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Evaluating the effects of bleaching on color stability and surface roughness in single-shade and multi-shade resin composites

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ABSTRACT

Aims: This study aimed to evaluate the effects of aging and bleaching procedures on the color stability and surface roughness of single-shade composite resins and compare them with a multi-shade composite resin.

Methods: Fifty composite resin specimens (n=10 per group) from five brands— Omnichroma (Tokuyama, Japan) (OMN), Zenchroma (President Dental, Germany) (ZNC), Charisma Diamond One (Kulzer, Germany) (CHR), Essentia Universal (GC Corporation, Japan) (ESU) and one multi-shade composite resin Filtek Z550 (3M ESPE, USA) (FLT), —were subjected to aging (1-year simulated staining and brushing) and bleaching procedures. Color measurements were taken at baseline, after aging, and after bleaching using a spectrophotometer, while surface roughness was measured using a contact mode profilometer. Data were analyzed using Generalized Linear Models and Tukey's test for multiple comparison, with a significance level set at $p<0.05$.

Results: Statistically significant differences in ΔE values were observed across the composites and time points ($p<0.001$). Single-shade composites generally exhibited higher color change compared to multi-shade composite, with OMN showing the highest ΔE values. In terms of surface roughness, single-shade composites (ZNC and OMN) showed similar roughness to the multi-shade composite (FLT), while ESU and CHR exhibited greater roughness after bleaching.

Conclusion: Single-shade composites showed comparable performance to the multi-shade composite in terms of color stability and surface roughness after aging and bleaching. However, variations in composite responses highlight the importance of material selection in clinical practice, particularly when bleaching procedures are involved.

Keywords: Single-shade composites, multi-shade composites, color stability, surface roughness, bleaching

INTRODUCTION

Composite resins are widely utilized in modern dentistry due to their ability to provide both aesthetic and functional restorations.[1] Achieving tooth-colored and natural-looking restorations is one of the primary uses of composite resins. The broad color spectrum of these materials gives clinicians the flexibility needed to achieve clinically successful outcomes.[1] Composite resins are generally categorized into two main types: multi-shade and single-shade. Multi-shade composite resins are available in various shades to match different tooth colors, which is particularly important for achieving high aesthetic demands in anterior teeth.[2] However, working with multiple shades can be time-consuming and may increase the likelihood of errors.[3] Single-shade composite resins were developed to address these challenges and simplify the procedure.[4] These materials offer the ability to match all tooth colors with a single-shade, allowing clinicians to perform restorations more quickly and effectively.[5] In busy clinical settings, where reducing complexity and chair time is critical, single-shade composites are particularly advantageous. They generally require less chair time and help achieve more consistent aesthetic results.[2,4] Despite their advantages, the performance of single-shade composites in terms of color stability and surface roughness under various clinical conditions, such as aging and bleaching, remains a critical area of investigation. Understanding how these materials respond to common dental treatments is essential for assessing their long-term success in restorative dentistry.[6]

Color stability of composite resins is crucial for the longevity and aesthetic success of restorations. Factors affecting color stability include intrinsic factors, such as

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material composition and filler size, as well as extrinsic factors like exposure to staining agents in food, beverages, and tobacco.[7-9] Single-shade composite resins are known for their ability to match a wide range of tooth shades, but their color stability under various clinical conditions is not fully understood. The impact of common staining agents, such as coffee and tea, on these materials, and the effectiveness of bleaching treatments in restoring their original color, requires further investigation. Comparing the color stability of single-shade composites with multi-shade composites is essential to determine their clinical reliability. Understanding these changes is key to assessing the aesthetic performance of restorations and overall patient satisfaction.

The surface roughness of composite resins plays a significant role in their aesthetic performance and longevity. Mechanical and optical profilometers, scanning electron microscope (SEM), and atomic force microscope (AFM) are widely used devices to measure and evaluate the surface roughness of restorative materials.[10] A smooth surface reduces plaque accumulation, staining, and improves the gloss of the restoration. However, various factors such as aging, brushing, and bleaching procedures can alter the surface roughness of these materials.[11,12] Single-shade composites, like all restorative materials, are subjected to wear and surface changes over time. The impact of aging and bleaching on their surface roughness is particularly important, as increased roughness can lead to more staining and plaque retention, compromising the restoration's appearance and longevity. Assessing the surface roughness of single-shade composites after such procedures, and comparing it with that of multi-shade composites, is crucial to understanding their durability and aesthetic outcomes in clinical practice.[6,13]

