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Original research

# Evaluation of shade matching in the repair of indirect restorative materials with universal shade composites

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**Purpose**

To evaluate color differences in repair of indirect ceramic and resin nanoceramic CAD/CAM blocks with two universal shade composites after different surface preparations.

**Materials and Methods**

120 samples were prepared from IPS Empress and GC Cerasmart270 CAD/CAM blocks and thermocycled (5000 cycles, 5°C–55°C). Initial colors of sample surfaces were measured using a spectrophotometer. Rectangular prism-shaped cavities were prepared and repaired with Tokuyama Universal Bond/Omnichroma and G-Multiprimer/G-Premio/Essentia Universal following surface preparation with aluminum oxide, Cojet, and bioactive glass (Sylc). Repaired samples were thermocycled (5000 cycles) and color measurement was performed. Color coordinates L*a*b* were recorded, and color differences were calculated using the CIELab formula. Color differences between pre-and post-repair ($\Delta E_1$) and between post-repair and post-aging ($\Delta E_2$) were determined. Data were analyzed using Three-way ANOVA with a significance level set at $p<0.05$.

**Results**

$\Delta E_1$ values in all subgroups exceeded the threshold of 3.3. No significant difference was found between the surface preparation processes regarding $\Delta E_1$ values. There was no significant difference between the composites and bonding agents in $\Delta E_1$ values, except for Cerasmart/Sylc and Empress/Sylc groups. No statistically significant difference was detected in $\Delta E_2$ values between the surface preparation treatments in all groups. ($p>0.05$).

**Conclusion**

Color match of the universal shade composites, which are preferred to increase the esthetic satisfaction and to simplify repair procedures, were found above the acceptable threshold. Post-aging color stability of universal shade composites was below the acceptable threshold.

***Keywords:*** *Dental restoration repair, Color, Composite resin, CAD/CAM, Surface preparation*

## Introduction

The use of CAD/CAM systems in dentistry is increasing due to the advantages such as time saving, easy and fast production, maximum compatibility of the restoration with the tooth tissue, as well as their decreasing costs. The diversity of biocompatible material options that provide high esthetics allows the production of restorations that appear similar to natural teeth in terms of color and shape (1-3). Advances in computerized systems has led to an improvement and increase in the restorative material options for performing successful treatments. CAD/CAM composite resin blocks can be processed and repaired more easily than ceramic blocks. In addition, they combine the advantages of ceramic and composite materi-

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als such as high loading capacity, fatigue resistance, superior elastic modulus, and fragility (4-8).

Each restoration has a limited lifespan, regardless of the type of the restorative material. The most common restoration-related complications in clinical diagnosis are secondary caries, marginal defects and staining, wear, discoloration and fracture, color mismatch between restoration and tooth, and fractures of the adjacent tooth structures (9, 10). Restoration fractures occur due to chewing forces and defects in the material structure (11). Repairing restoration failures is a simple and fast alternative treatment that provides satisfactory clinical performance (12, 13). In the statement of FDI about Restoration Repair in 2019 (14), the repair was defined as a minimally invasive approach that turns a clinically unacceptable restoration into a clinically acceptable one, with the application of restorative material.

In restoration repair, air abrasion methods are preferred, which are suitable for minimally invasive approach, are conservative, and provide high bonding values to the restoration surface with the repair composite without reducing the resistance of the existing restoration or tissue. Air abrasion methods are recommended for the repair of many restorative materials, as they facilitate the micromechanical connection between the restoration and repair composite (15).

Current advances in composite resin technology have made these materials indispensable in both anterior and posterior restorations (16,17). Composite resins are the first choice when repairing restoration failures (18). It is important to ensure both functional and esthetic integrity while repairing a restoration. If the restoration repair is considered esthetically successful by the patient and the dentist, it will make it an acceptable and frequently preferred treatment option. In addition, it is an environmentally friendly approach in clinical practice, where sustainable living habits are gaining importance day by day.

