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ORIGINAL RESEARCH ARTICLE

Evaluation of Color Stability in One and Multi-Shade Composite Resin Materials Polymerized with Different Curing Modes

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Abstract

Purpose: This in vitro study aimed to compare the color stability of one-shade (Omnichroma and Vittra APS Unique) and multi-shade (Filtek Z250) composite resin materials after light-curing using standard (ST) and soft-start (SS) curing modes.
Materials and Methods: Seventy-eight disc-shaped specimens (n=13 per subgroup) were prepared using Omnichroma, Vittra APS Unique, and Filtek Z250 composite resins. Specimens were light-cured in either Soft Start or Standard mode and immersed in coffee solution at 37°C for 30 days. Color changes (ΔE_{00}) were measured with a spectrophotometer on days 1, 7, and 30, using the CIEDE2000 formula.
Results: All materials showed significant and clinically unacceptable color changes ($\Delta E_{00} > 1.8$). The highest staining occurred during the first 7 days. Filtek Z250 exhibited the least staining, while SS curing mode led to greater discoloration compared to ST for Vittra APS Unique and Filtek Z250. Omnichroma's color change was not significantly affected by curing mode over 30 days.
Conclusions: Both curing modes failed to maintain clinically acceptable color stability in all tested materials. The type of composite resin and polymerization mode influenced staining, with soft-start curing increasing susceptibility to discoloration in certain materials.

Keywords: Color stability; Composite resin; Polymerization mode; One-shade composite; Soft-start polymerization

Introduction

Composite resin-based materials are frequently preferred by dental practitioners today for the construction of esthetic restorations. Nowadays, dentists are interested in using one-shade restorative materials as they reduce the need for a wide range of composite shades, minimize the wastage of unnecessary shades, and save chairside time for shade selection or combination.[1]

Color stability is a crucial physical property of esthetic restorations. The color stability of resin composites significantly impacts their clinical longevity and performance in the oral cavity[2] and in case of severe staining replacing the restoration could be inevitable.

Polymerization reaction starts when the cross-linking reaction begins, and the carbon-carbon double bonds are converted into carbon-carbon single bonds. The percentage of double bonds converted to single bonds is indicated by the degree of conversion (DC).[3] DC is an important factor for the clinical performance of resin-based composite restorations, as it affects various composite properties including mechanical properties, polymerization shrinkage and stress, biocompatibility, solubility, color stability, degradation, and water sorption.[4,5] DC of light-cured resin-based composites depends on extrinsic and intrinsic factors. Intrinsic factors are associated with the composition of restorative materials (photoinitiator system, monomer type and amount, and filler composition) while the extrinsic factors include variables related to the polymerization process such as the curing mode, the light curing tip positioning, irradiance, light spectrum, and post-cure reactions.[3] Composite resin restorations may show extrinsic staining due to insufficient polymerization, water or food's and beverages' col-

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orants absorption.[6,7] Residual monomers remaining as a result of an insufficient degree of conversion can cause color deterioration therefore polymerization adequacy is critical to achieve color stability.[8] Different curing modes, have appeared to improve polymerization by affecting polymer composition, degree of conversion, and number of cross-links.[9] Previous studies reported that curing mode has an impact on the color stability of the composite resins.[10,11] Thus, choosing of suitable curing mode is important to obtain long-lasting color stability of restorations. Besides the existence of residual unconverted monomers which can increase water sorption of resin matrix might result in absorption and adsorption of colorants of beverages such as coffee into the resin surface[12] and further staining, as well.

In recent years, growing interest in one-shade composites has led to increased research on their color stability. However, there is limited knowledge regarding the long-term impact of polymerization modes on the color stability of these composites in clinical settings. Thus, the aim of this study is to instrumentally compare the color stability of two different one-shade universal composite resin materials (Omnichroma and Vittra APS Unique) with the control group (Filtek Z250), a multi-shade composite resin material, after light-curing in soft start (SS) and standard (ST) curing modes, by using spectrophotometry.