Office-type bleaching is commonly used in clinical practice and can significantly affect the properties of composite resins. These treatment simulates long-term wear and exposure to staining agents, allowing researchers to evaluate the durability and aesthetic resilience of restorative materials under realistic conditions.[14] Bleaching treatments, in particular, which are widely used to enhance the appearance of teeth, may alter both the color and surface roughness of composite resins. While composite resins are susceptible to staining during use, it is important to recognize that the bleaching procedures commonly employed for natural teeth are generally ineffective in altering the shade of resin composites.[15] Although bleaching can partially reverse staining, it may also increase surface roughness, leading to a less smooth finish and a higher susceptibility to plaque accumulation and staining.[6,14]

Single-shade composites, despite their aesthetic advantages, may exhibit variability in color stability, especially when exposed to external factors such as bleaching and aging. This variability can be attributed to differences in the internal structure of the composite. For example, some studies have reported that the size and distribution of filler particles in single-shade composites play a significant role in their color stability.[8,14] Additionally, the composition of the resin matrix, particularly the monomer components, may interact with bleaching agents, leading to color changes after aging. Recent literature suggests that bleaching procedures may cause more pronounced color changes in single-shade composites.[6]

The aim of this study is to evaluate the effects of aging and bleaching procedures on the color stability and surface roughness of single-shade composite resins, comparing them with a multi-shade composite resin. Specifically, this study will test the following hypotheses:

1. The color stability of single-shade composite resins after different aging and bleaching procedures will not differ significantly compared to the multi-shade composite resin.
2. The surface roughness of single-shade composite resins after different aging and bleaching procedures will not differ significantly compared to the multi-shade composite resin.

METHODS

No biological materials were used in the laboratory study with composite resin, no personal data are available. Therefore, ethics committee approval is not required. All procedures were carried out in accordance with the ethical rules and the principles.

Study Design

Four single-shade composite resin Omnichroma (Tokuyama, Japan) (OMN), Zenchroma (President Dental, Germany) (ZNC), Charisma Diamond One (Kulzer, Germany) (CHR), Essentia Universal (GC Corporation, Japan) (ESU) and one multi-shade composite resin Filtek Z550 (3M ESPE, USA) (FLT), were analyzed in this study. The category manufacturers, lots, and compositions of the composite resins are presented in **Table 1**. **Figure 1** describes the study design, which shows the flow of the specimens through the different stages of the study. All specimens were subjected to staining, brushing and bleaching simulation. Color measurements were performed with spectrophotometer at baseline (t0), after 1 year brushing and staining (t1), and after bleaching (t2).

Specimen Size Calculation

Utilizing G* Power statistical software, the specimen size was computed. With a confidence level of 95% (1-α), a test power of 95% (1-β), and an effect size (f) of 0.655, the total specimen size required for one-way analysis of variance (ANOVA) has been determined to be 54, with 9 specimens

Table 1. The category, manufacturers, lot numbers, and compositions of the composite resins

Material	Code	Material type	Composition	Filler content wt%	vol%	Filler size	Shade	Manufacturer	Lot number
Omnichroma	OMN	Nanofilled	Spherical silica-zirconia filler Composite filler 1,6-bis(methacryl-ethyloxycarbonylamino) trimethyl hexane UDMA TEGDMA Mequinol Dibutyl hydroxyl toluene UV absorber.	79%	68%	0.3 µm	Single Shade Universal	Tokuyama, Japan	044EZ0
Filtek Z550	FLT	Nanohybrid	BIS-GMA UDMA BIS-EMA PEGDMA TEGDMA	81.8%	67.8%	0.01–3.5 µm	A2	3M ESPE, USA	NC45123
Zenchroma	ZNC	Microhybrid	Glass powder Silicon dioxide UDMA Bis-GMA, TEGDMA	75%	53%	0.005-3.0 µm	Single Shade Universal	President Dental, Germany	2022003395
Charisma diamond one	CHR	Nanohybrid	Barium Aluminium Boro Fluor Silicate Glass TCD-Urethaneacrylate Silica UDMA TEGDMA Titanium Dioxid, Fluorescent Pigments Metallic Oxide Pigments Organic Pigments Aminobenzoicacidester BHT Camphorquinone	81%	64%	0.05-20 µm	Single Shade Universal	Kulzer, Germany	K010025
Essentia Universal	ESU	Microhybrid	UDMA Bis-MEPP Bis-EMA Bis-GMA TEGDMA PPF Strontium glass Lanthanide fluoride Fumed silica FAISi Glass	91%	61%	0.1 µm	Single Shade Universal	GC Corp, Japan	2007231

