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Effect of a bleaching agent on the color stability of a microhybrid composite resin

Efeito de um agente de clareamento na estabilidade de cor de uma resina composta micro-híbrida

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Abstract

Objectives: To evaluate the effect of Opalescence™ PF home bleaching gel on the color stability of Amelogen™ Plus microhybrid composite resin. **Material and method**: Thirty disks were fabricated for testing using three different shades (A1, A2 and A3.5) of Amelogen™ Plus composite. Standardized L*a*b* parameters were determined and the specimens were subjected to 15% carbamide peroxide. The L*a*b* parameters were measured again and the color change (ΔE) in the composite disks were calculated. The data were analyzed using the One-way ANOVA and Tukey tests. ($\alpha = 0.05$) **Results**: In all specimens the mean of ΔE was more than 3.3. There was a significant difference between shade A3.5 and A2 and with shade A1, as A1 showed the lowest values of color change with bleached composites being lightened in comparison with the unbleached specimens. The greatest change occurred in the red-green (a*) parameter. **Conclusion**: 15% carbamide peroxide bleaching gel (Opalescence® PF) caused a clinically detectable color change with each of three different shades (A1, A2 and A3.5) of Amelogen™ Plus ($\Delta E > 3.3$) tested. The greatest color change occurred with the A3.5 shade and the least change was associated with the A1 shade.

Keywords: Bleaching. Composite resin. Color shade.

Resumo

Objetivos: *Avaliar o efeito do gel de clareamento doméstico Opalescente® na estabilidade de cor do microcompósito Amelogen® Plus.* ***Material e método***: *Parâmetros L*a*b* foram determinados e os espécimes foram sujeitos a peróxido de carbamida a 15%. Os parâmetros L*a*b* foram medidos novamente e a alteração de cor (ΔE) nos discos de compósito foi calculada. Os dados foram analisados pelos testes One-way ANOVA e Tukey (α = 0.05).* ***Resultados***: *Em todos os espécimes o valor médio de ΔE foi maior do que 3.3. Não houve diferença significante entre cores A3,5, e A2 A1. A1 mostrou o mais baixo valor, sendo mais claros os compósitos submetidos ao agente clareador em comparação aos espécimes não submetidos. A maior alteração ocorreu no parâmetro vermelho-verde (a*).* ***Conclusão***: *O gel de peróxido de carbamida a 15% (Opalescente® PF) causou uma alteração de cor clinicamente detectável em cada uma das diferentes cores (A1, A2 e A3,5) do compósito Amelogen® Plus testado. A maior alteração de cor ocorreu com a cor A3.5 e a menor foi associada à cor A1.*

Palavras-chave: *Clareamento. Resinas compostas. Cor.*

Introduction

The use of bleaching techniques is a relatively new approach to lighten teeth stained by either extrinsic or intrinsic means. The efficacy of bleaching agents depends on the type of stain, its etiology, and the exposure time of the bleaching agent used (1). However, tooth structure and composite resin restorations vary in their response to bleaching agents in terms of color change. Thus, composite restorations that matched the shade of restored tooth may no longer match following a bleaching procedure. Bleaching can also cause the deterioration the surface of composite restorations and induce bacterial adhesion (2) as well as increase the potential for future extrinsic staining of the restoration (3).

Previous studies revealed controversial results in evaluating the effects of bleaching agents on the color change of tooth-colored restorative materials (4-12). Studies (4, 5, 7-10, 13) have reported color changes of composite resin after bleaching can be affected by factors associated with the restorative material such as the:

– properties of the chemical activator;
– properties of the resin initiator and inhibitor;
– polymerization activation process;
– quality of the polymer;
– Bis-GMA in the monomer;
– type and quantity of inhibitor used;
– type of filler, quantity of filler in the composite;
– oxidation of unreacted carbon-carbon double bonds;
– concentration and type of bleaching agents.

Some studies have demonstrated a minimal degree of color change that was clinically undetectable in composite resin after vital bleaching with carbamide peroxide at concentrations ranging from 10 to 16% (5, 7, 9). In contrast, one study (8) reported a profound color change, or lightening and deterioration of composite resin after bleaching with carbamide peroxide at concentrations of 6%, 16% and 20% as well as another study using a concentration of 15% carbamide peroxide (10) employing the same bleaching technique.

