

Influence of Hydrogen Peroxide Bleaching Gels on Color, Opacity, and Fluorescence of Composite Resins

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Clinical Relevance

Bleaching therapies with 20% or 35% hydrogen peroxide gels influenced composite resin color and fluorescence. No influence on opacity was observed.

SUMMARY

The aim of the present study was to evaluate the effect of 20% and 35% hydrogen peroxide bleaching gels on the color, opacity, and fluorescence of composite resins. Seven composite resin brands were tested and 30 specimens, 3-mm in diameter and 2-mm thick, of each material were fabricated, for a total of 210 specimens. The specimens of each tested ma-

terial were divided into three subgroups (n=10) according to the bleaching therapy tested: 20% hydrogen peroxide gel, 35% hydrogen peroxide gel, and the control group. The baseline color, opacity, and fluorescence were assessed by spectrophotometry. Four 30-minute bleaching gel applications, two hours in total, were performed. The control group did not receive bleaching treatment and was stored in deionized water. Final assessments were performed, and data were analyzed by two-way analysis of variance and Tukey tests ($p < 0.05$). Color changes were significant for different tested bleaching therapies ($p < 0.0001$), with the greatest color change observed for 35% hydrogen peroxide gel. No difference in opacity was detected for all analyzed parameters. Fluorescence changes were influenced by composite resin brand ($p < 0.0001$) and bleaching therapy ($p = 0.0016$) used. No significant differences in fluorescence between different bleaching gel concentrations were detected by Tukey test. The

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greatest fluorescence alteration was detected on the brand Z350. It was concluded that 35% hydrogen peroxide bleaching gel generated the greatest color change among all evaluated materials. No statistical opacity changes were detected for all tested variables, and significant fluorescence changes were dependent on the material and bleaching therapy, regardless of the gel concentration.

INTRODUCTION

Recent beauty standards place a high value on oral esthetics. Therefore, the materials and techniques of esthetic dental procedures, such as composite resin restorations and bleaching therapies, are under constant development.¹

Tooth discoloration compromises esthetics and represents one of the major complaints of patients and a major reason for dental appointments. Bleaching procedures are nowadays largely employed by clinicians to reduce discolorations and improve or return tooth color. Dental bleaching is a conservative esthetic treatment that produces safe and acceptable results in a short period of time, assuming the technique and its indications are well known by clinicians.²

Because of the increased use of bleaching techniques, several studies have been performed to determine possible effects on dental structures. Although these studies on the effect of bleaching gels over soft and hard tissues are present in the literature, there is contradictive information regarding the interactions between esthetic restorative materials and bleaching gels, especially for those composed of high peroxide concentrations.³⁻⁵ This contradiction is of concern because of the large number of people undergoing bleaching procedures who also present with esthetic restorations. Bleaching gels might compromise the composite resin's mechanical characteristics, surface hardness, and roughness,⁶⁻⁸ as well as its optical characteristics such as translucency and color.^{1,9,10}

The development of composite resins that esthetically mimic human enamel and dentin according to color, opacity, and fluorescence has been a significant contribution to restorative dentistry. Human teeth are characterized by a translucency variety, which is dependent on enamel thickness, enamel crystal structures, and different mineralization patterns. Translucency affects the restoration's esthetics and represents how intense the light penetrates into both the tooth structure and

the restoration prior to being reflected to the external environment. Fluorescence is another important property to be reproduced by composite resins. When illuminated with a light source containing ultraviolet rays, such as sunlight, human teeth emit a bluish-white light perceptible to the naked eye.

It is known that dental materials' optical properties, translucency, opacity, and fluorescence are dependent on the composite resin's components.^{10,11} Therefore, to better reproduce these properties, the composition of inorganic fillers has been studied by adding fluorescent particles and different sizes and shapes of fillers. The literature, however, does not present accurate information regarding different types of composite resins and their optical properties when submitted to bleaching therapies. Considering that bleaching therapies are often performed in patients presenting composite resin restorations, the aim of the present study was to evaluate the effect of bleaching treatments with 20% or 35% hydrogen peroxide gels on different types of composite resins regarding their color, opacity, and fluorescence.

