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The effect of home-bleaching application on the color and translucency of five resin composites

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ABSTRACT

Objectives: The aim of this study was to investigate the effect of home bleaching agents on the color and translucency of resin composites.

Methods: Thirty disc shaped specimens (1 mm thick) were fabricated from each resin composite (Reflexions, Grandio, Gradia Direct, Clearfil Majesty Esthetic, Ceram-X Mono) and divided into 3 subgroups as carbamide peroxide (CP, Opalescence 10% PF), hydrogen peroxide (HP, 10% Opalescence Treswhite Supreme) and control group ($n = 10$). Baseline CIE $L^*a^*b^*$ color coordinates were measured with spectrophotometer and translucency parameters (TP) were calculated. CP and HP groups were treated with bleaching agents according to manufacturers' instructions and control group was stored in distilled water (DW) for 14 days. Color and translucency measurements were repeated and color differences were calculated, ΔE values > 3.3 were considered as clinically unacceptable.

Results: Clinically unacceptable color change was detected for all resin composites exposed to bleaching agents and there was significant color difference between the control group and bleached specimens ($P < 0.05$). However no significant color difference was found between CP and HP groups. Intragroup comparison revealed that Ceram-X Mono showed the highest color change but there was no significant difference among the other tested materials for both CP and HP groups. Intergroup comparison of TP values of CP, HP and control groups at the end of 14th day revealed that there was no statistical significant translucency difference among the groups.

Conclusions: Application of CP and HP resulted in clinically unacceptable color change for all resin composites. Translucencies of the resin composites were not affected by bleaching procedure.

Clinical significance: The results of this in vitro study suggest that patients should be informed regarding a potential color change of existing resin composite restorations with the use of home bleaching agents.

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1. Introduction

The use of bleaching systems has become a popular procedure over the last few decades due to the increased demand by patients for an aesthetic appearance of natural teeth. Bleaching agents are generally based on hydrogen peroxide (HP) or carbamide peroxide (CP) and may be in gel or liquid form. HP is the fundamental agent and CP is used as a vehicle for transporting low concentrations of HP.¹ After clinical application, CP dissociates into 3–5% HP and urea; after this, HP reacts to oxygen and water, while urea breaks down to ammonia and carbon dioxide.^{1,2}

Bleaching agents can be applied to the teeth in a dental office under professional supervision or at home by patients themselves.³ Home bleaching procedure involves the application of oxygenating agents, usually contains up to 15% HP⁴ or 22% CP as active ingredients, to the teeth via custom fabricated or ready-made guards.⁵ During at-home bleaching procedure, both teeth and existing restorations are exposed to bleaching agents for extended periods of time.⁶ Since home bleaching agents show efficacy via decomposition of peroxides into stable free radicals, which further breakdown into large pigmented molecules,² bleaching agent application may cause an alteration on the color of existing restorative material either.^{7,8} The alterations in color of the restorative materials have been attributed to the oxidation of surface pigments and amine compounds. The amount of resin matrix and the degree of conversion of the resin matrix to polymer might cause differences in color change between different restorative materials.^{9,10} Due to their organic matrix, resin composite materials especially are more prone to chemical alteration induced by the acidic component of bleaching agents compared to other restorative materials.¹¹

Matching the color of resin composite restorative material with the tooth has been of great concern for both clinicians and patients.¹² The color and translucency of natural teeth show a wide variation from patient to patient and even from one tooth to another. For clinical success, restorative materials should reproduce not only the color but also the translucency of natural dentition.^{13,14} Accordingly, it is essential to understand the effect of bleaching agents on the color and translucency of resin composites.

The studies^{2,4,7–9,12,15–17} investigated the color change after bleaching procedure reported that concentrations of bleaching agents, durations of exposure and particularly the composition of testing material effect the results. However, to the best of our knowledge, the available data on the effect of home bleaching treatment on translucency of resin composites is limited.

The aim of this *in vitro* study was to evaluate the color change and translucency of five different resin composites after 10% CP and 10% HP bleaching gel application.

