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Effect of 15% carbamide peroxide bleaching gel on color of Class V resin composite restoration

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ABSTRACT

Objective: To investigate effect of 15% carbamide peroxide bleaching gel on color of Class V resin composite restoration.
Materials and methods: 60 class V cavities were made in maxillary premolars Teeth were randomly divided into four groups of 15 specimens each (2 control and 2 experimental or bleached groups). Group A to be restored with light nanocomposite resin (Filtek Z350 XT) with no post-restoration bleaching procedure (control). Group B to be restored with light nanocomposite resin (Filtek Z350 XT, with post-restoration bleaching procedure (Experimental). Group C to be restored with microhybrid resin (Filtek 250 XT) with no post-restoration bleaching procedure (control). Group D to be restored with microhybrid resin (Filtek 250 XT), with post-restoration bleaching procedure (Experimental). The bleaching was made with 15% at home bleaching agent (Opalescence PF). Color, opacity and fluorescence were analyzed by taking digital photos for the specimens at baseline and 24 h after completion of the bleaching procedure. The color pattern was evaluated according to the CIE - L*, a* and b* color system. Bleaching according to the following equation (25) ΔE = [(ΔL) 2 + (Δa) 2 + (Δb) 2] 1/2 For optical analysis, the specimens were subjected to the color measurements on white and black patterns, considering only the L* coordinate, which was calculated according to the formula: Opacity = L*b/L*w, where L*b corresponds to the reading of the L* coordinate against a black background and L*w against a white background. This procedure was performed before after bleaching, and the difference in opacity between the two periods was calculated in percentage. While for fluorescence comparison, the Fluorescence parameter (FL) was calculated, at baseline and post bleaching procedure, as the difference in color (ΔE) depending on the inclusion or exclusion of the UV component according to the equation: FL = [(CIE L*100 – CIE L*0) 2 + (CIE a*100 – CIE a*0) 2 + (CIE b*100 – CIE b*0) 2] 1/2, where subscripts 100 and 0 denote the 100% UV-included and the UV-excluded conditions respectively. The recorded data for the tested materials' color, opacity and fluorescence were collected and statically analyzed with IBM® SPSS® statistical version 20 with the significance level set at P ≤ 0.05.
Results: There was no statistically significantly different between the two materials before as well as after bleaching.
Conclusion: the color change of the nanofilled and microhybride light activated composite after bleaching (home-bleaching) was not perceptible or significant.

1. Introduction

Bleaching is an effective and relatively safe esthetic treatment [1]. The bleaching agent usually contains peroxide (in the form of hydrogen peroxide, carbamide peroxide or sodium perborate) [1,2] and can be applied in office or at-home bleaching techniques [3]. Home bleaching has gained considerable acceptance among dentists and patients as a simple, effective, and safe procedure to lighten discolored teeth since its introduction by Haywood and Heymann in 1989 [4].

It has been reported that bleaching effect is directly related to the exposure time and concentration of active bleaching ingredient. The longer the exposure time and the higher the concentration of the whitening material, the greater will be the oxidation process and color change [5].

Whitening techniques and products improved the esthetic appearance of bleached teeth and also have influence on restorative materials

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Table 1
Materials used in our study.

Material	Type	Composition	Application Procedure	Manufacturer
Adper Scotchbond 1XT	Etch-and-rinse two-step adhesive system	Etching agent: 35% phosphoric acid (pH 0.7) Adhesive: Bis-GMA, HEMA, dimethacrylates, polyalkenoic copolymer, ethanol, water, photoinitiator	1. Apply phosphoric acid for 15 s, 2. Rinse for 15 s, 3. Blot excess moisture using a cotton pellet, 4. Apply two adhesive coats under pressure for 15 s, 5. Gently air thin for 5 s, 6. Light-cure for 10 s.	3M ESPE, St. Paul, MN, USA
Filtek Z250 Enamel Shade A3	Microhybrid methacrylate-based composite	Bis-GMA; UDMA; Bis-EMA; TEGDMA 77.6%–60% by volume zircon silica filler, average particle size 0.6 µm		3M ESPE, St. Paul, MN, USA
Filtek Z350 XT Enamel Shade A3	Nanofilled methacrylate-based composite	bis-GMA, UDMA, TEGDMA, and bis-EMA (6) resins non-agglomerated/non-aggregated 20 nm silica filler, non-agglomerated/non-aggregated 4–11 nm zirconia filler, and aggregated zirconia/silica cluster filler (comprised of 20 nm silica and 4–11 nm zirconia particles).		3M ESPE, St. Paul, MN, USA
Opalescence PF	15% carbamide peroxide gel	Carbamide peroxide, potassium nitrate and fluoride		Ultradent, S Jordan UT, USA

exposed to them [6]. Bleaching agents might induce changes in physical and chemical properties of tooth-colored restorations [7,8]. In addition, bleaching agents can induce color changes in tooth colored dental materials. The nanofilled composite was introduced to be used in all areas of the mouth with high initial polish and superior polish retention (typical of microfills), as well as excellent mechanical properties suitable for high stress–bearing restorations (typical of hybrid composites) [9,10].