Composite resins are produced in forms that can mimic various optical properties to imitate the natural tooth. In composite systems with different layering options, it is possible to encounter conditions that require technical sensitivity, such as selection of the wrong combinations or incorrect thickness in the layers, and different final colors (19-21). To avoid these issues, universal shade composite resins with maximum shade matching ability are produced, which will reduce the chair time and require minimum technical sensitivity. Single shade universal composites are available on the market to match all Vita colors from A1 to D4. While producing universal shade composites, manufacturers aimed to reveal a material with translucency that could best mimic the optical properties of dentin and enamel (22-24). Contrary to Essentia U with higher chameleon effect, Omnichroma presents Smart Chromatic Technology, does not contain dyes or pigments, has structural color. The manufacturer (Tokuyama Dental) reported that the structural color of Omnichroma combines with reflected color of the restoration/tooth and creates perfect match. Smart Chromatic Technology is obtained with supra nano spherical filler particles (25).

The color difference (ΔE) method, which evaluates the perceptibility and acceptability of color in clinical and social life, is the most commonly used method in the literature in the analysis of color match (26). *CIE Lab* system is generally used in color measurement devices. The magnitude of color difference or change is represented by the ΔE value in the *CIE Lab* system and is determined using the following formula (27):

$$\Delta E = [(L_1^* - L_2^*)^2 + (a_1^* - a_2^*)^2 + (b_1^* - b_2^*)^2]^{1/2}$$

The aim of this study is to evaluate the shade matching ability of two universal shade composites in repair of indirect ceramic and resin nanoceramic CAD/CAM blocks following different surface preparations. The clinical acceptability of the difference obtained by baseline and post-repair color measurements of the samples was evaluated. The null hypotheses in the study are as follows; 1: Universal shade composites used in restoration repair do not show any color difference with the repair surface, 2: There is no color difference on the surface repaired with universal shade composite before and after aging, 3: There is no color difference between the surface preparation methods in terms of ΔE values.

## Materials and Methods

*Sample size determination and preparation*

Composition of the materials used int this study are listed in Table 1. Power analysis was performed and the sample size was calculated as n=10 for color measurement in each group (Power= 100, α= 0.05). A total of 120 samples with the dimensions of 10×10×4 mm from IPS Empress LT (Ivoclar Vivadent, Schaan, Liechtenstein) (n=60) and Cerasmart 270 LT (GC Corp., Tokyo, Japan) (n=60) CAD blocks in shade A2 were cut under water cooling using a low speed diamond saw (Isomet 1000 – Buehler, IL, USA). Both surfaces of the prepared samples were polished with 600-grit silicon carbide paper under running water for 20 seconds and rinsed

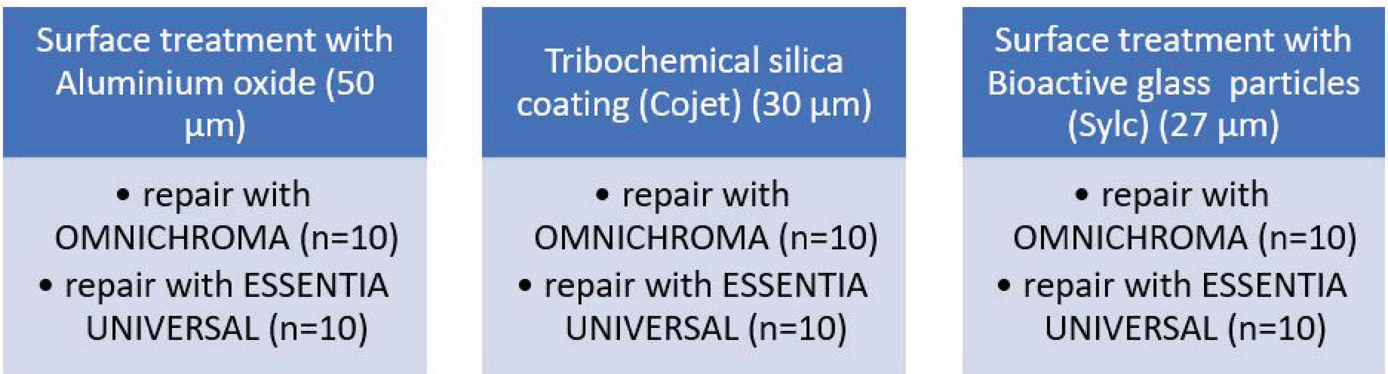


***Figure 1.*** *Subgroups according to the surface preparation process and repair composite of ceramic and resin nanoceramic samples.*

with distilled water. Aging was performed to prepare the samples for the repair procedure. All samples were thermocycled to correspond 6 months of clinical use (5ºC-55ºC; ±2ºC water bath, 5000x, 10 s transfer time and 30 s dwell time)(28). Following aging, the ceramic and resin nanoceramic samples were randomly divided into 12 subgroups. The groups according to the surface preparation methods and the repair composites are shown in Figure 1.

