Cumhuriyet Dental Journal, 29(3): 442-447, 2026
DOI: https://doi.org/10.7126/cumudj.1880961

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 Available online, ISSN: 1302-5805 Publisher: Sivas Cumhuriyet Üniversitesi

Effect of Bleaching After Staining with Coffee on Color Stability of Single-Shade Universal Composite Resins

***Beyza Arslandaş Dinçtürk*[1,a,*], *Ceren Başerdem*[1,b], *Cemile Kedici Alp*[1,c]**

[1]*Department of Restorative Dentistry, Faculty of Dentistry, Gazi University, Ankara, Türkiye.*
**Corresponding author*

Research Article

History

Received: 04/02/2026
Accepted: 12/04/2026

ABSTRACT

Objectives: The aim of this study was to evaluate the effect of office-type bleaching agent on the color stability of single-shade universal composite resin samples after storage in coffee solution.
Materials and Methods: In this study, five single-shade universal composites, Omnichroma (Tokuyoma Dental, Japan), Vittra APS Unique (FGM Dental Group, Brazil), Zenchroma (President Dental, Germany), Charisma Diamond One (Kulzer, Germany), and Essentia Universal (GC, Japan) were used. A total of 50 samples were prepared (n=10) by creating cylindrical cavities with a diameter of 6 mm and a thickness of 2 mm on acrylic teeth. For staining procedure, samples were immersed in a coffee solution (Nescafe Classic, Nestle, Türkiye) for 14 days. Opalescence® Boost Office Teeth Bleaching (40% HP) was used for the bleaching treatment of the stained composite samples. ΔE_{00} color values were measured with spectrophotometer (VITA EasyshadeAdvance, Vita) in 3-time intervals (initial, after staining, and after bleaching). Data were evaluated with One-way Anova test.
Results: As a result of the measurements, the ΔE_{00} values of all five composite resin groups between the initial and after staining were found to be greater than 1.8. Color difference between the after bleaching and after staining values was highest in the Zenchroma (President Dental, Germany) group, while it was lowest in the Essentia Universal (GC, Japan) group. The ΔE_{00} change between the initial and after bleaching values was observed to be less than 1.8 for all five composite resin groups. The value difference between the initial/after-staining for Essentia Universal (GC, Japan) composite was found to be significantly higher compared to Charisma Diamond One (Kulzer, Hanau, Germany) and Zenchroma (President Dental, Germany) composites ($p = 0.001$).
Conclusion: Office-type bleaching procedures are effective methods for significantly reducing the discoloration caused by solutions such as coffee, leading to lightening of the color in stained single-shade universal composite resins.

Keywords: Bleaching agents, color, composite resins

Tek Renk Universal Kompozit Rezinlerde Kahve ile Renklendirme Sonrası Ağartmanın Renk Stabilitesine Etkisi

