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Araştırma/ Research Article

INVESTIGATION OF SINGLE SHADE COMPOSITE RESIN SURFACE ROUGHNESS AND COLOR STABILITY

TEK RENK KOMPOZIT REZININ YÜZEY PÜRÜZLÜLÜĞÜNÜN VE RENK DEĞIŞIMININ İNCELENMESI

Dr. Öğr. Üyesi Numan AYDIN* **Prof. Dr. Serpil KARAOĞLANOĞLU***
Doç. Dr. Elif Aybala OKTAY* **Dr. Öğr. Üyesi Bilge ERSÖZ***

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Numan Aydın: *ORCID ID:* 0000-0001-8628-4507
Serpil Karaoğlanoğlu: *ORCID ID:* 0000-0003-0601-8028
Elif Aybala Oktay: *ORCID ID:* 0000-0003-4716-4509
Bilge Ersöz: *ORCID ID:* 0000-0003-1668-0592

ABSTRACT
Aim: Although it has been stated that composite resins should be used in the restoration of teeth after color shade selection, it has recently been stated that single-shade composite resins can be used for all tooth shades. The objective of our study is to evaluate the surface roughness and color change of single-shade composite resins compared with multi-shade system composite resins.
Material and methods: In our study, samples (8 mm diameter and 2 mm depth) were obtained using single-shade (Omnichrorma) and multi-shade system (Filtek Universal Restorative, Clearfil Majesty ES-2 Premium, Harmonize) composite resins. Two steps finishing and polishing system (Clearfil Twist Dia) was used in the finishing polishing processes of the samples. The initial roughness values of the samples were measured with a profilometer and color values with a spectrophotometer. Then, color measurements of the samples kept in coffee were made on the 1st, 7th and 30th days and after the last polishing process. The surface roughness (Ra) and color change (ΔE_{00}) were statistically analyzed using two-way variance analysis (ANOVA) and Tukey post-hoc test ($p<0.05$).
Results: There was no statistically significant difference between the initial surface roughness values of composite resins with single and multi-shade systems ($p>0.05$). Composite resin with single-shade system showed statistically significantly more color change than composite resin with multi-shade systems in all time periods ($p<0.001$). Although re-polishing these materials reduced the color changes, it could not decrease it below the acceptability threshold value (ΔE_{00}:1.8).
Conclusion: New generation single-shade composite resin with smart chromatic material technology can simplify color selection without sacrificing esthetic success. However, this composite resin shows more color changes than multi-shade systems composite resins.
Keywords: Color stability, Single-shade composite resin, Surface roughness

ÖZ
Amaç: Kompozit rezinler dişlerin restorasyonunda renk tonu seçildikten sonra kullanılması gerektiği belirtilmesine rağmen son dönemde tek renk kompozit rezinin tüm diş renk tonları için kullanılabileceği belirtilmiştir. Çalışmamızın amacı; tek renk kompozit rezinin çoklu renk sistemine sahip kompozit rezinlere göre yüzey pürüzlülük ve renk değişimini incelemektir.
Gereç ve Yöntem: Çalışmamızda tek renk (Omnichrorma) ve çoklu renk sistemine sahip kompozit rezinler (Filtek Universal Restorative, Clearfil Majesty ES-2 Premium, Harmonize) kullanılarak örnekler (8 mm çapında ve 2 mm yüksekliğinde) hazırlandı. Hazırlanan örneklerin bitirme ve cila işleminde iki basamaklı bitirme ve cila sistemi (Clearfil Twist Dia) kullanıldı. Örneklerin başlangıç pürüzlülük değerleri profilometre, renk değerleri spektrofotometre ile ölçüldü. Daha sonra örnekler kahve (Nescafe Klasik, Türkiye) içerisinde bekletilerek 1, 7, 30. gün ve son polisaj işleminden sonra renk ölçümleri yapıldı. Yüzey pürüzlülük (Ra) ve renk değişim değerleri (ΔE_{00}) iki yönlü varyans analizi (ANOVA) ve Tukey testi kullanılarak istatistiksel analiz yapıldı ($p<0.05$).
Bulgular: Tek ve çoklu renk sistemine sahip kompozit rezinlerin başlangıç yüzey pürüzlülük değerleri arasında istatistiksel olarak anlamlı farklılık görülmedi ($p>0.05$). Tek renk sistemine sahip kompozit rezin tüm zaman dilimlerinde çoklu renk sistemine sahip kompozit rezinlere göre istatistiksel olarak anlamlı şekilde daha fazla renk değişimi gösterdi ($p<0.001$). Bu materyaller üzerinde yapılan son polisaj işleminden sonra renk değişimleri azaltmasına rağmen kabuledilebilirlik eşiği değerinin (ΔE_{00}:1.8) altına düşmemiştir.
Sonuç: Akıllı kromatik malzeme teknolojisine sahip yeni nesil tek renkli kompozit rezin estetik başarıdan ödün vermeden renk seçimini basitleştirebilir. Fakat 30 gün sonunda tek renk kompozit rezin çoklu renk sistemine sahip kompozit rezinlerden daha fazla renk değişikliği göstermektedir.
Anahtar Kelimeler: Renk stabilitesi, Tek renk kompozit rezin, Yüzey pürüzlülüğü

