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Color Adjustment Potential of Two Single Shade Resin-Based Composites Before and After Staining

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Research Article

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ABSTRACT

Objective: This in vitro study aims to evaluate the visual color adjustment potential (CAP-V) of two single shade resin-based composite before and after coffee staining.

Materials and Methods: Class 3 cavities were prepared on the mesiobuccal surfaces of a total of 60 acrylic maxillary central denture, 30 in A2 shade and 30 in B1 shade. For the restoration of cavities, two different single-shade resin based composites (Omnichroma and Charisma Diamond One) and a nanohybrid composite (Filtek Ultimate, A2 and B1 Body shades) were used. After the restoration process, the samples were polished. The visual color adjustment potential (CAP-V) of all samples was evaluated 3 times respectively: before the staining process, after the staining process and after the re-polishing process. Data were analyzed with One-way analysis of variance (ANOVA) and Tukey tests (p=0.05).

Results: The Omnichroma B1 groups showed better CAP-V values for initial and re-polished groups. In the groups after staining, the best CAP-V values were in the Charisma Diamond One A2 group and the worst values were in the Filtek B1 group (p<0.001). Additionally, no statistically significant difference was found between Omnichroma and Charisma Diamond One in any group except the re-polished B1 group.

Conclusions: Within the limitation of this study, we can conclude that B1 shade dentures restored with single-color resin composites are more likely to lose visual harmony due to discoloration over time, compared to A2 shade dentures. However, it was seen that the visual harmony problem caused by staining could be reduced by re-polishing. The single-shade resin composites used in this study generally have similar CAP-V values.

Keywords: Color Adjustment Potential, Color Stability, Resin Composite, Staining

İki farklı tek renkli rezin kompozitin renklendirme öncesi ve sonrası renk uyum potansiyellerinin değerlendirilmesi

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ÖZ

Amaç: Bu in vitro çalışma, iki farklı tek renkli rezin kompozitin kahve ile renklendirme öncesi ve sonrası görsel renk uyum potansiyelini (CAP-V) değerlendirmeyi amaçlamaktadır.

Gereç ve Yöntemler: 30 adet A2 renk tonunda 30 adet de B1 tonunda olmak üzere toplam 60 adet akrilik santral dişin meziobukkal yüzeylerine sınıf 3 kaviteler açıldı. Kavitelerin restorasyonu için 2 farklı tek renkli rezin kompozit (Omnichroma and Charisma Diamond One) ve kontrol grubu olarak da farklı renklere sahip bir nanohibrit kompozit (Filtek Ulitimate) kullanıldı. Restore edilen dişler kahve ile renklendirme işlemine tabi tutuldu ve renklendirme sonrasında polisaj işlemi uygulandı. Tüm örneklerin renklendirme işleminden önce, renklendirme işleminden sonra ve polisaj işleminden sonra olmak üzere toplam 3 kez görsel renk uyum potansiyelleri değerlendirilmiştir. Veriler tek yönlü varyans analizi (ANOVA) ve Tukey testleri ile analiz edildi (p=0,05).

Bulgular: Omnichroma B1 grupları, başlangıç ve yeniden polisajlanmış gruplar içinde daha iyi CAP-V değerleri gösterdi. Renklendirme sonrası gruplar arasında en iyi CAP-V değerleri Charisma Diamond One A2 grubunda, en kötü değerler ise Filtek B1 grubunda görüldü (p<0,001). Ayrıca Omnichroma ve Charisma Diamond One arasında yeniden cilalanan B1 grubu dışında hiçbir grupta istatistiksel olarak anlamlı bir fark bulunamadı.

Sonuçlar: Bu çalışmanın sınırları dahilinde, tek renkli rezin kompozitlerle restore edilen B1 renk akrilik dişlerin, A2 renk akrilik dişlere göre zamanla renk değişikliği nedeniyle görsel uyumunu kaybetme olasılığının daha yüksek olduğu sonucuna varıldı. Ancak renklenmeden kaynaklanan görsel uyum sorununun yeniden cilalama yapılarak azaltılabileceği gözlendi. Bu çalışmada kullanılan tek renkli rezin kompozitler genel olarak benzer CAP-V değerlerine sahiptir.

