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Effect of Modeling Liquid Use on Color and Whiteness Index Change of Composite Resins#

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Research Article

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History

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ABSTRACT

Objectives: Composite resins are widely used in the restoration of teeth. The aim of this study is to examine the effect of modeling liquid use on the color and whiteness index changes of composite resins.
Materials and Methods: In the study, samples were prepared using different composite resins (Clearfil Majesty Esthetic, Estelite Asteria, G-aenial A'Chord and Omnichroma). Before polymerization of the prepared samples, modeling liquid was applied to one group with a composite brush, while modeling liquid was not applied to the other group. After the polymerization process, the samples were polished using the finishing and polishing system (Clearfil Twist Dia). Color measurement of samples kept in coffee was measured at the beginning, at 7th and 30th days using spectrophotometer. CIEDE2000 (ΔE_{00}) and whiteness index (WI_D) formulas were used to calculate color changes. Statistical analysis of the data was performed with one-way analysis of variance (ANOVA) and Tukey tests.
Results: There was a statistically significant difference between the color and whiteness index change values of the composite resins on the 7th and 30th days. There was no statistically significant difference between the color and whiteness index change values of the composite resins with and without modeling liquid. The control group, which did not undergo finishing and polishing, showed the statistically highest color change.
Conclusions: Composite resins showed change in color (ΔE_{00}:1.8) and whiteness index (ΔWI_D:2.6) above the acceptable threshold value (AT) in coffee. The use of modeling liquid did not affect the color and whiteness index changes of the composite resins.

Keywords: Composite Resin, Whiteness Index, Modeling Liquid, Color Change.

Modelleme Sıvısı Kullanımının Kompozit Rezinlerin Renk ve Beyazlık İndeksi Değişimine Etkisi#

Bilgi
#Bu çalışma 23-25 Kasım 2021 tarihleri arasında düzenlenen 'Sivas Cumhuriyet Üniversitesi 1. Uluslararası Diş Hekimliği Kongresi'nde sözlü bildiri olarak sunulmuştur.
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ÖZ

Amaç: Kompozit rezinler dişlerin restorasyonunda yaygın bir şekilde kullanılmaktadır. Bu çalışmanın amacı; modeling likit kullanımının kompozit rezinlerin renk ve beyazlık indeks değişimine etkisini incelemektir.
Gereç ve Yöntemler: Çalışmada farklı kompozit rezinler (Clearfil Majesty Esthetic, Estelite Asteria, G-aenial A'Chord ve Omnichroma) kullanılarak örnekler hazırlandı. Hazırlanan örneklerin polimerizasyondan önce bir gruba kompozit fırçası ile modeling likit uygulanırken, diğer gruba modeling likit uygulanmadı. Polimerizasyon işleminden sonra örnekler bitirme ve cila sistemi (Clearfil Twist Dia) kullanılarak polisaj yapıldı. Kahve içerisinde bekletilen örneklerin renkleri başlangıçta, 7. ve 30. günde spektrofotometre kullanılarak ölçüldü. Renk değişim değerlerinin hesaplamasında CIEDE2000 (ΔE_{00}) ve beyazlık indeks (WI_D) formülleri kullanıldı. Verilerin istatiksel analizi tek yönlü varyans analizi (ANOVA) ve Tukey testleri ile yapıldı.
Bulgular: Kompozit rezinlerin 7. ve 30. gündeki renk ve beyazlık indeks değişim değerleri arasında istatiksel olarak anlamlı farklılık görüldü. Kompozit rezinlerin modeling likit kullanılan ve kullanılmayan gruplarının renk ve beyazlık indeks değişim değerleri arasında istatistiksel anlamlı farklılık görülmedi. Bitirme ve polisaj işlemi yapılmayan kontrol gurubu istatistiksel olarak en fazla renk değişimi gösterdi.
Sonuçlar: Kompozit rezinler kahve içerisinde kabuledilebilir eşik değeri (AT) üzerinde renk (ΔE_{00}:1,8) ve beyazlık indeks (ΔWI_D:2,6) değişimi gösterdi. Modeling likit kullanımı kompozit rezinlerin renk ve beyazlık indeks değişimi etkilemedi.