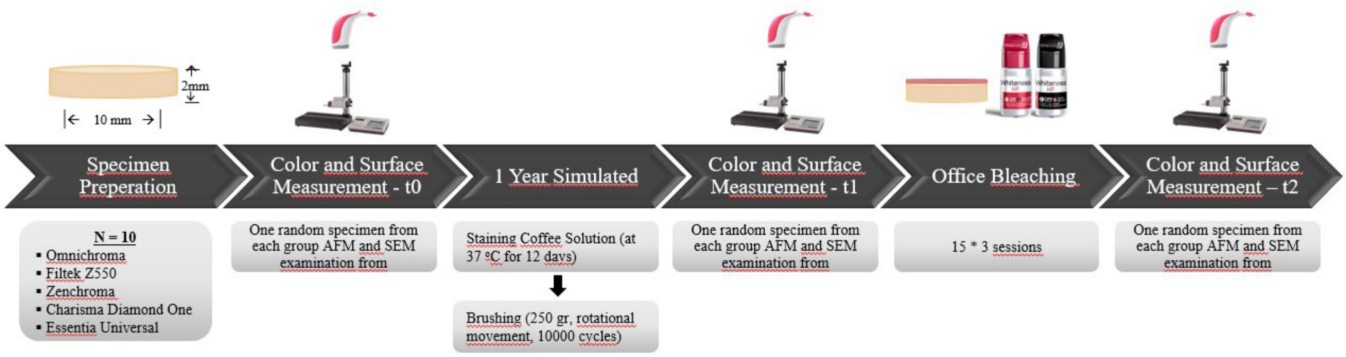

Figure 1. Flow chart of the study design

in each group. To account for potential specimen loss, the study was designed with a total of 10 specimens allocated to each group.

Specimen Preparation

A total of 50 specimens (n=10) were prepared using silicon molds of 10x2 mm.[8] After the resin composite was placed in the molds with a slight overflow, a mylar strip and microscope slide were placed on the upper surfaces of the materials and polymerized for 10 s using a curing light (SmartLite Focus, Dentsply Sirona, USA). The slide was then removed, and the materials were polymerized by applying the curing light for 10 s over the mylar strip, according to the manufacturer's instructions and. the same curing light was used for all polymerization steps and the output of the light was controlled periodically using a radiometer (Woodpecker LED-F, Woodpecker Medical Instrument Co., China) to ensure an intensity of at least 1000 mW/cm^2 throughout the preparation of the specimens. Following the polymerization process, each of the specimens was polished with usin polishing disc (Optidisc, Kerr Corporation, USA) from extra-coarse to extra-fine at speed 10,000 rpm and 10 s each. A new disc was used for each specimen. The specimens were rinsed with water for 10 seconds to clean debris from the restoration surface then were kept in distilled water at 37°C in an incubator for 24 h post-polymerization.[8] All the procedures on the materials were applied by a single operator. In order to control the effect of press-on force on the polishing accuracy, the initial and final measurements of the thickness of each specimen were carried out 3 times by a single operator using an industrial type screw thread digital caliper (0.01 mm) with 0-150 mm measuring range.[10]

Staining Procedure

For the preparation of the coffee solution, 3,6 g of coffee was used per 300 ml of 100ºC boiling water. All solutions were allowed to reach 37ºC. Eppendorf tubes were preferred to immerse the specimens individually in the study. 1.5 mm eppendorf tubes were filled with the solution and one specimen was placed inside. The tubes were kept in an oven at 37ºC for 12 days (t1–1 year) to replicate intraoral conditions. Specimens were turned over and immersed in fresh solutions every day to ensure uniform contact of the specimen with the staining solution and prevent contamination with bacteria and fungus.[8,16]

Brushing Procedure

The specimens removed from the solutions were subjected to brushing simulation with the MF-100 (Mod Dental, Esetron Smart Robotechnologies, Turkiye) brushing simulator. Toothbrush (Colgate Extra Clean 1+1, Colgate Palmolive, USA) and toothpaste (Sensodyne Çok Yönlü Koruma, Haleon, United Kingdom) with a relative dentin abrasivity (RDA) of 142 diluted 1/3 by volume were used in the brushing simulation. The specimens were subjected to 10,000 (t1-1 year) cycles of brushing under a load of 250 g, with a circular motion with a movement diameter of 20 mm, and a movement speed of 30 mm/sec, simulating 1 year of brushing. The toothbrush and paste were changed for each specimen.[17-19]

Bleaching Procedure

The bleaching product (FGM Whiteness HP, FGM Dental, Brazil) was applied to the composite specimens according to the manufacturer's instructions. A 1 mm layer of the bleaching gel was carefully applied to ensure consistent contact with the entire surface of the specimens.[20] The bleaching agent was allowed to remain on the specimens for 15 minutes and was activated every 4 minutes using a micro brush. This procedure was performed in a single session. After the bleaching session, the bleaching agent was removed from the specimens using gauze, followed by thorough rinsing under distilled water for 30 seconds. The specimens were then stored in distilled water at 37°C until color assessment. The gel layer was maintained between 0.5 and 1 mm in thickness to ensure optimal contact with the composite surface.