Initial color measurement was performed from the selected surface of the samples with a spectrophotometer (Easy Shade V; VITA Zahnfabrik, Bad Säckingen, Germany). The manufacturer states that Easyshade V is not affected by ambient conditions. While the visual color evaluation can be affected by ambient light, the digital systems which have their own light sources make the ambient light insignificant. Therefore measurements were performed in daylight conditions, using a grey background. Three consecutive measurements were made from each sample surface (4 mm distance between the tip of the spectrophotometer and the sample borders) and the average of these values was recorded. In all color measurement steps the spectrophotometer was positioned perpendicular to the sample surfaces. Calibration of the device was performed by placing the device on the charging unit as recommended. The L*, a*, and b* values obtained were recorded as $L_1$*, $a_1$*, and $b_1$*.

After initial color measurement, a rectangular prism-shaped cavity of 8 × 8 × 2 mm was prepared on the surface of the samples obtained from Empress/Cerasmart blocks. The cavities were prepared under copious water cooling using a handpiece with fine-grit cylindrical burs (Figure 2).

***Figure 2.*** *Cavity preparation with fine-grit cylindrical burs.*

Three different surface preparation procedures were performed on the prepared cavities (Figure 1). The surfaces of each group were sandblasted from a distance of 15-mm, under 2.5-bar pressure for 10 seconds, with 30-μm Cojet particles (3M Dental Productions, St Paul, USA), 27-μm Sylc (Velopex, London, UK) particles, and 50-μm aluminum oxide particles.

Following the surface preparation procedures, for the samples to be restored with Omnichroma (Tokuyama Dental Corp, Tokyo, Japan), the components A and B of the Tokuyama Universal Bond (Tokuyama Dental Corp., Tokyo, Japan) were mixed and applied to the cavity surfaces according to manufacturer's instructions (Figure 3). Omnichroma composite was placed into the cavities at a single step. A smooth surface was obtained by placing a mylar strip on the composite and pressing it with a glass slab, and the composite was polymerized for 20 seconds using Valo Cordless (Ultradent, USA) light curing device (1200 mW/cm²).

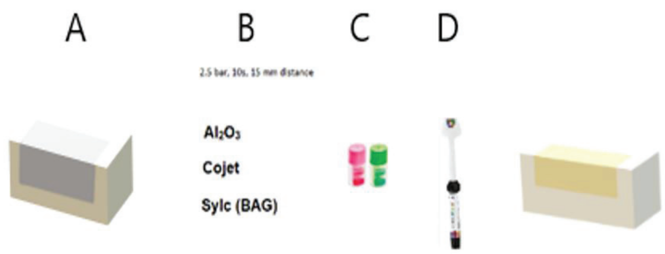


***Figure 3.*** *Preparation of the subgroups repaired with Omnichroma A) Cavity with dimensions of 8 ×8 × 2 mm, B) 2.5 bar; 10 s; surface preparation at a distance of 15 mm, C) Tokuyama Universal Bond application, D) Omnichroma composite application.*

For the Essentia Universal group, Multiprimer (GC Corp., Tokyo, Japan) and G-Premio Bond (GC Corp., Tokyo, Japan) were applied into the cavities in accordance with the manufacturer's instructions, and Essentia Universal (GC Corp., Tokyo, Japan) was placed and polymerized as previously described for the Omnichroma group (Figure 4).


***Figure 4.*** *Preparation of the subgroups repaired with Essentia Universal A) Cavity with dimensions of 8 × 8 × 2 mm, B) 2.5 bar; 10 s; surface preparation at a distance of 15 mm, C) Multiprimer application D) G-Premio Bond application E) Essentia Universal composite application.*

Subsequently, the samples were polished with Soflex (3M Dental Production, St Paul, USA) discs from coarse to fine grit, each for 10 s without water cooling. The samples were stored in distilled water for 24 hours before color measurements.