Two null hypotheses were established in the study. The first null hypothesis states that there is no difference between composite resin restorative materials in terms of color stability against staining, regardless of curing modes. The second null hypothesis suggests that the curing mode used for the polymerization, regardless of the composite resin material, does not affect staining.

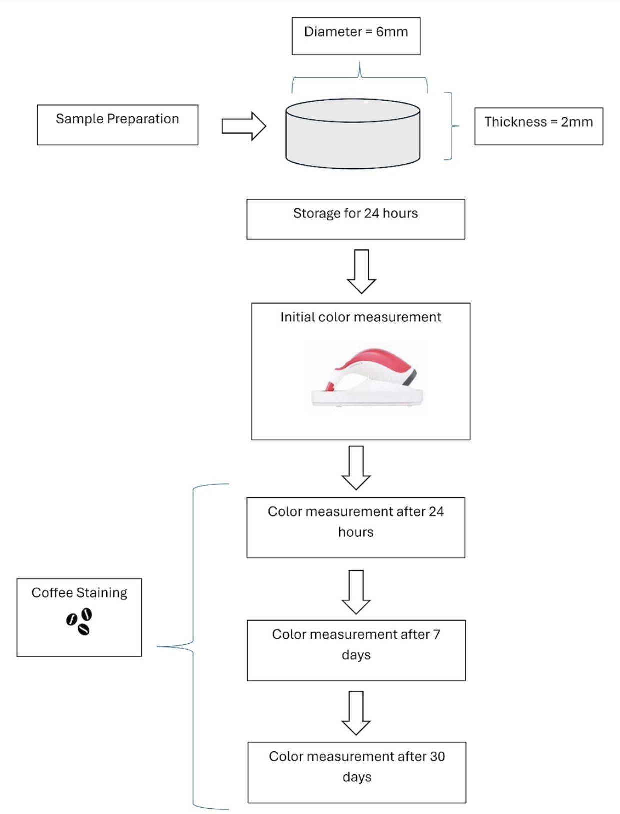

Figure 1. Flowchart of the study process

Material and Methods

Calculation of Sample Size

The calculation of the sample size required to test the research hypothesis was made with the G*Power 3.1.9 program. The minimum sample size for each tested subgroup was calculated as 11, which will provide 95% test power at a 95% confidence level, with the effect width for "Two-Way Variance Analysis in Repeated Measurements with Repetitions on a Single Factor" being small effect width, f=0.25, and each composite. An equal number of 26 samples were prepared for each material under two different curing modes, accounting for potential dropouts due to sample defects (n=13 for each group).

Specimen preparation

Two different one-shade composite materials, Omnichroma (Tokuyama Dental, Tokyo, Japan), Vittra APS Unique (FGM, Joinville, SC, Brazil), and A2 shade of Filtek Z250 (Filtek, 3M ESPE, St Paul, MN, USA), a multi-shade universal resin-based composite, were used for this study (Table 1). Seventy-eight discs (thickness=2 mm, and diameter=6 mm) were prepared by placing the material in a Teflon mold with a single increment (Figure 1). Then, the mold was covered with a mylar strip, and the excess material removed by gentle pressure was applied by placing microscopic slides on the top and bottom surfaces of the mold. In the group where ST curing mode was applied, discs were light-cured for 20 seconds at a constant light power of 1000-1200 mW/cm^2 using an LED device (B-Cure, Guilin Woodpecker Medical Instrument Co., Ltd., Guilin, China). In the group where SS curing mode was applied, discs were light-cured for 20 seconds at continuously increasing light power of 0-1200 mW/cm^2. The light device was rested for 30 seconds after every 10 exposures following the user instructions. The power of the unit was verified using a radiometer (Bluephase Meter II; Ivoclar Vivadent, Amherst, New York) after every third measurement. For polishing the samples, polishing discs with hard, medium, fine and super fine grains ranging from hard to super fine were used (Sof-Lex, 3M/ESPE, St Paul, MN, USA). Polishing operations were limited to 10 seconds for each disc to prevent microcracks formation. Each polishing disc changed in every 3 samples to avoid loss of abrasiveness.