Araştırma Makalesi

Süreç

Geliş: 04/02/2026
Kabul: 12/04/2026

ÖZ

Amaç: Bu çalışmanın amacı kahve içerisinde bekletilen tek renk universal kompozit rezin örneklere ofis tipi bir ağartma ajanı uygulanmasının renk stabilitesine etkisinin değerlendirilmesidir.
Gereç ve Yöntemler: Bu çalışmada Omnichroma (Tokuyoma Dental, Japan), Vittra APS Unıque (FGM Dental Group, Brazil), Zenchroma (President Dental, Germany), Charisma Diamond One (Kulzer, Germany) ve Essentia Universal (GC, Japan) olmak üzere 5 adet farklı tek renk üniversal kompozit kullanıldı. Akrilik dişler üzerinde 6 mm çapında ve 2 mm derinliğinde silindirik kaviteler açıldı. Toplamda 50 adet örnek hazırlandı(n = 10). Restoratif materyaller kahve (Nescafe Classic, Nestle) solüsyonu içinde, 14 gün süre ile renklendirildi. Renklenen kompozit materyalleri ağartmak için Opalescence® Boost Ofis Tipi Beyazlatma (%40 HP) kullanıldı. Renklendirme öncesi, renklendirme sonrası ve ağartma sonrası renk değerleri spektrofotometre (VITA EasyshadeAdvance, Vita)yardımıyla ölçüldü. Veriler, Tek Yönlü Anova testi ile değerlendirildi.
Bulgular: Ölçümler sonucu 5 kompozit rezin grubunun da başlangıç ve renklendirme sonrası ΔE00 değerleri 1.8'den büyük olarak ölçüldü. Ağartma sonrası ve renklendirme sonrası değerleri arasındaki renk farkı en fazla Zenchroma (President Dental, Germany) grubunda iken en az Essentia Universal (GC, Japan) grubunda saptandı. Başlangıç ve beyazlatma sonrası değerlerinin ΔE00 değişimi 5 kompozit rezin grubunda da 1.8'den küçük olarak gözlendi. Essentia Universal renklendirme öncesi ve sonrası renk farklılığı, Charisma Diamond One (Kulzer, Hanau, Almanya) ve Zenchroma kompozitlerine kıyasla istatistiksel olarak anlamlı derecede daha yüksek olduğu saptanmıştır ($p = 0,001$).
Sonuçlar: Kahve gibi renklenmeyi oluşturan solüsyonlar için ofis tipi ağartma işlemi etkili bir yöntem olup renklenmiş tek renk üniversal kompozit rezinlerde rengin başlangıç değerine yaklaşmasını sağlamıştır.

Anahtar Kelimeler: Kompozit rezinler, beyazlatma ajanları, renk

Copyright

This work is licensed under Creative Commons Attribution 4.0 International License

[a] *beyzaarslandas@gazi.edu.tr* *0000-0002-3581-4210*
[b] *cerenbaserdem@gazi.edu.tr* *0009-0001-8922-1584*
[c] *cemilealp@gazi.edu.tr* *0000-0002-1847-1367*

How to Cite: Arslandaş Dinçtürk B, Başerdem C, Kedici Alp C. (2026) *Effect of Bleaching After Staining with Coffee on Color Stability of Single-Shade Universal Composite Resins.* Cumhuriyet Dental Journal, 29(3): 442-447.

Introduction

Resin composites are frequently favored in dentistry because of aesthetic and high mechanical qualities, affordable costs, and conservative attitude.[1,2] The layering technique, which applies composites with varying chroma and opacity to each layer to mimic the optical characteristics of natural teeth, has been suggested for composite resin restorations since the 1980s.[3,4] Although successful color matching can be achieved with layering techniques, it is

much more complex and requires considerable clinical time and technical precision.[5] The extended time spent by the patient in the clinic, the dependence of color selection on environmental conditions and the operator, and the need for technical precision make it difficult to obtain resin composites in every shade. To address these issues, single-shade universal composites have been launched in restorative dentistry. According to manufacturers, these resins have a chameleon effect and could match any Vita Classical shade.[6] These single-shade universal composite resins eliminate the procedural complexity associated with layering techniques, reducing technical precision and increasing the efficiency of composite application.

Patient satisfaction and acceptability of dental cosmetic restorations are significantly influenced by the resin composite material's optical and structural compatibility with tooth structure. The material's capacity to produce a color that is comparable to the surrounding structure is known as the blending effect (BE), and it is accomplished through the chameleon effect.[3,4] The interaction between these two elements is referred to as enhanced color adjustment potential. Manufacturers claim that the higher color adjustment capacity (CAP) of these composites is the main advantage. The relationship between the physical and optical components of blending is defined and quantified by the color adjustment potential.[7] In addition to achieving correct color matching, stability of the composite's color is also of great importance for patient satisfaction. Factors related to the material, such as monomer content, filler ratio, and particle size, as well as clinician-dependent factors such as surface smoothness, proper finishing and polishing, and patient-dependent factors like frequent consumption of colored beverages and proper oral hygiene habits, all contribute to color stability. Researchers have reported that frequently consumed colored beverages like coffee, juice, and tea cause changes in the color of restorative materials.[8,9]

Renewing a composite resin restoration with compromised color stability is time-consuming and costly for the patient. Re-polishing or bleaching treatments can be considered less costly alternative treatments. Bleaching is a safe and efficient way to get rid of stains. There are various benefits to having a dentist conduct in-office bleaching over at home bleaching techniques, including precise control of the bleaching interval, reduced duration of treatment, and faster visible whitening results. Researchers have reported that bleaching treatments affect color change of stained resin composites.[10] Numerous studies have evaluated single-shade universal composite resins' color durability after staining, but there is limited research investigating impacts of bleaching on universal composite resins after staining.[11,12] Thus, aim of this research was to utilized impact of an in-office bleaching agent on color stability of single-shade universal composite samples that have been immersed in coffee solutions. First null hypothesis of this study was that coffee has no impact on staining of single-shade universal composite resins. Second null hypothesis of this study was in-office bleaching has no effect on color stability of single-shade universal composite resins.