Color Assessments

Color measurements of the specimens were conducted at three time points: t0, t1, and t2, using a digital spectrophotometer (Vita Easyshade V, Vita Zahnfabrik, Germany). The color evaluation was based on the CIE Lab* color space, which is a three-dimensional system that includes the parameters of lightness (L*), red-green chromaticity (a*), and yellow-blue chromaticity (b*). In this system, L* ranges from 0 (completely dark) to 100 (completely bright), a* represents the red-green axis, and b* represents the yellow-blue axis. For each specimen, three measurements were taken from the center, and the mean values of the L*, a*, and b* coordinates were recorded. The spectrophotometer was calibrated before each measurement session. An 18% grey card (L* =50, a*=0, b*=0) (JJC Photography Equipment Co. Ltd, China) was used as a reference for calibration.

The color differences (ΔE) between different time points were calculated using the CIEDE2000 formula, which provides a more accurate representation of perceptible color differences. These calculations were performed using an online ΔE calculator (http://www.colormine.org/delta-e-calculator/Cie2000).

Profilometric Examination

Quantitative profile analysis and surface roughness of the samples were evaluated using a contact mode profilometer (Surftest SJ-400 Mitutoyo, Japan). At the beginning (t0) and the end of the aging procedures (t1), and end of the bleaching session (t2) surface roughness measurements were made from 3 different points of the samples with a Surftest SJ-400 (Mitutoyo, Japan) profilometer and the average surface roughness values were obtained. During the measurements, the device was set in contact mode, the cut-off length was 0.08 mm, the tracing length was 0,5 mm, and the probe speed was 0.1 mm/sec.

Scanning Electron Microscope Imaging Analysis

One specimen from each group was analyzed using a SEM (Regulus 8230 FE-SEM, Hitachi High Tech Corporation, Japan) at three time points: t0, t1, and t2. Imaging was conducted at a magnification of×5000, and the images were recorded for further analysis. Prior to SEM examination, the specimens were surface coated with a 4 nm layer of gold/palladium particles (Leica EM ACE600C, Leica Microsystems Inc., Canada) to enhance surface conductivity.

Atomic Force Microscopy Examination

Three-dimensional images of the surface topography were obtained from one randomly selected specimen from each group using AFM (Park Systems XE 100, Korea) in non-contact mode. Scans were performed over a 2 µm×2 µm area with a resolution of 4000 data points per line at three time points: t0 (baseline), t1 (after aging), and t2 (after the bleaching session). The non-contact mode was chosen to prevent any potential damage to the specimen surfaces while capturing detailed surface features. The resulting data provided insights into changes in surface roughness and morphology due to the aging and bleaching processes.

Statistical Analysis

The data were analyzed using Minitab 14 and R software. The Shapiro-Wilk test was used to assess normality. For parameters that followed a normal distribution based on composite and time, comparisons were made using Generalized Linear Models, followed by Tukey's test for multiple comparisons. For parameters that did not follow a normal distribution, the Two-Way Robust ANOVA method was applied, with multiple comparisons conducted using the Bonferroni test. The results are presented as mean±standard deviation and median (min–max). Statistical significance was set at $p<0.05$.

RESULTS

The main effect of the composite was found to be statistically significant on the median ΔE values ($p<0.001$). The main effect of time was also found to be statistically significant on the median ΔE values ($p<0.001$). Additionally, the interaction between composite and time was statistically significant ($p<0.001$). At t1-t0, the highest median ΔE value was observed in the OMN composite (14.96), while the lowest value was recorded in the ZNC composite (2.37). At t2-t1, the highest median ΔE value was found in the ESU composite (12.15), whereas the lowest value was observed in the ZNC composite (0.78). At t2-t0, the highest median ΔE value was observed in the CHR composite (3.55), and the lowest value was recorded in the FLT composite (0.90) (**Table 2**).

The main effect of the composite was found to be statistically significant on the median profilometer values ($p<0.001$). The main effect of time was not statistically significant on the median profilometer values ($p=0.267$). However, the interaction between composite and time was statistically significant ($p=0.026$). At t0, the highest median profilometer value was observed in the ESU composite (0.022), while the lowest value was recorded in the OMN composite (0.013). At t1, the ESU composite again exhibited the highest median profilometer value of 0.033, whereas the ZNC composite showed the lowest value of 0.011. At t2, the highest median profilometer value was found in the ESU composite (0.031), and the lowest value was observed in the FLT, ZNC, and OMN composites (0.010) (**Table 3**).