*Color measurement*

Color measurement was performed from the center of the cavity surfaces (2 mm distance between the tip of the spectrophotometer and the cavity borders) where the composites were placed as described in the initial color measurement and the values were recorded as $L_2$*, $a_2$*, $b_2$*.

After the samples were aged again in 5000 cycles (5°C-55°C; ±2°C), final color measurement was performed, and the values of $L_3$* $a_3$* $b_3$* were obtained. The resulting color changes were calculated using the ΔE formula.

The color difference between the initial and post repair values ($L_1$*, $a_1$*, $b_1$*. and $L_2$*, $a_2$*, $b_2$* values difference) was calculated as $\Delta E_1$. To compare the color changes of the repaired composites following aging, the $\Delta E_2$ value was obtained by using the difference between $L_2$*, $a_2$*, $b_2$* and $L_3$*, $a_3$*, $b_3$* values.

*Statistical analysis*

Data were analyzed using SPSS version 22 (IBM SPSS, IBM, Armonk, USA). The normality of the data was checked with the Kolmogorov-Smirnov and Shapiro Wilks tests. The effects of the material, surface preparation, and repair composite factors on color change were tested with three-way analysis of variance (ANOVA) and the Tukey HSD test was used for pairwise comparasions. Significance level was set at $p<0.05$.

**Table 1:** *Composition of the materials used in the study*.*

| Material | Manufacturer | Composition |
|---|---|---|
| Omnichroma | Tokuyama Dental Corp, Tokyo, Japan | Filler: w 79% uniform size supra-nano spheric filler ($SiO_2$-$ZrO_2$ 260 nm), v 68%<br>Base monomer: UDMA, TEGDMA |
| Essentia Universal | GC Corp., Tokyo, Japan | Filler: w 81%, v 65%<br>Base monomer: BisEMA |
| Tokuyama Universal Bond A-B | Tokuyama Dental Corp, Tokyo, Japan | A: Phosphoric acid monomer (new 3D SR monomer), MTU-6, BisGMA, TEGDMA, aceton<br>B: γ-MPTES, borate, peroxide, acetone, isopropyl alcohol, water |
| G Premio Bond | GC Corp., Tokyo, Japan | MDTP, 4-MET, MDP, aceton, initiator, water, dimethacrylate monomers, silicon dioxide |
| G Multi Primer | GC Corp., Tokyo, Japan | Phosphoric ester monomer, ethanol, methacrylate monomer, γ-methacryloxy propyl trimethoxylan |
| Aquacare Sylc Powder | Velopex, London, UK | Bioactive glass ($SiO_2$ 46.1%, $Na_2O$ 24.4%, CaO 26.9%, $P_2O_5$ 2.6%) (in mol) |
| Cojet Powder | 3M Dental Productions, St Paul, USA | Tribochemical silica coating with 30 µm alumina particles modified by silica |
| Cerasmart 270 LT A2 | GC Corp., Tokyo, Japan | $SiO_2$, $Al_2O_3$, $K_2O$<br>Monomer: BisMEPP, UDMA<br>Filler: $SiO_2$, Ba glass<br>Filler weight: 78% |
| IPS Empress LT A2 | Ivoclar Vivadent, Schaan, Liechtenstein | $SiO_2$ 60.0 – 65.0<br>$Al_2O_3$ 16.0 – 20.0<br>$K_2O$ 10.0 – 14.0<br>$Na_2O$ 3.5 – 6.5<br>Other oxides 0.5 – 7.0<br>Pigments 0.2 – 1.0 |

*The content information is in line with the manufacturer's declaration.

## Results

The $\Delta E_1$ values obtained immediately after the repair of the resin nano-ceramic and ceramic samples with three different surface preparation processes and two different composites are shown in Table 2.

