Original Article

Color stability of bulk-fill and conventional composite resins following exposure to different mouthrinses: an in vitro study

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Abstract

Objective: The efficacy of composite restorations depends on their color stability, with discoloration cited as a principal reason for restoration replacement. The current investigation focused on assessing the influence of various mouthrinses on the color stability of conventional and bulk-fill composites.

Methods: In this in vitro study, 40 samples (4 mm in diameter and 4 mm in thickness) were constructed from Tetric N-Ceram and Tetric N-Ceram Bulk Fill composites (both from Ivoclar Vivadent). The initial color value of each specimen was recorded using an Easyshade spectrophotometer, in adherence with the CIELab color scale. Subsequently, the specimens were submerged in 20 mL of either distilled water or different mouthrinses including non-alcohol Misswake, alcohol-containing Listerine, or chlorhexidine. After incubating for 24 hours at 37°C, color values were measured again. The data were analyzed by two-way ANOVA, and a P-value<0.05 was considered statistically significant.

Results: Tetric N-Ceram demonstrated superior color stability compared to the Tetric N-Ceram Bulk Fill composite after immersion in non-alcoholic Misswake and alcohol-containing Listerine mouthwashes (P<0.05). In both composites, chlorhexidine exhibited the most pronounced color change (P <0.05). The color change was significantly greater in the alcohol-containing Listerine than in the non-alcoholic Misswake mouthrinse (P<0.05).

Conclusions: This study suggests that mouthrinses, especially chlorhexidine, significantly affect the color stability of both composite types, with conventional composites showing relatively more resistance to color change than bulk-fill composites. (*J Dent Mater Tech 2023;12(2): 98-103)*

Keywords: Chlorhexidine, Color Stability, Composite resin, Discoloration, Mouthrinse

Introduction

The visual appeal of tooth-colored, resin-based materials is paramount in dentistry. However, the esthetic outcome of these restorations can be compromised by discoloration due to both intrinsic and extrinsic factors. Intrinsic factors include changes in the resin matrix itself or interaction at the interface between the matrix and the fillers, leading to alterations in the overall color of the restoration (1). Extrinsic discoloration, on the other hand, arises from the absorption of colorants from exogenous sources such as food, drink, smoking, and oral hygiene products including mouthrinses (2). Despite recent technological advancements in composite production, such as the increase in filler content, reduction in filler particle diameters, and enhancement of hydrophobic properties, the issue of color stability in composites persists as a significant challenge (3).

Bulk-fill composites have emerged in recent years and become a popular type of resin-based composites. This popularity stems from their simplified procedure in performing posterior restorations., allowing filling in a single increment, reduced polymerization shrinkage stress, and improved depth of cure (4). They also possess superior light transmission properties due to the scattering of light at the filler-matrix interface, through reducing filler content or increasing filler size. Additionally, they offer a time-saving restorative option compared to traditional composites applied with a multi-incremental layering technique (5).

It has been suggested that the impact of intrinsic factors on the color stability of fully polymerized composite resin materials is minimal, as no significant color changes were observed after water immersion (3). Therefore, the focus has shifted to extrinsic discoloration

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Accepted: 19 April 2023. Submitted: 6 December 2022.

as the key factor that influences the color stability and long-term success of composite resin restorations (6). Notably, the use of mouthwash is a key contributor to the multifactorial etiology of composite discoloration. Ingredients such as substances with low pH, alcohol, emulsifiers, and organic acids found in mouthrinses may compromise the color stability of composites and lead to surface degradation. Previous studies have indicated varying degrees of color change in different types of composites after immersion in mouthrinses (7, 8).

It has been demonstrated that the rate of discoloration in bulk-fill composites is more significant than in conventional composites (5). This is possibly due to the presence of minute pores and the high adsorption of colorants in these composites, leading to discoloration on or beneath the surface (9, 10). However, determining how different beverages and mouthrinses affect the color of these materials, merits further research. Therefore, the objective of this study was to explore the impacts of various mouthrinses on the color stability of conventional and bulk-fill composites.

Materials and Methods

This experimental study was conducted with approval from the Ethical Committee of Ardabil University of Medical Sciences, Ardabil, Iran (IR.ARUMS.REC.1399.298).

Sample Preparation

A total of eighty disc-shaped specimens were prepared from two resin composites, Tetric N-Ceram and Tetric N-Ceram Bulk Fill (both A2, Ivoclar Vivadent), using a polyethylene mold measuring 4 mm in diameter and 4 mm in thickness (11). The composite resins were injected into these molds, slightly overfilled, and placed between two glass plates. Excess material was discarded by applying pressure using a glass slide. The conventional composite was applied in a 2 mm increment to achieve effective light penetration, whereas the bulk-fill composite was inserted to a thickness of 4 mm.