Other studies have documented the effect of hydrogen peroxide on the color change of composite resin (3, 4). Analysis of surface reflectance showed significant changes in microfilled and hybrid composite resin after application of highly concentrated whiteners containing 30-35% hydrogen peroxide (14). Only one previous study showed the loss of the surface gloss of composite materials after bleaching with carbamide peroxide (7). Replacement of existing composite restorations due to a mismatch of color between existing composite restorations and adjacent tooth structure as a result of the lightening effect carbamide peroxide bleaching on composite resins is an important clinical issue. Color change and resultant loss of the shade match between composite restorations and the surrounding tooth structure is perhaps the most frequent reason for replacement of existing restoration after bleaching (15). Patients who use home bleaching products can inadvertently alter the color match between tooth structure and composite restorations due to the lack of control of the bleaching agents in such systems.

The aim of this *in vitro* study was to evaluate the effect of Opalescence™ PF home bleaching agent on the color stability of Amelogen™ Plus microhybrid composite resin. The null hypothesis of this study was that the application of 15% carbamide peroxide has no significant effect on the color of microhybrid composite resin.

Materials and methods

Three different shades of a Amelogen™ Plus (Amelogen, Ultradent, South Jordan, UT, USA) microhybrid composite resin (A1, A2, A3.5) were used in the study. The rationale for use of this material was that it is used for the restoration of both anterior and posterior teeth. The Opalescence™ PF brand of 15% carbamide peroxide; (Ultradent, South Jordan, UT, USA) was selected for the bleaching process.

A stainless steel disk was machined to 20 mm in diameter and 2 mm in thickness. The disk was bonded to a glass slab. A single-mix impression of this disk was made with a silicone. (Speedex™, Coltene-Whaledent, Mahwah, NJ, USA) to fabricate a mold. Ten specimens of each shade of the composite resin were made by incrementally placing the material in the mold to create a total of 30 specimens. The specimens were polymerized for 40 seconds after placement of each increment of composite using a light-polymerizing unit (Optilux 500™, Demetron-Kerr, Orange, GA, USA) with a 1 cm tip. The same light-polymerizing unit was used for all specimens at an intensity setting of 400mW/cm² as measured using a light meter (Hilux Dental Curing Light Meter™; Benlioglu Dental, Inc., Ankara, Turkey). During the final light-polymerization process, a clear slab was placed over the mold to obtain a flat surface for the specimens.

Each specimen was inspected before and after treatment with the bleaching gel to determine if any alterations in the color of the surface of the specimens were visible to the naked eye. Prior the baseline color determination, the specimens were rinsed with running tap water for 1 minute and blotted dry. Three quantitative baseline color measurements were performed for each specimen using a Model C-10 Minolta, colorimeter (Minolta™, Tokyo, Japan) in accordance with the Commission International d'Eclairage (CIE) system and the mean of the readings was calculated.

The CIE system describes the colors visible to the human eye and is used to specify a spectral color precisely in terms of the proportions (tristimulus values) of three additive primary colors: red, blue and green. The system utilizes an abbreviation of L*a*b* to indicate a lightness scale (L* designation) and an opponent color axes for redness-greenness (a* designation) versus a yellowness-blueness (b*designation). Negative values of a* indicate green while positive values indicate magenta and negative values of b* indicate blue and positive values indicate yellow (16).

Next the experimental groups were immersed in; Opalescence™ PF home bleaching gel (15% carbamide peroxide) for 8 hours for 14 consecutive days to simulate nighttime bleaching using a mouthguard-type carrier. Throughout the experiment, specimens were stored in a dark environment at room temperature (24 ºC ± 2). After completion of the bleaching time the bleaching agent was rinsed away from the specimens with running tap water for 1 minute, blotted dry, and placed in Petri dishes filled with physiological saline solution for storage. At the end of the entire treatment period of 14 days, the specimens were again rinsed with running tap water, blotted dry and stored in saline solution for 24 hours.

The color of each specimen was then calculated again using the CIE/Lab system. Color changes (ΔE) were determined using the following equation (10):

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

In terms of CIE/Lab units, a ΔE of less than 3.3 is considered clinically insignificant. The data normality for all of the specimens was obtained using a nanparametric Kolmogrov Smirnov test ($p > 0.05$). Then, a parametric statistical analysis of one-way analysis of variance (ANOVA) and Tukey's Post hoc tests were performed for comparison of data between groups. ($\alpha = 5\%$).