Anahtar Kelimeler: Beyazlık İndeks, Kompozit Rezin, Modeling Likit, Renk Değişikliği

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Introduction

Composite resins, whose mechanical and optical properties have been improved, are widely used in the restoration of teeth as they provide color match with dental tissues.[1,2] Despite many positive properties of composite resins, the viscous resin monomers in their structures and the increase in inorganic filler ratios make the manipulation of materials difficult. Adhesion of the composite to the application tool during layered placement is a common problem.[3] Therefore, various modeling agents and equipment have been proposed to improve the adaptation and manipulation of composite resins.[2,4]

The use of modeling liquids, which are used in shaping composite restorations, has become widespread as the material facilitates manipulation. Less adhesion of the composite brush, which is wetted with modeling liquid, to the composite allows easy and fast application of the composite in the mouth. Using the brush moistened with modeling liquid in the last composite layer allows a smoother surface to be obtained.[5] However, it is stated that the modeling liquids used in the final restoration layer may interact with the beverages during feeding and adversely affect the optical properties and color stability of the composite material.[6]

Acceptable surface roughness and color stability are essential for clinical success in composite resins. Color changes in material were associated with water absorption, degree of polymerization, diet, and surface roughness of the restoration.[7] It is stated that the color sensitivity of the material to external factors has a direct effect on the polishing and finishing procedures as well as the composition of the material.[8] The rough surface of the restoration may be stained by external factors such as coffee, tea or red wine, causing the material to become discolored.[9,10]

Spectrophotometers used in the measurement of color change in dental materials measure the amount and spectral composition of the light reflected from the object and convert it into numerical data.[11] Despite the use of CIELAB (ΔE_{ab}) and CIEDE2000 formula (ΔE_{00}) over L*, a* and b* values in calculating the color change in dental materials[12], a new whiteness index (WI_D) has started to be used.[13] In the CIEDE2000 system, perceptibility threshold values (PT) are specified as ΔE_{00}>0.8 and the acceptability threshold value (AT) as ΔE_{00}≤1.8.[14] In the whiteness index, PT value is specified as ΔWI_D: 0.72 and AT value as ΔWI_D: 2.6.[14]

Although modeling liquids are widely used, their effects on the physical and surface properties of composite resins are limited in the literature. The aim of the *in vitro* study is to examine the effects of modeling liquid use on the color change and whiteness index of composite resins. Our first null hypothesis is that using modeling liquid will not affect the color change of composite resins. Our second null hypothesis is that using liquid modeling will not affect the whiteness index change of composite resins.

Materials and Methods

In our study, Omnichroma (Tokuyama Dental, Tokyo, Japan), Estelite Asteria A2B (Tokuyama Dental, Tokyo, Japan), Clearfil Majesty Esthetic A2 (Kuraray Noritake, Tokyo, Japan) and G-aenial A'Chord A2 (GC Corporation, USA) composite resins used (Table 1). Samples of 8 mm in diameter and 2 mm in height were prepared from the composite resins using a silicone mold. In the preparation of the samples, composite resins were placed in the space above the silicone mod with a mouth spatula. Then, one group was polymerized by placing a 1 mm thick glass (lamel) on the mylar strip, while the other group was smoothed with a brush (Composite Brush, GC, Japan) on which the top layer of modeling liquid (Modeling Liquid, GC, Japan) was applied, and then it was polymerized by placing 1 mm thick glass (lamel) on the mylar strip. In the polymerization of composite samples, the LED light device (DTE LUX E, Germany) was used as for 20 seconds at 1000 mW/cm² power. A total of 96 samples were prepared, as 24 from each material (n:8).

