ORIGINAL ARTICLE
DOI: 10.5152/EssentDent.2026.26003

Color Matching Ability Among Single-Shade Resin Composites: Instrumental and Visual Evaluation

Seda Gömleksiz

Department of Restorative Dentistry, Erzincan Binali Yıldırım University Faculty of Dentistry, Erzincan, Türkiye

Cite this article as: Gömleksiz S. Color matching ability among single-shade resin composites: instrumental and visual evaluation. *Essent Dent.* 2026, 5, 0003, doi: 10.5152/EssentDent.2026.26003.

Abstract

Background: This study aimed to evaluate the color-matching ability of 4 single-shade resin composites (RCs), using 2 different evaluation methods.

Methods: One hundred and twelve specimens (8 × 2 mm) were fabricated in disc shape using 4 single-shade RCs (Omnichroma (OM), Essentia Universal (EU), Zenchroma (ZC), and Charisma Diamond One (CDO)) (n=28). The specimens were randomly divided into 4 subgroups (n_a=7), and cylindrical cavities (4 × 1 mm) were prepared in the center of each specimen. The cavities were then restored with either the same material or one of the other single-shade RCs. Color matching was measured instrumentally using a spectrophotometer and visually using a 0-4 scoring scale. Data were recorded and statistically analyzed ($P < .05$).

Results: When instrumental analysis results were evaluated, ΔE_{00} values above the clinically acceptable threshold were observed in all groups except the control groups. The highest ΔE_{00} value was seen in the OM-EU group ($P < .05$); OM showed the worst color matching. The best color matching was observed in CDO. When visual analysis results were examined, the highest visual scores were seen in the EU-OM and ZC-OM groups ($P < .05$), whereas CDO presented the lowest visual scores.

Conclusion: Color-matching ability of single-shade RCs varies depending on the material composition. Single-shade RCs with higher translucency after polymerization and enhanced optical design may provide better color matching. Some color differences detected instrumentally may not always be visually perceptible under clinical conditions.

Keywords: Color matching, optical properties, repair, single-shade resin composite

What is already known on this topic?

- *Single-shade resin composites (RCs) have been developed to simplify shade selection procedures and to improve clinical efficiency by eliminating the need for multi-shade RCs.*
- *The color matching ability of single-shade RCs is influenced by their optical properties, including translucency, filler content, and resin matrix composition.*
- *Instrumental and visual evaluation methods are widely used to assess the color compatibility of restorative materials in dental research.*

What this study adds on this topic?

- *This study provides a comparative evaluation of the color matching ability of 4 commercially available single-shade RCs following immediate repair procedures.*
- *Materials with modified resin matrix formulations and adaptive light-matching behavior show improved visual integration with surrounding structures.*
- *The study also highlights that some color differences detected instrumentally may not always be visually perceptible under clinical conditions.*

INTRODUCTION

Resin composites (RCs) are among the widely preferred materials in restorative dentistry by allowing conservative cavity preparation, satisfactory aesthetic outcomes, and economical treatment options.[1] However, restoration fractures caused by faulty contact after restoration placement, inappropriate contour, and color mismatches between the restoration and tooth hard tissues may create a need for urgent repair.[2] In such cases, dentists must consider several factors to restore the natural structure, including function, phonation, and aesthetics. Following repair, a fundamental criterion in determining aesthetic success is that the restoration should visually blend seamlessly with the surrounding tissues to the point of being indistinguishable in color. The literature

Corresponding author: Seda Gömleksiz
e-mail: sedaozkanoglu1@gmail.com

Content of this journal is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

Received: January 23, 2026
Revision Requested: February 9, 2026
Last Revision Received: February 10, 2026
Accepted: February 24, 2026
Publication Date: August 14, 2026

indicates that the optical compatibility of the restoration with the surrounding structures directly affects patient satisfaction. In areas where aesthetics are paramount, ensuring accurate color matching after emergency repair requires particular attention.[3] Especially in restorations performed in the anterior region, even minimal color differences become clinically perceptible. The color matching exhibited by RCs is influenced by environmental conditions and operator-related variables, which may complicate the attainment of optimal visual outcomes.[4]