Materials and Methods

Study Design

Names and compositions of materials utilized in study are presented in 'Table 1.' For this research, five different single-shade universal composites; Essentia Universal (GC, Japan), Omnichroma (Tokuyoma Dental, Japan), Vittra APS Unique (FGM Dental Group, Brazil), Charisma Diamond One (Kulzer, Hanau, Germany) and Zenchroma (President Dental, Germany) were used. Power analysis was performed using G*Power software (Heinrich-Heine-University Düsseldorf, Germany) to determine the sample size. Assuming an effect size of f = 0.25, an alpha level of 0.05, a power of 0.85, the minimum required total sample size was calculated as 50. A total of 50 samples (n=10), cylindrical cavities (6 mm of diameter, depth of 2 mm) were prepared on middle third of acrylic anterior teeth's buccal surface (Elite, A2, Ankara, Türkiye). Single-shade universal composites were placed to cavity in single layer and polymerized for 20 seconds applying LED light-curing device (VALO LED Ultradent Products, South Jordan, UT, USA) based on the guidelines provided by the manufacturer through a transparent strip. Super-snap polishing disks (Shofu, Japan) were then used to polish composite surfaces using fine and super fine grades for a total of 30 seconds. A single operator prepared the samples. To enable post-curing, composites were stored at 37°C in distilled water for 24 h and 100% humidity.[13]

Table 1. Study materials and their compositions

Materials	Content
Essentia Universal (GC Corporation, Tokyo, Japan)	Matrix: UDMA, Bis-EMA, Bis-GMA, TEGDMA Fillers: 65% by volume pre-polymerized fillers, barium glass, silica.
Omnichroma (Tokuyama Dental, Tokyo, Japan)	Matrix: UDMA, TEGDMA. Fillers: By weight: 79% single-type supra-nano spherical filler (SiO2-ZrO2, 260 nm), round-shaped composite filler (contains 260 nm spherical SiO2-ZrO2).
Vittra APS Unique (FGM, Joinville, SC, Brasil)	Matrix: Methacrylate monomer mixture:** UDMA, TEGDMA, photoinitiator composition (APS). Fillers: 72-80% by weight, 52-60% by volume boron-aluminum-silicate glass.
Zenchroma (Presidental, Germany)	Matrix: Bis-GMA, Tetrametilen dimetakrilat, Diüretan dimetakrilat. Fillers: By weight:** 75% .By volume: 53% filler, consisting of silicon dioxide and glass powder.
Charisma Diamond One (Kulzer, Hanau, Germany)	Matrix: Enhanced TCD matrix, BPA-free. Fillers: 75% by weight filler.
Opalescence Boost (OPB-Ultradent, 40% HP)	40% hydrogen peroxide, potassium nitrate, fluoride.

Evaluation of Color Stability Following the previously stated production of composite samples, the colors of the samples were measured utilizing a spectrophotometer (Vita Easyshade V, Vita Zahnfabrik, Bad Sackingen, Germany) and recorded as CIE L* a* b* values. After five measurements, tool was adjusted. Standard lighting conditions and a white background were used for the measurements. Initial color measurements, color measurements after 14 days of staining, and color measurements after bleaching were recorded separately. The CIEDE 2000 color difference (ΔE_{00}) was calculated using the Excel spreadsheet application, following the method suggested by Sharma and colleagues.[14]

$$\Delta E00 = \sqrt{\left(\frac{\Delta L^*}{K_L S_L}\right)^2 + \left(\frac{\Delta C^*}{K_c S_c}\right)^2 + \left(\frac{\Delta H^*}{K_H S_H}\right)^2 + R_T \left(\frac{\Delta C^*}{K_C S_C}\right)^2 \left(\frac{\Delta H^*}{K_H S_H}\right)^2}$$

