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How the Translucency and Color Stability of Single-Shade Universal Resin Composites Are Affected by Coffee?

Tek Renkli Universal Rezin Kompozitlerin Translüsensi ve Renk Stabilitesi Kahveden Nasıl Etkilenir?

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ABSTRACT

Objective: The aim of this study was to examine how staining with coffee affects single-shade universal resin composites and a multi shade universal resin composite in terms of translucency and color stability.
Method: Five different resin composites (Omnichroma, Vittra APS Unique, Zenchroma, Charisma Diamond One, and Neo Spectra ST) were used to create 50 samples (n=10). A spectrophotometer was used to record translucency parameter (TP_{00}) and color changes (ΔE_{00}) at baseline and after immersion in coffee for 24 h. Color differences were calculated according to CIEDE2000. Data analysis was performed using one-way ANOVA and the paired-samples t-test.
Results: After immersion of resin composite samples in coffee for 24 h the Vittra APS Unique group showed the highest ΔE_{00} value and the Neo Spectra ST group the lowest (P<.001). At baseline, low TP_{00} values were observed in Neo Spectra ST and Charisma Diamond One and high TP_{00} values in Omnichroma and Vittra APS Unique (P<.001). After being stained with coffee On day 1, low TP_{00} values were recorded in Neo Spectra ST and Charisma Diamond One, and high values TP_{00} in Omnichroma and Zenchroma (P<.001).
Conclusion: Short-term staining resulted in less color change in the multi shade universal resin composite than in the single-shade universal resin composites. ΔE_{00} and TP_{00} values varied between the single-shade universal resin composites
Keywords: Color Stability, Multi shade Universal Resin Composite, Single-Shade Universal Resin Composite, Translucency Parameter

ÖZET

Amaç: Bu çalışmanın amacı, kahve ile renklendirmenin tek renkli universal rezin kompozitlerin ve bir çok renkli universal rezin kompozitin translüsensi ve renk stabilitesini nasıl etkilediğini incelemektir.
Yöntem: 50 örnek oluşturmak için beş farklı rezin kompozit (Omnichroma, Vittra APS Unique, Zenchroma, Charisma Diamond One ve Neo Spectra ST) kullanıldı (n=10). Başlangıçta ve 24 saat boyunca kahveye batırıldıktan sonra translüsensi parametresi (TP_{00}) ve renk değişikliklerini (ΔE_{00}) kaydetmek için bir spektrofotometre kullanıldı. Renk farklılıkları CIEDE2000'e göre hesaplandı. Veri analizi, tek yönlü ANOVA ve eşleştirilmiş örnekler t-testi kullanılarak yapıldı.
Bulgular: Rezin kompozit numunelerin 24 saat boyunca kahveye batırılmasından sonra en yüksek ΔE_{00} değerini Vittra APS Unique grubu, en düşük ΔE_{00} değerini ise Neo Spectra ST grubu gösterdi (P<.001). Başlangıçta; Neo Spectra ST ve Charisma Diamond One'da düşük TP_{00} değerleri, Omnichroma ve Vittra APS Unique'de ise yüksek TP_{00} değerleri gözlendi (P<.001). Kahve ile boyama sonrası 1. Günde ; Neo Spectra ST ve Charisma Diamond One'da düşük TP_{00} değerleri, Omnichroma ve Zenchroma'da ise yüksek TP_{00} değerleri kaydedildi (P<.001).
Sonuç: Kısa süreli renklendirme; çok renkli universal rezin kompozitlerde, tek renkli universal rezin kompozitlere göre daha az renk değişikliğine neden oldu. ΔE_{00} ve TP_{00} değerleri, tek renkli universal rezin kompozitler arasında değişiklik gösterdi.
Anahtar Kelimeler: Renk Stabilitesi, Çok Renkli Universal Rezin Kompozit, Tek Renkli Universal Rezin Kompozit, Translüsensi Parametresi

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INTRODUCTION

It is the task of restorative dentistry to restore the natural appearance of teeth that have lost material due to caries or trauma.[1] Resin composites are preferred because they give natural and esthetic results. When restoring

teeth using multi shade resin composites, dentists typically use a color guide and employ their visual skills to select a shade that is compatible with the tooth .[2] With the introduction of nanotechnology to reduce the time spent at the chairside, the use of single-shade resin composites has risen. These composites can simulate all shades alone, in contrast to multi shade resin composites.[3] It is reported that composites are in better harmony with the color of dental tissues due to their "chameleon effect".[4] This effect is synonymous with the blending effect and in resin composite restorations is the potential for color shift from reflected light to match the color of the surrounding tooth structures. When the restoration is illuminated, the light is diffused on the surface of the filling particles and is scattered in many directions.[5]

