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Original Article

The effect of in-office bleaching applications on the color and translucency of composite resins

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Abstract

Aim: The study aimed to evaluate the relationship between the caries frequency, which was determined using different caries indexes Objective: The aim of this study was to investigate the effect of in-office bleaching agents on the color and translucency of different resin composites.

Materials and Methods: Twenty-four disk-shaped specimens with 1 mm thickness and 8 mm diameter were fabricated from five different resin composites. The specimens were then divided into three subgroups, two office bleaching groups (40% Opalescence Boost, 38% Whitesmile Power Whitening) and one control group (n=8). All specimens were polymerized for 40 s with a LED light-curing unit. Color measurement was performed using a spectrophotometer. Bleaching agents were applied to the experimental groups in accordance with the manufacturer's instructions for 14 days, while the specimens in the control group were kept in distilled water only. Translucency parameters of the specimens before and after bleaching and the color changes after bleaching were calculated using CIE $L^*a^*b^*$ color coordinates. Data were analyzed using the paired sample t-test and ANOVA (α=0.05).

Results: Statistically significant differences were found between the control group and the bleached groups according to color change values ($p<0.05$). The highest mean color change value was observed in the Ceram-X / Opalescence Boost group. The Ceram-X / Opalescence Boost, Majesty Esthetic / Opalescence Boost, and Ceram-X / Whitesmile Power specimens showed clinically non-acceptable color changes. Translucency parameter values in each group between baseline and the end of the 14^{th} day revealed no statistically significant difference ($p>0.05$).

Conclusions: The office bleaching agents may affect the color and translucency parameters of composite resins depending on the structural properties.

Keywords: Bleaching; color; dental composite; translucency

INTRODUCTION

Resin composites are now mostly used for their exciting esthetic outcomes. Nevertheless, teeth and resin composites discolor in the oral environment. The primary reason for the refilling of resin composite restorations is unacceptable color matching between tooth and restoration (1).

Resin composites undergo various physical changes as a result of different oral environment conditions and polymerization reactions. Discoloration of resin composites may be caused by extrinsic and intrinsic factors. Intrinsic factors cause the discoloration of the resin material itself, such as a change in the resin matrix and the interface of matrix and fillers. Factors such as thermal changes catalyze discoloration of resin composites (2). Adsorption or absorption is the most significant extrinsic factor also capable of causing discoloration. Water sorption is a primary cause of discoloration of tooth colored restorative materials. Water molecules among the resin composites' matrix ions act as water molecules in enamel while activating tooth bleaching agents (3).

After tooth bleaching, resin composites exhibit various optical changes, such as color and translucency (4). Some studies have shown that bleaching applied to hybrid resin composites inclines micro fractures and bacterial adhesion, because surface roughness may increase after the process (5,6). The CIE Lab-system used for standardized and repeatable evaluation of color changes (ΔE) in restorative materials analyzes $L^*a^*b^*$ values (7). A ΔE value greater than 3.3 represents unacceptable discoloration of resin materials (8,9). Recent studies have shown that the use of 10% hydrogen peroxide in the extra coronal technique or heated 30% hydrogen peroxide in the

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intracoronal technique resulted in clinically detectable resin composite color changes with ΔE values ranging between 2 and 11 for the different tooth colored restorative materials tested (10-12). Translucency is the ability of a layer of colored matter to allow an underlying background to appear. To measure translucency, the color difference between the uniform thickness of the material on a white background and on a black background is measured. The resulting value is called the translucency parameter (13).

Recent studies have all reported that all discolored vital and non-vital teeth bleaching has a brief history (14, 15). Popular methods for bleaching discolored teeth use hydrogen peroxide and peroxide releasing agents, such as sodium perborate and carbamide peroxide. Today, vital tooth bleaching methods are widely used to achieve a perfect smile. In this method, hydrogen peroxide or carbamide peroxide containing tooth bleaching gels are applied to tooth surfaces. This can be done at home, with or without clinician supervision, or in-office by a qualified dentist (15). In the USA, home bleaching systems are the most popular methods with patients. Some patients are reluctant to use bleaching systems due to rising costs and the length of the application procedure. Under these conditions, office bleaching methods seem to represent the most practical method of tooth bleaching. Recent clinical studies have shown that office bleaching methods elicit the same degree of satisfaction as home bleaching methods (16-18).

In the literature, few studies have included participants with adhesive restorations on discolored teeth in clinical trials (19). Not enough studies about the optical changes caused by newly produced in-office bleaching kits in different resin composites. The purpose of this study was to investigate the effect of two office bleaching agents on the color and translucency of five different resin composites.