After being kept in distilled water for 24 h, composite resin sample surfaces' initial color measurement was examined. $\Delta E_{00} \geq 1.8$ was shown to be the clinically acceptable limit of color change.[15]

Staining Procedure

Samples were submerged in a coffee solution for 14 days after the initial color measurements were taken. The solution was made fresh every day. Coffee solution was made by mixing 20 grams of Nescafe Classic (Nestle, Istanbul, Turkey) coffee with 1000 ml of boiled distilled water.[16] After the staining process, the color measurements were repeated. After use, the coffee solutions bottle's lid was rapidly covered to stop unwanted evaporation. Following a 14-day storage period, all groups completed the previously indicated measurements.

Bleaching Procedure

Following the staining processes, teeth were cleaned using water, dried, treated using bleaching agents. 40% Opalescence Boost (OPB-Ultradent, 40% HP) in-office bleaching agent was applied based on guidelines provided by the manufacturer to bleach samples. Bleaching agent was left on surface (20 min), then rinsed and dried. This process was repeated twice, for a total of 40 minutes, and color measurements were taken after bleaching and recorded. The clinically acceptable threshold value was set at ΔE_{00}: 1.8.[15] The ΔE_{00} values of the study and their explanations are as follows;

ΔE_{001}: Initial – after-staining
ΔE_{002}: Initial – after-bleaching
ΔE_{003}: After-staining – after-bleaching

Statistical Analysis

Software (IBM SPSS Statistics 22) was utilized for statistical analysis in order to assess the study's results. The parameters were determined to be normally distributed after the Kolmogorov-Smirnov and Shapiro-Wilks tests were utilized to determine their normality. When analyzing study data, the Tukey HDS test was used to determine which group was responsible for the difference, and the One-way Anova test was utilized for intergroup comparisons of parameters. Qualitative data were compared using the Fisher Freeman Halton Exact Chi-square test. In $p < 0.05$ levels, significance was evaluated.

Results

There is a statistically significant difference among initial/after-staining levels in composites. The value difference between the initial/after-staining for Essentia Universal (GC, Japan) composite was found to be significantly higher compared to Charisma Diamond One (Kulzer, Hanau, Germany) and Zenchroma (President Dental, Germany) composites ($p = 0.001$). No significant difference was observed among initial/after-staining values for the other materials. There is a significant difference between initial/after-bleaching values among the composites. According to post hoc Tukey HSD results, the difference between initial/after-bleaching values of Omnichroma was found to be significantly lower compared to Essentia, Vittra, Zenchroma, and Charisma composites ($p = 0.001$). No significant difference was observed in initial/after-bleaching value differences among other composites. There is no significant difference among the after-staining/after-bleaching value differences in composites (Table 2).

All materials had ΔE_{001} and ΔE_{003} changes of 1.8 and above. There was no difference among composites in terms of proportion of ΔE_{002} being 1.8 and above ($p > 0.05$). ΔE_{002} was 1.8 or above in 40% of the Essentia group, 10% of the Vittra group, 30% of the Zenchroma group, and 30% of the Charisma group, while the entire Omnichroma group was below 1.8 (Figure 1; Table 3).

Table 2. Evaluation of materials in terms of their ΔE_{00} levels. The clinically acceptable threshold value was set at ΔE_{00}: 1.8[15]

	ΔE001	ΔE002	ΔE003
	Mean ± SD	Mean ± SD	Mean ± SD
Essentia Universal	4.60 ± 0.59a	1.72 ± 0.39a	2.97 ± 0.72a
Omnichroma	3.88 ± 0.72ab	0.88 ± 0.31b	3.14 ± 0.74a
Vittra APS Unique	3.96 ± 0.49ab	1.37 ± 0.29a	3.18 ± 0.64a
Zenchroma	3.23 ± 0.70b	1.66 ± 0.28a	3.20 ± 0.62a
Charisma Diamond One	3.37 ± 0.70b	1.63 ± 0.42a	3.23 ± 0.64a
p	0.001*	0.001*	0.924

*Oneway ANOVA Test, *p < 0.05*
The different lowercase letters in the columns indicate the differences between the materials.

