

Effect of hydrogen peroxide application on color and surface roughness of two restorative materials

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Abstract

Aim: This study investigated the effect of an in-office bleaching technique on lightness, color and surface roughness of two commercially available materials: a resin-modified glass-ionomer cement and a nanohybrid resin composite. **Methods:** Twelve disk-shaped specimens were prepared with both materials. The samples were bleached with 35% hydrogen peroxide. Bleaching was tested initially onto a smooth surface and later onto a polished one of the same specimens. The effect of the treatments on lightness and color was verified with a spectrophotometer. Surface roughness was measured with a digital surface roughness tester. The data were statistically analyzed by repeated measures ANOVA and post hoc Tukey's test ($\alpha = 0.05$). **Results:** Significant variation in lightness and color was observed on the resin-modified glass-ionomer cement after the first bleaching procedure. Roughness increased significantly only after polishing the resin-modified glass-ionomer cement surface. Composite color variation was evident in the last observation period, but roughness and lightness variation due to bleaching and polishing was not significant. **Conclusion:** The bleaching treatment caused significant color alterations on the materials tested. This study observed that the application of in-office bleaching onto the glass-ionomer cement promoted clinically observable color alteration, and polishing after bleaching is contraindicated for this material.

Key words: Resin-modified glass-ionomer cement. Composite. In vitro bleaching. Color behaviour. Surface roughness.

Introduction

Due to increased demand for aesthetic treatments, tooth bleaching has become a very popular procedure. Dental bleaching is considered an effective treatment, and various concentrations of carbamide peroxide (CP) or hydrogen peroxide (HP) are used during at-home and in-office techniques. The immediate result of dental bleaching is directly related to the agent's concentration and exposure time, despite the result after completion of the treatment being similar, clinically¹ and in vitro².

Patients should be advised that after the conclusion of the bleaching treatment restorations might require replacement, especially in anterior teeth, for not matching

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the tooth color achieved after the treatment. The restorations may darken more or less than the teeth after exposure to components in the oral environment, and may not respond to the same degree to the bleaching treatment. It is also recommended to carefully examine the restorations before a bleaching treatment and replace the ones without adequate sealing, in order to reduce the risks of adverse effects³. Restoration before the bleaching treatment is indicated to prevent sensitivity in non-carious cervical lesions and restoration replacement is recommended for those with marginal leakages. The effect of bleaching agents on restorative materials and adhesive/tooth interface has been investigated⁴, but has not been fully resolved because of the diverse material composition and experimental setting.

Composite resins and resin-modified glass-ionomer cements present organic resin matrix and inorganic filler particles. The bleaching agents can react differently with each phase or their interface. Bleaching treatments of restorative materials may affect surface gloss⁵, microhardness^{6,8}, roughness^{6,7,9-12}, color¹³⁻¹⁶, and the amount of elutable components^{17,18}. Surface polishing after bleaching may not restore the physical properties of the restorative material because subsurface layers up to 2.0 mm can be affected⁸. The interaction between the bleaching products with restorative materials is of clinical significance, and therefore needs to be evaluated. According to Wang et al. (2011), it is important to

investigate the alteration of restorative materials to bleaching in order to minimize the need for replacement of restorations after this treatment⁹.

The aim of this in vitro study was to investigate the effect of an in-office bleaching material onto two tooth-colored restorative materials, analyzing roughness, lightness and intrinsic color change. The null hypothesis of this study was that 35% HP would not result in significant roughness and color differences in the materials tested.

Material and methods

Disk-shaped specimens of a nanohybrid composite (Filtek Z250 XT, shade A3, Table 1) and of a resin-modified glass-ionomer cement (Vitremmer, shade A3, Table 1) were prepared according to manufacturer's instructions (n = 12). Each specimen (1.0 mm thick and 10.0 mm in diameter) was prepared after inserting the restorative material into a cylindrical nylon matrix and pressing between two polyester strips and two glass slides. The material was initially light-cured through the polyester strip; to ensure thickness uniformity. Specimens were polymerized by a LED unit (Optilight Max, DabiAtlante, Brazil) for 40 seconds (1000 mW/cm²). The protective gloss included in the Vitremmer kit was applied and polymerized onto both sides of Vitremmer disks.

Table 1 - Chemical composition and manufacturer of materials used in the present study.

