Evaluation of the Effect of Background Color on the Color Change of Composite Resins of Different Translucencies

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Article Info	ABSTRACT
	Aim: To evaluate the effect of background color on color change evaluation of composite resins with different translucency **Material and Method:** Estelite ∑ Quick (EQ) CE, OA2 and Filtek Ultimate (FU) A2 Enamel, A2 Dentin composites were used in our study. Samples were prepared by layering only enamel and dentin and enamel + dentin (n=10) from composites of both brands. After preparation, the samples were kept in distilled water for 24 hours and then in coloring solution for 10 days. The colors of the composite samples were measured with a spectrophotometer (VıtaEasyshade) on black, white and gray backgrounds after 24 hours (initial) and after coloring. Color change values of the same composites measured on different surfaces were compared. One-way ANOVA and Tukey's post-hoc tests were used for statistical analysis. (α=0.05). **Results:** When layered with dentin, enamel composites consistently showed lower ΔE00 values than enamel composites alone (p<0.05). When different translucent shades from the same company were compared on different substrates, the ΔE00 order was found to be enamel > dentin >/= enamel + dentin for all substrates. **Conclusion:** The different substrates did not affect the color assessment of samples containing an opaque composite resin, dentin composite; however, they did affect the color assessment of FU enamel, a translucent composite resin. More accurate color assessment can be achieved when translucent composite resins are layered with more opaque composite resins.

Farklı Yarı Saydamlıktaki Kompozit Rezinlerin Renk Değişikliğinin Değerlendirilmesi Üzerinde Arka Plan Renginin Etkisi

Makale Bilgisi	ÖZET
	Amaç: Bu çalışmanın amacı; farklı yarı saydamlıktaki kompozit rezinlerin renk değişikliği değerlendirilmesi üzerinde arka plan renginin etkisini değerlendirmektir. **Gereç ve Yöntemler:** Çalışmamızda Estelite ∑ Quick (EQ) CE (mine), OA2 (dentin) ve Filtek Ultimate (FU) A2 Mine, A2 Dentin kompozitleri kullanıldı. Her iki markanın kompozit rezinlerinden disk şeklinde örnekler mine ve dentin tek başına ve mine+dentin tabakalanarak hazırlandı (n=10). Örnekler hazırlandıktan sonra 24 saat distile suda, ardından 10 gün renklendirici solüsyonda (Nescafe Classic), bekletildi. Kompozit örneklerin renkleri 24 saat sonra (başlangıç) ve renklendirmeden sonra siyah, beyaz ve gri arka planda spektrofotometre (Vıta Easyshade) ile ölçüldü. Her arka plan için iki ölçüm değeri kullanılarak renk değişim değeri (ΔE00) hesaplandı. Aynı kompozitlerin farklı arka planlarda ölçülen renk değişim değerleri karşılaştırıldı. Ayrıca aynı firmanın farklı translüsent tonlarının ΔE00 değerleri farklı arka planlarda karşılaştırıldı. One-way ANOVA ve Tukey's post-hoc testleri istatistiksel analiz için kullanıldı. (α = 0.05). **Bulgular:** Mine kompozitleri dentin ile tabakalanarak kullanıldığında hep yalnız mine kompozitlerinin ΔE00 değerlerinden daha düşük değerler gösterdi (p<0,05). Aynı kompozit rezin örneklerin farklı arka planlardaki ΔE00 değerleri karşılaştırıldığında sadece siyah arka planda ölçülen FU mine diğer iki araka planda ölçülen ΔE00 değerlerinden yüksek bulunmuştur (p<0,05). Aynı firmanın farklı translüsent tonları farklı arka planda karşılaştırıldığında ΔE00 sıralaması tüm arka planlar için mine > dentin >/=mine+ dentin şeklinde bulunmuştur. **Sonuç:** Farklı arka planlar opak bir kompozit rezin olan dentin kompoziti içeren örneklerin renk değerlendirmesini etkilememiş fakat translüsent bir kompozit rezin olan FU minenin renk değerlendirmesini etkilemiştir. Translüsent kompozit rezinler daha opak kompozit rezinlerle tabakalanarak uygulandıklarında daha doğru renk değerlendirmesi yapılabilir.