* University of Health Sciences, Gulhane Faculty of Dentistry, Department of Restorative Dental Treatment, Ankara.

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INTRODUCTION

In recent years, ceramic and resin-containing restorative materials are preferred by dentists in the restoration of teeth to meet the esthetic expectations of individuals. Restorative materials with resin content are widely used as they easily adapt to tooth color and meet the esthetic expectations of individuals.[1]

With the use of nano technology in dentistry, manufacturers are introducing composite resins with single-shade systems instead of more complex color systems. It is stated that these composite resins consisting of nano fillers (nanomer) and nanomer groups (nanocluster)[2] provide more effective color harmony with dental tissues because of their "chameleon effect" properties.[3] Recently, single-shade composite resin, which can be used for all tooth shades, has been introduced to the dentist's use.[4,5] The biggest advantage of the one shade composite resin system is that it allows restoration appropriate with the tooth color in a short time without determining the tooth-shade in esthetic restorations.

Surface roughness, gloss and color stability affect the esthetic properties of resin based restorative materials.[6,7] It was stated in the literature that after the finishing and polishing procedure of the restorative materials, the surface roughness values above 0.2 µm create retention area for the attachment of the bacterial plaque,[8] and the adhesion of *streptococcus mutans* decreases at the surface roughness value below 0.15 µm.[9]

Color changes of composite resins, have been associated with water absorption, chemical reaction, diet and poor oral hygiene.[10,11] In many studies, it has been reported that beverages such as tea, coffee, cola and wine cause different degrees of discoloration on the surfaces of resinous restorative materials.[12-14]

In order to evaluate the color stability of restorative materials instrumental techniques such as spectrophotometers, colorimeters, or digital cameras are employed, (ΔE*) by referring to the Commission Internationale De L'éclairage (CIE) system. CIE L*a*b* values are the representative parameters indicating the color.[15] The L* value obtained from spectrophotometers used to evaluate the color changes in dental materials is a measure of lightness-darkness, a* redness or greennees, and b* yellowness or blueness.[15] The extent of the color difference that can be detected visually by the human eye is stated as PT (perceptibility threshold), and the extent of the color difference that constitutes the acceptability between restorative materials is stated as AT (acceptability threshold).[16,17] Paravina et al.[17] indicated that 50:50% PT value was ΔE_{00}:0.8 and 50: 50% AT value was ΔE_{00}:1.8.

Although there are studies about color change of composite resin materials, which are widely used in the restoration of teeth, there is no study about surface roughness and color change of single-shade composite. The aim of our study is to examine the surface roughness and color change of single-shade composite resins compared to multi-shade composite resins. The first of our null hypothesis is that the initial roughness values of the single-shade composite resin will not differ than composite resins with multi-shade systems. The second of our null hypothesis is that composite resins with single and multi-shade systems will not differ in color changes.