The success of a restoration esthetically speaking depends on its optical appearance. The color and translucency of esthetic restorations are important optical properties. The restorative materials applied should be able to imitate both the color and translucency of the natural tooth structure and be resistant to discoloration in the long term, which may be caused by external factors.[6] Absorption of pigments in staining liquids such as coffee, wine, and cola causes coloring of the resin composite.[7]

Knowledge of the processes related to color change in resin composites will contribute to improvement of their esthetic properties. In addition, color selection and matching will be simplified with a small number of color options. The number of single-shade system resin composites with different properties is gradually increasing. The variety in the chemical contents of resin composites implies that their clinical performance is affected by numerous factors.[8] Various clinical behaviors can be shown by single-shade resin composites with specific color-matching mechanisms through their filler structures.[9] There are limited data on color stability and translucency variation in the increasing number of single-shade resin composites. In the present study, four single-shade resin composites were examined in terms of their color stability and translucency parameters. The aim of the study was to examine how the color stability and translucency of four single-shade universal resin composites and a multi shade universal resin composite were affected by staining with coffee. The null hypothesis was that staining with coffee will not create any difference in the color stability or translucency of the universal resin composite samples tested.

METHOD

Since disc-shaped composite samples were used in the study, informed consent and ethics committee approval were not applied. The study was performed in vitro to evaluate a multi shade resin composite and four commercially available single-shade resin composites from different manufacturers. Details of the resin composites are presented in Table 1.[10] The composites tested were placed in silicone molds (8 mm in diameter and 2 mm in depth) in one go with the help of hand tools. The overflowing composite material was removed by placing a piece of transparent tape on the resin composites and applying finger pressure via a 1-mm-thick glass coverslip. The samples were polymerized for 20 s at 1000 mW/cm² by touching the tip of a Woodpecker LED-E light device (Woodpecker Medical Instrument Co., Guilin, China) onto the glass coverslip. The polishing was performed by a single experienced operator as described by the manufacturer (under slight hand pressure, 20 s application per sample). For polishing, a Minitech 233 (Presi, Grenoble, France) was used under running water (170 rev/min, 15 s). Power analysis was performed using the software package G*Power 3.1.[11] Sample size was calculated with a Type I error is 5% and power of 80% and large effect size 0,6 it is necessary to include at least 8 samples in each group. Considering data losses, 50 disc-shaped samples were prepared, 10 samples in each group, with an increase of 20%. The samples were finished and polished, and then placed in a 10-well plate (1 sample per well). Afterward, following 24 hours of incubation in distilled water at 37 °C, the baseline color of all samples was determined using a spectrophotometer (SpectroShade, MHT Optic Research, Niederhasli, Switzerland). The averages of three measurements obtained from each sample were calculated to determine the L*, a*, and b* values. The device was calibrated before each measurement. Color on a white background and translucency on a black and white background were conducted under D65 standard illumination conditions. Samples were prepared by mixing 3.6 g of coffee granules (Nescafe Classic, Nestle, India) with 300 ml of boiled coffee powder at 37 °C and incubated for 24 hours in an incubator (NUVE EN 55, Esetron, Ankara, Turkey). The colors of the samples were measured again, and the values were recorded. The ΔE_{00} and TP_{00} values were calculated using the CIEDE2000 formula based on the L*, a*, and b* values on the baseline and day 1.[12,13] The formulas for ΔE_{00} and TP_{00} are given below.

$$TP_{00} = \left[\left(\frac{L'_B - L'_W}{k_L S_L}\right)^2 + \left(\frac{C'_B - C'_W}{k_C S_C}\right)^2 + \left(\frac{H'_B - H'_W}{k_H S_H}\right)^2 + R_T\left(\frac{C'_B - C'_W}{k_C S_C}\right)\left(\frac{H'_B - H'_W}{k_H S_H}\right)\right]^{\frac{1}{2}}$$

$$\Delta E_{00} = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T\left(\frac{\Delta C'}{k_C S_C}\right)\left(\frac{\Delta H'}{k_H S_H}\right)}$$

The preliminary analysis, skewness coefficients, and histogram graphs showed that the measurements were in accordance with the normal distribution. The data obtained were analyzed with SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY) using one-way ANOVA and the paired-samples t test. Significance was set at $P<.01$.