INTRODUCTION

Since their introduction in the 1960s, resin composites have become one of the commonly used materials in aesthetic dentistry due to their sufficient strength, superior aesthetic qualities, cost-effectiveness compared to ceramics, and ability to bond to dentin and enamel. Natural-looking aesthetics are preferred over artificial ones in general.[1] An aesthetic restoration should provide a natural appearance that satisfies the patient, in addition to ensuring functionality.[2] In this sense, restorations should imitate the color and translucency of natural teeth for optimal aesthetic appearance. Translucency gives the restoration a genuine aspect by giving it a natural and lifelike appearance.[3] In restorations, achieving the desired optical properties of teeth sometimes requires using only a universal resin. In other cases, opaque (dentin) resins are necessary to address regional high value needs of the tooth and to conceal the dark oral cavity background. These opaque resins are occasionally used alone on the buccal surface of the restoration but are often covered with a more translucent enamel composite. To enhance the optical properties of the incisal area of teeth, resins with higher translucency are used.[4]

In aesthetic dentistry, choosing the right aesthetic materials that closely resemble real teeth is a critical first step. Dental and resin composite materials are semi-transparent materials, and the difference in light transmittance affects their clinical appearance.[5]

The instrumental color measurement of semi-transparent materials depends on the background conditions. When light reflects onto a semi-transparent sample against a bright or white background, a substantial amount of the light reaching the background is reflected. In contrast, if the sample is against a matte or black background or in a light trap, the amount of reflection is significantly reduced.[6]

Changes in color parameters brought about by the semi-transparent material's filtering effects while utilizing a solid background are impacted by interactions including optical scattering, absorption, the semi-transparent material's thickness, and background reflections.[7] To accurately assess the color of dental resin composites, it might be preferable to exclude the influence of background reflection. Initially, color changes were evaluated without a background color and subsequently on a white plate, highlighting considerable variations in color alteration based on the background used.[8] However, in studies evaluating the color stability of composite resins, discoloration occurring on the back surface, for example, in more translucent materials, can significantly affect the measured color from the top surface, leading to incorrect assessments compared to opaque materials. Emulating scenarios where more translucent resins like enamel composites are layered over dentin, or using a black background that could eliminate the effect of discoloration on the back surface, may be beneficial for achieving more accurate results.

The aim of this study is to evaluate the effect of background color on the assessment of color change in composite resins with different levels of translucency. The null hypothesis of the study:

1- There is no difference between the color change values of samples prepared from the same company's composite resins.
2- There is no difference between the color change values of the same composites measured on different backgrounds.

MATERIALS AND METHODS

In our study, Estelite ∑ Quick (EQ) CE (enamel), OA2 (dentin) (Tokuyama, Japan) and Filtek Ultimate (FU) A2 enamel and A2 dentin (3M Espe, Germany) composite resins were used. The compositions of the composites are provided in Table 1.

Table 1. Restorative materials used in the study

Material	Type	Contents	Filler Particle Amount	Manufacturer Company
Tokuyama Estelite Quick Sigma	Supra-nano spherical hybrid	**Matrix:** Bis-MPEPP, Bis-GMA, UDMA TEGDMA **Filler:** Supra-nano spherical filler containing 200nm spherical SiO2-ZrO2	82(w/w)	Tokuyama Dental Corporation, Taitouku Tokyo, Japan
Filtek Ultimate	Nanohybrid	**Matrix:** UDMA Bis-GMA, Bis-EMA, TEGDMA, and PEGDMA resin **Filler:** Silica, zirconia, and clustered zirconia/silica aggregate filler ranging in size from 0.6 to 10 micrometers	78.5 w/w	3M ESPE, Seefeld, Germany

Table 2. Polishing wheel used in the study

	Abrasive Particle	Contents	Manufacturer Company
Twist Dia	Pre-polisher: 14μm High shine polisher: 10μm	Two-stage Kuraray, Japan Polishing system Diamond-coated flexible silicone spirals	Kuraray, Japan