2. Materials and methods

2.1. Specimen preparation

Resin composite materials (shade A2) used in this study were Reflexions (RFX), Grandio (GRN), Gradia Direct (GRD), Clearfil

Majesty Esthetic (CME) and Ceram-X Mono (CXM) (Table 1). Thirty disc-shaped specimens from each resin composite material (150 specimens in total) were prepared using a Teflon mould (1 mm thick and 10 mm in diameter). A transparent polyester strip (Hawe, Kerr Dental, CA, USA) was placed between the mould and a glass slide and then, the mould was filled with resin composite material. The top of the mould was covered with a transparent polyester strip and lightly pressed with a glass slide to remove the excess materials. All specimens were polymerised for 40 s with a quartz-tungsten halogen light-curing unit (Hilux UltraPlus, Benlioglu Dental, Ankara, Turkey) in standard mode with an intensity setting of 700 mW/cm². The output intensity of the curing light was verified by a radiometer (Hilux Curing Light Metre, Benlioglu Dental, Ankara, Turkey). Distance between the light source and specimen was standardised by holding the tip of the light-curing unit in direct contact with the upper glass slide. After polymerisation, specimens were gently polished with silicon carbide papers (Buehler, Lake Bluff, IL, USA) under running water and ultrasonically cleaned (Tchibo GmbH, Überseering, Hamburg, Germany) for 30 min. The specimens were stored in distilled water for 24 h at 37 °C.

2.2. Color and translucency measurements

The color measurement was performed with a clinical spectrophotometer (VITA Easyshade Compact, VITA Zahnfabrik, Bad Säckingen, Germany). VITA Easyshade Compact is a hand-held spectrophotometer that consists of a cordless hand piece of which contact probe tip is approximately 5 mm in diameter. It contains several 1 mm-diameter fibreoptic bundles. During the measurement process, the tooth is illuminated by the periphery of the tip, directing the light from white LEDs into the tooth surface. The display presents the closest VITA shade in the VITA Classical or VITA 3D-MASTER shade guide designation and CIE $L^*a^*b^*$ color system.

CIE $L^*a^*b^*$ color system defines color space by L^* , a^* , and b^* coordinates. L^* represents the lightness, or black/white character of the color. The coordinates a^* and b^* describe the chromatic characteristics of the color. The a^* coordinate represents the red-green axis and b^* coordinate represents the yellow-blue axis.

Color measurements were performed in a custom made viewing booth with D65 illumination (Master TL-D 90 De Luxe 18 W/965 1SL, Philips, Eindhoven, Holland). Composite specimens were placed over a white tile ($L^* = 96.3$, $a^* = 0.1$, $b^* = 1.9$). The instrument was calibrated according to the manufacturer's instructions. Spectrophotometer's "tooth single" measurement mode was selected and the probe was placed in the centre of the specimen. Three consecutive measurements were made for each specimen and mean L^* , a^* , and b^* values were calculated.

Translucency was evaluated with translucency parameter (TP). Measurements were performed in the viewing booth under D65 illumination with the Easyshade Compact spectrophotometer. Specimens were placed over a white tile ($L^* = 96.3$, $a^* = 0.1$, $b^* = 1.9$) and a black tile ($L^* = 8.9$, $a^* = -0.7$, $b^* = 1.2$) and "tooth single" mode was selected. TP was obtained by calculating the color difference between the specimen over

Table 1 – Materials tested in the study.

Materials	Code	Type	Main composition		Manufacturer	
			Resin/Matrix	Filler		
				Filler volume		Filler type and size
Reflexions XLS	RFX	Nano-hybrid	Ethoxylated Bis-GMA	76 vol.% (88 wt.%)	Glass filler (5 µm) Amorphous silica (0.04 µm)	Bisco, IL, USA
Grandio	GRN	Nano-hybrid	Bis-GMA, TEGDMA	71.4 vol.% (87 wt.%)	Ba–Al–borosilicate glass (0.1–2.5 µm) and silica nanofiller (20–60 nm)	Voco, Cuxhaven, Germany
Gradia Direct	GRD	Micro-hybrid	dimethacrylate co-monomers, UDMA	65 vol.% (77 wt.%)	Fluoro alumino silicate glass (0.85 µm), prepolymerized filler, and silica (0.85 µm)	GC, Tokyo, Japan
Clearfil Majesty Esthetic	CME	Nano-hybrid	Bis-GMA, hydrophobicaromatic dimethacrylates, and hydrophobic aliphatic dimethacrylates	66 vol.% (78 wt.%)	Silanated barium glass (average particle size 0.7 µm) and pre-polymerised organic filler	Kuraray, Osaka, Japan
Ceram-X Mono	CXM	Ormocer based nano-hybrid	Methacrylate modified polysiloxane, dimethacrylate resin	57 vol.% (76 wt.%)	Ba–Al–borosilicate glass (1.1–1.5 µm) and methacrylate functionalised silica nanofiller (10 nm)	Dentsply, Konstanz, Germany
Opalescence 10% PF	CP	At-home bleaching	10% carbamide peroxide, deionized water, 0.5% potassium nitrate, 0.11% sodium fluoride ion, carbapol, glycerin			Ultradent, South Jordan, UT, USA
Opalescence Treswhite Supreme	HP	At-home bleaching	10% hydrogen peroxide, potassium nitrate, fluoride			Ultradent, South Jordan, UT, USA