The color-shifting phenomenon observed in dental aesthetic materials consists of 2 main components. One component is the blending effect, which is governed by human visual perception and is not amenable to instrumental quantification. The blending effect is a desirable feature in new generation RCs because it prevents or minimizes aesthetic problems that may arise due to color mismatches in the restorative material. The other is the translucency-related component, which can be quantitatively determined.[5] The blending effect defines the property a restorative material must possess in order to create visual uniformity in terms of color with the environment where it is applied.[6] It is claimed that the light absorbed by the material and a color shift originating from the tissue or different materials adjacent to the material are the source of this effect. When any light from the environment is reflected onto the material surface, the light is diffused within the matrix and reacts with the inorganic structure, scattering into the environment. The color of the existing restoration, cavity depth, material thickness, and formulation can alter the degree of this effect.[7] Materials with this feature can help improve aesthetic outcomes by facilitating color matching.[8] Manufacturers have sought products that utilize new technologies to eliminate the disadvantages arising from the optical properties and long color selection times of multi-shade RCs. Current studies in the field of RCs have introduced single-shade RCs without added pigments, a concept termed "smart chromatic technology,"[9] which relies entirely on structural coloring for its optical behavior. These composites aim to minimize time loss due to color selection procedures by achieving optimal color matching between tooth and restoration in the clinic.[10] Because color is a crucial criterion for patient satisfaction or failure in determining a restoration, the production of materials with innovative and technological structures in dentistry can be considered a breakthrough in this field. Scientifically, the colors that human teeth possess are within certain red-orange-yellow color shades. For this reason, a single-shade RC is expected to show similar color matching with all possible VITA Classic A shades. This is because many natural tooth colors fall within the orange spectrum.[11]

Various methods are used to evaluate color harmony in dentistry, with instrumental techniques using color measuring devices and visual techniques using ordinal scoring systems being the most frequently used methods.[12] To measure the color of any material using instrumental techniques, devices such as spectrophotometers, colorimeters, and scanner-based color assessment technologies are utilized.[13] Instrumental techniques can detect subtle color discrepancies that are imperceptible to the human eye. It has been reported that the use of instrumental techniques such as spectrophotometers in color analysis is much more sensitive and yields higher accuracy in analysis results when compared to visual techniques.[14] Visual techniques are subjective methods in which the results may vary depending on the observer's visual perception, the optical differences created by environmental conditions, and the inherent properties of the material being evaluated.[15] In clinical practice, visual perception is usually more prominent and is a determining factor in patient satisfaction.[16]

Despite many previous studies examining the color matching of single-shade RCs with tooth tissue or multi-shade RCs,[17,18] there is a lack of studies directly comparing the color-matching ability of these materials among themselves. This situation leads to a lack of clear scientific evidence regarding which material provides more successful color matching under which conditions among the single-shade RCs that are increasingly used in clinics. To increase the chances of success in restorations using single-shade RCs, it is essential to investigate the colorimetric response in these materials under different conditions. Therefore, the aim of this study was to comparatively evaluate the color matching ability of 4 commercially available single-shade RCs using instrumental and visual evaluation methods. The null hypothesis was that there would be no significant difference in color matching ability among single-shade RCs in instrumental and visual evaluations.

MATERIALS AND METHODS

Since this study was conducted under in vitro conditions using RCs, obtaining ethics committee approval and informed consent was not required. G*Power software (version 3.1.9.7; Heinrich-Heine University, Düsseldorf, Germany) was used to calculate the effect size. A 1-way analysis of variance power analysis revealed that at least 112 specimens were required with an effect size (f) of 0.428, 0.05 type 1 error rate and a statistical power of 95%. A minimum of 7 specimens per group was determined to be required.

Sample Preparation

This study compared 4 commercially available, newly developed single-shade RCs. Detailed information on the evaluated single-shade RCs is given in Table 1. To obtain the base samples, a total of 112 samples were prepared, 28 from each single-shade RC group. Disc-shaped plastic molds (6 × 2 mm) were used to prepare the samples. The plastic molds were placed on a Mylar strip and glass slab placed on a flat surface and filled sequentially with each single-shade RC. Then, a Mylar strip and a glass slab were placed again on

