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Staining Microhybrid Composite Resins With Tea and Coffee

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Abstract

Background: Color change is one major drawback of tooth-colored resin-based restorations.
Objectives: This study aimed to assess the color stability of three commonly used resin-based restorative materials upon exposure to tea and coffee.
Materials and Methods: Discs were fabricated from Spectrum TPH (Dentsply/Caulk), Denfil (Vericom), and Filtek Z250 (3 M) microhybrid composites and immersed in coffee and tea solutions for two hours on the first day and the whole of the second, third, and fourth days. The color was assessed visually and recorded using the Lobene Stain Index after each period of immersion. The color change of the three composite resins was compared using the Kruskal-Wallis test, Mann-Whitney U test, and Friedman test. The level of significance was set at 0.05. The Cohen's Kappa was also calculated to assess inter-rater agreement.
Results: The three composite resins showed statistically significant color changes after four days of immersion in a coffee solution ($P = 0.014$), but their color change in the tea solution was not significant ($P > 0.05$). A comparison of color changes in the composites after one (two hours) and four days of immersion in tea and coffee solutions revealed a significant difference in color changes between Spectrum TPH and the other two composites ($P < 0.001$).
Conclusions: The three microhybrid composites used in this study showed variable color stability upon exposure to a coffee solution. The color stability of Spectrum TPH was inferior to that of Denfil and Filtek Z250.

Keywords: Composite Resins, Composite Resins, Color, Discoloration

1. Background

In recent years, great advances have been made in dentistry, and research is ongoing to develop more efficient techniques and materials to enhance patient treatment. On the other hand, the demand for esthetic restorations has increased greatly (1). Aside from the function of restorations, esthetics is of the utmost importance to most patients due, to its positive psychological effects on self-esteem (2). With the increased demand for tooth-colored restorations, composite resins have become widely popular in aesthetic dentistry, owing to their favorable physic-mechanical and aesthetic properties (3).

Matching the initial shade of an uncured composite resin to that of adjacent natural teeth is a fundamental but challenging task in aesthetic dental practice (3). Composite resin restorations can often be made to match the natural tooth color, thanks to the availability of a wide spectrum of color shades. Moreover, microfilled and nanofilled composite restorations often have a good surface finish and smooth texture, giving a more natural appearance to restorations. Once an acceptable match is obtained, the color match should, ideally, be maintained after polymerization (4, 5).

The success of composite resin restorations depends highly on their color stability and the finishing and polishing of their surface (6, 7). However, discoloration after prolonged service in the oral environment remains a major problem, causing color mismatch, consequent patient dissatisfaction, and eventually additional costs for replacement of the restoration (8, 9).

Many factors in the oral environment can cause extrinsic discoloration of composites, such as exposure to mouth rinses and the consumption of acidic or coloring foods and drinks (10, 11). Tea, coffee, and soft drinks are highly popular drinks in today's world, especially in industrialized countries. It has been demonstrated that surface discolorations in composite resins are related to hygiene and eating habits, as well as smoking status (12). Maintaining the esthetics of a restoration is therefore related to the patient's habits and lifestyle (1). The physical properties of restorations are also influenced by the chemical environment of the oral cavity (13). Intrinsically, the structure of the resin matrix and characteristics of the filler particles in the composition of composite resins have a direct impact on surface roughness and susceptibility to extrinsic staining (14). Garoushi et al. showed that the physicochemical reactions occurring in deeper layers of the restoration could cause intrinsic stains (15). According to the literature, the color stability of composite resins directly relates to the size, type, and volume of fillers, the type of matrix and monomer, the degree of polymerization, and water sorption (15-18).

The color stability of esthetic dental materials is often paid less attention, compared to other physical and mechanical properties when choosing a tooth-colored dental material (19).

2. Objectives

The aim of this study was to compare the staining resistance of three commonly used composite resins, namely Spectrum TPH (Dentsply/Caulk), Denfil (Vericom), and Filtek Z250 (3 M) following immersion in tea and coffee solutions.