Material	Composition *		Manufacturer	Batch Number
Filtek Z250 XT	BIS-GMA, UDMA, BIS-EMA, PEGDMA, TEGDMA	Zircônia/ silica particles ≤3 microns, silica particles 20 nanometer	3M ESPE, Dental Products, St. Paul, MN, USA	1501300548
Vitremmer	Powder: fluoroaluminosilicate glass, Potassium persulfate Gloss: TEGDMA, BIS-GMA	Liquid: modified polycarboxylic acids (methacrylate groups), water, HEMA	3M ESPE, Dental Products, St. Paul, MN, USA	1421100285
Whiteness HP Maxx	35% Hydrogen Peroxide, thickener, dye, propylene glycol, filler, water		FGM Produtos Odontológicos, Joinville, SC, Brazil	131014

*Information provided by manufacturers.

Abbreviations: Bis-GMA, Bisphenol-A-glycidyl methacrylate; Bis-EMA, Ethoxylated bisphenol-A-glycidyl methacrylate; HEMA, 2-Hydroxyethyl Methacrylate, PEGDMA, polyethylene glycol dimethacrylate; TEGDMA, Triethylene glycol dimethacrylate; UDMA, Urethane dimethacrylate.

The nonirradiated surfaces were identified and the specimens were stored in distilled water at 37°C, with a weekly change of water. Two weeks after preparation, the specimens received the first bleaching treatment with Whiteness HP Maxx (35% HP, Table 1). The bleaching protocol used onto the specimen's irradiated surfaces followed the manufacturer recommendation: three consecutive applications of the gel for 15 minutes each, after freshly mixing the bleaching component with the thickener, without light acceleration. After each bleaching application the specimens were wiped with gauze. The disks were rinsed with water for 1 minute after finishing the bleaching procedure, and stored in distilled water at 37°C.

Two weeks after the first bleaching procedure the specimens were polished manually with 600 grit silicon carbide paper and water irrigation, and then thoroughly rinsed with tap water to remove any debris. Two weeks after polishing, the specimens

received the second bleaching treatment. Bleaching was performed initially onto a smooth surface and later onto a polished one, of each specimen. The roughness of the disks was verified with a digital handheld surface roughness tester (Surftest SJ-210P, Mitutoyo, Japan). The roughness value was calculated by averaging three readings of Ra (average roughness, measured in μm) of each specimen from three different orientations.

CIELab color parameters of the specimens were measured with a spectrophotometer (VITA Easyshade Advance 4.0, VITA Zanafabrik, Germany) calibrated with a white reflectance standard tile supplied by manufacturer and the specimens were placed against a white background. Color variation (ΔE) was calculated using the following equation (1)¹⁹.

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

Where, the L* represents the degree of lightness (ranges from 0 black, to 100 white), the a* coordinate represents the degree of green/red color (-a* green, +a red), and the b* coordinate represents the degree of blue/yellow (-b* blue, +b* yellow). ΔE^* values ≤ 3.3 were considered clinically acceptable for color variation, not relevant and not perceptible^{13,20}.

Roughness, lightness and color parameters were collected in five observation periods: T0 = baseline (one week after disk preparation); T1 = one week after the first bleaching treatment; T2 = one week after polishing, T3 = one week after the second bleaching treatment; T4 = two weeks after the second bleaching treatment. The parameter's variations were calculated between each observation period and baseline, and between every two consecutive observation periods.

The data were statistically analyzed using Statistica software (Version 10, StatSoft Inc., USA). Before the light variation analysis, the values were squared for handling the negative values.

A repeated measures analysis of variance (ANOVA) was used to analyze the significant differences between the variables with a significance level of 0.05. Whenever there was a significant interaction between them, a post hoc Tukey's test was used to detect specific differences with a significance level of 0.05.

Results

The mean values and standard deviations of color variation, lightness variation and roughness for the resin-modified glass-ionomer cement and the nanohybrid resin composite, after bleaching and polishing are summarized in Tables 2, 3 and 4. The analysis of variance (ANOVA) revealed a highly significant difference ($p = 0.000$) between the independent variables for Color and Lightness variation. These indicated that bleaching and polishing had a significant effect on the materials investigated.

Table 2 - Mean values (Standard deviation) of Color variation ΔE^* and Lightness variation ΔL^* of Vitremer and Z250 XT, between each time period and baseline.