Ten samples of each composite resin from both brands were prepared in disk shape either as enamel and dentin alone or layered as enamel+dentin (n=10). From the composite resins, samples in disk shape with a diameter of 8 mm and thickness of 2 mm were created using the plastic molds. For the enamel+dentin groups, samples were constructed by layering to achieve a structure with 1 mm of enamel and 1 mm of dentin, utilizing specially prepared molds. All samples underwent polymerization following the manufacturer's guidelines using an LED light source (Valo, Ultradent, South Jordan, USA). During polymerization, the light tip was placed in contact with a glass slide to minimize the light application distance, positioned centrally over the sample, and operated at 1000 mW/cm² power. Polymerization was verified using a radiometer for every set of 10 samples. The prepared samples were polished using two-stage diamond particle-impregnated polishing spirals (Twist Dia). Initially, a coarse-grit spiral (14μ) was applied without water cooling in a counterclockwise direction for 20 seconds, followed by a fine-grit spiral (10μ) applied at 10000 rpm in a counterclockwise direction for another 20 seconds, also without water cooling. Following preparation, the samples were cleaned with distilled water and left in an oven with distilled water set at 37°C for 24 hours to finish the polymerization process. Following this, initial color measurements (baseline - T0) were taken. Coffee solution was chosen as the staining solution since it is one of the most consumed beverages worldwide. The coffee solution was made by dissolving 3.6 grams of coffee (Nescafe Gold Classic, Nestle, Turkey) in 300 ml of boiled distilled water, which was cooled to room temperature. Subsequently, 2 ml of the coffee solution was added to specimen storage containers containing the samples, which were then placed in an oven at 37°C for incubation. The coffee solution was freshly prepared each day. After the staining period (10 days later), the samples were washed under running tap water for 10 seconds, dried with

blotting paper, and then second color measurements (T1) were taken.

Color measurements were conducted by a single researcher using a portable spectrometer device, Vita Easyshade 5 (Vita-Zahnfabrik, Bad Säckingen, Germany). Each color measurement was taken under standard conditions with black, white, and gray backgrounds. Each measurement was repeated three times, and the average L*, a*, b* values were recorded according to the CIEDE2000 color formulation. The device was calibrated every 10 measurements. Using the L*, a*, b* values at T0 and T1 for each background, ΔE00 was calculated using the CIEDE2000 formula.

Tukey's post-hoc tests and One-way ANOVA were used for statistical analysis (α = 0.05).

RESULTS

The ΔE00 values of EQ and FU composite groups are presented in Table 3 and 4.

Table 3. The mean and standard deviation ΔE00 values of the EQ composite resin groups. The letters in the upper right indicate statistical differences between the columns.

Estelite ∑ Quick	ΔE00 Mean ± Std. Deviation
White background-Enamel	4.81±1.22^C
White background-Enamel+dentin	1.97±0.31^A
White background-Dentin	2.69±0.85^{A,B}
Gray background-Enamel	5.76±0.54^C
Gray background-Enamel+dentin	2.79±0.65^{A,B}
Gray background-Dentin	2.45±0.47^{A,B}
Black background-Enamel	5.25±0.70^C
Black background-Enamel+dentin	3.37±0.59^B
Black background-Dentin	2.63±0.45^{A,B}

Table 4. The mean and standard deviation ΔE00 values of the FU composite resin groups. The letters in the upper right indicate statistical differences between the columns.

Filtek Ultimate	ΔE00 Mean ± Std. Deviation
White background-Enamel	9.54±0.86^E
White backggground-Enamel+dentin	2.77±0.74^A
White background-Dentin	8.98±2.05^{DE}
Gray background-Enamel	9.13±1.39^{DE}
Gray background-Enamel+dentin	3.64±0.56^{AB}
Gray background-Dentin	7.27±4.29^{C,D}
Black background-Enamel	10.95±0.61^F
Black background-Enamel+dentin	4.63±0.44^{A,B}
Black background-Dentin	6.18±2.26^{B,C,D}

The ΔE00 change values of the samples range from 1.97±0.31 to 10.95±0.61. The enamel groups' samples in both composite groups displayed the greatest color change, whereas the dentin-containing composite groups' samples displayed the lowest values.