The $\Delta E_1$ values for all subgroups were above the clinically acceptable threshold of $\Delta E \leq 3.3$. There was no statistically significant difference between the surface preparation processes in terms of $\Delta E_1$ values. In the repair of Cerasmart blocks, Essentia Universal composite after surface preparation with Sylc showed significantly higher color difference values than Omnichroma. Empress blocks repaired with Omnichroma showed significantly higher color difference than Essentia Universal in surface preparation with Sylc ($p=0.03$), (Table 2, 3), (Figure 5). There was no statistically significant difference between the amount of color change in terms of composite in other groups.

**Table 3:** *Significance levels for $\Delta E_1$ and $\Delta E_2$ (Sign + denotes the category of comparison).*

| Material | Composite | Surface preparation process | P values $\Delta E_1$ | P values $\Delta E_2$ |
|---|---|---|---|---|
| Cerasmart | Omnichroma | + | 0.056 | 0.434 |
| | Essentia | + | 0.485 | 0.640 |
| | + | $Al_2O_3$ | 0.247 | **0.002*** |
| | + | Cojet | 0.795 | **0.000*** |
| | + | Sylc | **0.041*** | **0.005*** |
| Empress | Omnichroma | + | 0.095 | 0.620 |
| | Essentia | + | 0.436 | 0.435 |
| | + | $Al_2O_3$ | 0.470 | 0.180 |
| | + | Cojet | 0.590 | **0.000*** |
| | + | Sylc | **0.030*** | 0.106 |
| + | Omnichroma | $Al_2O_3$ | 0.275 | 0.260 |
| + | Omnichroma | Cojet | 0.964 | 0.240 |
| + | Omnichroma | Sylc | **0.004*** | 0.455 |
| + | Essentia | $Al_2O_3$ | 0.494 | 0.327 |
| + | Essentia | Cojet | 0.657 | 0.266 |
| + | Essentia | Sylc | 0.159 | 0.715 |

**Table 2:** *Comparison of $\Delta E_1$ and $\Delta E_2$ values regarding the repair composite, surface preparation process, and blocks.*

| | | Surface preparation process | | | | | |
|---|---|---|---|---|---|---|---|
| | | $Al_2O_3$ | | Cojet | | Sylc | |
| **Material** | **Composite** | $\Delta E_1$ | $\Delta E_2$ | $\Delta E_1$ | $\Delta E_2$ | $\Delta E_1$ | $\Delta E_2$ |
| **Cerasmart** | Omnichroma | 4.88 ± 0.87 **a** | 3.29 ± 0.98 **A** | 4.33 ± 0.75 **b** | 3.05 ± 0.71 **B** | 3.65 ± 1.49 **c** | 3.67 ± 1.40 **C** |
| | Essentia Universal | 4.39 ± 0.95 **d** | 1.87 ± 0.74 **A** | 4.44 ± 1.11 **e** | 1.45 ± 0.81 **B** | 4.88 ± 0.90 **c** | 1.73 ± 1.33 **C** |
| **Empress** | Omnichroma | 4.33 ± 1.27 **f** | 2.89 ± 0.51 **D** | 4.3 ± 1.8 **g** | 3.45 ± 0.78 **E** | 5.55 ± 1.03 **h** | 3.07 ± 2.07 **F** |
| | Essentia Universal | 4.83 ± 1.71 **j** | 2.32 ± 1.19 **G** | 4.74 ± 1.76 **k** | 1.84 ± 0.71 **E** | 3.87 ± 1.94 **h** | 1.93 ± 0.64 **H** |

The $\Delta E_2$ values showing the color difference after thermalcycling following repair are shown in Table 2. There was no statistically significant difference between the surface preparation processes in terms of $\Delta E_2$ values in any of the groups ($p>0.05$). When comparing the $\Delta E_2$ values for the composites used in the repair process; in Cerasmart blocks, the color difference obtained with Omnichroma in all three surface preparation procedures was found to be statistically significantly higher than Essentia Universal ($p=0.002$, $p=0.001$, $p=0.005$) (Table 2, 3) (Figure 6). While there was no statistically significant difference between the composites in terms of $\Delta E_2$ values when $Al_2O_3$ and Sylc were applied to Empress blocks ($p>0.05$), it was determined that in Cojet application the mean $\Delta E_2$ values obtained with Omnichroma were statistically significantly higher than the values obtained with Essentia Universal ($p=0.000$; $p<0.05$) (Table 2, 3) (Figure 6).