After each polishing step, the sample was checked by washing and drying it with an air syringe to obtain a smoother and uniform surface. Then, the samples were kept in distilled water in a light-proof container at 100% humidity and 37°C for 24 hours before initial color measurement.

Staining procedure

The initial colors (L*, a* and b* values) of the samples were measured with a spectrophotometer device (Vita Easyshade V; VITA Zahnfabrik, Germany) under D65 lighting conditions.

The samples were placed in multiple well plates, each containing 5 ml of coffee. A coffee solution (Nescafe Classic; Nestle, Bursa, Turkey) was prepared according to the manufacturer's instructions (2 g of coffee per 200 ml of water) and added to the samples at 37 °C. The samples were then incubated at 37 °C for 30 days (FN 500, Nüve, Türkiye) to simulate color changes over time. The coffee solution was replaced with a fresh one every 24 hours. On the 1^{st}, 7^{th}, and 30^{th} days measurements of L*, a* and b* values of each sample were performed with the same spectrophotometer device in the abovementioned conditions. A schematic view of the study design is shown in Figure 2.

Statistical Analysis

The CIEDE2000 formula (ΔE_{00}) was used to calculate color changes in composite resins based on L*, a* and b* values of the samples

Table 1. Composite materials evaluated in this study

Material	Manufacturer	Filler type	Filler content wt% vol%	Particle size	Monomer	Shades
Omnichroma	Tokuyama Dental, Tokyo, Japan	Spherical Silica-Zirconia and Composite fillers	79 68	260nm	UDMA, TEGDMA	Universal Shade
Vittra APS Unique	FGM, Joinville, SC, Brazil	Charge particles of zirconia and silica	75 55		Mixture of methacrylate monomers	Universal Shade
Filtek Z250	3M ESPE, St. Paul, MN	Ceramic treated silane (65–90) Silica treated silane (1–10) Zirconium	84.5 60	0.01–3.5 μm	Bis-GMA, UDMA, BisEMA	A2

Abbreviations: Bis-EMA, bisphenol A polyethylene glycol diether dimethacrylate; Bis-GMA, bisphenol A diglycidylmethacrylate; TEGDMA, triethylene glycol dimethacrylate; UDMA, urethane dimethacrylate

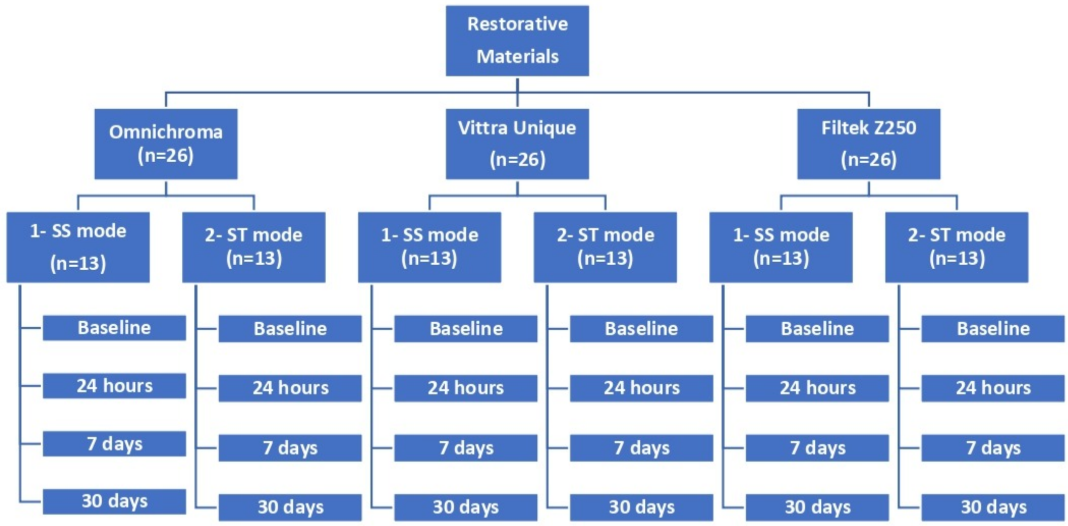

Figure 2. Schematic view of the study design

measured in different time intervals by using an Excel spreadsheet implementation of the CIEDE2000 formula. A measured color difference (ΔE_{00}) greater than 1.8 was considered a clinically unacceptable color change. By averaging the three ΔE_{00} values obtained for each sample, an average ΔE_{00} value was obtained for each of the samples of the three materials.