MATERIALS and METHODS

Specimen fabrication

The five A2 shade composite resins and two different bleaching materials used in this study are shown in Table 1. Three different nanohybrid and two different microhybrid resin composites were used; Filtek Ultimate (3M/ESPE, St. Paul, MN, USA), Majesty Esthetic (Kuraray Medical, Okayama, Japan), Ceram X (Dentsply DeTrey Gmbh, Konstanz, Germany), Gradia Direct Anterior (GC Dental Products Corp, Tokyo, Japan), and Valux Plus (3M/ESPE, St. Paul, MN, USA), respectively. Twenty-four disk-shaped specimens with 1 mm thickness and 8 mm diameter were prepared from each resin composite using a silicon mold.

Table 1. Resin composites and bleaching agents used in this study

Product	Type and Contents	Manufacturer	Batch No
Filtek Ultimate	Nanohybrid composite, Bis GMA, TEGDMA Filler 65 wt %	3M ESPE, St Paul, MN, USA	N239315
Majesty Esthetic	Nanohybrid composite, Bis-GMA, hydrophobic aromatic dimethacrylate and hydrophobic aliphatic dimethacrylate Filler 66 wt %	Kuraray Medical, Okayama, Japan	00027A
Gradia Direct Anterior	Microhybrid composite, Bis-GMA, UDMA Filler 66 wt %	GC Corporation Tokyo, Japan	1009161
Ceram X	Ormocer based nanohybrid composite, Methacrylate modified polysiloxane, dimethacrylate resin Filler 66 wt %	Dentsply DeTrey Gmbh, Konstanz, Germany	1104000904
Valux Plus	Microhybrid composite BisGMA, TEGDMA Filler 71 wt %	3M/ESPE, St. Paul, MN, USA	N317054
Opalescence Xtra Boost	Office bleaching agent 40% hydrogen peroxide	Ultradent Poducts, South Jordan, UT, USA	B63W8
Whitesmile Power Whitening	Office bleaching agent 40% hydrogen peroxide	White Smile 2011, Germany	11021

Bis-GMA: Bisphenol A diglycidyl methacrylate, UDMA: urethane dimethacrylate, TEGDMA: Triethylene glycol dimethacrylate

Specimens were prepared in a thickness suitable for color measurement, similar to literature(20,21), and were prepared by a single researcher to ensure standardization. During the preparation of the specimens, polyester strips (Hawe, Kerr Dental, CA, USA) were placed on the upper and lower surfaces of the mold and flat surfaces were created. All specimens were polymerized for 40 s using a LED light-curing unit (Valo LED, Ultradent Products, South Jordan, USA) in standard mode with an intensity setting of 1000 mW/cm2. The light intensity of the curing unit was checked for each group using a digital radiometer (Hilux Ultra Plus Curing Units, Benlioglu Dental, Ankara, Turkey) and the tip of the light device is brought into contact with the transparent tape placed on the specimens during polymerization. The specimens were then divided into three subgroups involving two different bleaching kits [Opalescence Boost (OB) with 40% hydrogen peroxide content and Whitesmile Power Whitening (WP) with 38% hydrogen peroxide content] and a control group (n=8).

Bleaching procedures and color measurements

The bleaching gels were applied to the top surface of each specimen according to their manufacturers' instructions, where the thickness of gels was 2 mm. After the application of bleaching gels, these were activated for 5 min with a LED light-curing unit (Valo LED, Ultradent Products, South Jordan, USA) in plasma emulation mode with an intensity setting of 3200 mW/cm^2. The specimens in the experimental groups were bleached on the 2nd and 14th days after polymerization. Specimens were stored in distilled water at 37^{o}C for the period other than bleaching applications. The control group specimens were stored in distilled water 37^{o}C for 14 days and bleaching was not performed.

Color measurement was performed 24 hours after polymerization (baseline) and repeated after 14 days bleaching period (second measurement) using a spectrophotometer (ShadePilot, Degudent; Hanau, Germany, Software V. 2.41). Baseline CIE L*a*b* color coordinates were measured using spectrophotometry, and TP were calculated using the formula

$$TP = [(LB^*-LW^*)^2 + (aB^*-aW^*)^2 + (bB^*-bW^*)2]^{½}$$

The means of B and W are standardized black background (B) and white background (W). Based on the mean result from three measurements, black background was L= 14.9, a= 1.3 and b= 3.9 and white background L= 91.2, a= -0.6 and b=1.4.

The magnitude of total color differences is represented by a single number ΔE, where

$$ΔE= [(ΔL^*)^2+ (Δa^*)^2+ (Δ b^*)]^{½}$$

ΔE values >3.3 were considered clinically unacceptable.

