HP Maxx) + 20 % sodium hydroxide; G2- 35 % hydrogen peroxide + 7 % sodium bicarbonate; G3- 38 % hydrogen peroxide (Opalescence Xtra Boost); G4: 35 % hydrogen peroxide + Halogen lamp; G5: 35 % hydrogen peroxide + 20 % sodium hydroxide + halogen lamp; G6: 35 % hydrogen peroxide + 7 % sodium bicarbonate + halogen lamp; G7: 38 % hydrogen peroxide + halogen lamp and G8: 35 % hydrogen peroxide. Blocks obtained from human molars were randomly divided into groups (n=5) in accordance with bleaching treatments. The efficacy of bleaching was measured using a spectrophotometer. Three bleaching sessions were performed (sessions 1 to 3). The results were submitted to ANOVA followed by the Tukey test ($p<0.05$). For both experiments, activated vs. non-activated bleaching did not differ significantly for all the times tested. In conclusion, the activating systems did not improve the whitening effectiveness.

Keywords: Spectrophotometry, Tooth bleaching, Catalyser.

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1 INTRODUÇÃO

A cor do dente é determinada pelo comportamento da luz incidida sobre a sua superfície, que dependendo das características do mesmo pode sofrer reflexão, transmissão, dispersão e absorção. Os pigmentos presentes no dente são responsáveis pela absorção de luz e quanto maior a quantidade de pigmentos, maior a absorção da luz incidida e mais escuro parece ser o dente (Bosh & Coops, 1995; Chu, 2003).

Por muitos anos o peróxido de hidrogênio tem sido o agente de escolha para a oxidação de pigmentos dentais (Viscio *et al.*, 2000). Com o seu uso, o clareamento dental ocorre promovendo uma mudança da matiz do dente. Isso acontece após a quebra do peróxido de hidrogênio que libera radicais livres de oxigênio responsáveis pela degradação dos compostos orgânicos que pigmentam a dentina. O baixo peso molecular do agente clareador permite a passagem deste pelos espaços interprismáticos do esmalte (Kihn, 2007).

Os agentes clareadores estão disponíveis na forma de gel e a indicação da sua concentração depende da forma de aplicação. O clareamento caseiro é realizado através do uso de moldeiras contendo peróxido de carbamida ou de hidrogênio em baixas concentrações. A reação de oxidação do peróxido de carbamida libera peróxido de hidrogênio e uréia. O peróxido de hidrogênio, sendo instável, se dissocia em água e radicais de oxigênio (Haywood, 2000). Já o clareamento de consultório é realizado com peróxido de hidrogênio em altas concentrações associado à fonte de luz ou calor para se conseguir maior quantidade de íons de oxigênio reativos em menor tempo possível. O objetivo é reduzir o tempo da sessão de clareamento em consultório sem perder a eficácia do mesmo (Viscio *et al.*, 2000; Sulieman *et al.*, 2004).

Clinicamente, o clareamento de consultório consiste na aplicação de uma camada de 1 a 2 mm de espessura do gel clareador sobre a face vestibular dos dentes após a proteção do tecido gengival através de uma barreira gengival de resina fotopolimerizável própria para este fim, ou mesmo através de isolamento absoluto. Após 2 minutos de espera, para melhor contato do gel nos tecidos dentais, o gel pode ser ativado por uma fonte de luz. Em seguida, o gel permanece de 8 a 15 minutos no dente antes de ser removido. Em cada sessão podem ser realizadas até 3 aplicações do gel clareador, dependendo da sensação de dor do

paciente. Deve ser aguardado 7 dias para repetição do procedimento clareador, caso necessário (Lima *et al*., 2006).

Várias fontes de luz têm sido utilizadas para ativar o peróxido de hidrogênio, como a lâmpada halógena, LEDs e laseres. A grande preocupação na associação do agente clareador com fonte de energia tem sido o aumento de temperatura causado na câmara pulpar (Zach & Cohen, 1965), uma vez que as fontes de energia têm sido utilizadas de forma empírica para ativar o peróxido de hidrogênio (Baik *et al.*, 2001; Joiner, 2006; Buchalla & Attin, 2007). No entanto, o tempo de exposição dessas fontes de luz deve levar em conta o comprimento de onda da mesma, a densidade de potência (mW/cm^2), a distância da fonte de luz à superfície irradiada e a presença de agentes fotossensíveis no gel clareador, que são capazes de absorver energia adicional da fonte de luz (Goodis *et al.*, 1989; Burgess *et al.*, 2002; Lima, 2005). O clareamento em consultório seria mais seguro se a reação química pudesse ser acelerada sem a utilização de calor.

A velocidade da reação química durante o procedimento clareador é determinada por diversos fatores como o aumento de temperatura, a concentração dos reagentes e a intensidade de luz (Feinman *et al.*, 1991). Segundo Sun (2000), o pH também é de grande importância na catalisação da reação. A ionização do peróxido de hidrogênio em pH alcalino pode aumentar a eficácia do clareamento (Frysh *et al.*, 1993). Chen *et al.* (1993) avaliaram a liberação de oxigênio a partir do peróxido de hidrogênio associado a diferentes substâncias, observando que a associação com o hidróxido de sódio a 20 % resultou em uma formação muito grande de oxigênio. Desta forma, os autores concluíram que a reação de clareamento pode ser mais efetiva em um meio básico.