Material	ΔE^*1	ΔE^*2	ΔE^*3	ΔE^*4
Vitremer	17.42 (± 1.84) ^a	16.14 (± 1.83) ^b	15.87 (± 1.75) ^b	14.41 (± 1.86) ^d
Z250XT	1.48 (± 0.73) ^a	1.70 (± 0.74) ^a	1.46 (± 0.94) ^a	2.37 (± 0.49) ^c
	ΔL^*1	ΔL^*2	ΔL^*3	ΔL^*4
Vitremer	41.11 (± 17.57) ^d	19.25 (± 10.27) ^c	13.31 (± 8.20) ^{b,c}	8.29 (± 4.80) ^{a,b}
Z250XT	1.07 (± 1.27) ^a	1.41 (± 1.79) ^a	1.57 (± 2.44) ^a	1.27 (± 1.61) ^a

Values with the same superscript letters in each group were not statistically significant differences at $p \geq 0.05$, $n = 12$.

Table 3 - Mean values (Standard deviation) of and Color variation ΔE^* and Lightness variation ΔL^* of Vitremer and Z250 XT between each time period: $\Delta 1$ (between T1 and T0), $\Delta 2$ (between T2 and T1), $\Delta 3$ (between T3 and T2), $\Delta 4$ (between T4 and T3).

Material	ΔE^*1	ΔE^*2	ΔE^*3	ΔE^*4
Vitremer	17.42 (± 1.84) ^c	2.31 (± 0.78) ^a	1.38 (± 0.91) ^b	2.13 (± 0.85) ^a
Z250XT	1.48 (± 0.73) ^{a,b}	0.51 (± 0.14) ^b	0.73 (± 0.49) ^{a,b}	2.03 (± 0.63) ^a
	ΔL^*1	ΔL^*2	ΔL^*3	ΔL^*4
Vitremer	41.11 (± 17.57) ^b	5.13 (± 3.48) ^a	1.03 (± 1.49) ^a	2.26 (± 2.21) ^a
Z250XT	1.07 (± 1.27) ^a	0.11 (± 0.09) ^a	0.39 (± 0.97) ^a	1.41 (± 2.15) ^a

Values with the same superscript letters in each group were not statistically significant differences at $p \geq 0.05$, $n = 12$.

Table 4 - Mean values (Standard deviation) of Roughness (μm) of Vitremer and Z250 XT observed in the periods T0, T1, T2, T3, and T4

Material	Ra0	Ra1	Ra2	Ra3	Ra4
Vitremer	0.31 (± 0.17) ^{a,b}	0.27 (± 0.15) ^{a,b}	0.48 (± 0.20) ^{c,d}	0.66 (± 0.31) ^d	0.61 (± 0.27) ^{c,d}
Z250XT	0.16 (± 0.11) ^a	0.24 (± 0.22) ^{a,b}	0.36 (± 0.36) ^{a,b,c}	0.31 (± 0.12) ^{a,b}	0.34 (± 0.08) ^{a,b,c}

Values with the same superscript letters were not statistically significant differences at $p \geq 0.05$, $n = 12$.

The analyses of color variation (ΔE^*) and lightness variation (ΔL^*) for Vitremer, between baseline and observation periods (Table 2), and between observation periods (Table 3) showed that alterations promoted by the bleaching procedure were significant after the first bleaching procedure (T1), on the material protected

by the gloss. Significant color variation for Filtek Z250 XT was detected in the last observation period (T4) compared to baseline, after polishing, bleaching and storage of the material (Table 2). The analyses of lightness variation for Filtek Z250 XT showed that alterations promoted by bleaching and polishing, between baseline

and observation periods (Table 2), and between observation periods (Table 3), were not significant.

The difference of roughness between the materials and observation periods was significant ($p < 0.000$). The analyses of the roughness values (Ra) for Vitremer demonstrated that the superficial modification promoted by the polishing procedure was significant and increased roughness, comparing both initial periods with the three final ones (Table 4). However, the bleaching effect onto roughness was not significant (Table 4). The analyses of roughness for Filtek Z250 XT revealed that the superficial alteration promoted by the bleaching and polishing procedures was not significant, as well as the variation of roughness promoted by bleaching onto smooth surface and roughened surface (Table 4).