MATERIALS AND METHODS

In our study, Filtek Universal Restorative A2 (3M ESPE, USA), Clearfil Majesty ES-2 Premium A2E (Kuraray Noritake, Tokyo, Japan), Harmonize A2E (Kerr Corporation, Orange, USA) and Omnichrorma (Tokuyama Dental, Tokyo, Japan) resin composites were used (Table 1). Composite resin samples were prepared using a silicone mold (8 mm diameter and 2 mm depth). In the preparation of the samples, composite resins were placed in the cavity on the silicone mold a 1 mm glass (coverslip) was placed on the mylar strip. Composite samples were polymerized for 20 seconds at 1000 mW/cm² power with the tip of the led light device (DTE LUX E, Germany) touching the glass slip. A total of 48 samples, 12 from each material, were prepared. A two-step diamond-containing finishing and polishing system (Clearfil Twist Dia, Kuraray, Japan) was used in the polishing processes of composite resin samples. The finishing and polishing of the samples were carried out under water cooling at a speed of 10 000 rpm for 20 seconds. After finishing and polishing procedures, composite samples were placed in a 24-well plate (1 sample in each well). Then the samples were kept in distilled water (37 °C) for 24 hours in the incubator.

The initial colors (L*, a* and b* values) of the samples of each group, after composite resin samples were kept in distilled water for 24 hours, were measured with a spectrophotometer device (Vita Easyshade V; VITA Zahnfabrik, Germany) under D65

Table 1**.** Properties of composite resin materials used in the study

Materials	Type	Composition		Filler content	Lot Number
		Matrix	Filler		
Filtek Universal Restorative A2 (3M ESPE, St. Paul, MN, USA)	Nanofill	AUDMA, AFM, diurethane-DMA, and 1,12-dodecane-DMA	Silica filler (20 nm), zirconia filler (4 to 11nm), ytterbium fluoride (100 nm)	76.5 /58.4	NA66211
Clearfil Majesty ES-2 Premium A2E Mine (Kuraray Noritake, Tokyo,Japan)	Nanohybrid	Bis-GMA	Barium glass filler, micro glass filler (1.5 µm), nano glass filler (20 nm), pre-polymerized organic filler	78/66	870033
Harmonize A2E-Mine (Kerr Corporation, Orange, CA, USA)	Nanohybrid	BisGMA BisEMA TEGDMA	Baryum glass fillers (5-400 nm)	81/64,5	7299635
Omnichroma (Tokuyama Dental, Tokyo, Japan)	Supra-nano spherical	TEGDMA UDMA	Supra-nano spherical filler, Composite filler (260 nm spherical SiO_2-ZrO_2)	79/68	00E639

*BisGMA: Bisfenol diglisidilmethacrylate, AUDMA: aromatic urethane dimethacrylate, UDMA: üretan dimethacrylate, TEGDMA: trietilenglikol dimethacrylate; AFM: addition-fragmentation monomers, Bis-EMA, bisphenol A ethoxylate dimethacrylate.

lighting conditions, and surface roughness value (Ra) was measured with a profilometer device (Perthometer M2; Mahr GmbH, Germany). The surface roughness and color measurements of composite resin samples were made from the center point of the same sample. In measuring the surface roughness values of the samples, the measurement length was taken as 1.75 mm and the cutting value as 0.25. The average of these values was calculated by taking three measurements from the surface of each sample.

After the initial color and surface roughness determination process of the samples, they were individually placed on 24-well plate and 5 ml coffee (Nescafe Classic, Turkey) were added on. For the time-dependent change in color, the samples were kept in the incubator for 30 days (FN 500, Nüve, Turkey) at 37 °C. After the coffee solution was prepared according to the manufacturer's recommend-dation (2 g of coffee and 200 ml of water), it was added to the samples at 37 °C. It was also replaced with a new coffee solution every 24 hours. The composite resins were re-polishing 30 days with the same finishing and polishing system under water cooling for 20 seconds. L*, a* and b* values of the samples were measured on the 1st, 7th, 30th days and after polishing. The CIEDE2000 formula (ΔE_{00}) was used to calculate color changes in composite resins based on L*, a* and b* parameters.[18]

Statistical analysis was using SPSS 22.0 program. The surface roughness and color change, L*, a* and b* values obtained in the study were analyzed using the two-way analysis of variance test (ANOVA). Different between groups were analyzed using the Tukey test ($p<0.05$).