Os trabalhos existentes na literatura que estudam a associação de clareamento de consultório a fontes de energia não utilizam protocolo padronizado de exposição do gel na amostra e ativação de luz para fazer comparações entre grupos. Além disso, os estudos apresentam resultados contraditórios em relação ao benefício da utilização de um agente catalisador (Papathanasiou *et al.*, 2002; Shethri *et al.*, 2003; Tavares *et al.*, 2003; Luk *et al.*, 2004; Sulieman *et al.*, 2005). Não se pode inferir a real contribuição de cada fonte de energia na ativação do gel e se há alguma diferença significativa em termos de mudança de cor em relação ao grupo sem ativação de luz (Joiner, 2006; Buchalla & Attin, 2007; Kihn,

2007). Dessa forma, o objetivo deste estudo foi avaliar a influência de diferentes catalisadores no clareamento com peróxido de hidrogênio em alta concentração.

2 CAPÍTULO 1

Influence of chemical or physical catalysts on high concentration bleaching agents.

ABSTRACT

The aim of this *in vitro* study was to evaluate the bleaching efficacy of high concentration bleaching agents activated by chemical or physical catalysts. For this, this study was divided in two parts: Experiment 1- evaluated the efficacy of tooth whitening after treatment with 35 % hydrogen peroxide (Whiteness HP Maxx) activated by different light-curing units: Halogen lamp (Conventional and Bleach mode) (Optilux 501C, Demetron/Kerr), LED 1st generation (Ultrablue IV, DMC), LED/ diode laser (Ultrablue IV, DMC), LED 2nd generation (Bluephase 16i, Ivoclar Vivadent) , and no light source (control group); Experiment 2- analysis of chemical and physical catalysts: G1- 35 % hydrogen peroxide (Whiteness HP Maxx) + 20 % sodium hydroxide; G2- 35 % hydrogen peroxide + 7 % sodium bicarbonate; G3- 38 % hydrogen peroxide (Opalescence Xtra Boost); G4: 35 % hydrogen peroxide + Halogen lamp; G5: 35 % hydrogen peroxide + 20 % sodium hydroxide + halogen lamp; G6: 35 % hydrogen peroxide + 7 % sodium bicarbonate + halogen lamp; G7: 38 % hydrogen peroxide + halogen lamp and G8: 35 % hydrogen peroxide. Blocks obtained from human molars were randomly divided into groups (n=5) in accordance with bleaching treatments. The efficacy of bleaching was measured using a spectrophotometer. Three bleaching sessions were performed (sessions 1 to 3). The results were submitted to ANOVA followed by the Tukey test ($p<0.05$). For both experiments, activated vs. non-activated bleaching did not differ significantly for all the times tested. In conclusion, the activating systems did not improve the whitening effectiveness.

Keywords: Spectrophotometry, Tooth bleaching, Catalyser.

INTRODUCTION

The in-office bleaching procedure has been used in order to achieve an optimal whitening effect in a reduced treatment time. For this purpose, hydrogen peroxide has been

used in high concentrations associated with light or chemical activators (Viscio *et al.*, 2000; Sulieman *et al.*, 2004). The bleaching process involves peroxide penetration through enamel prisms to reach the stains in dentin. The pigments molecules double bonds are broken down and the small compounds diffuse out of the tooth or absorb less light and hence appear lighter (Horn *et al*, 1998; Sulieman *et al.*, 2004). Whitening procedures are mostly used for patients whose teeth are stained by aging, chromogenic foods, endodontic treatment, trauma, tetracycline and tobacco (McEvoy, 1989; Kugel *et al.*, 2006). Tooth response to bleaching treatment depends on the type, intensity and duration of discoloration (Kihn, 2007).

The whitening mechanism consists of an oxidation reaction, with the release of free radicals (Sun, 2000). Since the 1900s, in-office bleaching has been used in combination with heated instruments or light sources to accelerate hydrogen peroxide break down. Many devices have been used, such as halogen curing lights, LEDs, diode lasers, argon lasers and plasma arc lamps. The activation protocol is still emphiric, but extensive periods of light activation are not recommended to avoid pulp damage (Joiner, 2006; Buchalla & Attin, 2007).

Tooth sensitivity has been reported as the most common side effect of bleaching treatment. This happens because the hydrogen peroxide byproducts reach the pulp, even in small portions, causing reversible pulpits (Kihn, 2007). The permeability of substances through dentinal tubules can be increased with the rise in temperature (Bowles & Ugwuneri, 1987). Care should be taken with the use of activating energy sources in bleaching procedures. High temperatures, above 5.5 ºC, may cause irreversible damage to the pulp (Zack & Cohen, 1965). For this reason, other forms of activating the hydrogen peroxide reaction have been researched (Lee *et al.*, 2007).

According to Sun (2000), the pH is of great importance in the rate of reaction. When hydrogen peroxide reaction occurs at an alkaline pH, to the order of 9 and 10, the process may be shortened, since the buffered hydrogen peroxide produces more perhydroxyl ions, considered to be a stronger free radical (Frysh *et al.*, 1993; Sun, 2000). Chen *et al.* (1993) measured the decomposition rate of 30 % hydrogen peroxide associated with different catalyst substances and found that 20 % sodium hydroxide accelerated hydrogen peroxide

decomposition. The authors concluded that the bleaching reaction could be more effective in an alkaline medium without the use of heat.

For many years, heat or light has been used with the purpose of hastening the break down of hydrogen peroxide for a faster whitening result. However, the literature raises questions on whether this activation is significant considering the results. Current studies show conflicting results about the benefits catalysts contribute to color improvement (Papathanasiou *et al.*, 2002; Shethri *et al.*, 2003; Tavares *et al.*, 2003; Luk *et al.*, 2004; Sulieman *et al.*, 2005). Thus, the aim of this study was to evaluate the bleaching efficacy of high concentration bleaching agents activated by chemical and/or physical catalysts. The null hypothesis for this study was that the type of catalysts would not interfere in the reflectance values of samples submitted to the bleaching treatment.