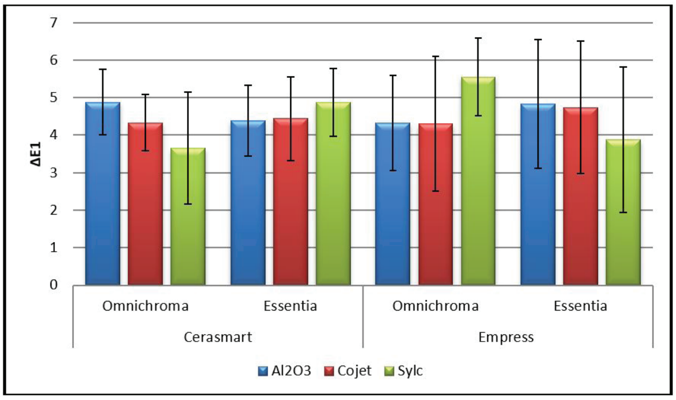


***Figure 5.*** *$\Delta E_1$ values obtained with 3 different surface preparation methods, 2 different CAD/CAM blocks and 2 different composites.*

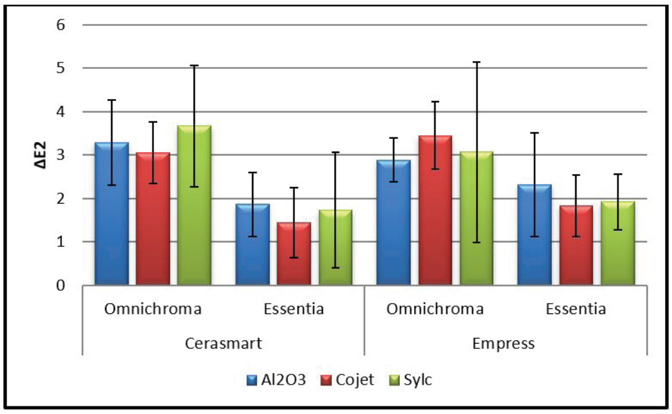


***Figure 6.*** *$\Delta E_2$ values obtained with 3 different surface preparation methods, 2 different CAD/CAM blocks and 2 different composites*

## Discussion

The esthetics of restoration depends on the characteristics of color, shape, surface form, opalescence, and translucency. Ceramic and composite based dental materials should mimic natural tooth color as much as possible to be esthetically acceptable (29). The successful shade match of the restoration depends on the appropriate shade selection and the imitability of the color. The acceptance of the selected shade by the patient and the dentist is the most important criteria for successful shade determination (30).

One of the goals of this study was to ensure the success of restoration by utilizing the high shade matching ability that single shade composites will provide on the repair surface, as well as to eliminate the complexity of shade determination and layered composite applications. In addition, many dentists have to pay for rarely used colors when buying composite sets. However, if shade matching ability of the universal shade composites is satisfactory, such material loss and expenses could be avoided. The economic burden caused by increased restoration cycles with restoration replacement can also be avoided. In addition, if the universal shade composites enhance shade matching, it would be possible to satisfy the esthetic expectation of patients and dentists and eliminate the problem of shade determination.

In dentistry, two parameters, acceptability and perceptibility, define the magnitude of the color difference. Acceptability thresholds are higher than perceptibility thresholds. For practical interpretation of color differences, the following thresholds are used: $\Delta E>1$ can be detected by observers; $\Delta E<3.3$ is clinically acceptable (31). Acceptability thresholds are also evaluated in the literature with different values such as $\Delta E <2.72$ or $\Delta E <3.7$ (32, 33). To reduce or eliminate the inconsistencies of traditional shade matching, spectrophotometers are preferred, which are useful, reliable, and provide mobility in shade matching (34). It is possible to evaluate the clinical color performance of restorative materials using intraoral spectrophotometers which are used in clinical and laboratory settings in many studies (30, 33). Spectrophotometers with an internal light source used in contact mode have been reported to be unaffected by ambient light (35). In this study, the Vita EasyShade V spectrophotometer was used in daylight conditions without using any extra light sources.