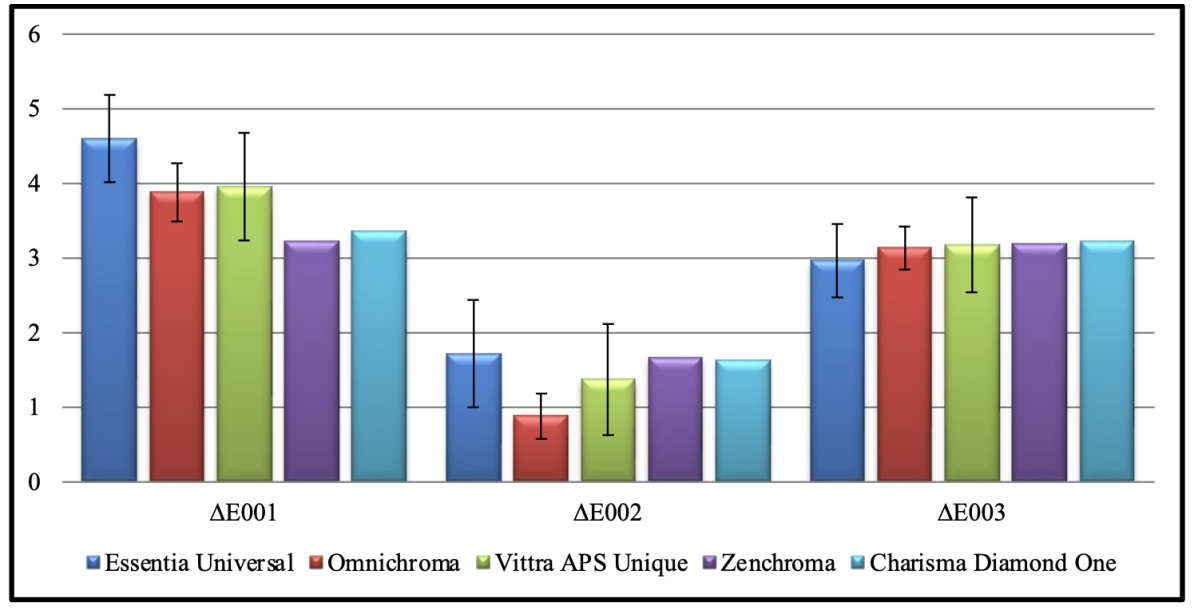


Figure 1. Color change values of single-shade universal composites used in the study.

Table 3. Evaluation of materials in terms of color changes

	Essentia (n = 10)	Omnichroma (n = 10)	Vittra (n = 10)	Zenchroma (n = 10)	Charisma (n = 10)	p
	n (%)	n (%)	n (%)	n (%)	n (%)	
ΔE001 ≥ 1.8	10 (100)	10 (100)	10 (100)	10 (100)	10 (100)	-
ΔE002 ≥ 1.8	4 (40)	0 (0)	1 (10)	3 (30)	3 (30)	0,193
ΔE003 ≥ 1.8	10 (100)	10 (100)	10 (100)	10 (100)	10 (100)	-

Fisher Freeman Halton Exact Test

Discussion

Clinical use of universal composite resins has increased in past few years. This research aimed to evaluate the effect of applying an in-office bleaching agent to single-shade universal composite resins on color stability. In this study, there was a significant difference between different single-shade composites used in terms of ΔE_{001} and ΔE_{002} levels, while there was no difference in terms of Δ_{E003} levels. Thus, it was observed that single-shade universal composites had an effect on color change compared to initial values after-staining with coffee solutions and compared to baseline values after in bleaching. Therefore, the first and second null hypotheses were rejected.