MATERIALS AND METHODS

This study was divided in two experiments: 1- Analysis of light curing units and 2- Analysis of chemical and physical activators.

For the experiments 1 and 2, 15 and 20 sound third human molars, respectively, were selected. The teeth were cleaned, polished and examined under a light microscope (X 4) in order to exclude those with cracks and caries lesions. Moreover, specimens with tetracycline and fluorosis stains or specimens with very dark or light color, standing out from the others, were rejected and replaced. The specimens remained immersed in artificial saliva during the entire experiment. This solution was changed everyday.

Seventy 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), 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 efficacy of bleaching was measured using a spectrophotometer (Oriel Instruments, 77702 model, Mountain View, CA, USA) in reflectance mode (Figure 1). For

the reflectance analysis a Teflon sphere was used. For this purpose, the specimens were positioned in the sample carrier that composes the sphere to obtain the reading (Figure 2). Before the bleaching procedure, an initial reading was taken (baseline). The specimen position in the spectrophotometer was standardized by demarcating one of the lateral faces of each specimen 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.

For the bleaching procedure, approximately 1 mm thickness of gel was applied to the enamel surface. For all groups three gel applications were made in each session and three bleaching sessions were performed for all groups in this study (S1, S2 and S3). At the end of each session, there was a waiting period of 24 h for the specimens to re-hydrate before spectrometer readings were taken. The intervals between the sessions were 7 days. All the bleaching treatments were performed at a controlled atmospheric temperature (23.0 ± 1 °C).

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 taken with the aid of a microcomputer. For this, spectral 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 a numeric data was obtained.

Experiment 1- Analysis of light curing units

This study evaluated the efficacy of tooth whitening after treatment with 35 % hydrogen peroxide (HP) (Whiteness HP Maxx - FGM Produtos Odontológicos, Joinville, SC, Brazil) activated by light-curing units: Halogen lamp (HC) (Optilux 501C, Demetron/Kerr, Danbury, CT, USA), Halogen lamp used in bleach mode (HB) (Optilux 501C, Demetron/Kerr, Danbury, CT, USA), LED/ diode laser (Ultrablue IV, DMC, São Carlos, SP, Brazil), LED (Ultrablue IV, DMC, São Carlos, SP, Brazil), LED (LED 2) used with High Power (Bluephase 16i, Ivoclar Vivadent, Liechtenstein, Austria); and no light source (control group). The potencies and wavelengths, in accordance with the

manufacturer's instructions for light curing units are described in Table 1. The potency measurements of the light-curing units were made using an optical power meter (Broadband Power Energy Meter- 13PEM001/ Melles Griot). The specimens were randomly divided into 6 groups (n=5), according to the treatment: G1- 35 % hydrogen peroxide + Halogen lamp (bleach mode); G2- 35 % hydrogen peroxide + Halogen lamp; G3- 35 % hydrogen peroxide + LED/ diode laser; G4- 35 % hydrogen peroxide + LED; G5- 35 % hydrogen peroxide + LED 2; G6- 35 % hydrogen peroxide. The bleaching protocols were as follows:

Non-activated Group (Control Group)

The gel remained on enamel surface for 15 min.

Activated Group

After application, the gel remained on the enamel surface for 2 min before being activated. The gel was activated in two application periods of 30 s, spaced by 1 min interval between them to allow the surface to cool. The tip of each catalytic source was positioned 2 mm from the specimen surface. Gel was removed 11 minutes after source activation. The gel remained on the tooth surface for a total of 15 min.

Experiment 2: Chemical and physical catalyst analyses

The specimens were randomly divided into 8 groups (n=5) according to the treatment: G1- 35 % hydrogen peroxide (Whiteness HP Maxx) + 20 % sodium hydroxide (SH); G2- 35 % hydrogen peroxide (Whiteness HP Maxx) + 7 % sodium bicarbonate (SB); G3- 38 % hydrogen peroxide (Opalescence Xtra Boost – Ultradent); G4: 35 % hydrogen peroxide (Whiteness HP Maxx) + Halogen lamp (Optilux 501C); G5: 35 % hydrogen peroxide (Whiteness HP Maxx) + 20 % sodium hydroxide + halogen lamp (Optilux 501C); G6: 35 % hydrogen peroxide (Whiteness HP Maxx) + 7 % sodium bicarbonate + halogen lamp (Optilux 501C); G7: 38 % hydrogen peroxide (Opalescence Xtra Boost) + halogen

lamp (Optilux 501C) and G8: 35 % hydrogen peroxide (Whiteness HP Maxx). The bleaching protocols were as follows:

35 % hydrogen peroxide (Whiteness HP Max)

The gel remained on the enamel surface for 15 min.

38 % hydrogen peroxide (Opalescence Xtra Boost)

For Opalescence Xtra Boost the hydrogen peroxide was mixed with a chemical activator that comes with the system before use, in accordance with the manufacturer's instructions. The gel remained on the enamel surface for 15 min.

35 % hydrogen peroxide (Whiteness HP Maxx) + chemical activator

Before application on the enamel surface, 10 μL of sodium hydroxide or sodium bicarbonate, according to the group, was mixed with one portion of gel that consisted of 90μL of hydrogen peroxide. The volume of activator used was defined in a pilot study. The gel remained on the enamel surface for 15 min.