Statistical analyses were conducted using SPSS version 25.0 software for Windows (IBM SPSS, Chicago, IL, USA) and Jamovi version 2.4 software. The normality of the distribution of variables was examined with the Shapiro-Wilk test. Descriptive analyses were presented using mean, standard deviation, median, minimum, and maximum values. To investigate significant differences in repeated measures obtained at different times across material groups, a Mixed-Effect Model was used. Differences between groups were determined by Dunn's Bonferroni Test. A $p < 0.05$ was considered statistically significant.

Results

The independent variables tested in the study were as follows:

- Type of composite resin material (Omnichroma, Vittra APS Unique, and Filtek Z250)
- Type of Polymerization Mode (Soft Start: SS and Standard: ST).
- Different time intervals (Baseline-24 hours, Baseline-7 days, Baseline-30 days, 24 hours-7 days, 24 hours-30 days, 7days-30 days)

Table 2. Mixed Effect ANOVA Model Results

	F	Num df	p
Material	104.75	2	<.001
Mode	117.20	1	<.001
Time	1039.95	5	<.001
Material ⋆ Mode	5.12	2	0.008
Material ⋆ Time	31.34	10	<.001
Mode ⋆ Time	89.32	5	<.001
Material ⋆ Mode⋆ Time	44.94	10	<.001

A mixed-effects ANOVA was conducted to evaluate the impact of composite resin material and polymerization mode on the mean color differences (ΔE_{00}) of specimens over time. The results are summarized in Table 2.

The ΔE_{00} values ranged from 0.93 to 11.74 after 30 days of exposure to coffee solutions, as shown in Figure 3. Mean color differences (ΔE_{00}), standard deviations, and median values for specimens polymerized using different curing modes and stained with coffee at various time intervals are presented in Table 3 and Figure 3.

The simple main effects analysis of the mixed-effects ANOVA revealed that the composite resin material had a statistically significant effect ($F(2) = 104.75$, $p < 0.001$). All materials were statistically significantly different from each other ($p < 0.001$ for all comparisons). Polymerization mode also showed a statistically significant effect ($F(1) = 117.20$, $p < 0.001$). Additionally, time demonstrated a statistically significant effect ($F(5) = 1039.95$, $p < 0.001$). Across all

Table 3. Comparisons of mean color differences (ΔE_{00}), standard deviations for specimens polymerized at different composite resin material and curing modes and stained with coffee at different times

Composite resin material	Time	Curing Modes SS	Curing Modes ST	p mat x mod x time	p material	p mat x mode	p mat x time
		$\bar{x}$ ± s	$\bar{x}$ ± s				
Omnichroma	Baseline-24 hours	3,26± 0,40^{a,A}	6,5± 1,09^{a,B}	<0.001			
	Baseline-7 days coffee	6,91± 0,32^{c,A}	7,02± 1,06^{c,A}	0.99			
	Baseline-30 days coffee	9,28± 0,96^{d,A}	8,48± 1,47^{d,A}	0.99			
	24 hours-7 days coffee	3,98± 0,84^{b,A}	0,95± 0,59^{b,B}	<0.001			
	24 hours-30 days coffee	6,24± 1,33^{a,A}	2,24± 0,85^{a,B}	<0.001			
	7days-30 days coffee	2,68± 0,78^{b,A}	1,94± 1,04^{b,A}	0.99			
p Omnichroma x mode		**<0.001**		**p**			
Vittra APS Unique	Baseline-24 hours	6,43± 0,57^{a,A}	4,63± 0,45^{a,B}	<0.001			
	Baseline-7 days coffee	10,26± 0,75^{c,A}	5,9± 0,59^{c,B}	<0.001			
	Baseline-30 days coffee	11,74± 0,85^{d,A}	9,1± 0,84^{d,B}	<0.001			
	24 hours-7 days coffee	4,28± 0,91^{b,A}	1,6± 0,12^{b,B}	<0.001	**<0.001**	**0.008**	**<0.001**
	24 hours-30 days coffee	5,65± 1,07^{a,A}	4,69± 0,74^{a,A}	0.99			
	7days-30 days coffee	1,57± 0,10^{b,A}	3,27± 0,84^{b,B}	<0.001			
p Vittra APS Unique x mode		**<0.001**		**p**			
Filtek Z250	Baseline-24 hours	3,07± 0,68^{a,A}	2,84± 0,17^{a,A}	0.99			
	Baseline-7 days coffee	5,87± 0,47^{c,A}	3,47± 0,50^{c,B}	<0.001			
	Baseline-30 days coffee	7,35± 0,60^{d,A}	5,78± 0,84^{d,B}	<0.001			
	24 hours-7 days coffee	3,17± 0,89^{b,A}	0,93± 0,42^{b,B}	<0.001			
	24 hours-30 days coffee	4,62± 0,84^{a,A}	3,02± 0,81^{a,B}	<0.001			
	7days-30 days coffee	1,55± 0,29^{b,A}	2,51± 1,00^{b,A}	0.99			
p Filtek Z250 x mode		**<0.001**					
	p time<0.001	**p mode<0.001**					
		p mod x zaman <0.001					
p mat x mod x time <0.001							