Anahtar Kelimeler: Renk uyum potansiyeli, renk uyumu, rezin kompozit, renklenme

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Introduction

Resin based composites (RBC) are widely used in restorative dentistry due to the demand for aesthetic procedures and the advocacy of minimal removal of dental tissues during tooth preparation.[1] For a composite restoration to be effective, the natural tooth tissue and the RBC must have such a harmonious hue that the human eye cannot tell them apart. The choice of RBC in restorative operations is based on color appearance, namely color match, color stability, and color interactions.[2] Color selection in resin composite restorations can be difficult because it varies depending on environmental and dentist-dependent variables.[3]

Recently introduced single-shade RBC match almost all color shades. However, this is also related to the size of the restoration and the tooth tissues surrounding it. Due to these properties, also called the chameleon effect, these composites simplify the restorative procedure by eliminating the color selection step.[4,5] Single-shade RBC have an added benefit known as the Color Adjustment Potential (CAP), which describes how perceptual and physical components interact.[6]

The interaction between two components, CAP-V (visual) and CAP-I (instrumental), is measured and described using the term Color Adjustment Potential (CAP). The perceptual component of a material is represented by CAP-V, which is computed based on the ratings that observers assign to the materials' color adjustment. Furthermore, the material's physical qualities are represented by CAP-I, which is computed using color difference values acquired using a color measurement tool.[7]

Staining is still seen as a significant disadvantage affecting the success of aesthetic restorations.[8] Composite resin staining may be due to intrinsic or extrinsic factors. Changes in the color of the resin material that are brought about by modifications to the resin matrix, the resin/filler interface, or chemical changes arising from the oxidation or modification of the amine catalyst, the polymeric matrix structure, or the unreacted methacrylate groups are referred to as intrinsic color changes.[9,10] On the other hand, extrinsic factors originate from superficial or deep absorption of colorants due to exposure to external sources leading to stains.[10,11]

This in vitro study aims to evaluate the CAP-V of a multi-shade nanofill composite (Filtek Ultimate) and two different SSRBC (Omnichroma and Charisma Diamond One) on class 3 restorations of acrylic denture in 2 different shades, both before and after staining with coffee.

The null hypothesis is as follows:

1. There is no difference between the CAP-V values of the RBC investigated in this study.

2. The color adjustment potentials of the RBC investigated in this study are similar after staining and re-polishing.

Materials and Methods

Preparation and distribution of samples

In this study, acrylic maxillary right and left central incisor dentures (Denture Lux Pe, Ankara, Turkey) in A2 and B1 shades according to the VITA Classic scale were used.

Class 3 cavities were prepared on the mesial surfaces of 60 dentures, 30 of which were A2 and 30 were B1 shades. The dimensions of the cavities were adjusted to be 2 mm mesiodistally and 3 mm inciso-gingivally. The palatinal wall of the prepared samples was 1 mm (Figure 1). Cavity preparations were performed by a single operator under water cooling, using round drills (#801-014, Hicare Medical Co. Ltd, Guangzhou, China), and after the preparation, the margins were minimally beveled with a 45° angle.

The prepared samples were randomly divided into 3 groups for each shade (n=10).