Curing and Polishing

The upper surfaces of all samples were cured for 20 seconds using an LED light-curing device (1,000 mW/cm2; Ivoclar Vivadent AG, Schaan, Liechtenstein, Germany) under standardized conditions. Before curing, the power of the device was verified with a radiometer (SDI Ltd, VIC, AUS). After curing, each specimen was polished using a fresh set of polishers (Sof-Lex, 3M ESPE, St. Paul, SM, USA), rinsed with water for 10 seconds to eliminate debris, and incubated at 37°C in 100% humidity for 24 hours.

Intervention Groups

Specimens were distributed into four groups (n=10) and submerged in either distilled water or different mouthrinses including non-alcoholic Misswake (Silaneh Sabz, Co., Iran) chlorhexidine (Donyaye Behesht pharmaceutical center, Iran), and alcohol-containing Listerine (TOTAL CARE, Johnson & Johnson S.p.A., Pomezia, Italy). Specimens were immersed in 15 ml of their respective solutions and incubated for 24 hours at 37°C to mimic two years of twice-daily mouthrinse application. The solutions were agitated every three hours for consistency.

Measurements

Baseline color measurements were recorded by a single operator using a calibrated digital spectrophotometer (VITA Easyshade® Advance, Vita Zahnfabrik, Bad Säckingen, Germany). The device was positioned perpendicularly to the surface of the composite resin, with samples set against a white background to eliminate external light interferences. The CIELab (Commission Internationale de L'Eclairage) color space coordinates were used to quantify color stability.

Following the 24-hour immersion, color measurements were replicated. The color change between post-immersion and baseline measurements (ΔE) was determined using the following formula:

$\Delta E= [\Delta L^2 + \Delta a^2 + \Delta b^2]$ ½

Statistical analysis

The data were analyzed by SPSS, version 22. The normal distribution of the data was verified using the Kolmogorov–Smirnov test ($P>0.05$). Two-way ANOVA was run and showed a significant interaction between the two variables ($P<0.05$). Therefore, One-way ANOVA and independent sample t-test were performed to ascertain significant differences in discoloration between the various media and the two composites, respectively. Bonferroni posthoc test was conducted to validate the significance of the discoloration resulting from different media in individual groups. The threshold for statistical significance was set at a p-value < 0.05.

Results

Table 2 presents the descriptive data of color change values after exposure to various mouthrinses in the two composite materials. A statistically significant difference was observed in the ΔE values between different media for both conventional and bulk-fill composite resins ($P<0.001$). In both groups, distilled water incited the

Table 1. The characteristics of composite resins used in this study

Material	Initial Shade	Base resin	Filler (wt/vol%)	Manufacturer
Tetric N-Ceram	A2	Bis-GMA, Bis-EMA, UDMA	81/57	Ivoclar Vivadent, Schaan, Liechtenstein
Tetric N-Ceram Bulk Fill	A2	Bis-GMA, Bis-EMA, UDMA	77/55	Ivoclar Vivadent, Schaan, Liechtenstein

Table 2: Mean and standard deviation (SD) of color change (ΔE) values in Tetric N-Ceram and Tetric N-Ceram bulk-fill composites after immersion in different media

Resin composite	Mouthrine				
	Distilled water	Non-alcoholic Misswake	Alcohol-containing Listerine	Chlorhexidine	*P*-value
Tetric N-Ceram	0.65±0.33[a]	1.46±0.41[b]	2.11±1.37[c]	3.64±0.29[d]	<0.001
Tetric N-Ceram Bulk Fill	0.90±0.20[a]	2.28±0.35[b]	3.71±0.65[c]	4.44±1.34[d]	<0.001
P-value	0.183	0.01	0.047	0.227	

*The groups that have been defined by different lowercase letters indicate statistically significant differences at P<0.05.

least change, followed by non-alcoholic Misswake, alcohol-containing Listerine, and finally, chlorhexidine, which caused the most significant color shift. This ranking of color alterations was confirmed to be statistically significant (P<0.05; Table 2).

Comparison of color change between the two composites revealed a significantly higher color change in bulk-fill than the conventional composite after immersion in non-alcoholic Misswake and alcohol-containing Listerine mouthwashes (P <0.05; Table 2). However, the difference in color stability between the two composites was not significant after immersion in distilled water and chlorhexidine mouthwash (P=0.183 and P=0.227, respectively; Table 2).

Discussion

Discoloration in composite resins can occur due to various factors, including water absorption, the hydrophilicity of the resin matrix, and the adsorption of pigments by the organic phase of composites (12). The increased refractive index of the filler and matrix due to water absorption can contribute to the material's susceptibility to discoloration (12). Additionally, the behavior of composites is influenced by their chemical compounds, including monomers, polymer configuration, and degree of conversion (13). It has been observed that hydrophilic materials tend to exhibit higher water absorption, making them more susceptible to color changes caused by dye infiltration compared to hydrophobic materials (14).