35 % hydrogen peroxide (Whiteness HP Maxx) + chemical activator + physical activator

After application of the gel associated with the activator on the enamel surface, two minutes were waited before light activation. The gel was activated in two application periods of 30 s, spaced by 1 min interval between them. The gel was removed 11 minutes after source activation. The gel remained on enamel surface for a total of 15 min.

The results were submitted to repeated measures One-Way ANOVA, followed by the Tukey test ($p<0.05$).

RESULTS

The results of the reflectance analysis are presented in Table 2 and 3. The higher the reflectance values (%), the higher the bleaching results achieved by the specimens.

For experiment 1, the ANOVA test revealed no significant differences among light curing units ($p=0.2361$). The Tukey test was applied for individual comparisons (Table 2). There was difference among sessions ($p=0.0001$) and light curing unit x session interaction ($p=0.0051$).

Activated vs. non-activated bleaching did not differ significantly for all the sessions tested. Session 1 revealed significant differences from baseline for all groups tested. Session 3 differed significantly from session 1, except for hydrogen peroxide activated by halogen light.

For experiment 2, the ANOVA test revealed no significant differences among treatments ($p=0.5753$). The Tukey test revealed significant differences among sessions ($p<0.0001$) (Table 3). The session and treatment interaction was significant ($p<0.0001$).

The treatments did not differ significantly for all the sessions tested. For the following treatments, HP 35 % + SB, HP 38 % and HP 38 % + HC, no significant differences were seen between session 1 and baseline. Session 1 did not differ significantly from sessions 2 and 3 for all treatments, except for the groups where HP 35 % was activated by SB and SH + HC. For these groups, the third session differed significantly from the first one.

DISCUSSION

A number of methods can be used to evaluate tooth whitening performance. Objective methods, such as colorimeters and spectrophotometers, are most used because they are reliable and permit to quantitatively measure the tooth color (Horn *et al.*, 1998; Ishikawa-Nagai *et al.*, 2004; Cesar *et al.*, 2005; Braun *et al.*, 2007). Spectrophotometers differ from colorimeters in that they measure reflected light within the entire visible spectrum, whereas colorimeters measure reflected light at only three wavelengths (Chu, 2003). Although colorimeters provide reproducible results, these can be affected by tooth

translucency, contour and texture (Luk *et al.*, 2004). Some conditions interfere in the measurement of tooth color, such as, rough surface and non-uniform surface geometry. The spectrophotometer in a diffuse reflectance mode minimizes edge losses at the side of the sample tooth and maximizes the collection of reflected light in all directions, which minimizes the disadvantages of sample characteristics (Kwon *et al.*, 2002).

Lights and chemical catalysts did not have a significant effect on the whitening process. In the first experiment, a single in-office treatment was not sufficient to achieve a maximum whiteness result, except for hydrogen peroxide activated by halogen light. In the second experiment, the additional sessions did not improve the results obtained in the first session, except for the groups where hydrogen peroxide 35 % was activated by sodium bicarbonate and sodium hydroxide + halogen lamp. For these groups, the third session significantly differed from the first one.

Over the years, efforts have been made to improve the performance of tooth whitening. The greatest advantage of the in-office procedure is that patient compliance is not required and tooth structures are subjected to less exposure time to whitening gels. The objective is to obtain the best result in a short period of time. For this purpose, light activation and chemical activators have been used. Hydrogen peroxide can form several different active oxygen species depending on temperature, pH, light, co-catalysts, presence of transitional metals and other conditions (Feinman *et al.*, 1991).

Lee *et al.* (2007) investigated the catalytic activities of transitional metals (Fe and Mn) and light irradiation on the reduction of orange II pigment by hydrogen peroxide. They found that when the pigment was in a test tube the degradation was accelerated by the catalysts. However, when the pigment was added to tooth specimens, no significant difference in inner dentin color change was found when the catalysts were used. Joiner (2006) has a critical opinion about the use of artificial stains, such as black tea, coffee, tobacco and red wine to pigment specimens. The author believes that these pigments may be different to those found inside the tooth.

Three factors should be considered when using a light source: light intensity, spectral distribution and irradiation time. Since the total energy depends on light intensity and irradiation time, light curing units with high light intensity may allow a reduction in

irradiation time. Second generation LEDs present higher potency than first generation ones (Hashimoto *et al.*, 2006). Asmussen & Peutsfeldt (2005) stated that the earlier reports that LED curing units generate smaller temperature rises than halogen units can only be considered when using the first generation curing units, which present a low power density. According to these authors, the temperature rise increases with the power density of the curing units. A way to reduce irradiance and consequently heat on the tooth surface is to increase the distance of the light guide from the irradiated surface (Price *et al.*, 2005).

The release of hydroxyl radicals from peroxide can be accelerated by light excitation (photolysis) or temperature rise. The light can be absorbed by hydrogen peroxide, causing bond fission, if the light wavelength corresponds to 248 nm or lower, which is in the ultraviolet region. This limits the use in the oral cavity, since ultraviolet radiation can cause damages to living cells. Thus, the catalyst most used to speed hydrogen peroxide reaction during in-office bleaching is heat. The energy emitted by a light-curing unit can in part be absorbed by the gel and converted into heat. A 10ºC temperature rise can speed hydrogen peroxide decomposition by a factor of 2.2 (Buchalla *et al.*, 2007). In addition, heat increases the peroxide penetration into dental structures (Bowles & Ugwuneri, 1987).

The difference between activated and non-activated groups was not significant, since the exposure time to gel was 15 min. This exposure time was sufficient for hydrogen peroxide to break down completely and the oxygen free radicals to cleave the stain molecules. Another hypothesis is that the exposure time of activator used in this study may not have been sufficient to significantly increase hydrogen peroxide degradation. Kashima-Tanaka *et al.* (2003) investigated the generation of free oxygen radicals by irradiating hydrogen peroxide with light or laser and found that the quantity of hydroxyl radicals varied according to the active agent concentration and irradiation time.