Table 1. Single-Shade Resin Composites Evaluated in this Study

Resin Composite	Manufacturer	Organic Matrix	Inorganic Filler	Filler Content (wt/vol)
Omnichroma (OM)	Tokuyama Dental, Tokyo, Japan	UDMA, TEGDMA	Spherical silica-zirconia and composite fillers (260 nm)	79/68
Essentia Universal (EU)	GC Corporation, Tokyo, Japan	UDMA, Bis-EMA, Bis-GMA, Bis- MEPP, TEGDMA	Prepolymerized resin fillers (17 μm): strontium glass filler (400 nm), lanthanide fluoride (100 nm), silica filler (16 nm), fluoro-alumino-silicate glass filler (850 nm)	81/-
ZenChroma (ZC)	President Dental GmbH, Allershausen, Germany	UDMA, Bis-GMA	Silica, glass powder and ultra-fine radiopaque filler	75/53
Charisma Diamond One (CDO)	Kulzer GmbH, Hanau, Germany	TCD-DI-HEA, TEGDMA, UDMA	Barium aluminium boro fluor silicate glass (5 nm-20 μm)	80/64

Bis-EMA, bisphenol A ethoxylated dimethacrylate; Bis-GMA, bisphenol A diglycidyl dimethacrylate; Bis-MEPP, 2,2-bis 4-methacryloxypolyethoxyphenyl propane; TCD-DI-HEA, 2-propenoic acid, (octahydro-4,7-methano-1 H-indene- 5-diyl) bis(methyleneiminocarbonyloxy-2,1-ethanediyl) ester; TEGDMA, triethylene glycol dimethacrylate; UDMA, urethane dimethacrylate.

top of the filled plastic mold. Polymerization of the specimens was performed for 20 seconds with an LED light-curing device (Valo Cordless, Ultradent, South Jordan, UT, USA) through the glass slab. The polymerized samples were carried out using a disc polishing system (Sof-Lex, 3M ESPE, USA) and then immersed in distilled water for 24 hours. After this period, the samples were removed from the solution and randomly divided into 4 subgroups (n_a=7). Then, cylindrical cavities (4 × 1 mm) were prepared in the center of each sample using a water-cooled high-speed handpiece and diamond burs (#1014, Plus, China). The prepared cavities of the dried specimens were treated with a universal adhesive agent (Single Bond Universal; 3M ESPE, USA) and polymerized for 10 seconds according to the manufacturer's recommendations. Following adhesive application, the cavities prepared in each sample were restored either with the same single-shade RC or with one of the other three different single-shade RCs. The polymerization and finishing polishing processes of the restorations were completed using the same procedure and the same equipment. The specimens were immersed in distilled water for 24 hours before measurement.

Instrumental Analysis

In this study, a D65 light source and a spectrophotometer (VITA Easyshade V, VITA Zahnfabrik) were used to perform accurate instrumental evaluation of the samples. Procedures were carefully performed to minimize any errors in measurements. Measurements were performed at baseline (after the preparation of base samples) and after restoration. First, each sample was placed individually on a neutral gray paper. During measurements, care was taken to ensure that the tip of the spectrophotometer made perpendicular contact with the surface of the sample. Each sample was measured 3 times with the same device, and calibration was performed between measurements. The mean values obtained from the measurements were recorded, and the color difference was calculated by applying the obtained values to the specified formula:

$$\Delta E_{00} = \sqrt{\left(\frac{\Delta L}{K_L S_L}\right)^2 + \left(\frac{\Delta C}{K_C S_C}\right)^2 + \left(\frac{\Delta H}{K_H S_H}\right)^2 + R_T \left(\frac{\Delta C}{K_C S_C}\right)\left(\frac{\Delta H}{K_H S_H}\right)}$$

In this research, the CIEDE2000 formula's parametric factors were set to 1. ΔE_{00}>0.8 was the threshold for perceptibility (PT), while ΔE_{00} < 1.8 was the threshold for acceptability (AT).[19]

Visual Analysis

In this study, 3 expert dentists (2 women and 1 man) performed the visual evaluation of the specimens. Prior to the visual evaluation, the observers were informed about the visual scoring procedure and the evaluation criteria. Each observer evaluated specimens that were randomly placed on a neutral gray paper and illuminated according to D65 criteria, viewing them at a 90° angle. During the evaluation process, care was taken to ensure blinding of the observers. Observers were given intermittent rest breaks to minimize eye strain and were instructed to look at a blue sheet of paper. Observers were asked to rate each specimen using a visual scoring scale between 0 and 4. The score explanations were as follows: 0: excellent match; 1: very good match; 2: not so good match (border zone mismatch); 3: obvious mismatch; 4: huge (pronounced) mismatch. After the evaluations, the scores given by all observers were recorded, and a mean visual score was calculated for each specimen.[17]

Statistical Analysis

Data were analyzed using IBM SPSS Statistics, version 23 (SPSS Inc.; Chicago, IL, USA). The normality of the data distribution was examined using the Shapiro–Wilk test. The Kruskal–Wallis *H*-test was used to compare the results obtained from the instrumental and visual analyses, and post hoc pairwise comparisons were performed using the Dunn test. The correlation between the 2 evaluation methods was assessed using Spearman's rho analysis. Statistical significance was set at $P < .05$.