RESULTS

The perceptible threshold value of ΔE_{00} determined was 0.8, and $\Delta E_{00}>0.8$ indicated visually perceptible color change. The acceptable threshold value determined for ΔE_{00} was 1.8, and values of $\Delta E_{00}>1.8$ were regarded as clinically unacceptable color changes.[14] The mean and standard deviation of ΔE_{00} in the resin composite groups according to the CIEDE2000 color system after coloring solution are shown in Table 2. ΔE_{00} values were between 1.2 and 2.76 in the resin composite groups after soaking in coffee. The highest statistically significant ΔE_{00} was in the VU single-shade composite resin group ($P<.001$), while the lowest statistically significant ΔE_{00} was in the NS multi shade resin composite group ($P<.001$). ΔE_{00} in the other three single-shade composite resin groups (OC, ZC, DO) were similar to each other.

In a study by Salas et al.[15], the translucency perceptibility and acceptability thresholds of resin composites according to the CIEDE2000 formula were 50%:50% TPT (perceptibility) 0.62 and TAT (acceptability) 2.62. In the present study, based on these threshold values, the TP_{00} values (6.97-11.98) were in the clinically unacceptable range for the resin composite groups after soaking in coffee. The mean and standard deviation TP_{00} values and comparative results of the resin composite groups before and after staining with coffee according to the CIEDE2000 formula are shown in Table 3.

Baseline, mean TP_{00} values differed significantly (P<.001). Among the groups, NS and DO showed similarly low TP_{00} values, while OC and VU showed similarly high TP_{00} values. After 1 day immersing in coffee, mean TP_{00} values again differed significantly (P<.001). NS and DO showed similarly low TP_{00} values among the groups. OC and ZC showed similarly high TP_{00} values. In addition, the values for ZC and VU TP_{00} were similar.

After 1 day immersing in coffee, the TP_{00} values of the ZC resin composite group were significantly increased (P=.009), while the TP_{00} values of the NS and DO resin composite groups were significantly decreased (P<.001). The TP_{00} values of the OC and VU resin composite groups were not affected by coffee staining (P=.114 and P=.083, respectively).

DISCUSSION

The effects of coloring solution on the color stability and increase/decrease in TP_{00} values of a multi shade universal resin composite and four single-shade universal resin composites were evaluated. The hypothesis that staining brown would cause no difference in color stability and increase/decrease in TP_{00} in the resin composite samples tested was rejected. Single-shade universal resin composites are used clinically to make color selection quicker and to decrease costs by reducing the amount of waste and because of their good esthetics.[16] The color stability of resin composite restorations in the anterior region is especially important. Discoloration of these restorations is considered an esthetic failure but can often be corrected by re-restoration.[17] The quality of the restoration surface is one of the most important indicators of external discoloration. There is information in the literature that polishing the restoration surface removes the resin-rich oxygen inhibition layer and, as a result, provides a smoother, smoother, more cleanable surface, and these features of the surface play an important role in external discolorations.[18,19] The use of transparent tape enables a shiny surface to be obtained. Although it is known that the part just below the band does not polymerize at the same rate as the entire resin composite, and when this layer is removed with polishing application, a harder and more resistant to discoloration surface is obtained.[20] In our study, taking into account the imitation of clinical applications, all sample surfaces were applied using standard polishing discs. A finishing polishing process was applied. The degree of monomer conversion affects the chemical stability of the material. Unconverted double carbon linkages can make the material more susceptible to degradation reactions.[21] This may result in decreased color stability.[22] It has been reported that composite resins that have not been sufficiently polymerized undergo significant color change when exposed to chemical dyes and food dyes.[23]

It's reported that color analysis with a spectrophotometer is more accurate and reproducible than visual color assessment.[24] A clinical study found that SpectroShade exhibited better reproducibility than VITA Easyshade (VITA Zahnfabrik, Bad Sackingen, Germany).[25] In addition, SpectroShade (SpectroShade, MHT Optic Research, Niederhasli, Switzerland) allows defining the outline of the tooth on the image and displaying color parameters for the entire tooth surface or the gingival, middle and incisal thirds. For this reason, the use of

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

Material	Manufacturer	Lot Number	Type	Monomer	Filler Composition/Size	Filler w/V%	Code
Omnichroma	Tokuyama, Japan	158S3	Nanofilled	UDMA TEGDMA	Uniform sized supra-nano spherical filler (SiO2-ZrO2) /260 nm	79/68	OC
Zenchroma	President Dental, Germany	2022003395	Microhybrid	UDMA Bis-GMA TEMDMA	Glass powder, silicon dioxide inorganic filler / (0.005–3.0 µm)	75/53	ZC
Charisma Diamond One	Kulzer, Germany	K010021	Nanohybrid	UDMA TCD-DI HEA TEGDMA	Barium Aluminium Boro Fluor Silicate Glass / (5 nm–20 µm)	81/64	DO
Neo Spectra ST HV A2	Dentsply, North Carolina, USA	2111000985	Nanohybrid	Bis(4-methyl-phenyl)iodonium hexafluorophosphate	Spherical, pre-polymerized SphereTECfillers, Methacrilate-modified polysiloxane barium glass, and ytterbium flüoride/ (3 µm-7 µm)	79/61	NS
Vittra APS Unique	FGM, Brazil	230921	Nanohybrid	UDMA TEGDMA	Zirconia charge, silica/ (200 nm)	82/72	VU