the white background and that over the black background with the following formula¹⁸:

$$TP = [(L_B^* - L_W^*)^2 + (a_B^* - a_W^*)^2 + (b_B^* - b_W^*)^2]^{1/2}$$

Subscript B refers to the color coordinates over the black background and subscript W refers to those over the white background. If the material is absolutely opaque, TP value is zero; if the material is totally transparent, TP value is 100. Thus, higher values for the TP value represent greater translucency.¹⁸

2.3. Bleaching procedure

Bleaching agents used in this study are displayed in Table 1. After the initial color and translucency measurements, 30 composite specimens from each resin composite group were randomly divided into 3 subgroups ($n = 10$) with lottery method. The first subgroup was the control (nonbleaching) group and in this group the specimens were stored in distilled water which was refreshed daily during the 14-day testing period. The specimens in the second subgroup were treated with CP bleaching solution for 8 h per day for 14 consecutive days; the third subgroup were exposed to HP bleaching solution for 60 min per day for 14 consecutive days according to the manufacturers' instructions.

HP bleaching solution used in this study is a pre-loaded bleaching agent in a tray. To prevent the contamination of rear surface of the specimen from bleaching agent, specimens

were not placed into the tray. The bleaching solution was transferred from tray to a syringe. Both of the bleaching agents were applied with the syringe (Hayat, Istanbul, Turkey) in equal amounts and uniformly spreaded with the help of a cotton applicator (MicroTim, Voco, Cuxhaven, Germany) on the same surface of the specimens every time where the thickness of the gel was approximately 1 mm and then the specimens were kept in dark containers. After daily bleaching procedure, specimens were cleaned under running water for 1 min, dried and then stored in distilled water till the next application. At the end of 14 days, specimens were cleaned and dried prior to the color and translucency measurements.

After bleaching treatment the CIE $L^*a^*b^*$ coordinates and TP values were determined for each specimen as previously described. The CIE $L^*a^*b^*$ color difference (ΔE) between baseline and after bleaching measurements was calculated for each specimen with the following equation:

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

Where ΔL^* , Δa^* and Δb^* indicate the differences before and after bleaching values. ΔE value ≥ 3.3 was considered clinically unacceptable.¹⁹

2.4. Statistical analysis

Normality of the data distribution was checked by the Shapiro–Wilks test and parametric tests were chosen since the data were distributed normally. Intragroup and intergroup

Table 2 – Mean (standard deviation) ΔE values of control group and specimens after bleaching application.

	HP	CP	DW
RFX	4.3 (1.2)	3.9 (1.7)	2.1 (0.9) ^b
GRN	5.5 (0.8)	5.2 (1.4)	2.1 (1.1) ^b
GRD	5.2 (0.8)	4.6 (1.5)	2.4 (0.8) ^b
CME	6.1 (0.5)	5.8 (0.9)	1.9 (1.1) ^b
CXM	7.7 (1.9) ^a	6.6 (1.4) ^a	2.4 (0.7) ^b

RFX: Reflexions, GRN: Grandio, GRD: Gradia Direct, CME: Clearfil Majesty Esthetic, CXM: Ceram-X Mono, HP: Hydrogen peroxide, CP: Carbamide peroxide, DW: Distilled water.
^a Significant difference in intragroup comparison.
^b Significant difference in intergroup comparison ($P < 0.05$).

comparisons of ΔE values of the resin composites in HP, CP and DW groups were analysed with one way analysis of variance (ANOVA) and Post hoc comparisons were performed using the Bonferroni test, when significance was detected. Intragroup translucency data of resin composites in HP, CP and DW groups were analysed by one way ANOVA and Post hoc comparisons were performed using the Bonferroni test when significance was detected. The paired t-test was used for comparison the difference in translucency between groups after bleaching agent application or storing in distilled water. Values of $P < 0.05$ were accepted as statistically significant.