One important aspect of resin composites is their color stability and aesthetics in restorative dentistry. Color change is often cited in the literature as a major justification for upgrading resin composite restorations.[17] Various factors can affect color matching and stability when restoring with a composite resin, including the resin's composition and particle size, the scale of the restoration, matrix material, composites' layering, the color and brand of composite.[18,19] In maintaining color stability, factors related to the material, such as correct finishing and polishing, as well as patient-related factors such as frequent consumption of colored foods and proper oral hygiene, are important. Clinical retrospective evaluations have shown Dietary behaviors, such as drinking tea, coffee, or cola, can increase the frequency of resin and tooth color mismatches.[20] Topçu et al.[21] and Domingos et al.[22] found that coffee has a greater color change potential compared to tea and cola.

Studies have reported that the CIEDE 2000 formula provides better alignment with visual parameters compared to the CIELAB formula.[23] The values calculated according to the CIEDE 2000 formula were evaluated for threshold values of 50:50 PT and 50:50 AT, with the threshold values set at 0.8 and 1.8, respectively.[24] Minimal color change that an observer can see is referred to as the Just-Noticeable-Difference (JND) or Perceptibility-Threshold (PT). A phenomenon known as the 50:50 perceptibility-threshold (PT) occurs when 50% of individuals detect a color difference among two objects, but the other 50% do not. The 50% acceptability-threshold (AT) corresponds to 50:50 acceptability threshold, in other words, while 50% of individuals believe that color of the restoration needs adjustment, the remaining 50% find the color difference acceptable.[25] Therefore, visual parameters in this study were evaluated using the CIEDE 2000 formula. In this study, coffee, which is frequently consumed and has a high color change potential, was chosen, and all single-shade universal resin composite samples showed a visually perceptible and acceptable difference after 14 days of immersion in coffee. Also, all single-shade universal resin composite samples showed visually perceptible and acceptable difference between after-staining and after-bleaching values. Therefore, based on these results, noticeable variations were stated

compared to initial state after staining (ΔE_{001}), and noticeable variations were also stated compared to stained composite surfaces after bleaching (ΔE_{003}). The lightening of the stained composite surfaces with bleaching is visible. However, the difference between the initial and after-bleaching states (delta e002) is not a visible difference and showed values less than 1.8. The difference observed in the Omnichroma composite, in particular, is significantly smaller. This indicates that they are approaching the initial color values.

An important factor that affects color stability of resin composites is organic matrix content of the resin. The hydrophilic nature and water absorption capacity of the monomers in the organic matrix are considered to affect color stability. Resins containing BisGMA and TEGDMA show higher water absorption compared to those with UDMA or other organic matrix structures.[26] In this study, similar to previous studies, the measurement value changes of all materials after initial- after staining (ΔE_{001}) and after staining- after bleaching (ΔE_{003}) were ΔE_{00}; 1.8 or higher. That is, all materials showed visually noticeable color changes after staining. The significantly higher color change observed in Essentia Universal compared to Zenchroma and Charisma Diamond One may be due to Essentia Universal being a microhybrid composite, which is harder to polish and more prone to staining compared to nanohybrid composites. The statistically insignificant lower color change in Zenchroma and Charisma Diamond One compared to Omnichroma and Vittra APS Unique in coffee solution might be due to Omnichroma and Vittra APS Unique having more hydrophilic structures because of their TEGDMA-containing organic matrices.

Previous studies have evaluate color change of single-shade universal composite resins,[27,28] but only a few have also assess the effects of bleaching treatments.[29,30] A most frequent clinical procedures nowadays is in-office bleaching, which uses higher concentration of hydrogen peroxide than at-home bleaching treatments. In-office bleaching is more effective than at-home bleaching and provides patient satisfaction in a shorter time. Before and after professional bleaching, visual and instrumental color matching of two single-shade composites (Venus Diamond One and Omnichroma) were assessed in a study by Forabosco et al.[31] It was found that both materials achieved acceptable color change in VITA color values before and after bleaching and reached an excellent degree of visual match. Similarly, in this study, the average color change of five resin composite groups was within the acceptable range of color change after bleaching ($\Delta E00 < 1.8$). In the study conducted by Mohamed MA et al.[32] the color change after bleaching using the single-shade universal composite Omnichroma was investigated. Cavities were prepared on the cervical areas of 10 extracted intact teeth, which were then restored with Omnichroma. Throughout all time intervals, no significant difference was found in L*, a*, and b* values between the tooth and the restoration, and clinician scores showed excellent harmony between the tooth and the composite across all intervals. Hubbezoğlu et al.[33] stated that color change caused by bleaching agent may be related to monomer structure of composites and volume of the resin matrix. In our study, the difference between the initial and after-bleaching values was 1.8 or higher in 40% of the Essentia Universal group, 10% of the Vittra APS group, 30% of the Zenchroma group, and 30% of the Charisma group. However, in the Omnichroma group, this ratio was below 1.8 for all samples. Although not statistically significant, the fact that all samples in the Omnichroma group showed after bleaching values close to the initial values, unlike the other groups, could be due to the composite's supranano-fill content and the hydrophilicity provided by the TEGDMA in the organic matrix, allowing it to interact more with the bleaching agent.