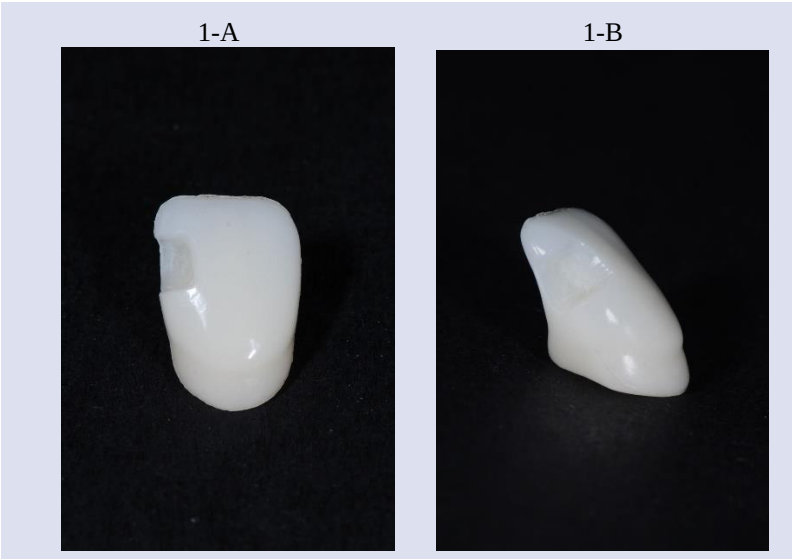

Figure 1: A representative sample of prepared cavities

Restoration

For restoration of cavities, two different single-shade universal RBC (Omnichroma and Charisma Diamond One) and one multi-shade universal nanocomposite (Filtek Ultimate; B1 Body and A2 Body shades), which we preferred as the control group, were used (Table 1). efore the restorations, a universal adhesive agent (Scotchbond Universal, 3M/ESPE, St. Paul, MN, USA) was applied according to the manufacturer's instructions and polymerized with a LED curing unit (Elipar, 3M ESPE, St. Paul, MN, USA) with 1,200 mW/cm^2 irradiation for 10 seconds. Restorations were standardized with a clear silicone stamp. After the bonding process, the composites were placed to the cavities, stamped with a slight pressure force, and polymerized for 20 seconds. The final finishing and polishing procedures were performed using Soflex discs respectively (3M ESPE, St. Paul, MN, USA). Course discs were not used. The discs were replaced with every three restorations. For 24 hours, the dentures were stored at room temperature in distilled water.

CAP-V rating

Eight dentists (four females and four male), who were tested and found successful according to ISO TR28642, were selected as observers. Every sample was visually assessed by observers in a light booth using a 0°/45° viewing geometry at 1-minute intervals while the samples were illuminated by a D65 light source and were situated at a distance of around 25 cm. Color match between the tooth and the restoration was scored from 0 to 4. According to this scale used in previous studies; "0" means excellent match, "1" means very good match, "2" means not a very good match (border zone incompatibility), "3" means obvious incompatibility and "4" means major (pronounced) discord.[5,7]

After the initial color match evaluation, the samples were kept in coffee solution (Nescafe Classic, Nestle Suisse, Vevey, Switzerland) at room temperature for 48 hours. After the staining process, the samples removed from the coffee solution were washed with tap water, and then the color match was evaluated for the second time. Then, all restorations were re-polished and color adjustment potential was evaluated for the third time. The stained and then re-polished samples created subgroups for each shade and restorations. Thus, we obtained 18 groups. The groups in this study and their abbreviations were shown in Table 2. Tukey tests and One-way analysis of variance (ANOVA) were used to analyze the data. (p=0.05).

Results

When the initial CAP-V of the restorations were examined, the best color adjustment was observed in OB, while the lowest color adjustment was observed in CA (p= 0.001). When the CAP-V of the restorations after being stained in coffee solution for 48 hours was examined, the best color adjustment was observed in SOA, while the lowest color adjustment was observed in SFB (p<0.001). When the CAP-V of the restorations re-polished after staining was examined, the best color adjustment was observed in POB, while the lowest color adjustment was observed in PCB (p< 0.05). The mean CAP-V scores of the groups at initial, after staining and after re-polishing are given in Table 3.

When the CAP-V values of the restorations after initial, staining and re-polishing were examined, there was no statistically significant difference between the Filtek Ultimate and Omnichroma groups in A2 shade dentures (p< 0.05). Statistically significant differences were found between the initial, post-staining and post-re-polishing CAP-V values of the other groups (p<0.05).

The initial CAP-V values of the restorations made with all three composites on B1 shade dentures were statistically significantly better than the CAP-V values after staining. However, no significant difference was observed between the initial CAP-V values and re-polished after staining CAP-V values on B1 shade dentures.

Omnichroma showed better CAP-V scores than Charisma Diamond One in all groups. However, this difference was statistically significant only in the repolished after staining group on B1 shade dentures.

The mean CAP-V values of the groups were shown in Table 3.

Table 1: Composition of used resin composites.

Material	Type	Content
Omnichroma (Tokuyama Dental, Tokyo, Japon)	Supra-nano filled	Organic: Urethane dimethacrylate, Triethylene glycol dimethacrylate, Mequinol, Dibutyl hydroxyl toluene and UV absorber Inorganic: Spherical silica-zirconia filler. 79 wt%, 68 vol%
Charisma Diamond One (Kulzer Gmbh, Hanau, Germany)	Nanohybrid	Organic: Urethane dimethacrylate, Bis-methacryloxyethoxy phenyl propane, Bisphenol-A ethoxylated dimethacrylate, Bisphenol-A glycidyl dimethacrylate, Triethylene glycol dimethacrylate Inorganic: Pre-polymerized fillers (17 µm): Strontium glass (400 nm), lanthanide fluoride (100 nm), Fumed silica (16 nm), FAISi glass (850 nm) 81 wt%, 65 vol%
Filtek Ultimate Body (3M/ESPE, St. Paul, MN, USA)	Nanofill	Organic: Bisphenola-A glycidyl dimethacrylate, Urethane dimethacrylate, Ethylene glycol dimethacrylate, Polyethylene glycol dimethacrylate, Bisphenol-A ethoxylated dimethacrylate, Triethylene glycol dimethacrylate Inorganic: Non-agglomerated/non-aggregated 20 nm silica filler, Non-agglomerated/non-aggregated 4 to 11 nm zirconia filler, Aggregated zirconia/silica cluster filler wt%, 63.3 vol%