Significantly lower ΔE00 values were observed when enamel composites were coated with dentin than with enamel-only composites for both brands across the entire background (p<0.05). When comparing the ΔE00 values of the same composite resin samples across different backgrounds, it was found that only the Filtek Ultimate (FU) enamel measured on the black background had higher ΔE00 values compared to those measured on the other two backgrounds (p<0.05) (Figure.1-2). The order of ΔE00 values was enamel > dentin >/= enamel + dentin in all backgrounds for both composites.

DISCUSSION

Because composite resins can mimic the natural appearance of teeth, they are now the material of choice for aesthetic restorations.[9] Modern dental resin composites used for restorative purposes vary mainly in terms of their resin matrix, particle size, and shape, providing a diverse array of options for selection.[10,11]
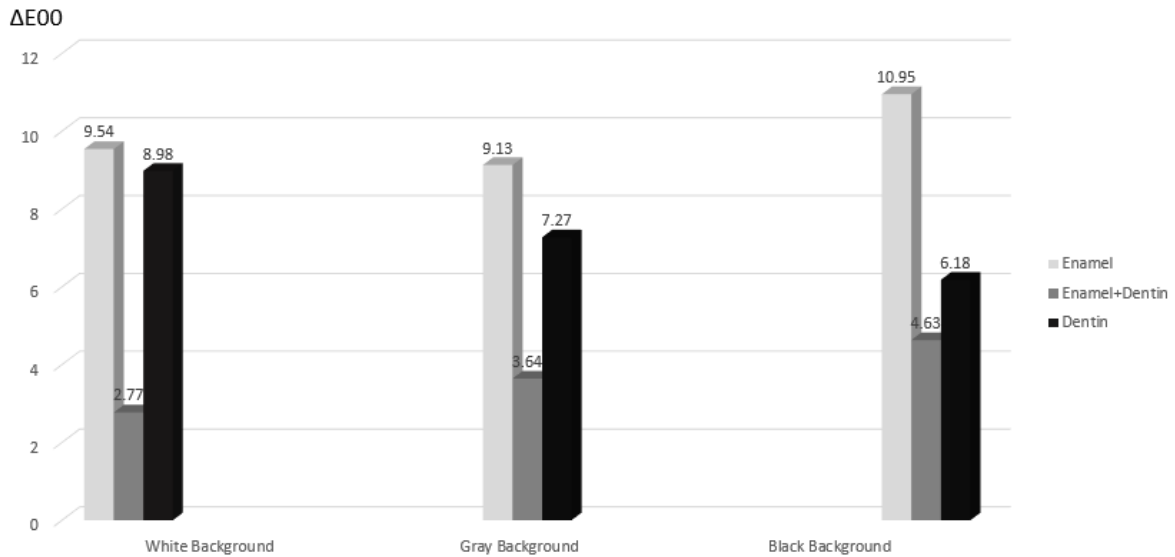
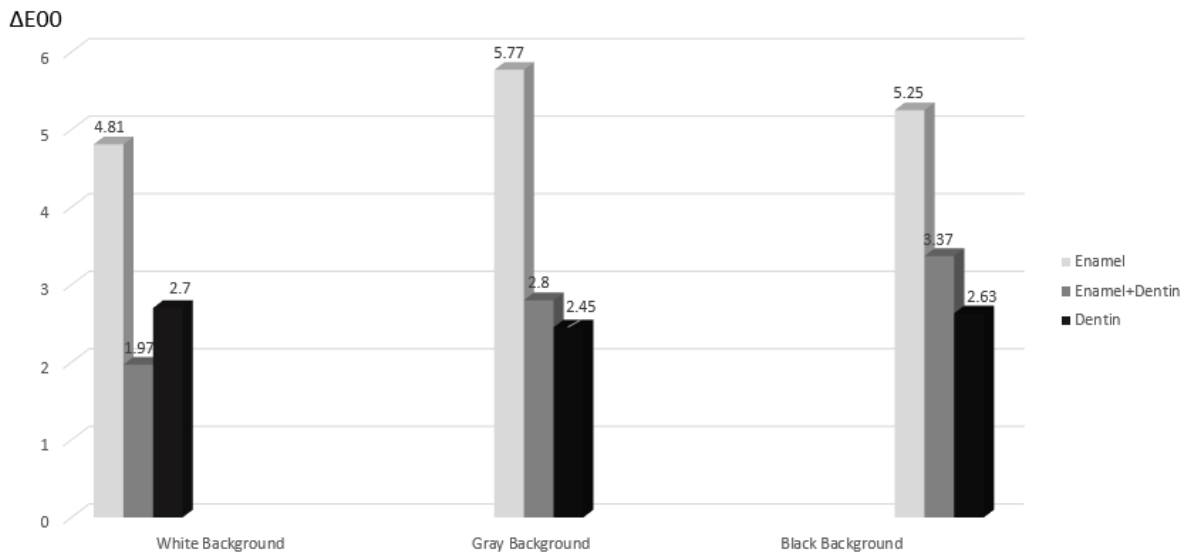**Figure 1.** Color change (ΔE00) values measured on different backgrounds for Filtek Ultimate.