Table 1 Properties of composite resin materials used in the study

Materials	Composition		Filler content (w/w)	Lot Number
	Matrix	Filler		
Clearfil Majesty Esthetic A2 (Kuraray Noritake, Tokyo, Japan)	Bis-GMA	Barium glass filler, micro glass filler (1.5 µm), nano glass filler (20 nm), pre-polymerized organic filler	78/66	870033
Estelite Asteria (Tokuyama Dental, Tokyo, Japan)	Bis-EMA TEGDMA UDMA	Supra-nano spherical filler, Composite filler (260 nm spherical SiO_2-ZrO_2)	%82	200912A
G-aenial A'Chord A2 (GC Europe, Tokya, Japon)	Bis-EMA TEGDMA UDMA	Barium glass filler (300 nm), fumed silica (16 nm), silica glass (3 nm)	%82	200912A
Omnichroma (Tokuyama Dental, Tokyo, Japan)	TEGDMA UDMA	Supra-nano spherical filler, Composite filler (260 nm spherical SiO_2-ZrO_2)	79/68	00E639
Modeling Liquid (GC Europe, Tokya, Japon)	UDMA, 2-hydroxyethyl methacrylate,3 dimethacryloxy propane, 2-hydroxy-1		-	2102161

*BisGMA: Bisfenol diglisidilmethacrylate, UDMA: üretan dimethacrylate, TEGDMA: trietilenglikol dimethacrylate, Bis-EMA, bisphenol A ethoxylate dimethacrylate.

Two-step finishing and polishing systems (Clearfil Twist Dia, Kuraray, Japan) were used in the finishing and polishing of the prepared samples. The finishing and polishing of the samples of composite resins was carried out for 20 seconds under water cooling at 10.000 rpm. Finishing and polishing was not used to the control group. After finishing and polishing processes, composite samples were kept in incubator (FN 500, Nüve, Turkey) for 24 hours in distilled water at 37°C.

After the composite samples were kept in distilled water for 24 hours, the initial color (L *, a * and b * values) of the samples belonging to each group were measured using a spectrophotometer device (Vita Easyshade V; VITA Zahnfabrik, Germany) under D65 lighting conditions. Color measurements of composite samples were made with three measurements from the center point of the same sample.

After determining the initial color of the composite samples, they were kept in coffee (Nescafe Classic, Turkey) in the incubator (FN 500, Nüve, Turkey) for 30 days at 37°C. Color measurements of the samples on the 7th and 30th days were made with a spectrophotometer device (Vita Easyshade V; VITA Zahnfabrik, Germany) and L*, a* and b* values were recorded. The coffee solution was prepared by dissolving 2 grams of coffee powder and 200 ml of boiled distilled water in line with the manufacturer's recommendation. The prepared coffee solution was added to the samples at 37 °C. It was also replaced with a new coffee solution every 24 hours. The CIEDE2000 formula (ΔE_{00}) and whiteness index (WI_D) was used to calculate color changes in composite resins based on L*, a* and b* parameters.

Statistical data analysis was performed using SPSS 22.0 Statistical Program (SPSS Inc., Chicago, IL, USA). Color change and whiteness index change values of composite resins at the end of 7th and 30th days were evaluated using one-way analysis of variance (ANOVA) and Tukey multiple comparison test ($p<0.05$).

Results

A statistically significant difference was observed between the color change values of composite resins at the end of 7th and 30th days ($p<0.05$). One-shade composite resin (Omnichroma) showed the most color change at the end of the 7th and 30th days ($p<0.05$). The least color change was seen in supranano composite (Estelite Asteria). One of the nanohybrid composite resins, G-aenial A'Chord showed more color change than the other nanohybrid composite resin (Clearfil Majesty Esthetic) ($p<0.05$), (Table2).

There was no statistically significant difference between the color change values of the composite resin groups, with and without use of modeling liquid on the 7th and 30th days ($p>0.05$). The control group, which was not applied finishing and polishing procedure, showed the statistically highest color change ($p<0.05$).