Table 2: The groups in this study (abb: abbreviations)

Denture Shade	Restorative Resin Composite	Initial groups abb.	Stained groups abb.	Re-polished groups abb. (after staining)
A2	Filtek Ultimate A2 Body	FA	SFA	PFA
A2	Omnichroma	OA	SOA	POA
A2	Charisma Diamond One	CA	SCA	PCA
B1	Filtek Ultimate B1 Body	FB	SFB	PFB
B1	Omnichroma	OB	SOB	POB
B1	Charisma Diamond One	CB	SCB	PCB

Table 3: Mean CAP-V scores of the groups at initial, after staining and after re-polishing.

Group	Mean CAP-V	Group	Mean CAP-V	Group	Mean CAP-V	
FA	1.76 ± 0.76^{Abc}	SFA	2.28 ± 0.64^{Abc}	PFA	1.68 ± 0.54^{Ab}	p>0.05
OA	1.41 ± 0.76^{Aabc}	SOA	1.24 ± 0.46^{Aa}	POA	1.03 ± 0.50^{Aab}	p>0.05
CA	2.09 ± 0.69^{Ac}	SCA	1.38 ± 0.56^{Ba}	PCA	1.13 ± 0.53^{Bab}	P<0.05
FB	1.04 ± 0.71^{Aab}	SFB	2.66 ± 0.46^{Bc}	PFB	1.48 ± 0.63^{Ab}	P<0.05
OB	0.76 ± 0.67^{Aa}	SOB	$1.66\ \ 0.71^{Bab}$	POB	0.69 ± 0.52^{Aa}	P<0.05
CB	$1.28 \pm 0,67^{Aabc}$	SCB	2.19 ± 0.65^{Bbc}	PCB	1.74 ± 0.61^{ABb}	P<0.05
	p<0.05		p<0.05		p<0.05	

*The same lowercase letters mean there is no statistically significant difference between the groups in up to down direction. The same uppercase letters means that there is no significant difference between the groups in same line.

Discussion

It is crucial that the color of the restorative material employed is invisibly consistent with the tooth's color to provide a solution that can live up to the ever-higher aesthetic standards of today. Some of the primary disadvantages of resin composites include their limited coverage of the human tooth color spectrum, lack of color stability, and uneven color definition of different materials.[2] The manufacturing of resin composite color systems has recently focused on color harmony, with less emphasis on the color pigments added to the content and more on the sophisticated photonic nanostructure of filler particles and how they are arranged inside the composite structure. This project reduced the number of colors by introducing composite materials with altered optical characteristics, which in turn produced the phenomena known as structural color. The production of composite systems with fewer colors has begun, and these systems are still developing.[12] The filler content and size of the composite, the organic matrix's composition, the tooth's size and structure, the composite layering technique, and the color and brand of the composite itself are just a few of the numerous sub-factors that can affect color adjustment in composite resin restorations.[13,14] A visual measurement technique was used to assess the color adjustment potential of the composites before and after coffee staining and re-polishing. Different denture colors (B1 and A2), single-shade RBC (Omnichroma, Charisma Diamond One), and multi-shade universal nanocomposite (Filtek Ultimate; B1 Body and A2 Body shades) were used in this study. Due to the evaluations performed in this study, the first hypothesis was rejected because there were differences between CAP-V values in restorations made with different RBC. The color adjustment potentials of the RBC examined in this study after staining and re-polishing were partially rejected because they were similar in some groups and not in others.