Table 2. Comparison of color changes (ΔE_{00}) of composite resins (between baseline and day 1)

Groups	Mean ± SD
Omnichroma	2.25 ± 0.36[b]
Zenchroma	1.81 ± 0.33[b]
Charisma Diamond One	2.0 ± 0.67[b]
Neo Spectra ST	1.2 ± 0.17[c]
Vittra APS Unique	2.76 ± 0.84[a]
ANOVA test	F=11.6; p: <0.001

a, b, c: Different letters indicate statistical differences between groups.

Table 3. Comparison of translucency parameter (TP_{00}) baseline and day 1 interval for each composite resin.

	Baseline	Day 1	Paired t test	
	Mean ± SD	Mean ± SD	t	*P*
Omnichroma	11.57 ± 0.47[a]	11.98 ± 0.56[a]	-1.748	.114[ns]
Zenchroma	10.76 ± 0.47[b]	11.50 ± 0.63[ab]	-3.287	.009[**]
Charisma Diamond One	7.82 ± 0.67[c]	7.10 ± 0.39[c]	5.603	<.001[***]
Neo Spectra ST	7.49 ± 0.64[c]	6.97 ± 0.67[c]	6.082	<.001[***]
Vittra APS Unique	11.48 ± 0.37[a]	10.97± 0.95[b]	1.952	.083[ns]
ANOVA test	***F*** 141.3	137.3		
	P <.001	<.001		

Ns: not significant, **:P<.01; ***: P<.001
SD: standard deviation.
Different letters indicate statistical differences between the same columns(P<.001).

SpectroShade was preferred in this study. Its disadvantage compared to the clinical spectrophotometer Vita Easyshade is that it may not provide L*, a* and b* values. However, it can be used in studies as stated in the literature.[26]

CIELAB is calculated using the ΔE_{00} formula with the L*, a*, and b* color change values in the materials. In 2001, an updated formula, CIEDE2000, was introduced by the CIE.[27] Researchers have reported that the CIEDE2000 formula is more suitable for evaluating color differences[28] and has greater sensitivity than the CIELAB.[29] Therefore, in our study, color differences and TP_{00} values were calculated with the CIEDE2000 formula.

Tea, coffee, and wine are beverages commonly consumed daily and cause the most color change.[30] In this study, coffee, was used for short-term coloring. Ertaş et al.[31] reported that keeping samples in coffee for 24 h mimics approximately 1 month of coffee consumption. In the present study, the resin composites were subjected to short-term staining. They were kept in coffee for 24 h and so were exposed to the equivalent of 1 month of staining. The water absorption rate is related to the material's resin content and the bonding at the filler/resin interface. The resin expands and becomes plastic if water absorption is excessive. This causes microcracks in the resin composite that prepare the environment for stain penetration and color change.[32] In addition, resin composites with the main monomer content of Bis-GMA have been reported to show less water absorption than those containing TEGDMA and more water absorption than those containing UDMA and Bis-EMA.[33] Ertaş et al.[31] reported that greater change was seen in TEGDMA resin composites in their study about color change in nanohybrid and microhybrid resin composites caused by various drinks (water, cola, tea, instant coffee, and red wine). The monomer TEGDMA is usually found in the structure of monochrome resin composites. Reis et al.[34] stated that the structure of the material and the amount of organic matrix filler are important factors affecting color change in resin composites. It has been reported that the colors of composites with more filler particles are more stable because they absorb less water.[30] The smaller particle size found in resin composites, on the other hand, may explain their lower susceptibility to coloration. The presence of smaller filler particles is associated with lower susceptibility for surface smoothness and coloration compared to other resin composites with larger filler particles.[35] Ren et al.[36] reported that the porosity of zirconia/silica nanoparticles facilitate the penetration of fillers and dyestuffs. They emphasized that although the resin matrix structures are similar, differences in color stability are related to the differences in filler composition.[36] In our study, coloration equivalent to 1 month the resin composite showing the greatest color change was VU. Although the amount of filler particles in VU is high and the filler particles are small, the reason for its greater staining may have been the zirconia-silica nanoparticles it contains. More studies on the color change of VU are needed. In our study, it was the NS multi shade universal resin composite group that showed the least color change. This may have been because NS does not contain TEGDMA. Coloration equivalent to 1 month , NS showed clinically acceptable color change values (1.2 ± 0.17). Fidan et al.[37] reported that single-shade composite resins found a higher color change than the multi-shade composite resin. Within the limitations of our study, short-term staining of resin composites can be demonstrated. The color change in NS can be evaluated with long-term staining.