While producing universal shade composites, manufacturers aimed to create a material with translucency and opacity that could best mimic the optical properties of dentin and enamel. High filler content affects the translucency of the composite (22). Suh *et al*. (36) found that an increase in filler content improved the opacity and blending effect of the resin. It is known that color mismatches or differences between teeth/restoration are minimized with a high blending effect. Previous studies have reported that the blending effect of the composite depends on the material and shade. The decrease in restoration volume and increase in translucency is enhancing blending effect (23, 37). The filler amount of Essentia Universal is 81% by weight and 65% by volume, while Omnichoma's is 79% by weight and 68% by volume.

In this study, the shade matching of two universal shade composites in repair of ceramic and resin nanoceramic CAD/CAM blocks was evaluated and it was observed that the color difference values were above the clinically acceptable threshold. The first null hypothesis of the study was rejected.

In the study of de Abreu *et al*. (22), the shade matching of Omnichroma and several brand composites in the incisor teeth was evaluated and similarly, the $\Delta E$ values of Omnichroma were found to be high. In this study, it can be thought that the size of the cavity volume was not sufficiently tolerated by the composite, causing high $\Delta E$ values to be obtained in universal shade composites. Lucena *et al.* (38) evaluated the optical properties of universal shade composites and Omnichroma showed higher opalescence at 2mm thickness compared to other thicknesses. Arimoto *et al.* (39) emphasized that the opalescence of composite samples increased above 1 mm material thickness. The effect of the depth and volume of the cavity on the performance of universal shade composites should be evaluated with further studies.

Iyer *et al*. (19) evaluated the shade matching instrumentally and visually, and Omnichroma showed lower ΔE values with lighter colors in terms of shade matching. It also showed a better match with lighter colors in visual evaluation (19). Pereira Sanchez *et al*. (23) emphasized that the potential for shade matching is an optical illusion, and visual evaluation is important in the evaluation of color differences as well as instrumental evaluations.

In this study, no superiority was observed between Omnichroma and Essentia Universal composites in terms of shade matching, except for the use of Sylc for surface preparation on Cerasmart and Empress samples. While Essentia Universal showed higher color difference in Sylc treated Cerasmart270 CAD block, Omnichroma revealed higher color difference in Sylc treated Empress block. This may be caused by the effect of the Sylc particles adhering on the surfaces of Cerasmart270 and Empress blocks on the optical properties of Omnichroma and Essentia Universal, which have different chromatic technologies. The lack of studies examining the effect of surface preparation methods on the color performance of the repair material shows that there is a need for new studies on this subject. In this study, there was no statistically significant difference between the surface preparation processes in terms of $\Delta E_1$ values. Considering the $\Delta E_1$ values, the third hypothesis of the study was accepted.

The color difference of the resin nanoceramic and ceramic samples repaired with Omnichroma and Essentia Universal following aging ($\Delta E_2$) were found to be below the clinically acceptable threshold in most of the samples ($\Delta E<3.3$). The 2nd hypothesis of this study was partially accepted. However, the color difference in the groups with Tokuyama Universal Bond was found to be higher than the groups with G-Premio Bond. This may be caused by the prevention of hydrolysis-induced discoloration that occurs with aging due to the HEMA-free structure of G-Premio Bond. On the other hand, it has been observed that Tokuyama Universal Bond contains HEMA. The effect of HEMA in self-adhesive systems on the color difference in restoration repair may be a different research topic.

The microstructural properties of resin composites and the degradation resistance of the composite are effective on its performance. The monomer conversion, water absorption, solubility and color stability of the co-polymer BisEMA/TEGDMA offered physicochemical properties suitable for further development as a base monomer in dental composites. It has been shown that water sorption in composite resins containing BisGMA and UDMA is higher than composites containing TEGDMA (40, 41). Fonseca *et al*. (41) showed that color stability is directly related to water sorption and solubility, which are associated with the basic monomer formulation.

It has been reported by the manufacturers that Essentia Universal contains BisEMA and Omnichroma contains UDMA and TEGDMA. In this study, Omnichroma showed higher color difference in four groups following the aging procedures. This may be due to the fact that BisEMA content has lower hydrophilicity than other monomers and thus causes less water sorption (42, 43).