RESULTS

Mean ΔE_{00} values for the instrumental analysis of color matching are presented in Table 2. The Kruskal–Wallis test revealed that color matching in single-shade RCs was significantly affected by the type of RC used ($P < .001$). According

Table 2. Median (Minimum-Maximum) Values of Color Differences (ΔE_{00}) Among Single-Shade Resin Composites Tested in the Study

	Repair Resin Composite				
Base Resin Composite	**OM**	**EU**	**ZC**	**CDO**	*P*
OM	1.66 (1-3)^{abc}	7.93 (8-9)^{d}	5.58 (5-7)^{cd}	2.02 (1-3)^{abc}	<.001
EU	6.98 (6-8)^{d}	1.1 (0-2)^{a}	2.23 (1-3)^{abc}	5.65 (4-7)^{cd}	
ZC	5.1 (5-6)^{abcd}	3.63 (2-4)^{abcd}	1.61 (1-2)^{ab}	4.05 (3-6)^{abcd}	
CDO	1.34 (1-2)^{ab}	5.59 (5-6)^{cd}	4.34 (4-5)^{abcd}	1.9 (0-2)^{abc}	

Kruskal Wallis *H*-test. ^{a,b,c,d}: Different letters within the same row indicate statistically significant differences ($P < .05$).
CDO, Charisma Diamond One; EU, Essentia Universal; OM, Omnichroma; ZC, ZenChroma.

to the instrumental analysis, the ΔE_{00} values of all repair groups, except the control groups, were above the clinically AT. The highest mean ΔE_{00} value was observed in the Omnichroma-Essentia Universal (OM-EU) group, and this value was statistically similar to all other OM groups except the OM-Charisma Diamond One (CDO) and CDO-OM groups ($P > .05$). The EU-CDO and CDO-EU groups showed higher ΔE_{00} values than the control groups ($P < .05$). The lowest ΔE_{00} values were obtained in the control groups. Overall, OM showed the worst color matching among the single-shade RCs, whereas CDO exhibited the best.

Mean scores for the visual analysis are presented in Table 3. Statistical analysis revealed a significant difference between the groups ($P < .001$). The highest mean visual scores (2.67) were observed in the EU-OM and Zenchroma (ZC)-OM groups, and these 2 groups were statistically similar ($P > .05$). The lowest visual scores were observed in the control groups. According to the observers' evaluations, among the single-shade RCs, the worst color matching was observed in the EU, which most frequently received a score of "3: obvious mismatch." Charisma Diamond One demonstrated the best color matching, most frequently receiving a score of "1: very good match." Visual analysis results were generally consistent with the instrumental analysis results. No samples received a score of "4: severe mismatch."

Spearman's rho analysis revealed a moderate positive correlation between instrumental and visual analysis ($r = .490$).

DISCUSSION

Restoration repair is a treatment method that aims to recreate the original restoration structure by adding the same or a different restorative material to a damaged restoration that is clinically acceptable. In clinical practice, the repair of composite restorations requires achieving aesthetically pleasing results in addition to maintaining function. To provide a solution that meets increasing aesthetic standards, it is crucial that the RC used matches the color of the existing restoration. This study aimed to compare the color matching of 4 different single-shade RCs using instrumental and visual evaluation methods. The results of the present study showed significant differences in color matching among the single-shade RCs for both methods; therefore, the null hypothesis was rejected.

Both instrumental and visual evaluation techniques can be used in the color analysis research for determining the color matching abilities of RCs. Devices used for color measurement provide data by defining color coordinates. Spectrophotometers, frequently preferred in instrumental analyses conducted in clinical and in vitro studies, are considered useful devices for both dentists and researchers due to their ease of use and reproducibility.[14] Therefore, the CIEDE2000 formula was used in the instrumental analysis of this study. This formula is recommended by the Commission Internationale de l'Eclairage for use in color analysis studies. It is considered more advanced than Commission Internationale de l'Éclairage Laboratory (CIELAB) and is more accurate and more compatible with human visual perception.[11] Although visual evaluation methods have some disadvantages, such as subjectivity, they are one of the most common techniques used in research for both color identification and evaluation processes. However, using spectrophotometers in conjunction with one of the visual evaluation techniques can increase the accuracy of the results obtained from the studies. For this reason, in this research, the color matching of single-shade RCs was evaluated using both instrumental and visual evaluation techniques.