Translucency can be defined as a state between full opacity and full transparency, where the background appears as a result of the light transmitted through the material. Higher values for TP_{00} indicate greater translucency of the material. A completely opaque material has a zero TP_{00} value. In a previous study, a higher TP_{00} was said to indicate a higher blending effect.[38] Large filler particles (about 10 µm in diameter) transmit less light and appear opaquer.[39] When baseline TP_{00} values were compared in our study, OC and VU showed high TP_{00} values, while NS and DO showed low TP_{00} values. This may have been because OC and VU resin composites contain smaller filler particles compared to the other composites, and NS and DO resin composites contain larger filler particles. However, it is stated that the ratios of radiopaque substances (barium glass particles, etc.) added to resin composites affect their TP_{00} values.[40] The reason for the low TP_{00} values of NS and DO may be related to the barium particles they contain. After staining with coffee, OC and ZC showed high TP_{00} values and NS and DO showed low TP_{00} values. The content differences and coloration status of the materials after staining with coffee may have caused the changes in TP_{00} values. It has also been reported that aging affects the color stability and translucency of resin composite materials.[41] Differences between resin composites may be attributed to the chemical structure of the materials, the number of particles, or the diameter of the particles. Researchers have reported that Bis-GMA has greater translucence than UDMA and TEGDMA.[42] The reason given was that the refractive index of Bis-GMA was similar to that of silica filler. However, the ZC group in our study showed significantly higher TP_{00} values with OC only after staining with coffee, although it contained Bis-GMA. In addition, a significant increase was observed in the TP_{00} values of ZC after staining with coffee (P=.009). In a study conducted by Fidan et al.[41], the TP_{00} value of ZC has decreased after aging. This may have been related to the monomers and fillers contained in ZC. Translucency changes may occur in composites due to light curing or aging.[43] In a study examining the color and translucency change of single-shade composite after repeated heating cycles and coloring, it was reported that the TP_{00} value decreased significantly after one heating cycle.[44] Quek et al.[45] found that red wine and coffee significantly reduced the TP_{00} values of direct and indirect restorative material after 7 days. TP_{00} values in the NS and OC resin composite groups showed a significant decrease after staining with coffee. Weakening of the bond between resin and filler and then colorants leaching into the resin matrix might be responsible for this decrease.[42] The translucency of esthetic restorative materials was established by comparatively small additions of pigments and possibly all other chemical components in these materials, including initiating components and filler coupling agents as well as more macroscopic factors, like matrix and filler composition and filler content.[46] For success in complex clinical cases, the clinician must test the translucency, opalescence, chroma, and fluorescence of the material beforehand.[47] How each component affects changes in translucency should be studied further. This study evaluated many single-shade composite resins that have recently been introduced to the dental market. The color stability of the single-shade composite resin selected for clinical success in esthetic restorations may be important for the clinician. In addition, we thought that the color change and increase/decrease in translucency that occurs after short-term staining with coffee in single-shade composite resins may be useful in clinical studies planned in the future. Limitations of this study include short-term coloration, the use of only one multi shade composite resin, and it was in vitro study. To better interpret the color results of the materials, FTIR, Vickers, adsorption and solubility, and surface roughness tests should be performed and included in future studies. Laboratory experiments cannot fully simulate intraoral conditions. Future in vivo studies are needed.

CONCLUSION

Short-term staining with coffee resulted in less color change in the multi shade universal resin composite than in the single-shade universal resin composites. ΔE_{00} and TP_{00} values varied between the single-shade

universal resin composites. Since the physicochemical properties of the material and the patient's dietary habits as well as oral hygiene practices are important determinants of color changes in composite resins, we think that including this parameter in future studies will be beneficial in terms of the results obtained.

Etik Komite Onayı: Çalışmada disk şeklinde kompozit numuneler kullanıldığı için Etik Kurul Onayı alınmamıştır.
Hasta Onamı: Kompozit numuneler kullanıldığından hasta onam formu alınmamıştır.
Hakem Değerlendirmesi: Dış bağımsız.
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