Sulieman *et al.* (2005) used xenon halogen light, plasma arc lamp, halogen lamp, diode laser, and no light in a study to activate bleaching gels, and obtained the same results for activated and non-activated bleaching. Papathanasiou *et al.* (2002) evaluated, in vivo, the effectiveness of light curing vs no light curing of 35 % hydrogen peroxide and found no significant differences between these two groups. On the other hand, Luk *et al.* (2004)

showed that the benefits light sources contribute to the improvement of tooth whitening are material dependent. Tavares *et al.* (2003) found that light increased the tooth whitening effect of peroxide that was activated by a gas-plasma light for 20 min. This is considered a very extended activation period and is not recommended.

Researches have demonstrated that the use of intense light elevates the temperature of the teeth (Baik *et al.*, 2001; Wetter *et al.*, 2004; Asmussen & Peutzfeldt, 2005). Large temperature increases can cause pulpal damage. Eriksson *et al.* (1982) stated that 42ºC was a critical temperature when maintained for 1 min. Pulpal temperature increases associated with light application could be lessened by decreasing the power of the energy source (Wetter *et al.*, 2004) or reducing the duration of light exposure (Luk *et al.*, 2004).

In-office bleaching would be safer if the chemical reaction could be accelerated without heat. Efforts have been made to promote a condition whereby a larger number of stronger free radicals are obtained in less time (Frysh *et al.*, 1993; Sun, 2000). Sodium hydroxide and sodium bicarbonate increase the pH of hydrogen peroxide, enhancing peroxide decomposition (Marshall *et al.*, 2001). Chen *et al.* (1993) found that 20 % sodium hydroxide was efficient in accelerating the decomposition of hydrogen peroxide, producing a high level of gas after 3 min. In the present study, the use of hydrogen peroxide associated with 20 % sodium hydroxide or 7 % sodium bicarbonate did not differ significantly from hydrogen peroxide alone for obtaining tooth color change. Moreover, the 38 % hydrogen peroxide (Opalescence Xtra Boost) used in this study, which comes with a chemical activator that increases the pH (Sulieman *et al.*, 2005), did not differ significantly from the other treatments. In a similar study, Shethri *et al.* investigated the efficacy of 35 % hydrogen peroxide (Star Brite, Interdent Inc) and 38 % hydrogen peroxide *in vivo*, when the gels remained on the specimens for a total of 45 min (3 applications of 15 min). The results showed no statistical difference in bleaching efficacy. The period during which the gel remained in contact with the tooth surface may not have been sufficient to achieve the maximum result without requiring the use of an activator. According to Lu *et al.* (2001), the number of applications and duration of each are important factors for achieving a good result.

The most significant whitening effect was achieved in the first session for Experiment 1, however, the third session showed a significant improvement and differed from the first session. For Experiment 2, the additional sessions did not improve tooth whitening for all groups, except for 35 % hydrogen peroxide activated by sodium bicarbonate and 35 % hydrogen peroxide activated by sodium hydroxide + halogen lamp. For these groups, the third session significantly differed from the first one. According to Kihn (2007), the length of treatment depends on the severity of tooth discoloration. Cases in which the staining is not very intensity and the discoloration is yellow or brown and not gray or blue, in general respond more readily to the bleaching treatment. The number of the bleaching sessions necessary to achieve optimal whitening depends on the type and intensity of discoloration. In most cases two or more treatment sessions are necessary for optimal results (Shethri *et al.*, 2003; Joiner, 2006). Some of the shade difference after an in-office bleaching session results from dehydration caused by isolating the teeth and the heat generated by light curing unit, which may contributes to a significant rebound (Papathanasiou *et al.*, 2002; Kugel *et al.*, 2006). In the present study, the analyses were made 24 h after the bleaching treatment to allow the specimens to rehydrate.

The null hypothesis for this study was accepted, since that changes in reflectance values were not influenced by the catalysts systems. Further research is needed to determine the effects of the physical and chemical activators on a reduced period of treatment session.

CONCLUSION

For both experiments, the activating systems did not improve the whitening effectiveness.

In the first experiment, a single in-office treatment was not sufficient to achieve a maximum whiteness result, except for hydrogen peroxide activated by halogen light.

In the second experiment, the additional sessions did not improve the results obtained in the first session, except for the groups where hydrogen peroxide 35 % was activated by sodium

bicarbonate and sodium hydroxide + halogen lamp. For these groups, the third session significantly differed from the first one.

ACKNOWLODGEMENTS

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CAPTIONS

Figure 1: Spectrophotometer used in reflectance mode (Oriel Instruments, 77702 model).

Figure 2: Positioning of the sample port and optical fiber inside the sphere**.**

Table 1: Potencies and wavelengths of light-curing units

Table 2: Mean (%) and standard deviation of reflectance for experiment 1.

Table 3: Mean (%) and standard deviation of reflectance for experiment 2.