Table 2. Color change values of composite resins at 7th and 30th days

Composite Resin	Model liquid use	7th day ΔE_{00}	30th day ΔE_{00}
Clearfil Majesty Esthetic	No	2.95 ± 0.3^{a}	3.93 ± 0.3^{a}
	Yes	3.13 ± 0.2^{a}	3.96 ± 0.2^{a}
	Control (No Polishing)	4.05 ± 0.3^{b}	6.05 ± 0.6^{b}
Estelite Asteria	No	2.50 ± 0.2^{c}	2.92 ± 0.2^{c}
	Yes	2.57 ± 0.2^{c}	3.30 ± 0.2^{c}
	Control (No Polishing)	3.52 ± 0.2^{b}	4.50 ± 0.3^{d}
G-aenial A'Chord	No	4.91 ± 0.4^{d}	6.06 ± 0.4^{b}
	Yes	5.09 ± 0.4^{d}	6.28 ± 0.4^{b}
	Control (No Polishing)	5.88 ± 0.5^{e}	7.58 ± 0.5^{e}
Omnichroma	No	14.23 ± 0.6^{f}	15.25 ± 0.6^{f}
	Yes	13.58 ± 0.5^{f}	15.42 ± 0.6^{f}
	Control (No Polishing)	14.51 ± 0.4^{f}	15.78 ± 0.8^{f}
P		0.000	0.000

*Statistical significance difference between rows (a-f). $p<0.001$

Table 3. Whiteness index change values of composite resins on the 7th and 30th days

Composite Resin	Model liquid use	Basaline WI_D	7th day ΔWI_D	30th day ΔWI_D
Clearfil Majesty Esthetic	No	8.02 ± 0.5^{a}	4.21 ± 0.5^{a}	5.48 ± 0.5^{a}
	Yes	7.50 ± 0.5^{a}	4.08 ± 0.3^{a}	4.97 ± 0.5^{a}
	Control (No Polishing)	9.82 ± 0.4^{b}	8.72 ± 0.4^{b}	13.35 ± 0.9^{b}
Estelite Asteria	No	4.58 ± 0.3^{c}	4.59 ± 0.3^{a}	5.26 ± 0.4^{a}
	Yes	4.28 ± 0.4^{c}	4.49 ± 0.3^{a}	4.96 ± 0.4^{a}
	Control (No Polishing)	5.72 ± 0.5^{d}	7.86 ± 0.5^{c}	11.79 ± 0.8^{c}
G-aenial A'Chord	No	4.44 ± 0.5^{c}	5.95 ± 0.9^{d}	7.14 ± 0.6^{d}
	Yes	4.23 ± 0.5^{c}	6.69 ± 0.8^{d}	7.37 ± 0.8^{d}
	Control (No Polishing)	4.19 ± 0.5^{c}	9.09 ± 0.9^{b}	12.49 ± 0.6^{b}
Omnichroma	No	44.08 ± 1.2^{e}	26.89 ± 2.5^{e}	32.37 ± 0.8^{e}
	Yes	42.32 ± 1.3^{e}	25.96 ± 1.8^{e}	32.33 ± 1.1^{e}
	Control (No Polishing)	41.37 ± 0.8^{e}	27.86 ± 1.4^{e}	34.88 ± 1.4^{e}
P		0.000	0.000	0.000

*Statistical significance difference between rows (a-f). $p<0.001$

A statistically significant difference was observed between the whiteness index change values of composite resins at the end of 7th and 30th days ($p<0.05$). One-shade composite resin (Omnichroma) showed the highest whiteness index change at the end of the 7th and 30th days ($p<0.05$). There was no statistically significant difference between the whiteness index change values of the supranano composite (Estelite Asteria) and the nanohybrid composite (Clearfil Majesty Esthetic) at the 7th and 30th days (Table 3).

Composite resin groups with and without use of modeling liquid did not show statistically significant difference between the whiteness index change values on the 7th and 30th days ($p>0.05$). The control groups in all composite resins, which did not used finishing and polishing processes showed statistically the highest whiteness index change ($p<0.05$).

Color and whiteness index change values of composite resins increased over time. The color and whiteness index change values of the composite resins at the end of the 7th and 30th days exceeded the AT value (ΔE_{00}:1.8, WI_D:2.6).