High degree of conversion is important in color stability. In a study by Fonseca *et al*. (41), the BisEMA composite with a high conversion degree showed the best color stability. It can be considered that, in addition to the above-mentioned factors, the BisEMA content of Essentia Universal affects the color stability of the composite favorably, causing it to show a lower $\Delta E_2$ value. In addition, the TEGDMA content in Omnichroma, may have result in inferior performance in color matching following aging.

It was observed that the color difference was not affected by surface preparation processes. When the effect of surface preparations on $\Delta E_2$ was evaluated, the third hypothesis of the study was accepted regarding the effect of surface preparations on $\Delta E_2$.

Based on this study with different components, further studies should evaluate whether shade matching and color stability are affected by adhesive systems in addition to composites.

## Conclusion

Within the limitations of this study, the use of universal single shade composites in the repair of ceramic and resin nanoceramic indirect restorations was found to be close to acceptable limits in terms of shade matching. In addition, the post-aging color performance of the universal single shade composites was within acceptable limits. However, in order to obtain values below the acceptable threshold, further studies that also evaluate the effect of the restoration size and surface preparation methods on the color difference and the performances of the newly released universal shade composites would be beneficial.

**Türkçe özet:** *İndirekt Restoratif Materyallerin Üniversal Renk Kompozitlerle Tamirinde Renk Uyumunun Değerlendirilmesi. Amaç: Bu çalışmanın amacı farklı yüzey hazırlık işlemleri uygulanmış seramik ve rezin nano seramik CAD/CAM bloklardan elde edilen restorasyonların iki farklı üniversal renk kompozit ile tamirinde renk uyumunun değerlendirilmesidir. Gereç ve Yöntem: IPS Empress ve GC Cerasmart 270 CAD/CAM bloklardan 10x10x4 mm boyutlarında 120 adet numune hazırlanarak 5000 devir termal döngüde yaşlandırılmıştır. Numune yüzeylerinden spektrofotometre ile renk ölçümü yapılmasının ardından bu yüzeylerde 8*8*2 mm boyutlarında dikdörtgen prizma şeklinde kavite açılmıştır. Kaviteler $Al_2O_3$, Cojet ve Sylc (Aquacare) sistemleri ile yüzey hazırlığına tabi tutulduktan sonra Tokuyama Universal Bond/Omnichroma (Tokuyama) ve G-Multiprimer/G-Premio/Essentia Universal (GC) materyalleri ile tamir edilmiştir. Tamir yüzeylerinden renk ölçümü yapılıp 5000 devir termal döngüye maruz kaldıktan sonra tekrar spektrofotometre (Easyshade V, VITA) ile renk ölçümü yapılmıştır. L*, a*, b* koordinatları kaydedilip CIELab formülüne göre renk farkı hesaplanmıştır. Tamir öncesi ile tamir sonrası ($\Delta E_1$) ve tamir sonrası ile yaşlandırma sonrası ($\Delta E_2$) renk farkları Three-way ANOVA testi ile $p<0,05$ anlamlılık düzeyinde değerlendirilmiştir. Bulgular: Tüm alt gruplarda elde edilen $\Delta E_1$ değerleri 3,3 eşik değerin üzerindedir. Yüzey hazırlık işlemleri arasında $\Delta E_1$ değerleri açısından istatistiksel olarak anlamlı bir farklılık tespit edilmemiştir ($p>0,05$). Kompozit ve bonding ajanlar açısından Cerasmart/Sylc ve Empress/Sylc grupları dışında $\Delta E_1$ değerleri arasında istatistiksel olarak anlamlı bir fark bulunmamıştır. Tüm gruplarda yüzey hazırlık işlemleri arasında $\Delta E_2$ değerleri açısından istatistiksel olarak anlamlı bir farklılık saptanmamıştır. Sonuç: Restorasyon tamirinde estetik tatmini yükseltmek ve uygulama kolaylığını artırmak amacıyla tercih* *edilen üniversal renk kompozitlerin tamir renk uyumu değerleri kabul edilebilir eşiğin üzerinde bulunmuştur. Üniversal renk kompozitlerin yaşlanma sonrası renk stabilitesi kabul edilebilir eşiğin altında bulunmuştur. Anahtar kelimeler: dental restorasyon tamiri, renk, kompozit rezin, CAD/CAM, yüzey hazırlığı*

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