Figure 2. Color change (ΔE00) values measured on different backgrounds for Estelite ∑ Quick.

In our study, two nanohybrid composite resins (Filtek Ultimate, Estelite ∑ Quick) were used. Composite resin samples in this study were prepared by placing them into 2 mm silicone molds, similar to the method described in the study and Bagheri et all.[12]

Recently, new systems have been introduced to streamline the polishing process for resin composites, with Clearfil Twist Dia being one of them. According to a study by Korkut et all.,[13] which examined how various polishing systems affect the discoloration of microhybrid and nanohybrid composite resins,

the spiral-shaped Clearfil Twist Dia polishing system was found to be more effective and advantageous compared to other systems. In our study, after preparing the composite samples, we employed Clearfil Twist Dia spiral disks for a two-stage polishing process, each stage lasting 20 seconds.

Güler et all.[14] reported that the normal consumption time for a cup of coffee is 15 minutes, and regular coffee consumption among daily drinkers averages 3.2 cups per day. In our study, samples were immersed in coffee for 10 days, which approximately simulates 10 months of coffee consumption.

In dentistry, besides visual assessment, instrumental color measurement can be performed using spectrophotometers and colorimeters. Consistent with previous studies,[15-16] to eliminate biases associated with human eye evaluation, in our study, color measurements were conducted using the portable spectrometer device Vita Easyshade 5 (Vita-Zahnfabrik, Bad Säckingen, Germany).

For the evaluation of composite resin colors, CIELAB (ΔEab) and CIEDE2000 ($\Delta E00$) formulas can be used. The CIEDE2000 formula incorporates three weighting functions: hue, value, and chroma. It has been reported that the CIEDE2000 system provides a better indicator of perceptibility by the human eye and the acceptability of color changes.[16-17] Perceptibility refers to the smallest color difference perceived by the human eye, whereas acceptability means the color difference between a restoration and an adjacent tooth being acceptable.[18] Data obtained from the CIEDE2000 formula were adjusted according to the perceptibility and acceptability thresholds defined by Paravina et all.[18] as $\Delta E00<0.8$ units and $\Delta E00>1.8$ units, respectively. In our study, all measurements taken after exposure to coffee were above the acceptability threshold of 1.8 units, similarly with Ertaş et all.[19]

In our study, it was observed that when enamel composites were used alone, they showed more color change than dentin composites, but when they were used layered with dentin, there was no difference between them and dentin alone, and they showed less color change than enamel composites. For this reason, the first hypothesis of our study which there is no difference between the color change values of samples prepared from the same company's composite resins was rejected. Similarly earlier research has indicated that translucent composites undergo greater color changes than opaque composite resins.[20,21] Lago et all.[22] observed that enamel composites colored with red wine showed significantly

more color change compared to dentin composites. Similarly, Mada et all.[23] found in their study that Filtek Supreme 3M composite left in coffee solution exhibited more discoloration in the enamel composite compared to the body composite. They suggested that this effect likely stems from the interaction and absorption differences between the staining solution and the organic matrix of the composite resins.