Although bleaching at high concentrations can slightly change the enamel surface, it can have a negative impact on the surface quality and texture of restorations [11]. Due to the presence of organic matrix, composite materials are more susceptible to adverse changes compared to other tooth colored restorative materials [12]. Peroxides, through oxidative reactions, might influence the physical properties of the composite restorations; by degradation of the polymer network consisting of carbon-carbon bonds [6].

The results of studies on the effect of bleaching on properties of resin composite materials are controversial [12] and this effect is claimed to be material-dependent [13]. Some studies have demonstrated that the impact of bleaching treatment containing peroxide on the color of tooth-colored restorations is not clinically perceptible [14,15]; while some researchers have reported this effect to be significant [12]. Conflicting results in this respect are attributed to the difference in organic matrix volume, filler type and loading [13].

Patients seeking bleaching treatment may have teeth restored with different kinds of esthetic restorative material. It is possible that chemical changes, resulting from bleaching, may affect the clinical color stability of these colored materials. Drastic color changes to existing restorations may compromise esthetics; therefore, it is important to understand the effect of bleaching agents on the color of restorative materials. The interaction between the bleaching agent and restorative material is of clinical significance because the color change may be noticed by the patient [45,46].

Considering the fact that change in optical properties has been attributed to the type of material, matrix and filler, the present study compared the effect of a bleaching agent (15% carbamide peroxide) on two different dental composites with different volume and type of filler particles (nanohybrid and microhybrid).

2. Materials and methods

A total of 60 sound maxillary premolar teeth that had been recently extracted as part of an orthodontic treatment plan and were free from carious lesions, cracks, fracture, or restorations were selected. Extracted teeth were cleaned with scalar and pumice to get rid of debris and stains from enamel surface. The extracted teeth were stored in artificial saliva solution at 37 ± 2 °C.

The roots of these teeth were amputated 2 mm from the cementoenamel junction using diamond disc (Edental Golden S.A.W., Switzerland) in a high-speed hand piece under copious water coolant. Teflon molds were filled with self-cure acrylic resins and then each sectioned tooth was embedded in the acrylic resin with the outer labial surface of the tooth exposed.

Standardized cavities were made in the center of the teeth buccal surface, measuring 2 mm in diameter and 2 mm in depth. Cylindrical diamond burs #2294 were used (KG Sorensen Ind. Com., Brazil). This diamond bur features a particular penetration cutoff, therefore providing standardized cavities [16].

Cavity dimensions were measured with a periodontal probe to maintain standardization. The same operator prepared all cavities to ensure a calibrated size and depth. After five preparations, the used bur was discarded and a new one was selected [17].

Teeth were randomly divided into four groups of 15 specimens each (2 control and 2 experimental or bleached groups). Group A to be restored with light nanocomposite resin (Filtek Z350 XT®, 3M/ESPE,St. Paul,MN,USA) with no post-restoration bleaching procedure (control). Group B to be restored with light nanocomposite resin (Filtek Z350 XT®, 3M/ESPE,St. Paul,MN,USA), with post-restoration bleaching procedure (Experimental). Group C to be restored with microhybrid resin (Filtek 250 XT®, 3M/ESPE,St. Paul,MN,USA) with no post-restoration bleaching procedure (control). Group D to be restored with microhybrid resin (Filtek 250 XT®, 3M/ESPE,St. Paul,MN,USA), with post-restoration bleaching procedure (Experimental). Cavities were thoroughly washed with distilled water to remove any debris before the application of adhesive system. In all groups, Adper Scotchbond 1XT Etch-and-rinse two-step adhesive system (3M/ESPE,St. Paul,MN,USA) was used for the bonding procedure according to manufacturers' instructions [17] (Table 1). The prepared cavities were then restored using the resin composite for the designated group. The composite was placed in a single increment, covered with polyester strip and light polymerized with an Elipar S10 light-curing unit (3M ESPE, 1100 mW/cm2) for 20 s [18]. The restorations were finished and polished with polishing disks Sof-Lex discs (3M ESPE Dental Products, St. Paul, MN, USA) to achieve uniform and smooth surfaces and remove all possible contaminants and the oxygen-inhibited layer [19]. After being polished, the samples were stored in artificial saliva solution at 37 ± 2 °C [20].