RESULTS

There was no statistically significant difference between the initial surface roughness values of single and multi-shade system composite resins ($p> 0.05$). After finishing and polishing procedure, the lowest surface roughness value (Ra: 0.096 µm) was observed in the Filtek Universal Restorative, while the highest surface roughness value (Ra: 0.123 µm) was observed on the Harmonize group (Table 2).

There was a statistically significant difference between the color change values of the composite resins at the end of the 1st, 7th and 30th days ($p<0.001$). Among the composite resins Omnichroma, single-shade composite resin, showed statistically significantly more color changes in all time periods ($p<0.001$). Nanofill composite resin (Filtek Universal Restorative) of the multi-shade composite resins, showed less color change than nanohybrid composite resins (Clearfil Majesty ES-2 Premium and Harmonize) after the 1st, 7th and 30th days ($p<0.001$). Color changes of composite resins at the end of the 30th day are listed as Filtek Universal Restorative<Clearfil Majesty ES-2 Premium<Harmonize<Omnichroma (Table 3). The color change of all composite resins increased statistically significantly in course of time ($p<0.001$).

It was observed that the initial L* value of Omnichroma (L*: 97.6), was very close to 100, but the L* value at the end of 30 days (L*: 85.6) was close to the L* value (L*:85.6) of the nanofill composite resin (Filtek Universal Restorative). While the initial L* value of the nanofill and nanohybrid composites was close to each other, the lowest L* value (L*: 77.5) was observed in the nanohybrid composite resin (Harmonize) at the end of the 30th day. In addition, it was observed that the a* and b* value of the single-shade composite resin changed

more than the composites with multiple shade systems (Table 4). Although re-polishing on these materials reduced the color changes, it could not decrease it below the AT value (ΔE_{00}:1.8), (Figure 1).

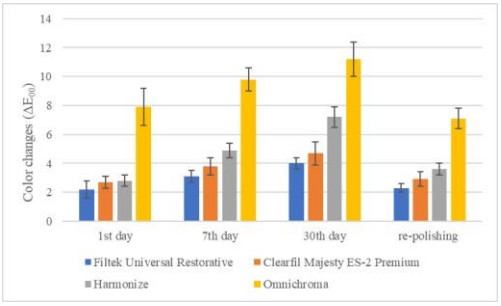

Figure 1 Investigation of color changes (ΔE_{00}) of composite resin samples kept in coffee solution.

the single-shade composite resin with smart chromatic technology, which has been released recently, matches all VITA classic A1-D4 shades with a single-shade through a perfect reflection of a certain wavelength of the tooth color.[21] In our study, we examined the surface roughness and color change of this new generation single-shade composite resins.

Although mechanical 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.[22]

Table 2. Investigation of surface roughness (Ra) of composite resins

Finishing and polishing system/Materials	Ra	P
Filtek Universal Restorative	0.096±0.02^{a}	0.102
Clearfil Majesty ES-2 Premium	0.123±0.03^{a}	
Harmonize	0.106±0.02^{a}	
Omnichroma	0.108±0.03^{a}	

* a shows the statistical significance difference between lines (p <0.05)

Table 3. Investigation of color changes (ΔE_{00}) of composite resins

Finishing and polishing system/Materials	1st day	7th day	30th day	re-polishing	P
Filtek Universal Restorative	2.2±0.6^{a,A}	3.1±0.4^{a,B}	4.0±0.4^{a,C}	2.3±0.3^{a,A}	0.000
Clearfil Majesty ES-2 Premium	2.7±0.4^{b,A}	3.8±0.6^{b,B}	4.7±0.8^{bC}	2.9±0.5^{b,AB}	0.000
Harmonize	2.8±0.4^{b,A}	4.9±0.5^{c,B}	7.2±0.7^{c,C}	3.6±0.4^{c,A}	0.000
Omnichroma	7.9±0.7^{c,A}	9.8±0.8^{d,B}	11.2±1.2^{d,C}	7.1±0.7^{d,A}	0.000
P	0.000	0.000	0.000	0.000	0.000