METHODS AND MATERIALS

Seven composite resin brands, shown in Table 1, were tested. Two hundred ten specimens, 3-mm in diameter and 2-mm thick, were fabricated using a silicon matrix, with 30 specimens of each composite resin brand. All specimens were fabricated in shade A3. Specifications of tested composite resins are presented in Table 1.

Specimens were light activated for 40 seconds with 550 mW/cm² light intensity using an LED emitter (Schuster Comercio de Equipamentos Odontologicos Ltda, Santa Maria, RS, Brazil) and stored in Eppendorf vials with 2 mL of deionized water for 24 hours. Specimens were further polished with #4000 sandpaper using a circular polishing machine (Poliplan 2, Panambra, São Paulo, SP, Brazil).

The specimens of each composite resin group were then subdivided into three subgroups (n=10) according to bleaching therapy. Subgroup 1 received bleaching therapy with 20% hydrogen peroxide gel (Whiteness HP 20-FGM, Produtos Odontologicos Ltda, Joinville-SC, Brazil), subgroup 2 received bleaching therapy with 35% hydrogen peroxide gel (Whiteness HP 35-FGM, Produtos Odontologicos Ltda), and subgroup 3 (control) received no bleaching treatment but was immersed in deionized water during the entire research period.

Table 1: *Types of Composite Resin Tested in the Present Study*

Market Brand	Classification Based on Particles	Manufacturer	Composition
Admira	Microhybrid Ormocer	VOCO GMBH, Cuxhaven, Germany	Complex inorganic-organic copolymers tridimensionally polymerized (ormocers), aliphatic dimethacrylates; 56% of 0.7- μm fillers in volume
Amaris	Microhybrid	VOCO GMBH, Cuxhaven, Germany	Bis-GMA and UDMA 20-nm silica and 5- to 20-nm zirconia particles
Estelite Sigma	Microhybrid with spherical submicron fillers	Tokuyama Dental, Shibuya, Tokyo, Japan	Methacrylates and 82% by weight of silica-zirconia filler sized between 0.1 and 0.3 μm
Esthet X	Microhybrid	Dentsply, Petrópolis, RJ, Brazil	Bis-GMA, Bis-EMA, triethylene glycol dimethacrylate (TEGDMA), camphorquinone, stabilizers, tints, barium aluminofluoroborosilicate (BAFG) with silicone dioxide particles (1 μm) silica nanoparticles (0.04 μm)
Venus	Microhybrid	Heraeus Kulzer, Grüner, Germany	Bis-GMA and TEGDMA and submicron barium glass particles with mean size of 0.7 μm and filler volume greater than 78% by weight
Filtek Z 350	Nanofilled	3M ESPE, St Paul, MN, USA	Bis-GMA, Bis-EMA, UDMA, and TEGDMA; 20-nm nanosilica, and 5- to 20-nm zirconia nanoagglomerates
GrandioSO	Nanohybrid	VOCO GMBH, Cuxhaven, Germany	Bis-GMA, Bis-EMA, UDMA, and TEGDMA with 87% of filler by volume

Specimens were stabilized on a glass slide using utility wax. The bleaching gel was applied to completely cover the specimens' surface. Four 30-minute applications comprised the two-hour bleaching protocol. Bleaching gel was removed with an endodontic cannula between bleaching procedures, while the last application was rinsed with deionized water.

Two readings were performed: the baseline and the final. The baseline color, opacity, and fluorescence readings were performed 24 hours after the specimens' fabrication. The final readings were performed 24 hours after the bleaching therapy. Color changes (ΔE) for each treatment were assessed by variation of L^* (ΔL^*), a^* (Δa^*), and b^* (Δb^*) values, by subtracting the final data from baseline data. Readings were performed using a spectrophotometer CM-2600D (Konica Minolta, Osaka, Japan) calibrated for small samples reading (SAV). Color determination was performed following the CIE (Commission Internationale de l'Eclairage) $L^*a^*b^*$ model, by means of Spectra Magic NX software (Konica Minolta, Osaka, Japan), using standard illuminant D65 on reflectance mode.

The equipment was adjusted to perform three consecutive readings and to calculate the mean L^* , a^* , and b^* values. For standardization, readings were performed with specimens over white and black epoxy resin backgrounds. ISO standard #2469 was followed during the measurements. The spectrophotometer was connected to an Acer Aspire 3624WXM computer for data storage.