Results

The mean and standard deviation of ΔE and color coordinates (ΔL^*, Δa^* and Δb^*) for the three groups of specimens are shown in Table 1 and Figure 1.

Table 1 - Means and standard deviation of ΔE, ΔL*, Δa*and Δb*in each group and ANOVA results

Groups	ΔL*	Δa*	Δb*	ΔE	SD	F value
A1	0.6	-5.78	0.48	6.2855	1.5926	1.59569
A2	1.45	-8.4	1.12	8.8156	2.2227	2.22270
A3/5	2.45	-10.49	2.75	11.2011	1.2427	1.24279

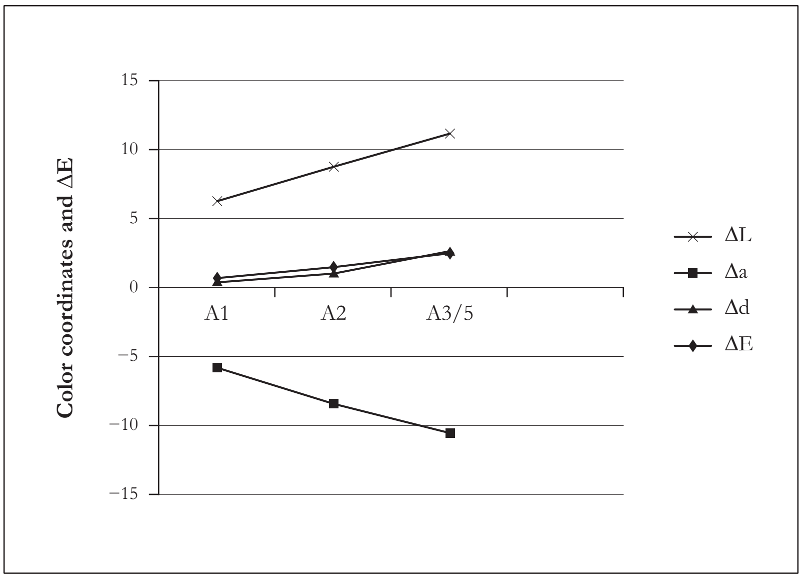

Figure 1 - Means of ΔE, for the ΔL*, Δa*, Δb* of the three experimental groups

The color difference between baseline and bleaching for each shade were more than 3.3. This means after bleaching three different shades of Amelogen™ Plus demonstrated a clinically significant color change (ΔE > 3.3). The One-way ANOVA revealed significant differences in ΔE for three groups ($p < 0.05$). The Tukey's Post hoc comparison showed the least color change for the A1 and the most for the A3.5 color shades of Amelogen™ Plus. The degree of color change of the A2 shade was between the two aforementioned shades with respect to lightening using 15% carbamide peroxide.

Discussion

Although the null hypothesis was rejected, this study showed that bleaching with 15% carbamide peroxide produced a significant color change which is consistent with some previous investigations (4, 8, 10). This investigation used three shades of one microhybrid composite (A1, A2 and A 3.5) representing three distinct areas of the color spectrum.

The optical characteristics of composite resin are dependent on the type and size of filler particles and the pigment of the resin (17). The filler particles absorb the scatter light due to refractive and reflective properties thus alter the transmission spectrum (18). This difference in light transmission properties results in different shades of the restorative material.

The color changes in shades A1, A2 and A3.5 were all within a clinically acceptable range (ΔE > 2.72) (19) after bleaching. Therefore bleaching with 15% carbamide peroxide had a significant effect on lightening of this microhybrid composite. A greater improvement in color change occurred with composite resin specimens with a darker original color.

The pair wise comparison showed a significant difference in ΔE values among the three test groups indicating that the 15% carbamide peroxide bleaching agent significantly influenced the color change of Amelogen™ Plus microhybrid composite resin.