Prior to second color measurement, bleaching agents were cleaned off, and specimens were dried with gentle air in experimental groups. Three measurements at the top of surface of specimens were then taken as previously described for baseline measurements. Data were analyzed using the paired sample t-test and ANOVA (α=0.05) with SPSS 20 software.

RESULTS

The means and standard deviations of the translucency changes (TP) and color changes (ΔE) in all tests are set out in Tables 2 and 3.

Duncan's test at a 95% confidence level showed that the mean translucency parameter (TP) for Ceram-X bleaching with the OB group was significantly higher than the values for Filtek Ultimate, Majesty Esthetic, Gradia Direct Anterior and Valux Plus, those bleached with both bleaching agents. There were no significant differences in translucency parameters among the other groups.

Table 2. TP values before (24 h) and after (14 days) bleaching treatments (Mean ± SD)

TP	Opalescence Xtra Boost (OB)		Whitesmile Power Whitening (WP)		Control	
	Before	After (14days)	Before	After (14days)	Before	After(14days)
Gradia Direct Anterior	15.80±1.81^{ab,A}	15.40±1.801^{ab,A}	16.30±0.821^{a,A}	15.76±0.811^{a,A}	15.10±1.211^{ab,A}	15.11±1.151^{a,A}
Filtek Ultimate	15.26±1.331^{ab,A}	14.24±0.981^{ab,A}	15.60±1.391^{a,A}	16.00±1.451^{a,A}	15.36±0.801^{ab,A}	15.00±0.281^{a,A}
Majesty Esthetic	15.17±0.711^{ab,A}	14.85±1.021^{ab,A}	15.35±0.41^{a,A}	14.33±0.64^{b,A}	14.54±0.651^{ab,A}	15.25±1.101^{a,A}
Valux Plus	16.76±0.571^{a,A}	16.70±1.071^{a,A}	16.0±0.961^{a,A}	15.89±1.051^{a,A}	15.76±1.081^{aa,A}	15.79±1.141^{a,A}
Ceram-X	12.47±1.381^{c,A}	12.15±0.701^{b,A}	11.71±1.371^{b,A}	12.25±0.52^{c,A}	12.48±1.111^{c,A}	12.07±1.981^{b,A}

*For each whitening kit, means followed by different lowercase letters in the columns differ statistically according to Duncan's test and uppercase letters in the rows differ statistically according to the paired sample t-test at the 5% level

According to ΔE values stated in Table 3, the mean color change in the Ceram-X/OB group was significantly higher than those in the other groups ($p<0.05$). At the end of the 14-day period, all specimens showed an appreciable color change, while Ceram-X / OB, Majesty Esthetic / OB, and Ceram-X / WP specimens showed clinically unacceptable color changes (ΔE>3.3). In all composites, the specimens in the control group showed lower mean color change compared to the bleaching groups. Valux Plus/WP specimens exhibited the lowest color change among the tested materials after bleaching.

Table 3. Test group ΔE values ± SD

ΔE	Opalescence Xtra Boost (OB)	Whitesmile Power Whitening Xtra (WP)	Control
Gradia Direct Anterior	3.11±0.17^{A,a}	3.15±0.38^{A,bc}	1.98±0.11^{A,ab}
Filtek Ultimate	2.68±0.38^{A,a}	2.65±0.11^{A,ab}	2.25±0.64^{A,ab}
Majesty Esthetic	2.96±0.14^{A,a}	2.99±0.71^{A,a}	1.07±0.94^{B,b}
Valux Plus	2.63±0.98^{A,a}	2.27±0.42^{A,bc}	2.94±0.73^{A,a}
Ceram-X	4.13±0.58^{A,a}	3,79±0.93^{A,a}	2.15±0.17^{B,ab}

* Means followed by different lowercase letters in the columns and uppercase letters in the rows differ statistically according to Duncan's test

DISCUSSION

With the increasing demand for cosmetic dentistry, restorative materials are expected to mimic not only the physical and mechanical properties of the tooth, but also the aesthetic properties such as color and translucency (22,23). In this context, bleaching practices have become widespread, and the effects of bleaching materials on teeth, surrounding tissues and existing restorations have also been discussed. In particular, it is thought that the organic matrix structure of composite resin is affected by the acidic structure of bleaching agents. The change in composite resin matrix structure may affect the properties of the restoration such as color, translucency and durability (24). Color changes can be evaluated using color measurement devices such as spectrophotometers. Most spectrophotometers employed in dental practice use the Commission International de I'Eclairage CIE L*a*b* color system to determine color changes. In this system, color is measured in three coordinate dimensions of L* representing lightness, a* corresponding to the green-red axis, and b* corresponding to the blue-yellow axis (25).