The results from our study revealed that the Tetric N-Ceram composite exhibited a lower degree of discoloration (ΔE) compared to the Tetric N-Ceram Bulk Fill composite. This difference was significant for non-alcoholic Misswake and alcohol-containing Listerine mouthwashes, whereas no significant difference was found between the two composites after immersion in distilled water or chlorhexidine mouthwash.

Several factors can contribute to the color stability of conventional composites compared to bulk-fill composites. These include the use of larger filler content, lower resin volumes, and reduced utilization of camphorquinone amine (15). The optical properties of bulk-fill composites can be influenced by factors like the content of photoinitiators, the level of translucency, and the type of fillers (16). It has been noted that the presence of high levels of camphorquinone, along with an amine initiator can result in undesired oxidative color changes in resin composite formulations (17). Furthermore, alterations in the filler type to enhance the depth of light transmission and translucency can lead to variations in the optical properties of bulk-fill composites (18). In addition, modifications in the monomer system can affect the formation of cross-networks, reducing stress during polymerization and subsequently impacting the optical properties of bulk-fill composites (19). Cavalcanti et al. (20) showed that filler size and density in composites can influence the resistance to discoloration, with smaller size and higher density conferring a smoother and more color-resistant composite material. The fillers' volume and weight in bulk-fill composites are marginally higher than in conventional composites, potentially contributing to greater color change (21).

In the present study, the hierarchy of color changes after immersion in different solutions was similar for both composite resins. Distilled water incited the least change, followed by non-alcoholic Misswake, alcohol-containing Listerine, and finally, chlorhexidine, which caused the most significant color shift. The color changes observed after immersion in distilled water were found to be clinically acceptable, indicating that water intake itself does not significantly impact the color of composites (21-23).

In the present study, the rate of discoloration was highest after exposure to the chlorhexidine mouthrinse in both conventional and bulk-fill composites. This is consistent with the findings of Musalli et al. (24), who evaluated the color stability of porcelain and demonstrated the highest ΔE values in chlorhexidine, followed by Listerine and distilled water. The mechanisms explaining the origin of chlorhexidine-induced discoloration are multifactorial and complex, involving non-enzymatic Maillard reactions, interactions with metal pigments, and reactions with food products (25).

The presence of alcohol in mouthrinse is another potential influencing factor in composite color change. In this study, the color change in both composites was significantly greater in the alcohol-containing Listerine compared to the non-alcoholic Misswake mouthrinse. Nasoohi et al., (26) indicated that the use of an alcohol-containing mouthrinse resulted in more discoloration in composite resins than that of the non-alcohol mouthrinse. Ceci et al. (27) noted that the solubility of composite in zero-alcohol mouthrinse is lower than in an alcohol-containing mouthrinse. Another study demonstrated the compromised mechanical properties of composites in alcohol-containing solutions (28). It is believed that alcohol-containing mouthrinses may reduce the surface integrity of resin composites, promote degradation of organic components, and impact staining resistance (22). Therefore, alcohol-free mouthrinses might be preferable for patients with extensive composite restorations.

In contrast to the outcomes of this study, there is some evidence suggesting that the efficacy of alcohol-containing and zero-alcohol mouthrinses does not significantly differ (29). The discrepancy in the reported effects of mouthrinses on composite discoloration might be attributed to the variations in the composition of mouthrinses, different fluoride concentrations, and differences in experimental procedures, such as the absence of surface polishing in some studies (21).

Color stability should be recognized as a key attribute of aesthetic restoration, and its consideration should be integrated into the decision-making process when selecting restorative materials (30). The findings of this study can guide dental practitioners to make informed clinical decisions regarding material selection and prescribing mouthrinses for patients. These findings should be interpreted with the consideration that clinical conditions may be different from those of in vitro experiments. Salivary agents in the oral environment may form a protective pellicle on the surface of composite restorations and reduce the degree of discoloration by diluting or neutralizing the pH of mouthrinse solutions (25).

The present study did not employ aging methods to simulate the impacts of chewing or thermal cycles that occur in oral conditions. Only two types of composite resins were tested, which may limit the ability of these results to be extrapolated to other composite materials. Future studies may benefit from testing a broader variety of composites and commercial mouthrinses in samples subjected to thermocycling and mechanical loading cycles**.** Future in vivo studies are also suggested to validate the findings of this study under clinical conditions.

Conclusions

This in vitro study demonstrated that both the type of composite resin and the type of mouthrinse significantly influenced the degree of discoloration. Generally, Tetric N-Ceram demonstrated superior color stability compared to the Tetric N-Ceram Bulk Fill composite. Among mouthrinses, chlorhexidine caused the most severe color change and distilled water the least. The degree of discoloration was significantly greater in non-alcoholic Misswake than in alcohol-containing Listerine for both composite types.

Acknowledgments

The authors would like to thank the Vice President for Research of Ardabil University of Medical Sciences for support of this project.

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