Table 2. Comparison of ΔE values by composite and time

Time	Composite					Total		Q	p
	FLT	ESU	ZNC	CHR	OMN				
t1-t0	12.14 (11.61 - 12.49)^{A}	13.23 (12.05 - 14.96)^{AD}	2.37 (1.53 - 3.25)^{BEF}	3.99 (2.84 - 4.84)^{G}	14.96 (14.28 - 16.16)^{D}	12.03 (1.53 - 16.16)^{a}	Composite	258.507	<0.001
t2-t1	11.8 (11.44 - 13.2)^{A}	12.15 (10.87 - 13.35)^{A}	0.78 (0.19 - 1.43)^{C}	1.33 (0.52 - 3.16)^{BCE}	12.14 (10.25 - 13.1)^{A}	11.53 (0.19 - 13.35)^{a}	Time	362.555	<0.001
t2-t0	0.9 (0.64 - 1.12)^{BC}	1.57 (0.93 - 2.46)^{E}	2.24 (1.21 - 3.65)^{DEF}	3.55 (1.65 - 4.18)^{FG}	3.03 (2.25 - 5.8)^{FG}	2.22 (0.64 - 5.8)^{b}	Composite*Time	1451.512	<0.001
Total	11.8 (0.64 - 13.2)^{a}	12.13 (0.93 - 14.96)^{a}	1.72 (0.19 - 3.65)^{b}	3.22 (0.52 - 4.84)^{c}	12.14 (2.25 - 16.16)^{a}	3.33 (0.19 - 16.16)			

Q: Two-Way Robust ANOVA; Median (min - max); a-c: No difference between main effects with the same letter; A-G: No difference between interactions with the same letter.

Table 3. Comparison of Profilometer Values According to Composite and Time

Time	Composite					Total		Q	p
	FLT	ESU	ZNC	CHR	OMN				
t0	0.17 (0.08 - 0.22)^{ABCD}	0.22 (0.12 - 0.32)^{ABCDE}	0.21 (0.13 - 0.41)^{ABCDE}	0.19 (0.13 - 0.36)^{BCD}	0.13 (0.09 - 0.17)^{ABC}	0.17 (0.08 - 0.41)	Composite	12.603	<0.001
t1	0.12 (0.09 - 0.16)^{ABC}	0.33 (0.27 - 0.37)^{E}	0.11 (0.06 - 0.2)^{ABC}	0.2 (0.17 - 0.33)^{CD}	0.17 (0.06 - 0.21)^{ABCD}	0.18 (0.06 - 0.37)	Time	1.321	0.267
t2	0.1 (0.08 - 0.15)^{AB}	0.31 (0.21 - 0.44)^{DE}	0.1 (0.07 - 0.25)^{A}	0.19 (0.16 - 0.24)^{CD}	0.1 (0.05 - 0.2)^{A}	0.13 (0.05 - 0.44)	Composite*Time	17.383	0.026
Total	0.11 (0.08 - 0.22)^{a}	0.3 (0.12 - 0.44)^{b}	0.13 (0.06 - 0.41)^{a}	0.19 (0.13 - 0.36)^{c}	0.12 (0.05 - 0.21)^{a}	0.17 (0.05 - 0.44)			

Q: Two-Way Robust ANOVA; Median (min - max); a-c: No difference between main effects with the same letter; A-E: No difference between interactions with the same letter.

Scanning electron microscopy (SEM) images at 5000x magnification revealed the surface morphology of the composites before and after treatment. The SEM analysis confirmed that there were no significant changes in the surface morphology of the composites, with all groups maintaining a consistent and uniform surface texture. Minor surface irregularities were observed, particularly in the ESU and CHR groups, but these were not substantial enough to impact the overall material performance (**Figure 2**).

The Atomic Force Microscopy (AFM) analysis provided detailed three-dimensional surface topography images of the composite resins at different time points. The AFM results showed that the surface roughness of the composites varied slightly after the aging and bleaching procedures, with minor increases in roughness observed in the OMN and ZNC groups. However, the overall surface topography remained relatively smooth, indicating that the composites retained their structural integrity throughout the study (**Figure 3**).