Abbreviations: $\bar{x}$: mean; s: Standard deviation. SS: Soft start, ST: Standard. *Different superscript lowercase letters in the same column indicate a statistically significant difference between time intervals within each material and curing mode (p< 0,05). *Different superscript uppercase letters in the same row indicate a statistically significant difference between curing modes within each composite resin material (p< 0,05).

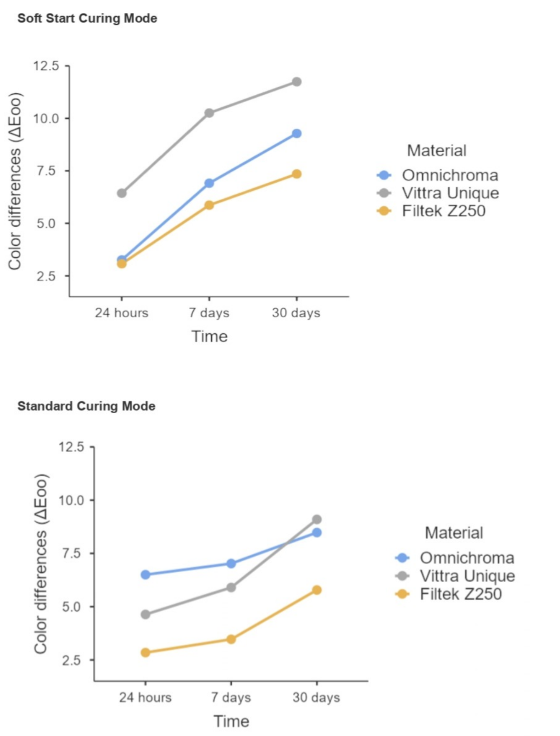

Figure 3. Time-dependent color changes of various materials with different polymerization modes

materials and polymerization modes, the most significant staining occurred within the first 24 hours and during the first 7 days.

There was a statistically significant interaction between the effects of composite resin material and polymerization mode ($F(2) = 5.12$, $p = 0.008$). The variability in values across materials differed between polymerization modes. Additionally, there was a statistically significant interaction between the effects of composite resin material and time ($F(10) = 31.34$, $p < 0.001$). All materials exhibited statistically significant increases in color change over time, regardless of the polymerization mode (Table 3 and Figure 3).

There was a statistically significant interaction between the effects of polymerization mode and time ($F(5) = 89.32$, $p < 0.001$). The changes over time differed between polymerization modes, regardless of the material. Additionally, a statistically significant three-way interaction was observed between composite resin material, polymerization mode, and time ($F(10) = 44.94$, $p < 0.001$). For all three materials, polymerization modes demonstrated significant interactions with time ($p < 0.001$ for all comparisons).