In order to perform the bleaching procedure, each 5 teeth were stabilized in a silicone block, an alginate impression was taken and a plaster model was obtained. The labial model teeth surfaces were covered with 1 mm thick spacer up to 1 mm of the cervical margin. A vacuum-forming machine was used to make a 0.8 mm thick custom tray [21]. Then the bleaching was carried out using Opalescense PF home bleaching gel (Ultradent product, UT, USA). For each group, the bleaching gel was loaded in the tray and applied over the teeth once daily for 4 h for a total duration of 2 weeks [22].

Following each cycle of treatment, specimens were cleaned with a soft brush for 1 min and stored in screw-top vials filled with distilled water, at room temperature, during the time intervals between treatment phases. Distilled water was refreshed daily in all groups [22].

Color, opacity and fluorescence were analyzed by taking digital photos for the specimens at baseline and 24 h after completion of the bleaching procedure. The digital images were recorded using USB Digital microscope with built-in camera (Scope Capture Digital Microscope, Guandong, China) at fixed magnification of 50X and at a resolution of 1280x 1024 pixels per image. The images were then analyzed using Image Analyzer software (Image Analyzer version 1.43–2012 Meesoft) [23,24].

The color pattern was evaluated according to the CIE - L*, a* and b* color system. The color change (ΔE) among the tested composites was analyzed by comparing the color coordinates L*, a* and b* readings at baseline and after bleaching according to the following equation [25].

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

where L* describes the luminance reflectance, while a* and b* describe the red-green and yellow-blue color coordinates, respectively.

For optical analysis, the specimens were subjected to the color measurements on white and black patterns, considering only the L* coordinate, which was calculated according to the formula:

$$\text{Opacity} = L^*b \,/\, L^*w$$

where L*b corresponds to the reading of the L* coordinate against a black background and L*w against a white background. This procedure was performed before after bleaching, and the difference in opacity between the two periods was calculated in percent-age [26].

While for fluorescence comparison, the Fluorescence parameter (FL) was calculated, at baseline and post bleaching procedure, as the difference in color (ΔE) depending on the inclusion or exclusion of the UV component according to the equation: $FL = [(CIE\ L^*_{100} - CIE\ L^*_{0})^{2} + (CIE\ a^*_{100} - CIE\ a^*_{0})^{2} + (CIE\ b^*_{100} - CIE\ b^*_{0})^{2}]^{1/2}$, where subscripts 100 and 0 denote the 100% UV-included and the UV-excluded conditions respectively [27].

The recorded data for the tested materials' color, opacity and fluorescence were collected and statically analyzed with IBM® SPSS® statistical version 20 with the significance level set at $P \le 0.05$.

3. Results

This study was introduced to evaluate the effect of hydrogen peroxide bleaching on optical characteristics of two different composite resins. Data were presented as mean and standard deviation (SD) values and the significant level was set as $P \le 0.05$.

Table 2 shows that microhybrid composite showed statistically significant higher mean (△L) and (△E) than the nanofilled resin composite.

Regarding opacity results there was no statistically significantly different between mean (△ opacity) for the two tested materials (Table 3).

In addition, there was no statically significant difference between mean fluorescence values between microhybrid resin composite and nanofilled resin composite before bleaching and after bleaching. The mean fluorescence value before blecacmean fluorescence value = x

Table 2
The mean values of (△L) and (△E) for nanofilled and hybrid resin composite groups.

Material	Nano		Hybrid		*P*-value
	Mean	SD	Mean	SD	
△L	1.1	0.3	3.6	0.8	0.002*
△E	2.5	0.9	4.9	1.1	0.032*

Significant level was set at $P \le 0.05$.

Table 3
Mean values of (△opacity) for nanofilled and hybrid resin composite groups.

Material	Nano		Hybrid		*P*-value
	Mean	SD	Mean	SD	
△ opacity	0.9	0.2	0.7	0.2	0.275

Significant at $P \le 0.05$.

while after bleaching mean fluorescence value = 29 and nanofilled resin composite before bleaching mean fluorescence value = while after bleaching mean fluorescence value = 26.8.

There was no statistically significantly different between the two materials before as well as after bleaching.

4. Discussion

Nowadays “white teeth” is one of the most common demand esthetic from dental patients and tooth bleaching is a relatively non-invasive approach to achieve this goal. As bleaching of teeth has become extremely popular, the effect of bleaching on esthetic appearance of dental materials must be considered [43].

The tooth bleaching technique is based mainly on the oxidation by hydrogen peroxide or one of its precursors, and those are often used in combination with an activating agent such as heat, light or chemically. The use of peroxide-containing at home tooth bleaching agents has increased in the recent decade [28]. The at home commercial products of tooth bleaching are usually fabricated in a gel form and can be administered at home (home bleaching) using 15% carbamide peroxides [42,44].