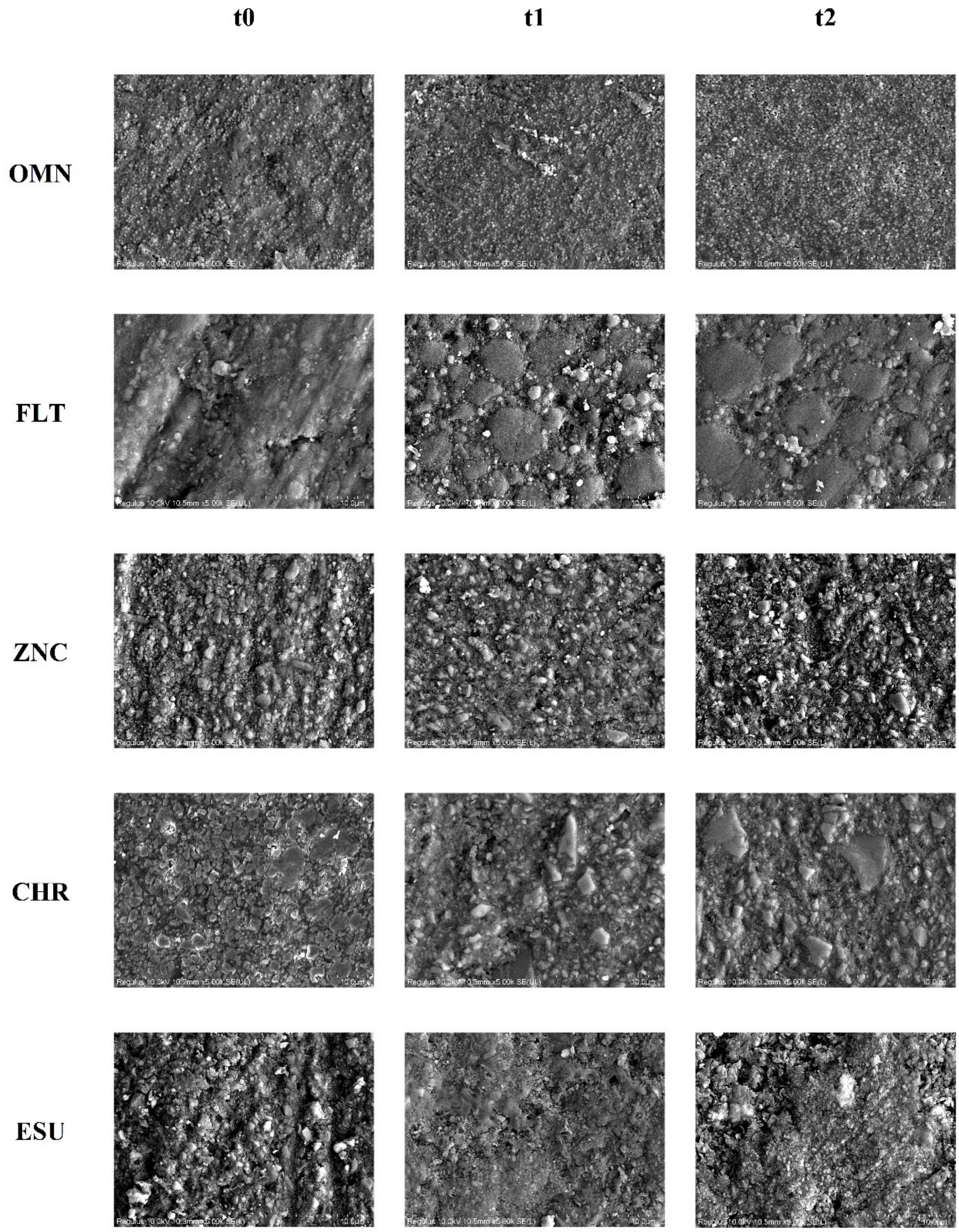

Figure 2. SEM analysis at 5000x magnification reveals the surface morphology of the groups