For the Omnichroma material, polymerization modes showed significant differences at all time points except for Baseline–7 days, Baseline–30 days, and 7 days–30 days. For the Vittra APS Unique material, significant differences were observed at all time points except for 24 hours–30 days. In the Filtek Z250 material, polymerization modes showed significant differences at all time points except for Baseline–24 hours and 7 days–30 days (Table 3).

Based on the comparisons between Baseline–30 days, Vittra APS Unique samples cured with the SS mode exhibited the highest staining, while Filtek Z250 samples cured with the ST mode exhibited the least staining (Table 4).

After the first 24 hours, the curing mode had no statistically significant effect on staining for Filtek Z250 samples (Table 3).

When comparing measurements between Baseline–30 days, no statistical difference was observed between the curing modes in terms of staining for Omnichroma samples. However, Filtek Z250 and Vittra APS Unique samples exhibited greater staining when cured with the SS mode (Table 4).

For measurements taken between 24 hours–7 days, no statistically significant differences in staining were observed among any

Table 4. Mean color differences (ΔE_{00}), standard deviations, and significant differences for each time interval among composite resin material specimens cured using two different modes

Light Curing Mode	Soft Start			Standard		
Composite Resin Material	Omnichroma	Vittra APS Unique	Filtek Z250	Omnichroma	Vittra APS Unique	Filtek Z250
	$\bar{x} \pm s$	$\bar{x} \pm s$	$\bar{x} \pm s$	$\bar{x} \pm s$	$\bar{x} \pm s$	$\bar{x} \pm s$
Baseline-24 hours	3,26± 0,40^{A}	6,43± 0,57^{B}	3,07± 0,68^{A}	6,5± 1,09^{A}	4,63± 0,45^{B}	2,84± 0,17^{C}
Baseline-7 days coffee	6,91± 0,32^{A}	10,26± 0,75^{B}	5,87± 0,47^{A}	7,02± 1,06^{A}	5,9± 0,59^{A}	3,47± 0,50^{B}
Baseline-30 days coffee	9,28± 0,96^{A}	11,74± 0,85^{B}	7,35± 0,60^{C}	8,48± 1,47^{A}	9,1± 0,84^{A}	5,78± 0,84^{B}
24 hours-7 days coffee	3,98± 0,84^{A}	4,28± 0,91^{A}	3,17± 0,89^{A}	0,95± 0,59^{A}	1,6± 0,12^{A}	0,93± 0,42^{A}
24 hours-30 days coffee	6,24± 1,33^{A}	5,65± 1,07^{AB}	4,62± 0,84^{B}	2,24± 0,85^{A}	4,69± 0,74^{B}	3,02± 0,81^{A}
7days-30 days coffee	2,68± 0,78^{A}	1,57± 0,10^{A}	1,55± 0,29^{A}	1,94± 1,04^{A}	3,27± 0,84^{B}	2,51± 1,00^{AB}
	p mat x mod x time <0.001					

Abbreviations: $\bar{x}$: mean; s: Standard deviation. SS: Soft start, ST: Standard. *Different superscript letters in the same row indicate a statistically significant difference among composite resin materials within the same curing mode (p< 0,05).

composite resin materials for either curing mode. Similarly, no significant differences were observed for measurements taken between 7–30 days among materials cured with the SS mode (Table 4).

Discussion

Color stability is a key factor affecting the esthetic outcome of composite restorations providing dentists' and patients' satisfaction. Changes in color over time can be attributed to the material itself as well as the factors associated with dental practitioners such as curing light intensity, ignoring the manufacturer recommendations, or poor isolation revealed during the application procedure. Also, the dietary habits of patients with partially frequent/long-lasting consumption of discoloring beverages might result in surface staining. In this context, the time during which the restorations are exposed to staining beverages should also be considered.

Two null hypotheses were tested in the present study. The first null hypothesis stated that there was no difference between restorative materials in terms of color stability against staining, regardless of curing modes while the second null hypothesis stated that regardless of the restorative material, the curing mode used, does not affect staining. According to the findings of the study, the staining amount resulting from exposure to the colorant varied according to the material and the curing mode affected the staining in all time intervals except the first 24 hours. Therefore, both null hypotheses were rejected.