*Shows the statistical significance difference between A-C columns and a-d lines (p <0.001)

Table 4. Examination of the changes in composite resins L*, a* and b* values

Composite Resins	Baseline			30th days		
	L*	a*	b*	L*	a*	b*
Filtek Universal Restorative	88.7±0.7^{a}	2.0±0.1^{a}	33.3±0.4^{a}	82.6±0.9^{a}	3.2±0.2^{a}	33.9±0.5^{a}
Clearfil Majesty ES-2 Premium	87.7±1.0^{a}	1.6±0.4^{b}	20.6±1.2^{b}	82.0±0.6^{a}	3.9±0.3^{b}	24.4±0.9^{b}
Harmonize	87.9±0.7^{a}	2.7±0.1^{c}	34.5±1.0^{a}	77.5±1.1^{b}	4.4±0.4^{b}	35.9±0.6^{a}
Omnichroma	97.6±1.6^{b}	-3.9±0.2^{d}	12.8±1.1^{c}	85.8±1.7^{c}	1.6±0.9^{c}	24.5±1.7^{b}
P	0.000	0.000	0.000	0.000	0.000	0.000

DISCUSSION

Together with the use of nano technology in the field of dentistry, composite resins with simplified layering technique and facilitated tooth color selection were used to the use of dentists.[19,20] It is stated that Aytaç et al.[23] stated in their study on the surface roughness of composite resins that the lowest Ra value was observed in the supra-nano composite resins and there was no significant difference between the surface roughness values of the other composite resin groups. Moda et al.[24] in their study on

microhybrid, microfill and nanofill composite resins, stated that the least surface roughness was seen in the nanofill composite resin. Bayraktar et al.[25] in their study on the surface roughness of three different hybrid and nanofill composite resins (Photo Posterior, Filtek Ultimate, Aelite LS Posterior), stated that the least surface roughness was seen on the nanofill composite.

In our study, although the diamond finishing and polishing system created less surface roughness on nanofill composite resin (Filtek Universal Restorative), as similar to the literature, there was no statistically significant difference between supra-nano composite (Omnichroma) and nanohybrid composite resins (Clearfil Majesty ES-2 Premium and Harmonize). Our first null hypothesis was accepted because of no difference between the surface roughness values of composites.

Despite the effective finishing and polishing processes performed in the restorative materials containing resin, the color change formation causes patient dissatisfaction.

In recent years, spectrophotometer is widely used in measuring tooth color. The clinical spectrophotometer device (Vita Easyshade V), which was reported to offer more objective values in the literature[26] and which can be used safely in dental material studies[27], was used in the basic shade mode to measure the color of the samples.

CIELAB is calculated with the formula ΔE_{ab} using the color change values L*, a*, b* in the materials. In 2001, a new formula CIEDE2000 (ΔE_{00}) updated by CIE was introduced.[18,28] The CIEDE2000 formula was preferred in our study as Gómez-Polo et al.[29] stated in their study that CIEDE2000 (ΔE_{00}) formula was more sensitive in measuring color changes than the CIELAB (ΔE_{ab}) formula.

It is stated that these color changes in the material are related to many factors, both internal and external.[30] Although it is stated that beverages taken with daily diet may show different color changes on dental materials, it is stated that wine, coffee, and tea constitute the most color change.[13] Coffee is effective in the color change of composite resins due to its yellow colorant pigment, which has a strong affinity with polimers.[31] Therefore, the coffee which is used for color change of samples in many studies was also preferred in our study.