The statistical analysis was performed by two-way analysis of variance (ANOVA) and Tukey tests, with the level of significance at 5%.

RESULTS

For color analysis, two-way ANOVA detected significant differences for different bleaching therapies ($p < 0.0001$). The type of composite resin had no statistical significance ($p = 0.3006$). The bleaching therapy influence on color variations performed by Tukey test is shown in Table 2.

Opacity variations were not statistically influenced by composite resin type and bleaching therapy ($p = 0.1410$ and $p = 0.3872$, respectively). However,

Table 2: Tukey Test Analysis, Mean Values, and Standard Deviation (\pm SD) of Color Variation (ΔE) According to Different Bleaching Therapies

Bleaching Therapy	Mean	\pm SD	Homogeneous Groups ^a
Control	1.90	1.35	A
20%	2.50	2.43	A
35%	3.44	1.77	B

^a Groups with same letter are statistically similar.

Table 4: Tukey Test Analysis, Mean Values, and Standard Deviation (\pm SD) of Fluorescence Variation According to Different Bleaching Therapies

Bleaching Therapy	Mean	\pm SD	Homogeneous Groups ^a
Control	0.70	1.52	A
20%	1.38	1.61	B
35%	1.47	1.37	B

^a Groups with same letter are statistically similar.

the interaction of both factors was statistically significant ($p=0.0316$).

Fluorescence changes were statistically influenced by composite resin type ($p<0.0001$) and bleaching therapy ($p=0.0016$). The interaction of both variables also influenced the fluorescence changes ($p=0.0137$). The Tukey test analyses for both variables are presented in Tables 3 and 4.

DISCUSSION

The effect of bleaching procedures on dental materials is important as this therapy is largely employed by clinicians, and patients usually present composite resin restorations. Recent composite resins mimic tooth color, opalescence, and fluorescence properties. Thus, it seems important to evaluate all of these

properties on composite resins after bleaching therapies.

The influence of bleaching procedures on total color alteration (ΔE values) of composite resins was observed in previous studies.^{5,9} In this study, the multiple comparisons test revealed that 35% hydrogen peroxide bleaching therapy resulted in greater color variations compared with both 20% hydrogen peroxide and control groups, while no differences were detected between 20% hydrogen peroxide and the control group. This leads to the assumption that not only does the hydrogen peroxide influence color change, but the concentration of hydrogen peroxide gels will also influence the degree of color change. Although this study detected color changes with hydrogen peroxide, there are studies that observed similar alterations with other types of bleaching agents, such as carbamide peroxide.¹²

This study's observations of color changes contradict previous studies, which reported either color stability¹³ or differences in color changes among different materials.^{9,10,14} The type of composite resin used has been reported as a factor influencing color changes after bleaching therapies due to its organic matrix⁹ or mainly to its inorganic composition.^{9-11,15,16} However, in the present study, although the tested composite resins presented different fillers, this difference did not influence the color change. As the organic matrix of the tested materials was very similar, this matrix might also play a role on how color changes or stabilizes after bleaching therapies. Moreover, the degree of conversion of the composite resin matrix to polymer may influence color stability,⁵ because non-reacted monomers could be attacked and degraded by bleaching solutions.

The following main factors might be responsible for color changes: first, the oxidation of readily accessible surface pigments; second, the oxidation

Table 3: Tukey Test Analysis, Mean Values, and Standard Deviation (\pm SD) of Fluorescence Variation According to Different Composite Resin Types

Composite Resin Types	Mean	\pm SD	Homogeneous Groups ^a
Venus	0.42	1.66	A
Grandio SO	0.80	2.15	A
Amaris	0.96	0.70	A B
Estelite	1.05	1.17	A B C
Esthet X	1.11	1.18	A B C
Admira	1.90	1.39	B C
Z350	2.05	1.51	C

^a Groups with same letter are statistically similar.

of amine compounds, which are responsible for composite resin color stability^{4,5}; and third, the composite surface microcrack areas.⁹ The microcracking areas are related to different filler components of composite resins,¹⁷ and this fact might be related to instant or future color changes and surface degradation of composite restorations.