In the field of dentistry, precise measurement of color differences is critical for assessing dental restorative materials. The CIELAB (ΔE_{ab}) formula is a commonly employed method that quantifies color using three spatial coordinates: L* (lightness), a* (red-green axis), and b* (yellow-blue axis). This model has been foundational in color difference evaluation. However, the CIEDE2000 (ΔE_{00}) model offers an enhanced approach by incorporating factors such as lightness, chroma, and hue, alongside weighting functions that adjust for perceptual non-uniformities. Crucially, ΔE_{00} includes an interaction term that accounts for the interplay between chroma and hue differences, which better reflects the shade differences as recognized by the human eye compared to the CIELAB formula. Consequently, the CIEDE2000 formula provides a superior correlation between visually perceived color differences and mathematically calculated values.[13] In light of these advantages, the CIEDE2000 color difference formula was selected for data evaluation in our study.[14,15] Establishing perceptual and receptive thresholds for color differences is crucial for effectively interpreting and assessing clinical outcomes. Specifically, perceptibility thresholds (PT) and acceptability thresholds (AT) for clinical judgment have been defined based on color difference values. For the CIEDE2000 model, PT and AT values are set at 0.8 and 1.8, respectively. In the present study, the color changes observed in materials following staining challenges were not found to be within the acceptable range according to these thresholds.

During an ST light-cure application with an immediate application of full light power intensity, the gel point typically occurs in 1.5-2 seconds. The most crucial period for stress decrease is in the initial seconds after polymerization begins, as this is when the culminant adhesive bond strength is still forming. Consequently, delaying the attainment of the gel point can slow down the development of stress by extending the viscous phase, allowing for greater flow capability and resulting in a decreased definite polymerization stress.[16,17] The SS curing mode is an alternative technique that gradually increases light intensity over the first few seconds before maintaining maximum intensity for the rest of the curing process. Previous studies demonstrated SS light curing technique results in relatively lower polymerization shrinkage stress, but this effect depends on the restorative material type.[16,18–20] However, modifying the light intensity may decrease the degree of cure in relatively deeper cavities[21] leading to the remaining of unreacted monomers. In the present study, the greater color change observed in the SS groups following staining challenges can be attributed to the under-polymerization of the restorative materials. This under-polymerization likely leads to increased water absorption and the solubility of the unreacted monomer, rendering the materials more susceptible to staining. These findings are consistent with previous research indicating that the curing mode can significantly impact the staining susceptibility of restorative materials.[10,11] Furthermore, our study corroborates the findings of Ozan et al. demonstrating that the curing mode did not influence the degree of staining within the first 24 hours.[10] This similarity underscores that despite the different polymerization methods, neither approach could maintain clinically acceptable color stability over time. However, another study demonstrated that polymerization time has no effect on the amount of color change of one-shade or multi-shade composites.[22] The absence of difference in terms of discoloration could be attributed to variations in curing time rather than the curing mode. Interestingly, samples subjected to the energy drink maintain clinically acceptable color stability for 7 days under certain protocols applied in the aforementioned study.