Beltrami et al.[32] stated that when the discoloration of esthetic restorative materials that have different finishing and polishing systems, were examined after being kept in coffee solution for 28 day, the least color change is observed in nanofill composites, followed by nanohybrid and microhybrid composite resins. They also stated that as the composite resin particle size decreases, discoloration decreases due to the decrease in surface roughness as well.[32] In their study on the effects of composite resins on color stability, Topcu et al.[33] stated that the microhybrid composite (Filtek Z250) showed a higher color change level than the nanofill composite (Filtek Ultimate). In our study, nanofill composite (Filtek Universal Restorative) at the end of 30 days created the least color change (ΔE_{00}: 4.0) after finishing and polishing. However, in our study, single-shade composite resin (Omnichroma) in supra-nano structure showed the most color change (ΔE_{00}:11.2). Our second null hypothesis was rejected because the color change of composite resins differs from each other's.

Pereira Sanchez et al.[21] determined that optical control and manipulation of materials can produce photonic bands by preventing the propagation of light at certain frequencies in certain directions. In our study, although the initial L* value (lightness-darkness) of the single-color composite resin was very high (L*:97.6), it was observed that the L* value (L*:85.8) was close to the nanofill composite resin level (L*: 82.6) after the samples were kept in coffee solution. We consider that this decrease in L* value of the single-shade composite resin influences the color change.

Increasing the amount of resin in composite resins increases the water absorption amount of the material and creates hydrolytic degradation.[34] 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.[35] In addition, as Bis-GMA causes rigid network formation, it is stated that composite resins whose main monomer content is Bis-GMA shows less water absorption than composites containing TEGDMA and more than composites containing UDMA and Bis-EMA.[36] Ertaş et al.[37] stated in their studies on the color change of microhybrid and nanohybrid composite resins as a result of different beverages (water, cola, instant coffee, tea and red wine) that composite resins with TEGDMA showed more color changes. TEGDMA monomer is present in the structure of the single-shade composite resin

(Omnichroma) which showed the most color change in our study. In addition, Clearfil Majesty ES-2 Premium, of the nanohybrid composites with the same particle size, showed less color change compared to the other nanohybrid composite Harmonize. It is considered that the difference in color change is caused by the TEGDMA monomer in Harmonize's organic matrix.

Perceptibility threshold (PT) and acceptability threshold (AT), which are an important factor for evaluating the color stability of dental materials, are indicated in the literature as PT ΔE_{00}:0.8 and AT ΔE_{00}: 1.8.[38] In our study, composite resins with single and multi-shade systems, which were kept in coffee for 30 days, showed color change over PT and AT values.

It has been stated in the literature that the stains on the resin containing materials, which were caused by beverages that are included in diet, can be reduced to an acceptable level with re-polishing process.[39,40] In our study, despite the application of re-polishing on single and multi-shade system composite resins, color changes in groups could not be reduced below the clinically acceptable level.

This study involved an *in vitro* experimental procedure that induced discoloration on both sides of the restorative material, which provided us with limited results. In clinical procedures, on the other hand, the restoration is fixed on the tooth itself, and the restoration surface is simply exposed to solutions. In addition, the color changes in the restorations may be the result of different drinks consumed daily by the individual. In future studies, it will be useful to examine the effect of different beverage groups on the color change of single-shade composite resin.

CONCLUSION

According to the results of our *in vitro* experiment on composite resins:

1. Surface roughness values of single and multi-shade system composite resins were similar at the end of the polishing process.
2. The single-shade composite resin tested showed more color change in all time periods than the composite resins with multi-shade systems that were tested.
3. The color change of composite resins at the end of 30 days is above 50:50% PT and AT. In addition, although re-polishing to procedures of composite resins decreases the color change, it cannot decrease it below 50:50% AT (ΔE_{00}:1.8).
4. Despite the re-polishing application, unlike composite resins with multi-shade system, the single-shade composite resin tested showed an "extremely unacceptable" color change (ΔE_{00}:7.1).

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Conflicts of interest statement
The authors declare no conflict of interest

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Sorumlu Yazarın Yazışma Adresi
Numan Aydın, DDS, PhD
University of Health Sciences, Gulhane Faculty of Dentistry, Department of Restorative Dental Treatment, Etlik 06018 Ankara, Turkey
Phone: +903123043000
e-mail: numan.aydin@sbu.edu.tr