Because of their filler characteristics, nanofilled composite resins are reported to present greater color stability in comparison with microfilled composite resins when submitted to bleaching treatment.¹⁰ No microfilled composite resin was tested in the present study, and no differences were detected among nanofilled, microhybrid, and nanohybrid composite resins regarding color and opacity variations.

The optical properties of composite resins, such as color, opacity, and fluorescence, are reported to be directly influenced by their different compositions. The filler type, size, concentration, and morphological distribution into resin matrix influence light propagation and perception.^{10,11,15,16}

No significant difference was detected among the tested materials with regard to their opacity variations, contradicting reported greater translucency characteristics after bleaching procedures.⁵ This greater translucency was, however, not of clinical significance.⁵ The opacity is related to the filler quantity and distribution, and bleaching therapies may not alter these particles. Surface gloss is reported to deteriorate after bleaching.^{12,18} As gloss is related to light reflection off of the material's surface, this might influence the optical perception of these materials.¹⁸ However, this association was not detected in a previous study assessing gloss and color of composite resins,¹² and as gloss was not a studied variable in this study, there was not a way clearly to determine this interaction between gloss and opacity or color.

Important opacity information to be addressed is the detection of an interaction between bleaching therapy and composite resin type with the present data. This means specific materials under specific bleaching regimens might behave differently, although no individual statistical differences were detected. This information should be further investigated and might be related to differences of inorganic components within the tested composites.^{10,11,15,16}

For the fluorescence analysis, significant differences were detected for the assessed variables, the bleaching therapy, and the type of composite resin,

as well as for the interaction of both. The composite resin brand Z350 presented the greatest fluorescence variation. This fact might be due to its composition of nanosilica and nanoagglomerated zirconia fillers. The fluorescence of restorative materials has been reported to be nonstable with aging¹⁹; thus, bleaching therapies might speed the aging process of restorative materials, and this may explain the observed results. Fluorescence has been shown to be dependent on the type of tested materials and, consequently, on their composition.^{15,16}

The correlation between opacity and fluorescence was not the purpose of this study, and there may not be an association between the two. The opalescence of composite resin is reported to be considerably increased by the addition of TiO₂ nanofillers, while the fluorescence does not change.¹¹

From a clinical standpoint, it is difficult to determine the importance of the detected statistical differences. As teeth undergo a lightening process by the bleaching therapy, the changes in composite resin color might follow the color changes of tooth structures. Thus, clinical color discrepancies after bleaching procedures are dependent on both composite resin and tooth color variations. Some reports disagree on the ΔE values that would represent perceptible clinical color changes, varying from 1 to 2⁵ and greater than 3²⁰ or 3.7.²¹ Considering this information, only subgroup 2 (35% hydrogen peroxide) would result in clinically perceptible color changes.

Although color changes detected immediately after bleaching therapies might not be clinically observed, bleaching gels lead to composite resin surface degradation and microcracks.⁹ This may influence the clinical acceptability of composite resin restorations in a long-term evaluation. In a microhardness assessment study,²² it was suggested that the oxidation promoted by hydrogen peroxide affects more than the subsurface of the restoration, thus compromising not only the restoration surface but also the body of the restoration.

The controversies of several studies might be related to differences in employed methodologies, differences of restorative materials, variations of concentration, bleaching gels presenting different pH, different periods of application of bleaching gels, and specimen storage methods.^{1,13,23–25} As bleaching therapies and composite resins are under constant development, it is important to test them frequently.

Based on recent reports, it is important that clinicians have knowledge about the optical changes

of composite resins submitted to bleaching therapies when using or recommending office bleaching with hydrogen peroxide. This will provide an efficient and safe treatment. Patients should also be informed that bleaching procedures in the presence of an esthetic filling might speed its aging process or require filling substitution because of its color variations.

CONCLUSIONS

- Thirty-five percent hydrogen peroxide gel produced the greatest color changes on the tested materials.
- No changes of opacity were detected with the tested bleaching protocols and materials.
- Fluorescence changes were statistically influenced by tested materials and bleaching protocols, regardless of the bleaching gel concentrations.

Conflict of Interest Declaration

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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