Figure 1

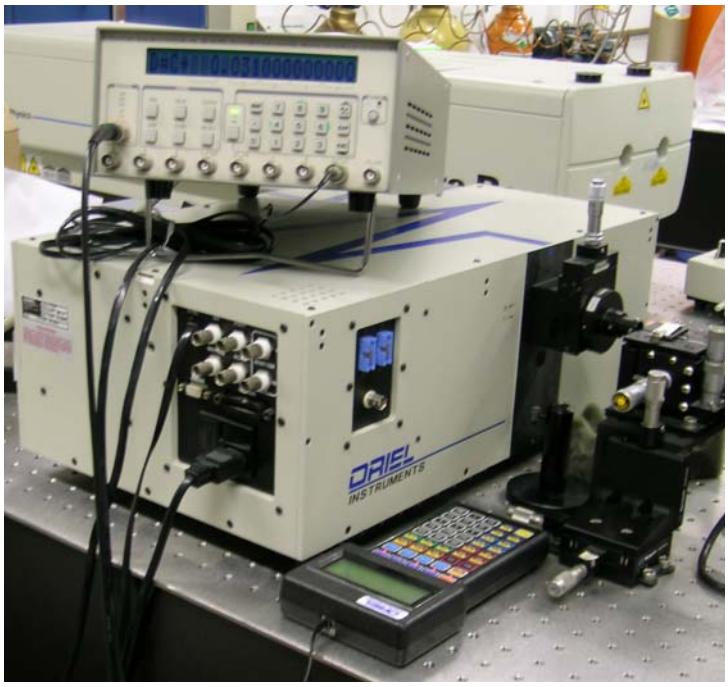

Figure 2

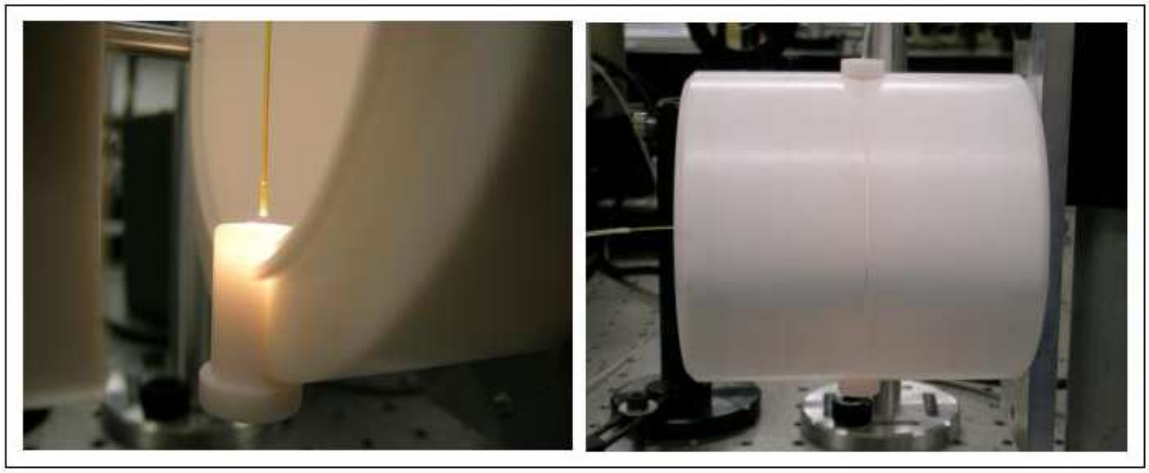

Table 1

LIGHT SOURCE	POTENCY	WAVELENGTH*
Halogen Lamp	470 mW (Conventional tip)	350 - 500 nm
Halogen Lamp (Bleach mode)	460 mW (Turbo tip)	350 - 500 nm
LED	164 mW	450 - 500 nm for LED
LED/Diode Laser	260 mW for LED and 128 mW for diode laser	450 - 500 nm for LED and 830 nm for diode laser
LED 2 (High Power mode)	880mW	430 - 490 nm

*According to the manufacturers' instructions.

Table 2

LIGHT UNITS	SESSION			
	Initial (Baseline)	**1**	**2**	**3**
HB	15098.75 (368.7) C a	17609.25 (461.4) AB a	17521.72 (460.7) B a	18370.90 (834.1) A a
HC	15147.43 (335.7) C a	17342.24 (571.7) B a	17696.92 (431.9) AB a	18267.57 (369.7) A a
LED/Laser	14947.61 (512.9) C a	16677.35 (495.0) B a	17185.07 (831.1) AB a	17968.85 (670.7) A a
LED	15785.85 (251.5) C a	16917.05 (464.1) B a	17400.36 (516.4) AB a	18183.02 (585.9) A a
No source	14951.27 (472.0) C a	16793.11 (325.7) B a	17686.40 (327.7) A a	18002.52 (655.7) A a
LED 2	15143.87 (592.6) C a	17612.13 (424.2) B a	17948.11 (379.3) A a	18484.24 (253.9) A a

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.

Table 3

TREATMENT	SESSION			
	Initial (Baseline)	**1**	**2**	**3**
HP 35% + SH	15121.38 (480.1) B a	17524.95 (826.2) A a	17973.75 (778.7) A a	18317.75 (376.4) A a
HP 35% + SB	14850.92 (355.2) B a	16960.81 (273.9) B a	17641.21 (516.6) AB a	17913.44 (351.0) A a
HP 38%	16228.16 (638.8) B a	17073.51 (664.9) AB a	17740.84 (494.6) A a	17928.91 (563.0) A a
HP 35% + HC	15893.9 (443.0) B a	17284.70 (199.3) A a	18061.16 (182.4) A a	17998.92 (723.8) A a
HP 35% + SH + HC	14641.03 (439.3) C a	17200.65 (294.1) B a	18037.33 (309.5) AB a	18212.76 (305.6) A a
HP 35% + SB + HC	15455.42 (410.6) B a	17483.99 (565.4) A a	18055.80 (365.8) A a	18083.71 (506.9) A a
HP 38% + HC	15955.60 (568.6) B a	16982.4 (401.7) AB a	17686.77 (632.9) A a	17683.92 (741.6) A a
HP 35%	15913.28 (639.5) B a	17210.24 (432.3) A a	17677.11 (260.8) A a	17858.86 (382.1) A a

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.