3. Results

Mean color differences (ΔE) and standard deviations of bleached specimens and control group are displayed in Table 2. All of the bleached specimens showed clinically unacceptable color changes ($\Delta E > 3.3$). Intragroup comparisons for both HP and CP revealed that there was no statistically significant color difference among RFX, GRN, GRD and CME (Table 2). However, CXM showed the highest color difference among the tested materials, for CP and HP groups ($P < 0.05$). Intergroup comparison indicated no significant difference between CP and HP groups ($P > 0.05$), however ΔE values of bleached specimens were significantly higher than control group ($P < 0.05$) (Table 2).

Mean TP values and standard deviation of the specimens and control group are presented in Table 3. For CP, HP and DW groups, comparison of baseline TP values of specimens revealed that CXM was the least translucent resin composite, however there was insignificant difference among the other

tested materials. For both CP and HP groups, intragroup comparison exhibited that there was no significant difference among TP values of RFX, GRN, GRD and CME ($P > 0.05$), however TP values of CXM were significantly lower than the other resin composites ($P < 0.05$). Control group showed statistically not significant translucency decrease for all tested materials at the end of day 14. Intergroup comparison of CP, HP and DW revealed that there was no statistical significant translucency difference among the groups ($P > 0.05$) (Table 3).

4. Discussion

Bleaching has become a routine cosmetic dental procedure. However, especially during home bleaching treatment, the existing restorations are also subjected to bleaching agents. Therefore, the effect of home bleaching agents on the color and translucency of resin composites is of great concern.

The bleaching agents used in this study were 10% CP and 10% HP. Since 10% CP breaks into 3.5% HP in the mouth after clinical application,²⁰ the HP content of 10% CP is approximately 3 times lower than 10% HP.² Therefore, in the present study, 10% HP was expected to cause significantly higher discoloration when compared to 10% CP as it has been shown in a previous study.² Yalcin and Gurgan²¹ also showed that 6.5% HP strip band demonstrated higher ΔE values compared to 10% CP when applied to resin composites. However no statistically significant color difference was found between the bleaching agents tested in this study. This may be due to the total application time of the bleaching agents. According to the manufacturers' instructions both bleaching agents were applied for 14 days but CP was applied 8 h per day whereas HP was applied 60 min per day.

In the present study, CIE $L^*a^*b^*$ color system was chosen to measure color differences. A color difference of approximately one ΔE unit is visually detectable for 50% observers under controlled conditions.²² The threshold for the clinically acceptable ΔE values varies widely in the literature and several authors have reported the thresholds as $\Delta E \leq 2.72$,²³ $\Delta E \leq 3.3$,¹⁹ and $\Delta E \leq 3.7$.²⁴ In this study, ΔE values less than 3.3 were considered as clinically acceptable.¹⁹

Three nano-hybrid (RFX, GRN and CME), an ormocer based nano-hybrid (CXM) and a micro-hybrid (GRD) resin composites were used in this study. All of the resin composites tested showed clinically unacceptable color changes ($\Delta E > 3.3$) after their exposure to 10% CP and 10% HP bleaching agents. The

Table 3 – Mean (standard deviation) TP values of control group and specimens before and after bleaching application.

	HP		CP		DW	
	Before	After	Before	After	Before	After
RFX	19.22 (2.3)	19.91 (2.1)	19.78 (0.9)	20.47 (1.5)	19.61 (2.1)	19.47 (1.0)
GRN	22.95 (2.8)	22.1 (1.9)	22.3 (1.3)	21.36 (0.9)	22.72 (2.3)	22.22 (2.1)
GRD	20.49 (2.3)	19.93 (2.4)	20.77 (1.3)	20.46 (1.1)	21.58 (1.8)	21.24 (2.2)
CME	19.61 (1.4)	19.11 (1.9)	19.76 (2.6)	19.22 (1.8)	19.64 (1.9)	19.43 (1.8)
CXM	16.16 (1.8) ^a	16.86 (1.6) ^a	15.78 (1.6) ^a	16.61 (1.4) ^a	18.41 (1.2) ^a	18.04 (1.8) ^a