Table 3. Median (Minimum-Maximum) and Mean Rank Values of Visual Scores of Color Difference Among Single-shade Resin Composites Tested in the Study

Base Resin Composite	**OM**	**EU**	**ZC**	**CDO**	*P*
OM	1 (0.33-2)/ 28.71^{ab}	2 (1.67-2.67)/ 68.93^{abcd}	1.67 (1-2)/ 46.50^{abcd}	1.67 (0.33-2.67)/ 45.36^{abcd}	<.001
EU	2.67 (2.33-3.33)/ 101.71^{d}	1 (0.67-2)/ 36.29^{ab}	1.67 (0.67-2)/ 50.43^{abcd}	2.33 (1.67-3)/ 82.36^{bcd}	
ZC	2.67 (2-3)/ 99.36^{cd}	1.33 (1-2.33)/ 48.71^{abcd}	2 (1.33-2.67)/ 65.50^{abcd}	2.33 (1.33-2.67)/ 75^{abcd}	
CDO	1 (0.67-1.67)/ 29.50^{ab}	2 (1.33-2.67)/ 68.14^{abcd}	1 (0.33-2)/ 41.14^{abc}	1 (0-1.33)/ 16.36^{a}	

Kruskal Wallis *H*-test. ^{a,b,c,d}: Different letters within the same row indicate statistically significant differences ($P < .05$)
CDO, Charisma Diamond One; EU, Essentia Universal; OM, Omnichroma; ZC, ZenChroma.

In dentistry, the terms PT and AT are used in studies investigating the optical behavior of restorative materials. The term AT quantitatively expresses the maximum clinically acceptable state for an aesthetic restoration, while the term PT refers to the smallest color discrepancy that the human eye can detect on the material.[12] Current literature indicates that there is considerable variation in the proposed PT and AT values of color differences in dental materials.[20] Many researchers have reported that the PT and the AT, as suggested by Paravina et al,[12] are widely used as reference values for evaluating color matching.[10,13] Findings from the instrumental analysis in this study showed that the ΔE_{00} values of the repaired single-shade RC groups exceeded the AT, except for the control groups. Previous studies examining the color compatibility of single-shade RCs with surrounding structures show that AT values are frequently exceeded.[13,21] However, a review of the literature reveals that the number of studies examining color matching in the repair of restorations made with single-shade RCs is still limited. In previous research by Buldur et al,[21] ΔE_{00} values above the AT were reported in the repair groups, except for the control groups, after repairing 3 different single-shade RCs with the same or different single-shade RCs. The findings of the present study are consistent with these results.

In recent years, various manufacturers have developed numerous single-shade RCs, and performance inconsistencies have been reported, particularly with regard to their optical properties.[17,22] In the present study, OM showed the worst color matching among the single-shade RCs tested. Studies have shown that the color matching depends on the material content, shade,[5,18] and degree of change in material translucency.[8,23] Omnichroma is the first original single-shade RC to be introduced to the market and contains no dyes or pigments.[24] According to the manufacturer, OM's color matching mechanism is based on the integration of homogeneous inorganic particles with a diameter of 260 nm into the matrix structure. It is stated that the distribution of spherical inorganic particles in OM's matrix structure ensures the distribution of light within the restoration, thus providing better color matching with the surrounding structures. Furthermore, it is noted that these special inorganic particles enable the RC to generate colors ranging from red to yellow as it absorbs light.[25] In the literature, the color matching ability of OM has been investigated in vitro using human teeth[13,22] or samples made from multi-shade RCs.[17,18] Two color matching studies using human teeth reported that OM demonstrated satisfactory color matching ($\Delta E_{00} \leq 1.8$) across various shades.[26,27] In a previous study comparing single-shade and multi-shade RCs, it was stated that OM showed superior color matching among the tested RCs.[22] In contrast, another study evaluating different RCs reported that OM did not yield instrumentally acceptable results ($\Delta E_{00} > 1.8$).[28] The worse color matching of OM demonstrated in this study is consistent with many studies in the literature.[10,17,18] Omnichroma has been evaluated in many studies in the literature; however, there are still insufficient studies evaluating the color adaptation of other single-shade RCs that can be directly compared with the present study. These discrepancies may be attributed to differences in material formulation, experimental design, or evaluation methods.