Among previous studies in which the color change of composite resin was evaluated as a result of bleaching with 16% carbamide peroxide, only one study (7) found no significant clinically detectable color change with a microhybrid composite resin which is not in agreement with the findings of the present study. That study differed in that only the A3 color shade was tested using three different whiteners Whiteness Perfect™ (16% carbamide peroxide) Whiteness Super™ (37% carbamide peroxide) and 35% hydrogen peroxide. The effect of different whitening agents on only one shade of one ormocer, one micofilled and one microhybrid composite was examined. In contrast the present study examined three different color shades to compare them with each other regarding the difference in color change after whitening using just one bleaching agent. The investigators in that study concluded that because a microhybrid composite resin consists of lower volumetric filler content in a urethane dimethacrylate monomer there was a higher degree of oxidation of the composite by the bleaching agent resulting in a lower filler loading in resin monomer (20). The microhybrid composite resin used in the present study consisted of a Bis-GMA resin monomer. Results of previous study claimed that methacrylate-based materials demonstrated more color stability, or a slow color change when exposed to a 25% hydrogen peroxide with bleaching agent at a pH of 8 (Rembrandt™) (21).

In the present study the three color shades of A1, A2 and A3.5 were compared with respect to differences in color change after vital bleaching with 15% carbamide peroxide that had not been studied previously. The greatest lightening of the composite material was found in the A3.5 shade group followed by the A2 shade group. There was a significant difference between these two groups and the A1 shade group which showed the least color change. Even though the A1 group showed the least amount of the color change (ΔE = 6.28) among groups, its color change was still clinically detectable (19).

One study showed that oxidation of readily accessible surface pigments by a bleaching agent is one of the mechanisms resulting in a substantial lightening of darker shades of microhybrid composite resin (3). In addition, the degree of conversion of resin matrix to polymer may allow some resins to be attacked by bleaching solutions. Therefore, the bleaching effect is both material and concentration dependent. In the present study Amelogen™ plus demonstrated a substantial sensitivity to 15% carbamide peroxide gel which is consistent with reports that Bis-GMA-based restorative materials have shown color change in response to a bleaching agent (4, 5, 15).

Monaghan and Trowbridge (3) stated that the formulation of each shade of composite resin is uniform and is effected uniquely by the bleaching process. In the present study examination of the chromatic values of the bleached composites revealed all shades of composite resin showed a slight increase in the red/green color element based on their a* values. This was also in agreement with the results of studies done by Monaghan and Trowbridge (3) as well as Hubbezoglue et al. (7) who concluded that it is difficult to give a clear explanation for this phenomenon, but attribute this change to some amine synergists may create red/green by-products.

The lightening of specimens was depicted as an increase in L* while actual hue-chroma changes was demonstrated in changes in a* or/and b*.However a change in a* or *b directions can also result in a shift in the L* direction (9). Canay et al. (5) were unable to demonstrate a color change in hybrid and macrofilled composite after using a 10% carbamide peroxide bleaching agent. They stated the amount of color change in tooth-colored materials appeared to be related to the matrix contents, the amount of filler and the filler type.

In previous studies the color change of microflled and hybrid (5); microfilled, microhybrid (Gradia) (7) and microfilled, nanofilled (8) composite resins following a bleaching procedure has been cited as a disadvantage for composite restorations. These studies focused on composites that perfectly matched the surrounding tooth structure prior to bleaching and may no longer match once the teeth have become lighter or brighter as a result of bleaching.

However, if other physical and mechanical properties of the composite are not compromised this phenomenon could be a desirable outcome despite the findings of one study that demonstrated a minimal degree of statistically significant deterioration of hardness and discoloration of microhybrid composite (3M, Valux™) after the bleaching process (4). For example, the lightening of composite veneers placed in several anterior teeth using a safe and easy procedure such as carbamide peroxide bleaching to spare the patient a complex and expensive replacement process.

The present study only evaluated the color change of Amelogen™ Plus and did not address other physical properties of the material such as the degree of softening, dilution of the resin elements, status of surface hardening, presence of cracks and bacterial adhesion to the surface of composite. Future studies are needed investigate these characteristics of microhybid composite resins in order to confirm that these restorations are still clinically acceptable after bleaching. Another limitation of this study was the use of only on one brand of composite. Other composite resins need to be evaluated in the future. The conclusions the present study might apply to all microhybid composites but it is not known if they would applicable to monomer-based resins.

Clinical significance

Color matching microhybrid composite resin restorations in dark-shaded teeth can be expected to lighten during a home bleaching procedure even when a low concentration (15% carbamide peroxide) whitening gel is used and eliminating the necessity of replacing these restorations based on a color mismatch alone.

Conflict of interest

The authors declared no conflict of interest in the present manuscript.

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