A limitation of this study is the difficulty in replicating all clinical conditions such as saliva, biofilm, brushing, changes in oral pH, and temperature with a high degree of accuracy in laboratory research. Additionally, more accurate results could be obtained by using the resin in combination with natural teeth to assess amount of color change following bleaching and staining. Therefore, additional in vitro and clinical research is required to confirm the findings of this study, which evaluates the degree of color change brought on by coffee and other colored beverages as well as the impact of bleaching agents on single-shade universal composite resins.

Conclusions

In this study, the ΔE_{001} and ΔE_{003} values were greater than the clinically observable color change threshold of 1.8, indicating that the color changes between the initial-staining and staining-bleaching phases were clinically perceptible. However, the ΔE_{002} value was smaller than this threshold, and the color change between the initial and after-bleaching phases were not show a visually perceptible difference compared to before staining. For single-shade universal composites, the color difference between initial and after-bleaching was observed to be below the visually perceptible threshold. Although statistically insignificant, microhybrid composites were found to approach the initial color less after bleaching compared to nanohybrid composites. Office-type bleaching procedures were effective methods for significantly reducing the discoloration caused by solutions such as coffee, leading to lightening of the color in stained single-shade universal composite resins.

Acknowledgements

The authors declare that this study received no financial support. This study was presented at the 3rd International Dentistry Congress of Necmettin Erbakan University.

Conflicts of Interest Statement

The authors deny any conflicts of interest related to this study.