The results of the present study revealed that the color change was material dependent. Therefore, it should be considered that single-shade restorative materials tested in the present study were declared to have innovative and unique content by manufacturers. Omnichroma (Tokuyama Dental, Tokyo, Japan) was introduced as the first one-shade composite resin material claimed to adapt to all tooth shades within the 16 VITA classic colors, from A1 to D4, due to its uniformly sized supra-nano spherical filler (260 nm spherical SiO_2-ZrO_2) combined with Smart Chromatic Technology.[23] Vittra APS Unique (FGM, Joinville, SC, Brazil), is a one-shade universal composite that mimics the shade of the dental substrate during the polymerization process and provides color imitation thanks to the chromatic reflection properties of the composite. The manufacturer declares that the exclusive APS Technology (Advanced Polymerization System) provides shadow transmission and mirroring esthetics by more transparent photoinitiators. Specifically, the overall color change for Filtek Z250 (3M ESPE, St Paul, MN, USA), was lower compared to Omnichroma (Tokuyama Dental, Tokyo, Japan) and Vittra (FGM, Joinville, SC, Brazil). This superior staining resistance of Filtek Z250 (3M ESPE, St Paul, MN, USA), can be attributed to its formulation, which does not include Triethylene glycol dimethacrylate (TEGDMA). In contrast, both Omnichroma (Tokuyama Dental, Tokyo, Japan) and Vittra (FGM, Joinville, SC, Brazil), contain TEGDMA, a component known to increase water absorption and thus susceptibility to staining. These findings are consistent with other studies that have reported Filtek Z250 (3M ESPE, St Paul, MN, USA), to be more color-stable due to its use of a hydrophobic resin system, which results in lower water sorption rates and consequently better resistance to staining.[24] In contrast, another study evaluated the color stability of different restorative materials and demonstrated a relatively higher tendency for staining of Filtek Z250 (3M ESPE, St Paul, MN, USA).[25] This controversial finding could be attributed to the difference between coloring beverages used in the study and restorative control materials.

The difference in filler size among Filtek Z250 (3M ESPE, St Paul, MN, USA), Omnichroma (Tokuyama Dental, Tokyo, Japan), and Vittra (FGM, Joinville, SC, Brazil) may have influenced their surface smoothness. Materials with nano-sized fillers, such as Omnichroma (Tokuyama Dental, Tokyo, Japan) and Vittra (FGM, Joinville, SC, Brazil), are generally thought to achieve a smoother surface compared to microhybrid restoratives like Filtek Z250 (3M ESPE, St Paul, MN, USA). However, according to the present study, this advantage in surface smoothness did not translate to a decreased tendency for staining of materials with nano-sized fillers. This suggests that despite the enhanced surface smoothness associated with nano-sized fillers, it does not necessarily improve the stain resistance of dental restorative materials.

Previous studies have reported that one-shade resin composites exposed to wine, coffee, and black tea exhibit greater color changes compared to multi-shade resin composites.[22,26–28] Only one accessed study found no difference in terms of color change among one-shade composite resin and multi-shade composite resin materials.[29] Moreover, studies compared evaluated discoloration after thermocycling protocol revealed a higher tendency to color change of one-shade composites.[27,30,31] These findings are concerning because one-shade composites are often used to quickly and effectively achieve esthetic results by matching the tooth shade. However, their tendency to become significantly discolored over time implies that additional interventions may be necessary to maintain the esthetic functions of the material. On the other hand, it is important to note that due to the limited number of brands of one-shade and multi-shade materials used in this study, making a general judgment regarding the performance of one-shade versus multi-shade composites would be premature. The staining of composite resins is influenced by a variety of factors beyond the resin matrix and filler type, including the composition of activators, inhibitors, and initiators. Therefore, further research involving a broader range of materials is required to draw more definitive conclusions about the impact of shade variability on staining.[32]

In studies evaluating the color stability of restorations, the oral environment is typically simulated using various colorants such as coffee, wine, and energy drinks. However, these study designs have limitations and are insufficient to fully replicate real oral conditions. Factors such as brushing frequency, abrasion due to the kinds of toothpaste used, and nutrition involving hard foods cannot be adequately simulated in experimental conditions, yet they can significantly impact the staining of restorations. Ozan et al.[10] reported that while brushing can reduce superficial staining caused by substances like tea and cola, it is not effective in completely removing these stains. Conversely, brushing with abrasive dentifrices can deteriorate the surface smoothness of restorations, potentially leading to increased staining. On the other hand, one-shade composites showed comparable performance to multi-shade composites in terms of color stability after aging in samples that underwent brushing simulation.[31] Therefore, it is important to acknowledge that accurately replicating the dynamic conditions of the oral cavity in study designs is virtually impossible.

Conclusion

In alignment with earlier studies, our results reinforce the notion that both curing modes failed to achieve the desired color stability in all tested restorative materials, suggesting a need for improved techniques or materials that can better withstand staining challenges.

Ethical Approval

Ethical approval was not required for this study.

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Critical Review : K.Y. , B.E.

Conflict of Interest

The authors declare no competing interests.

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