Translucency is a critical factor in achieving optimum color matching results because, depending on the degree of translucency of the restorative material, any color around the restoration or at the cavity floor may alter the perceived color.[29] Clinically, deeper cavities or strongly chromatic adjacent tooth structures may influence the color matching ability of single-shade RCs, as color perception is known to be affected by surrounding optical conditions and background characteristics.[19] In the present study, specimen thickness and cavity depth were standardized, and both instrumental and visual evaluations were performed on a neutral gray paper to minimize the influence of surrounding variables. The composition of a material (particle ratio, size, and resin matrix structure) affects its light interaction and color matching ability with the tissue to which it is applied.[30] Both teeth and RCs are translucent, and color matching improves as translucency increases.[23] One of the important components of a restorative material that affects translucency is the filler content. Earlier research has shown that an increased filler concentration in RCs is associated with higher translucency, thereby improving their color matching.[31,32] In this study, the percentage of inorganic filler particles in the single-shade RCs tested ranged from 75% to 81% by weight. However, it has been suggested that the matrix formulation of RCs has a significant effect on translucency, and that RCs containing Bisphenol A diglycidyl dimethacrylate (Bis-GMA) monomer among the matrix monomers have higher translucency.[18] The fact that OM tested in this study is an RC without Bis-GMA may have reduced its translucency and, consequently, its color matching.

One of the innovations in recent years to improve the aesthetic performance of RCs is the modification of composite formulations through adaptive light-matching technology. This technology aims to achieve a natural appearance by ensuring better optical integration of the RC with the surrounding tooth tissues. The application of advanced adaptive light-matching technology improves the optical properties of RCs by increasing translucency and bond strength, while simultaneously enhancing their aesthetic performance.[33] In this research, CDO demonstrated the best color matching among all tested single-shade RCs. Charisma Diamond One, which is produced using adaptive light-matching technology,[34] contains urethane dimethacrylate monomer in its matrix composition. Studies have shown that adding longer carbon chains to the structure of urethane dimethacrylate monomer reduces the refractive index, which in turn leads to increased translucency after polymerization. The modified formulation of CDO and its increased translucency after polymerization may explain its superior color matching

compared with other RCs. Numerous studies in the literature support the findings of this study. [31,35]

In this research, visual evaluation was carried out by 3 evaluators with high aesthetic analysis skills and expert competence in the field. The expert evaluators who performed the analysis were subjected to the Ishihara test before the visual evaluation to verify their color discrimination ability. Visual analysis is frequently used in the current literature, particularly in studies involving color detection, evaluation, and comparison. The Fédération Dentaire Internationale(FDI) World Dental Federation criteria emphasize that visual analysis methods should be preferred when performing color analysis studies on restorations.[25] Visual scoring is one of the parameters that has been shown to be clinically effective for evaluating optical properties in dentistry and is recommended for use in conjunction with instrumental evaluation methods. Many studies in the literature where instrumental and visual evaluations are used and evaluated together have stated that there is a positive correlation between the 2 evaluation methods.[25] In this research, the scores obtained for the tested single-shade RCs support the presence of a significant relationship with instrumental evaluation. Among the RCs tested, all repair groups except the EU-OM group showed color matching values within the clinically acceptable range. In visual analysis, the worst color matching was observed in EU, while CDO yielded the best color matching. The results of the visual evaluations conducted by the observers revealed that most of the groups did not show a significant difference in the mean visual scores given after repair with the single-shade RCs tested in the study. This result shows that the differences detected through instrumental analyses are not easily noticeable visually by observers in a clinical setting, or aesthetically by patients. The human eye and visual system involve many subjective factors and therefore have a high degree of complexity. Unfortunately, there is no definitive scientific explanation for how color-related visual phenomena occur. This subjectivity and variation in evaluations can lead to inconsistencies in the results of studies.

The present in vitro study has several limitations. In this study, it was aimed to evaluate the color matching of single-shade RC restorations after repair in the presence of conditions requiring emergency repair due to various reasons. This is a short-term assessment, and no evaluation was performed regarding the changes that restorations undergo in the oral environment over time and the effect of these changes on their color matching. The fact that the study is an in vitro study prevented patient variables such as age, gender, and oral health from affecting the results. Furthermore, although attempts were made to standardize the visual evaluation methods in the study, subjective differences in visual evaluation are inevitably present, and it is impossible to conduct assessments under exactly the same conditions. The findings of this study contribute to the existing literature by providing insight into the optical properties of newly developed single-shade RCs during repair procedures, thereby partially filling the current data gap related to their color matching ability. Future studies are recommended to include long-term aging methods, such as thermocycling, as well as clinical studies, and comparative evaluations with conventional multi-shade RCs to further investigate the color stability and color matching ability of single-shade RCs.