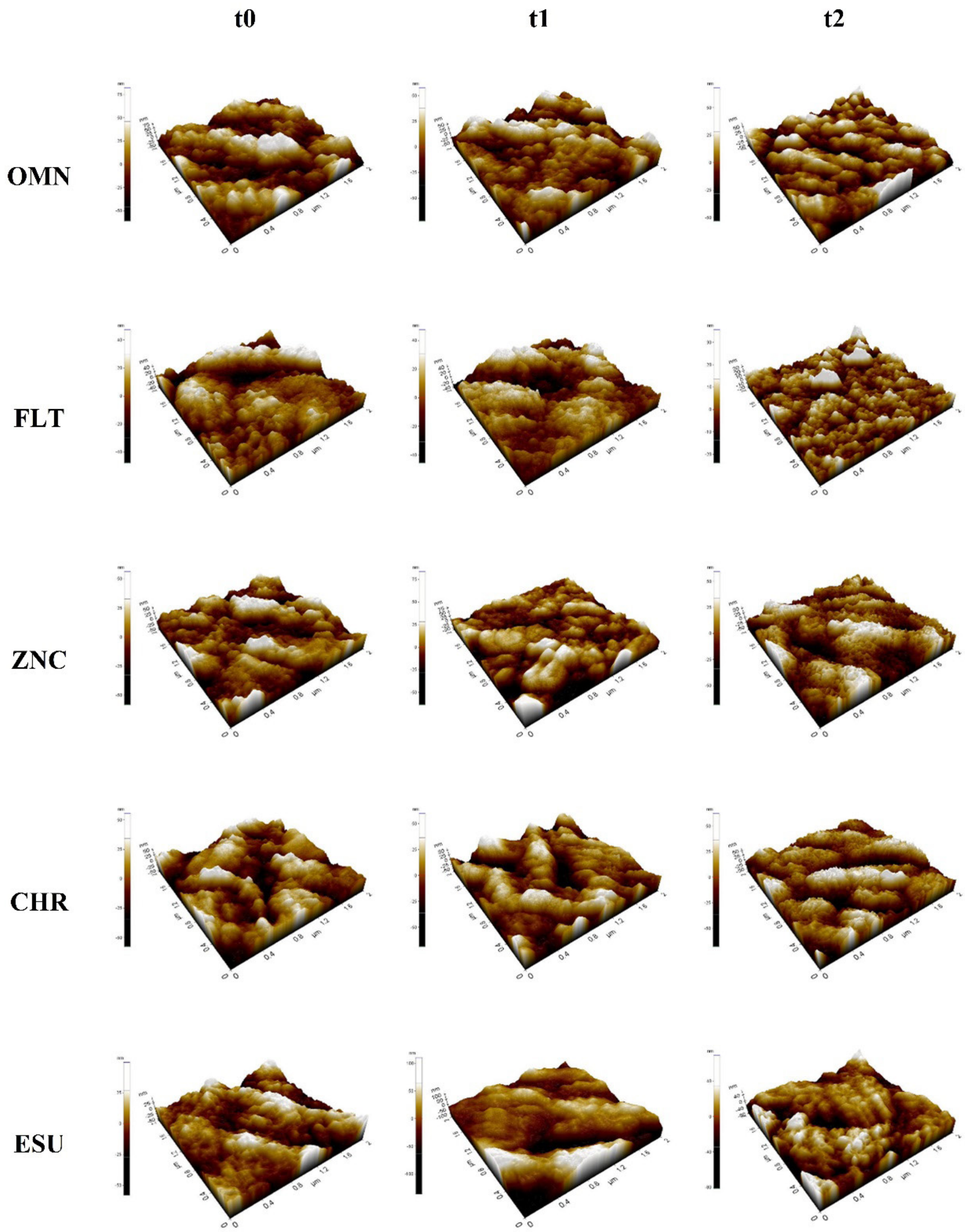

Figure 3. AFM analysis showcasing the three-dimensional surface topography of the groups

DISCUSSION

The widespread use of various shades of adhesive composites for esthetic restorations in both anterior and posterior teeth has highlighted challenges related to the multiple application steps and the significant time required, which can be demanding for clinician.[2,3] To address these issues, manufacturers have recently introduced single-shade resin composites, offering the benefits of reduced chair time and simplified shade selection.[2] However, it has been noted that any discoloration in resin composites can adversely affect their esthetic outcomes.[21,22] The findings of this study indicate that single-shade composite resins, such as OMN and ESU, did not show a significant difference in color stability compared to the multi-shade composite resin, FLT, after aging and bleaching procedures. These results support the acceptance of the color stability hypothesis, demonstrating that single-shade composites perform similarly to multi-shade composites under these conditions. Additionally, the surface roughness of single-shade composite resins, such as ZNC and OMN, did not differ significantly from that of FLT after aging and bleaching treatments. This finding supports the acceptance of the surface roughness hypothesis, confirming that single-shade composites exhibit similar surface characteristics to multi-shade composites and are a reliable option for clinical use.

Color measurement is commonly performed using the CIELAB color system. The CIE Lab* system is widely adopted due to its standardized methodology, which allows for precise analysis of ΔE* values. This system is known for its ability to detect subtle color changes accurately and offers several advantages, including objectivity, repeatability, and high sensitivity.[23-25] In this study, the CIEDE2000 color difference formula was selected for its ability to provide a more sensitive evaluation of minor to medium color discrepancies, offering a single-number shade pass/fail criterion that improves upon the traditional CIE Lab* system.

Office-type bleaching is widely utilized in dental practices to enhance the aesthetic appearance of teeth. Although bleaching can sometimes effectively remove surface stains from composite restorations and restore their color, it does not lighten composite resins in the same way it affects natural tooth structures.[26] Researches have shown that bleaching treatments can improve the removal of stains from composite resins, but they may also lead to alterations in the color of these materials.[27,28] A study on a single-shade composite (OMN) found no significant differences in L*, a*, and b* values between the composite restoration and the tooth at various time intervals after bleaching, with both visual and instrumental analyses confirming a perfect match between the two.[29] In the current study, the FLT group retained a color closer to its initial shade compared to the single-shade composites, highlighting a significant difference in their response to bleaching. While single-shade composite resins did undergo color change due to the bleaching process, they were less effective at maintaining their original shade compared to the multi-shade composite.[30] The highest ΔE values in OMN can be attributed to the size and distribution of its filler particles and the interaction of its resin matrix with bleaching agents. Increased water absorption in this composite may have also contributed to the color change. The higher surface roughness observed in ESU and CHR may be due to larger filler particles and differing wear rates during bleaching. The abrasive effect of bleaching agents likely contributed to the increased surface roughness as well.