Furthermore, another study indicated that composite resin shades with lower chroma tended to exhibit reduced color stability compared to higher chromatic shades.[20] It was suggested that pigments and unreacted components, which could oxidize over time, might compromise optical stability, particularly in highly translucent resins where these effects could be more noticeable.[24]

Çobanoğlu et all.[21] discovered that enamel composites showed more color change than dentin and body composite resins when they measured color on a white background after exposure to coffee. They hypothesized that, due to the enamel hues' greater translucency, the stains on the back of the samples could be more noticeable than with opaque resins. In the current study, we tried to reveal the effect of two different methods, which are predicted to be more accurate in evaluating the color of an enamel composite resin layer that will not be exposed to coloring solution from the back side when applied to dentin tissue or dentin composite, similar to its use in the clinic. In the first method, the enamel composite was layered with dentin, while in the second method, the sample prepared only with enamel composite was exposed to discoloration, so even if the backside also became discolored, measurements were taken on a black background under the assumption that the reflected color from the back would be similar before and after discoloration.

Samples where enamel composites were layered with dentin showed less color change

than samples prepared with enamel alone. Considering these results, since enamel composites are mostly used in the clinic by applying them on dentin tissue or dentin composites, when evaluating the color stability of enamel composites, applying them layered with dentin composites rather than alone may give more accurate results. In this way, the effect of the background color on the evaluation will be reduced.

Conversely, however when comparing the ΔE00 values of the same composite resin samples on different backgrounds, only the ΔE00 value measured on a black background for FU enamel was found to be higher than the ΔE00 values measured on the other two backgrounds (p<0.05). For this reason, the second hypothesis of our study which there is no difference between the color change values of the same composites measured on different backgrounds was rejected. In color measurement, the effect of the background is a highly debated topic. Stefano Ardu's review [15] suggested that the background has no effect or minimal effect on color perception. Ardu reported that black and gray backgrounds simulate the intraoral environment better than a white background. In our study, the background did not affect the dentin and dentin-layered enamel groups but did influence the color change in the FU Enamel group.

In a study examining resin translucency, shades that were more translucent showed lower lightness, lower chroma, and higher hue. This translucency was found to increase the effect of a black background.[25] This explanation is consistent with the color change values measured on a black background, contrary to our expectations from this study. Compared to opaque resins, the black background color may have been more pronounced before discoloration in the translucent enamel composite than after discoloration. For this reason, the color change may have been found more on the black background than on other backgrounds.

In our study, the appearance of greater color change for FU enamel when seen against a black background, such as the oral cavity, compared to when layered with dentin, necessitates considering the effect of a black background when using translucent materials for aesthetic restorations.

Furthermore, in our study, the variation in background did not statistically significantly affect the ranking of color change values for composite resins. The hypothesis that change in background does not affect the order of color change values for composite resins has been accepted. The order of ΔE00 values was enamel>dentin>/=enamel+dentin in all backgrounds for both composites.

CONCLUSION

Different backgrounds did not affect the color evaluation of samples containing an opaque composite resin, dentin composite. However, the color change value of FU enamel, which is a translucent composite resin, was influenced, resulting in higher color change values when seen against a black background. This outcome should be taken into consideration, especially in scenarios such as the taking the oral cavity where a black background is involved into consideration. Moreover, placing translucent composite resins over less transparent ones improves the precision of color assessments.

Author Contributions

Design: TS, AO, TK, Data collection or data entry: TS, TK, Analysis and interpretation: TS, AO, Literature search: TS, A, YO, TK, Writing: TS, AO.

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