3 CONCLUSÃO

As fontes de luz e os catalisadores químicos não alteraram o comportamento do agente clareador.

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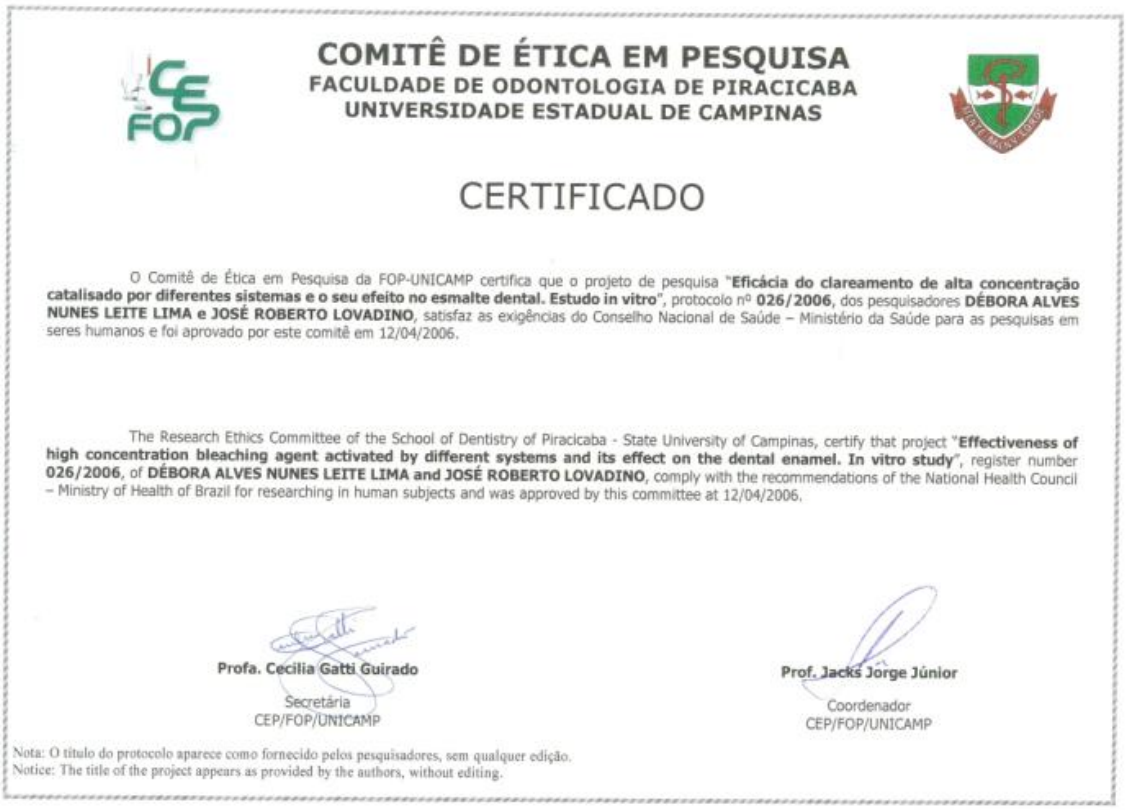
* De acordo com a norma da UNICAMP/FOP, baseadas na norma do International Committee of Medical Journal Editors – Grupo de Vancouver. Abreviatura dos periódicos em conformidade com o Medline.

ANEXO 1 – CERTIFICADO DE APROVAÇÃO DO COMITÊ DE ÉTICA EM PESQUISA



COMITÊ DE ÉTICA EM PESQUISA
FACULDADE DE ODONTOLOGIA DE PIRACICABA
UNIVERSIDADE ESTADUAL DE CAMPINAS

CERTIFICADO

O Comitê de Ética em Pesquisa da FOP-UNICAMP certifica que o projeto de pesquisa "**Eficácia do clareamento de alta concentração catalisado por diferentes sistemas e o seu efeito no esmalte dental. Estudo in vitro**", protocolo nº **026/2006**, dos pesquisadores **DÉBORA ALVES NUNES LEITE LIMA e JOSÉ ROBERTO LOVADINO**, satisfaz as exigências do Conselho Nacional de Saúde – Ministério da Saúde para as pesquisas em seres humanos e foi aprovado por este comitê em 12/04/2006.

The Research Ethics Committee of the School of Dentistry of Piracicaba - State University of Campinas, certify that project "**Effectiveness of high concentration bleaching agent activated by different systems and its effect on the dental enamel. In vitro study**", register number **026/2006**, of **DÉBORA ALVES NUNES LEITE LIMA and JOSÉ ROBERTO LOVADINO**, comply with the recommendations of the National Health Council – Ministry of Health of Brazil for researching in human subjects and was approved by this committee at 12/04/2006.

Profa. Cecilia Gatti Guirado
Secretária
CEP/FOP/UNICAMP

Prof. Jacks Jorge Júnior
Coordenador
CEP/FOP/UNICAMP

Nota: O título do protocolo aparece como fornecido pelos pesquisadores, sem qualquer edição.
Notice: The title of the project appears as provided by the authors, without editing.

ANEXO 2 – RESULTADO DO TESTE ANOVA PARA ANÁLISE DA REFLECTÂNCIA (EXPERIMENTO 1).