CONCLUSION

Within the limitations of this study, the following can be concluded:

1. The color matching ability of single-shade RCs in immediate repair varies depending on material formulation and optical properties.
2. In instrumental evaluation, OM showed the worst color matching; in contrast, CDO exhibited better color matching compatibility with all single-shade RCs except EU.
3. In visual evaluation, EU was scored as the least compatible RC, while CDO showed better visual compatibility than the other single-shade RCs.
4. Color differences identified through instrumental analysis may not always be distinguishable visually in the clinic.

Clinically, material selection can be crucial in determining aesthetic outcomes when using single-shade RCs in repair procedures. In appropriate cases, opting for composites with higher translucency and improved optical design after polymerization may provide more predictable aesthetic results.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Artificial Intelligence Usage Statement: The authors declared that no Artificial Intelligence Tool was used in the preparation of the manuscript.

Ethics Committee Approval: Ethical approval and informed consent were not required for this study, as no human participants, human data, or animal subjects were involved.

Informed Consent: Ethical approval and informed consent were not required for this study, as no human participants, human data, or animal subjects were involved.

Peer-review: Externally peer-reviewed.

Declaration of Interests: The author has no conflict of interest to declare.

Funding: The author declared that this study has received no financial support.

REFERENCES

1. Fahl Jr N, Ritter AV. Composite veneers: the direct–indirect technique revisited. *J Esthet Restor Dent*. 2021;33(1):7-19. [CrossRef]