References

1. Ferracane JL. Resin composite--state of the art. Dent Mater 2011;27:29-38.

2. Değirmenci A, Balousha J, Pehlivan İE. The Effect of Light-Curing Devices and Modes on the Physical Properties of Three Universal Single-Shade Resin Composites. Cumhuriyet Dent J 2025;28:302-309.
3. Dietschi D, Fahl N, Jr. Shading concepts and layering techniques to master direct anterior composite restorations: an update. Br Dent J 2016;221:765-771.
4. Fahl N Jr, Denehy GE, Jackson RD. Protocol for predictable restoration of anterior teeth with composite resins. Pract Periodontics Aesthet Dent 1995;7(8):13-22.
5. Trifkovic B, Powers JM, Paravina RD. Color adjustment potential of resin composites. Clin Oral Investig 2018;22:1601-1607.
6. Ismail EH, Paravina RD. Color adjustment potential of resin composites: Optical illusion or physical reality, a comprehensive overview. J Esthet Restor Dent 2022;34:42-54.
7. Ahmed MA, Jouhar R, Khurshid Z. Smart monochromatic composite: a literature review. Int J Dent 2022;2022:2445394.
8. Choi JW, Lee MJ, Oh SH, Kim KM. Changes in the physical properties and color stability of aesthetic restorative materials caused by various beverages. Dent Mater J 2019;38:33-40.
9. Pereira Sanchez N, Powers JM, Paravina RD. Instrumental and visual evaluation of the color adjustment potential of resin composites. J Esthet Restor Dent 2019;31:465-470.
10. Gul P, Harorlı OT, Ocal IB, Ergin Z, Barutcigil C. Color recovery effect of different bleaching systems on a discolored composite resin. Niger J Clin Pract 2017;20:1226-1232.
11. Maciel CM, Santana TR, Dos Santos PH, Faria ESAL. Tooth bleaching effects on colour matching of single-shade composite restorations. J Can Dent Assoc 2025;91:3.
12. Şahin HC, Korkut B. Color adjustment of single-shade composites following staining, repolishing, and bleaching procedures. BMC Oral Health 2025;25:248.
13. Paolone G, Mazzitelli C, Zechini G, Scolavino S, Goracci C, Scotti N, et al. Influence of modeling liquids and universal adhesives used as lubricants on color stability and translucency of resin-based composites. Coatings 2023;13:143.
14. Sharma G, Wu W, Dalal EN. The CIEDE2000 color-difference formula: Implementation notes, supplementary test data, and mathematical observations. Color Res Appl 2005;30:21-30.
15. Paravina RD, Ghinea R, Herrera LJ, Bona AD, Igiel C, Linninger M, et al. Color difference thresholds in dentistry. J Esthet Restor Dent 2015;27 Suppl 1:S1-S9.
16. Koksal T, Dikbas I. Color stability of different denture teeth materials against various staining agents. Dent Mater J 2008;27:139-144.
17. Ahmed MA, Jouhar R, Vohra F. Effect of different ph beverages on the color stability of smart monochromatic composite. Appl Sci 2022;12:4163.
18. Paravina RD, Westland S, Imai FH, Kimura M, Powers JM. Evaluation of blending effect of composites related to restoration size. Dent Mater 2006;22:299-307.
19. Paravina RD, Westland S, Kimura M, Powers JM, Imai FH. Color interaction of dental materials: blending effect of layered composites. Dent Mater 2006;22:903-908.
20. Lempel E, Lovász BV, Meszarics R, Jeges S, Tóth Á, Szalma J. Direct resin composite restorations for fractured maxillary teeth and diastema closure: A 7 years retrospective evaluation of survival and influencing factors. Dent Mater 2017;33:467-476.
21. Topcu FT, Sahinkesen G, Yamanel K, Erdemir U, Oktay EA, Ersahan S. Influence of different drinks on the colour stability of dental resin composites. Eur J Dent 2009;3:50-56.
22. Domingos PA, Garcia PP, Oliveira AL, Palma-Dibb RG. Composite resin color stability: influence of light sources and immersion media. J Appl Oral Sci 2011;19:204-211.
23. Gómez-Polo C, Portillo Muñoz M, Lorenzo Luengo MC, Vicente P, Galindo P, Martín Casado AM. Comparison of the CIELab and CIEDE2000 color difference formulas. J Prosthet Dent 2016;115:65-70.
24. 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;31:103-112.
25. Paravina RD. Critical appraisal. Color in dentistry: match me, match me not. J Esthet Restor Dent 2009;21:133-139.
26. Rüttermann S, Dluzhevskaya I, Grosssteinbeck C, Raab WH, Janda R. Impact of replacing Bis-GMA and TEGDMA by other commercially available monomers on the properties of resin-based composites. Dent Mater 2010;26:353-359.
27. Sensi L, Winkler C, Geraldeli S. Accelerated Aging Effects on Color Stability of Potentially Color Adjusting Resin-based Composites. Oper Dent 2021;46:188-196.
28. de Abreu JLB, Sampaio CS, Benalcázar Jalkh EB, Hirata R. Analysis of the color matching of universal resin composites in anterior restorations. J Esthet Restor Dent 2021;33:269-276.
29. Forabosco E, Consolo U, Mazzitelli C, Kaleci S, Generali L, Checchi V. Effect of bleaching on the color match of single-shade resin composites. J Oral Sci 2023;65:232-236.
30. Arslandas Dincturk B, Kedici Alp C. The Effect of modeling liquid on color stability and surface roughness of single-shade composites: a sem study. Oral Health Dental Sci 2023;7:1-9.
31. Forabosco E, Checchi V. Visual and instrumental color match evaluation of single shade composites before and after bleaching procedures: a pilot study. TODJ 2023;17.
32. Mohamed M, Afutu R, Tran D, Dunn K, Ghanem J, Perry R, et al. Shade-matching capacity of omnichroma in anterior restorations. J Dental Sci 2020;5:000247.
33. Hubbezoglu I, Akaoğlu B, Dogan A, Keskin S, Bolayir G, Ozçelik S, et al. Effect of bleaching on color change and refractive index of dental composite resins. Dent Mater J 2008;27:105-116.