The SAS System

The GLM Procedure

Class Level Information

Class	Levels	Values
fonte	6	1 2 3 4 5 6
amostra	5	1 2 3 4 5
tempo	4	1 2 3 4

Number of observations 120

The SAS System

The GLM Procedure

Dependent Variable: valor

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	47	179047376.4	3809518.6	29.73	<.0001
Error	72	9225413.3	128130.7		
Corrected Total	119	188272789.7			

R-Square	Coeff Var	Root MSE	valor Mean
0.951000	2.101789	357.9535	17030.90

Source	DF	Type I SS	Mean Square	F Value	Pr > F
fonte	5	4727229.2	945445.8	7.38	<.0001
fonte*amostra	24	15425486.1	642728.6	5.02	<.0001
tempo	3	154089314.2	51363104.7	400.86	<.0001
fonte*tempo	15	4805346.8	320356.5	2.50	0.0051

Source	DF	Type III SS	Mean Square	F Value	Pr > F
fonte	5	4727229.2	945445.8	7.38	<.0001
fonte*amostra	24	15425486.1	642728.6	5.02	<.0001
tempo	3	154089314.2	51363104.7	400.86	<.0001
fonte*tempo	15	4805346.8	320356.5	2.50	0.0051

Tests of Hypotheses Using the Type III MS for fonte*amostra as an Error Term

Source	DF	Type III SS	Mean Square	F Value	Pr > F
fonte	5	4727229.249	945445.850	1.47	0.2361

The SAS System

The GLM Procedure

Level of fonte	Level of tempo	N	valor Mean	valor Std Dev
1	1	5	15098.7537	368.706826
1	2	5	17609.2492	461.429590
1	3	5	17521.7165	460.716972

1	4	5	18370. 8986	834. 064534
2	1	5	15147. 4359	335. 682755
2	2	5	17342. 2390	571. 743891
2	3	5	17696. 9203	431. 933104
2	4	5	18267. 5689	369. 757233
3	1	5	14947. 6091	512. 941704
3	2	5	16677. 3469	494. 963689
3	3	5	17185. 0712	831. 144388
3	4	5	17968. 8539	670. 663528
4	1	5	15785. 8534	251. 491309
4	2	5	16917. 0557	464. 144947
4	3	5	17400. 3595	516. 378207
4	4	5	18183. 0164	585. 957477
5	1	5	14951. 2720	471. 960059
5	2	5	16793. 1063	325. 745063
5	3	5	17686. 4051	327. 734816
5	4	5	18002. 5166	655. 711241
6	1	5	15143. 8751	592. 587527
6	2	5	17612. 1278	424. 235778
6	3	5	17948. 1159	379. 295506
6	4	5	18484. 2419	253. 956925

ANEXO 3 – RESULTADO DO TESTE ANOVA PARA ANÁLISE DA REFLECTÂNCIA (EXPERIMENTO 2).

The SAS System

The GLM Procedure

Class Level Information

Class	Levels	Values
trat	8	1 2 3 4 5 6 7 8
amostra	5	1 2 3 4 5
tempo	4	1 2 3 4

Number of observations 160

The SAS System

The GLM Procedure

Dependent Variable: valor

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	63	192282949.2	3052110.3	22.40	<.0001
Error	96	13080138.0	136251.4		
Corrected Total	159	205363087.2			

R-Square	Coeff Var	Root MSE	valor Mean
0.936307	2.152894	369.1225	17145.41

Source	DF	Type I SS	Mean Square	F Value	Pr > F
trat	7	3443952.7	491993.2	3.61	0.0017
trat*amostra	32	19120153.6	597504.8	4.39	<.0001
tempo	3	157091045.3	52363681.8	384.32	<.0001
trat*tempo	21	12627797.5	601323.7	4.41	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trat	7	3443952.7	491993.2	3.61	0.0017
trat*amostra	32	19120153.6	597504.8	4.39	<.0001
tempo	3	157091045.3	52363681.8	384.32	<.0001
trat*tempo	21	12627797.5	601323.7	4.41	<.0001

Tests of Hypotheses Using the Type III MS for trat*amostra as an Error Term

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trat	7	3443952.738	491993.248	0.82	0.5753

The SAS System

The GLM Procedure

Level of trat	Level of tempo	N	valor Mean	valor Std Dev

1	1	5	15121. 3836	480. 105418
1	2	5	17524. 9579	826. 210919
1	3	5	17973. 7466	778. 675957
1	4	5	18317. 7547	376. 376598
2	1	5	14850. 9183	355. 169924
2	2	5	16960. 8141	273. 947881
2	3	5	17641. 2140	516. 606020
2	4	5	17913. 4480	350. 967703
3	1	5	16228. 1666	638. 791858
3	2	5	17073. 5196	664. 894063
3	3	5	17740. 8483	494. 581031
3	4	5	17928. 9173	562. 968133
4	1	5	15893. 8658	443. 038409
4	2	5	17284. 6982	199. 312052
4	3	5	18061. 1692	182. 387571
4	4	5	17998. 9191	723. 758407
5	1	5	14641. 0268	439. 275449
5	2	5	17200. 6485	294. 135060
5	3	5	18037. 3341	309. 521479
5	4	5	18212. 7619	305. 634419
6	1	5	15455. 4241	410. 633507
6	2	5	17483. 9853	565. 386918
6	3	5	18055. 7961	365. 766430
6	4	5	18083. 7177	506. 907309
7	1	5	15955. 6034	568. 641639
7	2	5	16982. 3573	401. 715996
7	3	5	17686. 7741	632. 885306
7	4	5	17683. 9216	741. 645963
8	1	5	15913. 2787	639. 534825
8	2	5	17210. 2370	432. 322611
8	3	5	17677. 1128	260. 791139
8	4	5	17858. 8557	382. 057669