2. Rocca GT, Bonnafous F, Rizcalla N, et al. A technique to improve the esthetic aspects of CAD/CAM composite resin restorations. *J Prosthet Dent*. 2010;104(4):273-275.
3. Choi MS, Lee YK, Lim BS, et al. Changes in color and translucency of porcelain-repairing resin composites after thermocycling. *J Biomed Mater Res B Appl Biomater*. 2006;78(1):1-6. [CrossRef]
4. Boksman L. Shade selection: accuracy and reproducibility. *Ont Dent*. 2007;84(4):24.
5. Paravina RD, Westland S, Johnston WM, et al. Color adjustment potential of resin composites. *J Dent Res*. 2008;87(5):499-503. [CrossRef]
6. Mohamed Mostafa Elhatery A, Hafez M. Instrumental and visual comparison of color matching of two universal shade resin composites in different thicknesses versus A2 Vita Classical Shade. *Egypt Dent J*. 2024;70(2):1857-1866. [CrossRef]
7. Furusawa K, Kobayashi S, Yamashita A, et al. Effect of filler load on structural coloration and color adjustment potential of resin composites. *Dent Mater J*. 2023;42(3):343-350. [CrossRef]
8. Paravina RD, Westland S, Imai FH, et al. Evaluation of blending effect of composites related to restoration size. *Dent Mater*. 2006;22(4):299-307. [CrossRef]
9. Ahmed MA, Jouhar R, Khurshid Z. Smart monochromatic composite: a literature review. *Int J Dent*. 2022;2022(1):2445394. [CrossRef]
10. Cubukcu I, Gundogdu I, Gul P. Color match analysis of single-shade and multi-shade composite resins using spectrophotometric and visual methods after bleaching. *Dent Mater J*. 2023;42(6):826-834. [CrossRef]
11. Chen F, Toida Y, Islam R, et al. Evaluation of shade matching of a novel supra-nano filled esthetic resin composite employing structural color using simplified simulated clinical cavities. *J Esthet Restor Dent*. 2021;33(6):874-883. [CrossRef]
12. Paravina RD, Pérez MM, Ghinea R. Acceptability and perceptibility thresholds in dentistry: a comprehensive review of clinical and research applications. *J Esthet Restor Dent*. 2019;31(2):103-112. [CrossRef]
13. Ercin O, Kopuz D. The visual and instrumental analyses of different single-shade resin composites. *Odovtos Int J Dent Sci*. 2024;26(1):54-64.
14. Bai X-D, Yan Y-Z, Li Q. Spectrophotometric evaluation of color errors generated in the visual color duplication procedure for current ceramic veneers. *J Dent Sci*. 2021;16(1):145-153. [CrossRef]
15. Lehmann KM, Devigus A, Igiel C, et al. Repeatability of color-measuring devices. *Eur J Esthet Dent*. 2011;6(4):428-435.
16. Trifkovic B, Powers JM, Paravina RD. Color adjustment potential of resin composites. *Clin Oral Investig*. 2018;22(3):1601-1607. [CrossRef]
17. de Abreu JLB, Sampaio CS, Benalcázar Jalkh EB, et al. Analysis of the color matching of universal resin composites in anterior restorations. *J Esthet Restor Dent*. 2021;33(2):269-276. [CrossRef]
18. Iyer RS, Babani VR, Yaman P, et al. Color match using instrumental and visual methods for single, group, and multi-shade composite resins. *J Esthet Restor Dent*. 2021;33(2):394-400. [CrossRef]
19. Paravina RD, Ghinea R, Herrera LJ, et al. Color difference thresholds in dentistry. *J Esthet Restor Dent*. 2015;27(suppl 1):S1-S9. [CrossRef]
20. Korkut B, Dokumacigil G, Murat N, et al. Effect of polymerization on the color of resin composites. *Oper Dent*. 2022;47(5):514-526. [CrossRef]
21. Buldur M, Ayan G. Is it possible for single-shade composites to mimic the color, lightness, chroma, and hue of other single-shade composites? an in vitro study. *Oper Dent*. 2024;49(6):691-703. [CrossRef]
22. Kobayashi S, Nakajima M, Furusawa K, et al. Color adjustment potential of single-shade resin composite to various-shade human teeth: effect of structural color phenomenon. *Dent Mater J*. 2021;40(4):1033-1040. [CrossRef]
23. Vattanaseangsiri T, Khawpongampai A, Sittiphol-vanichkul P, et al. Influence of restorative material translucency on the chameleon effect. *Sci Rep*. 2022;12(1):8871. [CrossRef]
24. Sharma N, Samant PS. Omnichroma: the see-it-to-believe-it technology. *EAS J Dent Oral Med.* 2021;3(3):100-104.
25. Pereira Sanchez N, Powers JM, Paravina RD. Instrumental and visual evaluation of the color adjustment potential of resin composites. *J Esthet Restor Dent*. 2019;31(5):465-470. [CrossRef]
26. Saegusa M, Kurokawa H, Takahashi N, et al. Evaluation of color-matching ability of a structural colored resin composite. *Oper Dent*. 2021;46(3):306-315. [CrossRef]
27. Arai Y, Kurokawa H, Takamizawa T, et al. Evaluation of structural coloration of experimental flowable resin composites. *J Esthet Restor Dent*. 2021;33(2):284-293. [CrossRef]
28. Atasayar E, Ulusoy N. The effect of blocker application on color matching of different colored composite resin systems. *Materials (Basel)*. 2023;16(14):4954. [CrossRef]
29. Lee Y-K. Translucency of human teeth and dental restorative materials and its clinical relevance. *J Biomed Opt*. 2015;20(4):045002. [CrossRef]
30. Arikawa H, Kanie T, Fujii K, et al. Effect of filler properties in composite resins on light transmittance characteristics and color. *Dent Mater J*. 2007;26(1):38-44. [CrossRef]
31. Altınışık H, Özyurt E. Instrumental and visual evaluation of the color adjustment potential of different single-shade resin composites to human teeth of various shades. *Clin Oral Investig*. 2023;27(2):889-896. [CrossRef]
32. Suh Y-R, Ahn J-S, Ju S-W, et al. Influences of filler content and size on the color adjustment potential of nonlayered resin composites. *Dent Mater J*. 2017;36(1):35-40. [CrossRef]
33. Geha O, Inagaki LT, Favaro JC, et al. Effect of chemical challenges on the properties of composite resins. *Int J Dent*. 2021;2021(1):4895846. [CrossRef]
34. Kulzer GmbH. *Charisma Diamond/Topaz One Shade Technical Report*. https://www.kulzer.com/int2/en/products/charisma-diamond-topaz-one.html.
35. Santana MLC, Livi GJS de, Faria-E-Silva AL. Color discrepancy of single-shade composites at different distances from the interface measured using cell phone images. *Restor Dent Endod*. 2024;49(1):7. [CrossRef]