Recent research tested four single-shade composites (OMN, CHR, Vitra Unique, and ESU) on 40 human incisors, using a VITA Easyshade Compact V spectrophotometer to evaluate ΔE. The study reported that all tested composites exhibited acceptable color-matching, with no significant differences between tooth shades and the resin composites.[31] These findings differ partially from our study, likely due to differences in composite selection and specimen preparation methods. While both studies observed similar composite behavior, our analysis revealed statistically significant differences between the composites. In another study, the effect of thickness on the translucency and whiteness of single-shade resin composites (OMN, Vitra Unique, ZNC, and CHR) was compared to a multi-shade composite (Filtek Z250) after thermocycling. The study found that single-shade composites had higher translucency and whiteness values than the multi-shade composite, both before and after aging.[32] However, unlike the present study, bleaching procedures were not performed, which may explain the differences observed in color stability.

It is well-documented that the surface roughness of resin composites can significantly impact their optical properties and ability to adjust color.[6,24] However, previous studies have produced inconsistent results regarding the effect of whitening treatments on the surface roughness of resin composites.[28,33] For instance, some research has found no significant difference in surface roughness after applying 40% hydrogen peroxide to both microhybrid and nanohybrid resin composites.[33] This variation in findings is likely due to several influencing factors, including the type of resin composite, the concentration of the whitening agent, the duration of exposure, the application protocol, and the type of measuring device used. In this study, surface roughness was measured using a contact mode profilometer. The results showed that the surface roughness of the multi-shade composite (FLT) was similar to that of the single-shade composites (ZNC and OMN) after bleaching treatments, while the other single-shade composites (ESU and CHR) exhibited significantly different roughness values. This suggests that different composite materials, whether single-shade or multi-shade, respond variably to bleaching. These findings have important implications for clinical practice, particularly in selecting materials that maintain surface integrity after whitening procedures. Further research is needed to establish standardized protocols for assessing and predicting the impact of bleaching on various composite resins.

SEM and AFM analyses confirmed the morphological changes on the composite surfaces, adding a qualitative dimension to the quantitative findings. SEM images showed that the surface morphology was largely preserved across all groups, while AFM results indicated slight increases in surface roughness. These irregularities, particularly observed in the OMN and ZNC groups, are not considered substantial enough to negatively impact clinical performance. Overall, the findings suggest that the composites maintained their structural integrity and are suitable for long-term use. However, the minor surface irregularities observed in the SEM and AFM analyses should not be overlooked in terms of their potential impact on clinical performance. Although these irregularities are small, they could negatively affect clinical parameters such as plaque accumulation, biofilm formation, and wear. Increased surface roughness may facilitate plaque buildup, potentially compromising the long-term aesthetic and biological performance of the restorations. Therefore, the surface morphology of composites is crucial not only for aesthetics but also for long-term clinical outcomes.

Limitations

This study has several limitations that should be considered when interpreting the results. First, the study was conducted in vitro, meaning that the conditions simulated in the laboratory may not fully replicate the complex environment of the oral cavity. Factors such as saliva, temperature fluctuations, and mechanical stresses in the mouth could influence the performance of composite resins differently than observed in this study. Second, the aging and bleaching procedures were performed over a relatively short time period. Although these procedures were designed to simulate long-term clinical conditions, they cannot perfectly mimic the cumulative effects of years of use in a real-world setting. Longitudinal clinical studies are needed to confirm the durability and performance of single-shade composites over time.

Clinical Relevance

The results of this study provide valuable insights for dental practitioners when selecting restorative materials, particularly in cases involving aging and bleaching treatments. Single-shade resin composites demonstrated comparable color stability and surface roughness to multi-shade composites, making them a viable option for esthetic restorations. However, variations in the performance of different composites highlight the need for careful material selection, especially in patients undergoing bleaching procedures. Understanding how these materials respond to clinical conditions can improve long-term outcomes and patient satisfaction.

CONCLUSIONS

These findings indicate that while single-shade composites offer significant advantages in simplifying shade selection and reducing clinical time, their performance under various clinical conditions is largely comparable to that of the multi-shade composite. Specifically, the results show that the color stability of single-shade composites, particularly OMN and ESU, did not differ significantly from that of FLT after aging and bleaching treatments. Furthermore, surface roughness measurements revealed that single-shade composites like OMN and ZNC maintained surface qualities similar to FLT, even after extensive aging and bleaching procedures.

ETHICAL DECLARATIONS

Ethics Committee Approval

No biological materials were used in the laboratory study with composite resin, no personal data are available. Therefore, ethics committee approval is not required.

Informed Consent

No biological materials were used in the laboratory study with composite resin, no personal data are available. Therefore, ethics cinformed consent is not required.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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