Natural teeth have several layers and colors. Moreover, the color of natural human teeth is the result of complex interactions between light and teeth, which are influenced by various factors such as tooth type, location and age.[15] In this study, for color and size standardization of teeth and cavities, instead of extracted teeth, acrylic dentures consisting of a layered structure and selected from the common colors of natural teeth (B1 and A2) were preferred in accordance with the dental literature.[16,17]

The CAP values of composite resins are assessed both visually and instrumentally in several types of investigations.[5-7] An objective technique for measuring hue, chroma and lightness differences in color is called instrumental assessment.[18] The use of visual methods to evaluate color harmony or disharmony is often subjective, but it can be a determining factor in the overall acceptance of treatment by the patient.[7,19] In our study, we used the CAP-V assessment to measure color harmony.

In the literature, visual color assessments were performed at an observation angle of 0°/45°, light, and observer-sample distances of roughly 25-30 cm. Furthermore, a neutral grey background and a D65 light source were employed in other investigations. In this study, in accordance with current research, a scoring system was used, where 0 points corresponds to color incompatibility and 4 points corresponds to perfect harmony. The visual analysis method used in our study is similar to the methods used in the dental literature.[7,16,20]

In our study, Omnichroma without Bis-GMA exhibited a higher color adjustment potential than Filtek Ultimate Body and Charisma Diamond One resin composites containing Bis-GMA. Durand *et al.*[21] concluded in their study on composite disc samples that Omnichroma has the highest color adjustment and translucency adjustment potential among the resin composites tested (Filtek Universal, Harmonize, and Omnichroma), despite

the fact that this is at conflict with a study reporting a positive correlation between the amount of Bis-GMA in resin composite samples and the translucency of the composite material.[22] This is consistent with our research, which demonstrates that Omnichroma's translucency is much enhanced in situ, enabling it to primarily reflect the color of the environment and producing better color correction.

In the study by Zajkani *et al.*[9] the samples immersed in coffee and tea solutions did not return to their initial color values even after re-polishing, but improved significantly, in agreement with the results of previous studies. Re-polishing will not bring back the original color of the discoloration because internal discoloration results from coloring ingredients penetrating the organic phase and causing surface discoloration.[23]

In comparison to other composite types (nanofilament, nanohybrid, and microhybrid), resin composites with supra-nano spherical filler particles display better scattering and light transmission. The size and form of the filler particles are most likely to blame for this.[24] Based on CAP-I data, the supra-nano spherical Omnichroma resin composite in our investigation showed better color adjustment potential than the nanohybrid resin composite Filtek Ultimate Body and Charisma Diamond One groups. In our study, Omnichroma provided the best color adjustment potential in shade B1. Iyer *et al.*[17] compared the color adjustment potential of three different composites (Omnichroma, Tetric Evo Ceram and TPH Spectra ST) in different shades (A2, B1, B2, C2, D3). Similar to our study, theirs stressed that lighter teeth had a greater Omnichroma color adjustment than darker teeth. Chen *et al.*[25] compared the color matching of newly developed composites containing supra-nano filler particles (Omnichroma and Estelite Sigma Quick) with other composite types. They argued that these materials exhibited better color matching in A2, A3 and A4 shade teeth compared to A1 shade teeth. In a study comparing the color matching of Omnichroma material with multicolored RBC on central dentures of different shades (A1, A2 and A3), it was reported that there was no significant difference between dentures shades.[16]

Shade A is a reddish brown hue while shade B is a yellow-red color according to the Vita Shade Guide.[26] Shade B has more lightness than shade A does. In comparison to the backdrop, lighter hues more clearly display the effect of color shift.[27] According to our findings, B1 colored dentures were more likely than A2 colored dentures to gradually lose their visual harmony because of discoloration. In their study, Manabe *et al.*[28] also discovered that the discoloration of the B1 shade of composite resin was greater in coffee and tea than in A1.

This study was carried out in an in vitro environment and acrylic dentures were used in the study. The color adjustment potential of the samples was evaluated only visually and was not compared with any other evaluation method. Furthermore, color adjustment potentials were investigated for two different shades and in one type of cavity type and one type of composite finishing procedure. The specimens were stained with a single beverage and the effect of ageing on long-term color stability was not evaluated. These can be considered as limitations of the study.

Conclusions

Within the limitations of this study, we can conclude that B1 shade dentures restored with single-shade RBC are more likely to lose visual harmony due to discoloration over time, compared to A2 shade dentures. However, it was seen that this visual harmony problem caused by staining could be reduced by re-polishing. Therefore, we can comment that these two resin composites have similar CAP-V values. Coloring of composite resins has a negative effect on CAP-V values, while re-polishing has a positive effect on CAP-V values.

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Conflicts of Interest Statement

The authors declared that there is no conflict of interest.

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