Discussion

The use of composite resins with modeling liquid in the restoration of teeth facilitates the finishing procedure of the restoration and provides a significant time saving for the dentist. However, doubts have arisen about the changes that may occur in the color stability of composite restorations over time due to the compounds of modeling liquids.[15,16] In this *in vitro* study, the effect of modeling liquid used with a brush on the color and whiteness index changes of composite resins was studied. As the modeling liquid did not affect the color and whiteness index changes of the composite resins, our first and second null hypotheses were accepted.

Although the many properties of composite resins, which are widely used in the restoration of teeth, have been improved, the surface roughness obtained after finishing and polishing affects the clinical success of the material. Low surface roughness increases the esthetic appearance and success of composite resins, while rough surfaces cause plaque accumulation, recurrent caries and discoloration of the restoration.[17] It has been reported in the literature that the diamond-containing finishing and polishing system creates less color change on composite resins.[18,19] For this reason, a two-step diamond finishing and polishing system was used in our study.

Color changes in dental materials are related to many internal and external factors.[20] Although beverages show different color changes on dental materials, red wine, coffee and tea cause the most color changes.[21] As a result of the yellow coloring pigment in coffee, it is effective in the color change of composite resins.[22] In our study, coffee was preferred in the examination of the color change of composite resins.

Due to the difference in the refractive index of the composite resins before and after polymerization, the translucency of the material increases after polymerization. Increasing the translucency made possible the composite resin structure that responds to light waves at a certain frequency and reflects a certain wavelength in it.[23] It is reported that single shade composite resins with increased translucency match a wide range of colors in a one-shade and are compatible with all tooth tones.[24,25] The very high initial WI_D value of the one-shade composite resin in our study can be explained by their translucency. However, after being kept in coffee, it was observed that the ΔE_{00} and WI_D value decreased more than the composite resins in the multi-shade system. It is considered that this decrease in the WI_D value causes single shade composites to show more color changes.

As a result of the increase in the amount of resin contained in dental materials, the amount of water absorption increases, creating hydrolytic degradation in the material. Substances separated from the structure of the material by hydrolytic degradation can cause physical and optical properties to change. Water absorbed by the polymer matrix has been reported to increase coloring by causing the bond between the matrix and the filler to break or hydrolytic decomposition of the filler itself.[26] In addition, as Bis-GMA causes rigid network formation, it is reported that composites whose main monomer content is Bis-GMA shows less water absorption than composites containing TEGDMA and more than composites containing UDMA and Bis-EMA.[27] There is UDMA monomer in the structure of the modeling liquid we used in our study.

It has been reported in the literature that modeling liquids can be successful in increasing the adaptation between the composite layers and preventing the coloration of the composites.[28,29] Bayraktar et al. reported that modeling agents reduce the surface microhardness of composite resins, but Modeling Liquid (GC, Japan) can be used as a safer wetting agent in terms of surface microhardness.[6] The modeling liquid (Modeling Liquid, GC) we used in our study did not make a statistical difference on the color and whiteness index changes of the composite resins.

The acceptability threshold value (AT), which is an important factor for evaluating the color stability of dental materials, has been specified as 50:50% AT value ΔE_{00}:1.8 and ΔWI_D:2.6 in the literature.[14] Sulaiman et al. reported in their study on the color stability of composite resins (in coffee and grape juice) that all composite resins showed a color change over 50:50% AT.[30] Composite resin groups in our study with and without modeling liquid showed a color and whiteness index change over 50:50% AT.

This study is an *in vitro* study inducing stains on both sides of the restorative material. In clinical use, only the outer surface of the restored tooth is exposed to beverages. In addition, consumed drinks can be diluted in the mouth with saliva. Although it was observed that the use of modeling liquid in our study did not affect the color and whiteness index change of the material, it is considered that it would be beneficial to conduct clinical studies on this subject.

Conclusions

According to the results of our *in vitro* experiment in which we examined the effect of composite modeling liquid on the color stability of composite resins;

- One-shade composite resin in coffee showed more color and whiteness index changes than composites with multiple color system.
- The use of modeling liquid did not affect the color and whiteness index changes of the composite resins.

Although the composite resins were shaped with modeling liquid, the color and whiteness index change values were above the AT value.

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Conflicts of Interest Statement

The authors declare that they have no conflict of interest.

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