Discussion

The null hypothesis was rejected for Z250 XT, because the color alteration of the nanohybrid composite was significant, but in a clinically acceptable range of color change ($\Delta E^*4 = 2.37$). The ΔE^* value is considered clinically undetectable if less than 1, acceptable if between 1 and 3.3 and unacceptable if greater than 3.3^{13,20}. The roughness variation due to bleaching onto smooth surface and polished composite surface was not significant.

The color alteration observed on the resin-modified glass-ionomer, due to the first bleaching treatment with 35% HP, was significant and clinically detectable ($\Delta E^*1 = 17.42$). It was not due to superficial color alteration of the specimens, but intrinsic color change, because it persisted with time, even after the wear promoted by the polishing procedure. The substantial and positive ΔL^* for Vitremer, after the first bleaching treatment would be clinically unacceptable, if the natural dental structure did not lighten to the same degree. The color change in experimental subsequent periods was acceptable ($\Delta E^* \leq 2.31$), with a tendency for recuperation towards the original color and lightness, but without matching them. Vitremer roughness increased after polishing, but was not affected significantly after the bleaching agent was applied onto the more irregular surface.

The choice of these parameters should be elucidated, because roughness can promote greater accumulation of food debris, biofilm formation, and increased colonization by cariogenic bacteria²¹; and alteration of color may impair the aesthetics. Unacceptable color match of restorations, which may discolor more easily than teeth after prolonged exposure to the oral environment, is one reason for replacement of restorations. The present study analysed the color change of two restorative materials without any previous discoloration, both shade A3 as provided by the manufacturer. The in-office bleaching procedure used was recommended by the manufacturer, in order to represent the clinical conditions without continuous exposure or simulating the cumulative effect over a period of time.

The gloss applied onto the resin-modified glass-ionomer, immediately after restoration, protects the material from syneresis and imbibition. Surface protection is also recommended onto earlier restorations of glass-ionomer, when using rubber dam isolation and topical application of fluoride. The initial smooth surface with the gloss did not protect the material from intrinsic

color change caused by the bleaching. The significant color alteration of the resin-modified glass-ionomer from the first bleaching treatment could be clinically detectable, and continued throughout of the experiments. The present study corroborates with a previous one, which compared the color stability of fluoride-containing restorative materials and composites, and observed significant difference in color of ionomer cements²². The bleaching effect difference between the two shade A3 products might be due to water affinity, because the hydrophilic resin modified glass-ionomer cement showed lower intrinsic color stability than the hydrophobic nanohybrid composite²².

Some studies affirm that bleaching agents can remove the extrinsic staining from composite resins, but not promote intrinsic color change^{13,23}. The intrinsic color alteration of the nanohybrid composite tested in this study, two weeks after the second bleaching, was significant, but considered clinically undetectable (mean ΔE^* value < 3.3). One limitation of this study is that no control was used to verify the color or roughness change caused by the storage of the specimens, immersed in distilled water at 37°C during the study period of 9 weeks.

The superficial alteration promoted by the bleaching and polishing procedures onto Filtek Z250 XT was not significant. Studies with composites reported no observable or significant roughness alteration after bleaching^{9,24}, and no significant effect on the microhardness^{14,24,25}; agreeing that no replacement of restorations may be required after bleaching. It is recommended caution in bleaching treatments when restorations are present, in order to minimize the impact of bleaching therapies on restorative materials and restorations^{3,5}. Bleaching treatments may affect the color and surface roughness of existing restorations, and even though the alterations may not be clinically relevant to indicate the replacement of the restoration, they require close monitoring by the dentist and should not be used indiscriminately when restorations are present.

Color matching may be a problem when the intrinsic restoration color matches the dental element before bleaching. In the case of a composite restoration, it will remain unchanged, contrasting with the altered dental color after bleaching. However, resin-modified glass ionomer restoration will present color alteration with the bleaching.

Conclusions

Within the limits of the present study, it can be concluded that the in-office bleaching material caused significant and clinically detectable alterations on color of a resin-modified glass-ionomer cement. Therefore, this study contraindicates the application of in-office bleaching products on resin-modified glass ionomer restorations, if the color shade is to be maintained, and also polishing after bleaching.

The 35% HP bleaching material also caused significant alteration on the intrinsic color of a nanohybrid composite, but it is considered clinically undetectable. Therefore, this study does not contraindicate the application of bleaching gel on the composite, or polishing the restoration after bleaching.

Even though there is no sufficient reason to indicate the

replacement of restorations after bleaching, this may be necessary to match the color variation of the dental elements.

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