RFX: Reflexions, GRN: Grandio, GRD: Gradia Direct, CME: Clearfil Majesty Esthetic, CXM: Ceram-X Mono, HP: Hydrogen peroxide, CP: Carbamide peroxide, DW: Distilled water.
^a Significant difference in intragroup comparison ($P < 0.05$).

color change in control group (distilled water) was also visually detectable but in clinically acceptable ranges (Table 2). These findings were not in agreement with the previous studies that found clinically acceptable color changes after application of bleaching agents of which concentrations were similar to the agents used in this study.^{4,7,15,21} However, Canay and Cehreli² demonstrated that the color change of resin composites resulting from 10% HP exposure was detectable to the naked eye. Rosentritt et al.⁸ found that the application of different bleaching agents with 10% CP concentration partly caused ΔE values higher than 3.3 on a microhybrid and an ormocer based resin composite materials tested. The discrepancies between these studies may be caused by the type of the bleaching agents used and total application time of the agents or the type of resin composite tested.^{2,25}

In the literature, it has been suggested that color change after exposure to bleaching agent might be dependent on the matrix structure, volume and type of filler particles of the resin composites.^{2,12,26} In this study there was no statistically significant difference among the ΔE values of nano-hybrid resin composites and the micro-hybrid resin composite however ΔE values of ormocer based nano-hybrid resin composite CXM were statistically higher. These findings were in agreement with previous studies.^{6,27} Celik et al.⁶ and Kwon et al.²⁷ compared the color change of CXM after bleaching agent exposure with a micro-hybrid and a nano-hybrid resin composite. Both of the studies^{6,27} revealed that CXM demonstrated higher ΔE values. CXM was defined as nanoceramic resin composite by the manufacturer. There are two important differences between CXM and conventional hybrid composites in terms of filler and resin type. CXM includes methacrylate-modified silica containing nanofiller (10 nm) substitutes for the microfiller that is used in hybrid composites and most of the conventional resin matrix is replaced by a matrix full of highly dispersed methacrylate modified polysiloxane particles. The nanoceramic particles are inorganic-organic hybrid particles.²⁸ The volume of resin matrix of CXM was greater than the other resin composites tested in this study because of lower volumetric filler content (Table 1). A resin composite with higher resin matrix content is expected to be more prone to degradation after bleaching agent application^{8,12} and therefore may undergo color changes. The greatest color change of CXM specimens when compared to the micro- and nano-hybrid composites tested in this study may be attributed to these structural differences.

Translucency is the ability of a material to allow the appearance of underlying background to show through¹⁸ and can be described as partial opacity or a state between complete transparency and complete opacity.²⁹ Translucency is comparable in importance to color in the shade matching procedure to achieve natural looking restorations.³⁰ The translucency level also affects the ability of composite to mask the oral cavity or discolored teeth.³¹ TP has been usually used to evaluate the translucency of resin composites in the literature³²⁻³⁵ and therefore TP method was chosen in the present study to assess the effect of bleaching on the translucency of resin composites. The TP of a material refers to the difference in color between a uniform thickness of a material over a black and a white background, and provides

a value corresponding directly to common visual assessment of translucency.¹⁸

Surface texture is an important factor that effects the perceived translucency of a material. Translucency reduces as the surface roughness increases.³⁶ It has been shown that bleaching agents increased the surface roughness of resin composites.^{16,37} However, in the present study, there was no statistically significant difference between baseline and after bleaching TP values of all resin composites. The concentrations of bleaching agents used in this study were lower when compared to previous studies,^{16,37} therefore bleaching application might not effect the surface roughness of specimens. In further studies the effect of surface roughness on TP values of resin composites exposed to bleaching agents with higher concentrations can be investigated.

The effect of bleaching agents on color and translucency of restorative materials is still not clear. Resin composites tested in this study should also be investigated in terms of surface roughness and the relation between bleaching induced surface roughness and aesthetic properties may be clarified.

5. Conclusions

Within the limitations of this study it is concluded that there was a significant and clinically unacceptable color change after 10% CP and 10% HP application. The highest color difference was detected in ormocer based nano-hybrid resin composite (CXM). The translucency of resin composites were not affected by bleaching agent application when compared with the samples treated with distilled water. The effect of home-bleaching agents on the color of resin composites should be considered and the patients should be informed regarding a potential color change after bleaching.

Conflicts of Interest statement

The authors state that there is no conflict of interest in this study.

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