Although bleaching agents improve the esthetic appearance of bleached teeth, their contact with resin composite might induce discolorations in these materials [9,10]. This complicates the process of trying to establish and maintain good color match between the light activated resin composite restoration and the adjacent tooth structure. Changes in the chemical and morphological structure of resin composites must be of concern when bleaching is used as a bleaching treatment [42–44].

The effect of bleaching agents on tooth-colored restorative materials is of clinical interest and several studies have evaluated the effect of commonly used bleaching agents on a number of restorative materials. Since quantitative evaluation of minimal color change by means of visual assessment is not possible besides presenting low reproducibility; standardized electronic devices are more preferred for such measurements [29].

In the current study, we evaluated the effect of an at-home carbamide peroxide tooth-bleaching agent on color change of two different composite resins. Carbamide peroxide is one of the most widely used bleaching agents, which is supplied in various concentrations for at-home applications [30].

Digital image analysis was used for assessment of the samples as it provided the accuracy and the reproducibility required for the research [31]. Such assessment was carried out using the most widely accepted system used for color measurement in dentistry: The CIELAB color

Table 4
The mean fluorescence values for nanofilled and microhybrid resin composite groups.

Material	Nano		Hybrid		*P*-value
	Mean	SD	Mean	SD	
Before bleaching	25.8	6.8	25.3	6	0.843
After bleaching	26.8	3.6	29	7.7	0.434

Significant at P ≤ 0.05.

notation system [25,32].

In the current study the two selected resin composite are Filtek Z250 and Filtek Z350 XT. Filtek Z250 showed a statistically significant higher mean △E (△E = 4.9) than the Filtek Z350 XT (△E = 2.5) (Table 2). Such results were in accordance with results obtained by previous studies [33].

These results can be explained by the manufacturer claim that the Filtek Z350 XT (nanofilled composite) more resistant to the bleaching procedure. This is regarded to its fine particle size and the presence of nanosilica filler and Zirconia/Silica Nano-cluster which provide more cross linking with the organic matrix making it more resistant to bleaching agent. It was reported that chemical softening of resin composite materials caused by peroxide gel is responsible for the observed color change. This explains why the cross-linking reported with nanofilled composite make them less prone to color change by bleaching procedure. These findings match the findings of Kim et al. [49] where the influence of tooth-whitening film and strip on the color and surface roughness of dental composite resins was negligible. However, such results were in contradiction with results obtained by other studies. Cooley and Burger tested the composite resins for changes in surface hardness, roughness, and lightness after exposure to 10% carbamide peroxide gels and found that these three parameters increased significantly after exposure [8,34,47,48].

No consensus has been reached on the clinically perceptible ΔE value. 1, 2 [35], more than 3 [36] and even more than 3.7 [37] have been reported to be clinically perceptible. However, according to literature the results obtained by this research indicates that the color change for both resin composite is clinically perceptible. In addition, The L* index indicates luminosity or brightness and the human eye sees and perceives this color parameter more clearly because the quality of rods responsible for black and white vision is much higher than that of cones responsible for color vision [38] and this parameter increased in both resin composite materials tested in this research (Table 2); which indicated that all composites got lighter after bleaching.

Several studies have discussed the effect of peroxide based bleaching materials on opacity of resin composite. In the current research no significant effect on opacity of both tested resin composite materials was recorded. This was in support with other studies that showed in opacity of resin composite material [39]. This was attributed to the previously explained strong cross-linking of nanofilled composite. While for the microhybrid resin, this can be explained by the presence of Zirconia and silica fillers as well as the by the effect of its Bis-GMA, UDMA organic matrix which resist changes induced by the peroxide gel. Such results were opposed by data recorded by other studies that showed increased resin composite translucency after whitening [40].

Regarding fluorescence results, there was no statistically significant (Table 4) change for both tested materials, Polydorou [51] stated that there is no sufficient reason to indicate the replacement of restorations, except the cases that have esthetic involvement which was in opposition to other researches that showed changes in fluorescence after exposure of resin composite to bleaching agents [39,40].

The controversies of several studies might be related to differences in employed methodologies, differences of restorative materials, variations of concentration, pH of bleaching gels, different periods of application of bleaching gels, the frequency with which the bleaching agents were changed as well as specimen storage methods conditions including type and duration [41]. Plus in the vitro studies are limited in their attempt to simulate clinical conditions. It was shown that peroxide levels in bleaching products are depleted during use depending on the in vivo situation [50].

5. Conclusions

According to the limitation and the results of this study it was concluded that the color change of the nanofilled and microhybride light activated composite after bleaching (home-bleaching) was not perceptible or significant. Therefore, no replacement of restorations is required after bleaching except that if the patients have esthetic issues.

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