In this study, 38% hydrogen peroxide bleaching agents were applied to different resin-based composites following the manufacturers' guidelines. Hydrogen peroxide is an aggressive oxidant that breaks down into water and oxygen and exposes free radicals which result in oxidation of the colorant pigments which cause intrinsic or extrinsic discoloration (26,27). This molecule acts on the tooth tissues with its high diffusion ability and assumes the task of breaking down the pigments (28). If there is composite resin restoration in the area of hydrogen peroxide instead of dental tissues, this molecule can affect the organic matrix, filler or both. Generally, hydrogen peroxide exerts its main effect on the organic matrix structure, since there are reinforced glasses or ceramic fillers in the resin (29).

According to Monaghan et al. (30), highly concentrated office bleaching systems affect the color of composite resins while low concentrations of home bleaching systems do not. Tooth bleaching results in post-operative sensitivity in some cases. In order to eliminate this sensitivity, potassium nitrate desensitizing agents are added to the Opalescence bleaching agent used in this study. No significant differences were observed between the two bleaching agents in terms of color changes or translucency. These results suggest that addition of potassium nitrate to the bleaching agent does not affect the bleaching process.

In the studies examining the clinical importance of color change in the literature, it was reported that the ΔE value greater than 1 causes color change that can be distinguished by the human eye, and the value greater than 3.3 indicates the clinically unacceptable color change (16,31). In the present study, Majesty Esthetic/OB and Ceram X with OB/WP exhibited color changes equal or greater than 3.3 (32). The color change that occurs as a result of the interaction of these composites and bleaching agents has clinical importance as it can be noticed by the patient. Similar to our study, Canay and Cehreli (33) also detected visible color changes in all specimens and they examined the effect of bleaching agents containing 10% hydrogen peroxide on the color of composite resins. In this study, it was determined that the control group specimens showed more yellow-dark color than the bleached specimens.

In our study, when the color change of composite resins was examined with the application of hydrogen peroxide containing bleaching agents, the highest color change and TP differences were seen in polysiloxane resin based composite (Ceram-X), without depending on contents of bleaching agents compared to other resin-based composites used. Similar to our study, Celik et al.(34) and Kwon et al. (35) compared color change in Ceram-X after bleaching with a micro-hybrid and a nano-hybrid resin composite. Both studies revealed that Ceram-X demonstrated higher ΔE values. Ceram-X Mono composite contains modified polysiloxane particles, ceramic nanoparticles called ormocer and glass fillers. Ormocers are described as cross-linked copolymers and contain organic copolymers in addition to inorganic silanized filler particles. Unlike traditional polymer structures, ormocers have an inorganic backbone, and this structure is functionalized with polymerizable organic units (36). The high color change and TP differences of Ceram-X Mono specimens in our study may be due to this matrix structure and organic units.

Studies have reported that the effect of bleaching applications on composite resins on the color and optical properties of the resin may vary depending on the type of composite resin, matrix structure, filler type, volume, and particle size (37). A previous study using 10% carbamide peroxide showed that Valux Plus exhibited higher color changes values than micro hybrid resin-based composites with no diluent monomer (TEG-DMA) (33). However, in our study, the lowest mean ΔE value was observed in Valux Plus specimens after bleaching applications. Valux Plus was the one with the highest filler content among the composites used in our study (71% wt).Despite the TEGDMA content, high glass particle fillers may cause Valux Plus specimens to be less affected by hydrogen peroxide. In addition, the mean ΔE values of microhybrid Gradia Direct Anterior specimens were higher than nanohybrid composites used in this study.

Translucency is the ability to show the background of a material and is defined as a situation between opacity and full transparency (38). In addition to color, translucency feature should also be taken into account in order to obtain natural looking restorations. The translucency level also affects the composite's appearance close to enamel, and the ability to mask the oral cavity or dentine color. The TP value is often used to evaluate the translucency of composite resins (36). For this reason, TP method was evaluated in our study to evaluate the effect of bleaching on the translucency of resin composites. When different bleaching agents were applied to composite resins, no significant difference was observed between the groups before and after bleaching procedures ($p > 0.05$). The translucency change of composite resin due to bleaching application depends on the tested composite resin type, filler content, and size. The light absorption is generated by the resin matrix, while scattering is due to the refractive index mismatch between the filler particles and resin matrix (39). In our study, higher mean TP values of Valux Plus specimens may be explained with its filler structure, which causes less refractive index between the resin matrix and filler particles, allowing greater light penetration into the bulk of the material.

CONCLUSION

Within the limitations of this in vitro study, bleaching agents containing hydrogen peroxide can affect the color and translucency values of composite resins depending on the matrix structure, filler type and volume. The clinician should consider this situation in patients undergoing bleaching, restorations should be done after bleaching, and old restorations should be renewed after bleaching.

Conflict of interest: The authors declare that they have no competing interest.

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