3. Materials and Methods

Three microhybrid composites were evaluated in this in-vitro experimental study, namely Spectrum TPH (Dentsply/Caulk), Denfil (Vericom), and Filtek Z250 (3 M). The composition of the composite resins is shown in Table 1. The "A2" shade of the three composite resins was used, and they were coded as A, B, and C by an individual blinded to the study. The sample size was calculated to be ten specimens in each group of composite, according to a similar study (20). Thirty specimens were fabricated (10 from each composite resin) measuring 10 mm in length, 10 mm in width, and 2mm in thickness. The specimens were immersed in tea and coffee solutions for two hours on the first day and for the whole of the second, third, and fourth days. For the fabrication of specimens, a rectangular piece of wax measuring 10 × 10 × 2 millimeters (dimensions of composite specimens) was cut out of a dental wax sheet (Changsha Zhongbang Medical Instrument Co., Ltd., Hunan, China) (Figure 1). A box was also fabricated with a dental wax sheet with 20 × 20 × 30 mm dimensions. The rectangular wax piece was placed and sealed onto the floor of the prepared box. Dental stone was mixed and poured into the box and allowed to set. Wax walls were removed, yielding a gypsum mold. Composite resin was applied to the mold to fill it, and a glass slab was placed on top of it to obtain a smooth, flat surface. Each 5 mm portion of the composite was light-cured for 20 seconds using the overlapping technique. The composite specimen was then removed from the mold and light-cured from the bottom to ensure complete polymerization. Fabricated specimens were polished by the same operator using Shofu Polishing disks from coarse to fine grit (Shofu Dental Corporation, CA, USA) (Figure 1), according to the manufacturer's instructions. A total of 30 specimens were fabricated, ten from each composite. Of the ten specimens in each group, five were immersed in a tea solution, and five in a coffee solution.

Table 1. Studied Composites and Their Composition

Composite	Spectrum TPH	Denfil	Filtek Z250
Matrix	BisGMA, TEGDMA, BisEMA	BisGMA, TEGDMA	BisGMA, UDMA, BisEMA
Filler content	Boro-silicate/aluminum barium and silica	Barium aluminosilicate, Fumed silica	Zirconia/silica
Type	Microhybrid	Microhybrid	Microhybrid
Shade	A2	A2	A2
Filler % in mass	77	80	82
Manufacturer	Dentsply/Caulk	VERICOM	3 M ESPE

Tea solution: Four grams of dry tea (Ahmad, Tehran, Iran) was added to 500 mL of boiling water and brewed for four minutes. The solution was then allowed to cool to room temperature, approximately 37 ± 1°C.

Coffee solution: Four grams of coffee (Nescafe, Nestle, Switzerland) was added to 500 mL of boiling water and brewed for four minutes. The solution was then allowed to cool to room temperature, approximately 37 ± 1°C.

Five specimens fabricated of each composite were immersed in the tea solution for two hours (120 minutes) on the first day, and for the whole of the second, third, and fourth days (4.440 minutes), corresponding to weeks and months of exposure in the clinical setting, depending on the amount of consumption. The solution was refreshed every 24 hours.

After each period of immersion (after two hours, at the end of the second day, at the end of the third day, and at the end of the fourth day), specimens of each group were removed from the solutions, rinsed under running water for 20 seconds, and dried with a paper towel before stain measurement. Stains were assessed visually by two examiners (restorative dentists) with an inter-examiner reliability of 82%. The observers were blinded to the group allocation of specimens and assessed the amount of stains under constant light conditions using the Lobene Stain Index, which

Figure 1. A, Wax box; B and C, Fabrication of Gypsum Mold

is a four-point scale (21):

0 = No stain;

1 = Light stain (yellow to light brown or gray);

2 = Moderate stain (medium brown);

3 = Heavy stain (dark brown to black);

Nonparametric tests were performed. The Kruskal-Wallis test was applied to compare the color change of composites following each immersion period in the two solutions, and to compare solutions on the first and fourth days of immersion. Pairwise comparisons of composites on the first and fourth days of immersion were performed by the Mann-Whitney U test. The color change of each composite, based on the immersion period and solution type, was compared using the Friedman test. The level of significance was set at 0.05.

Considering the qualitative nature of the dependent variables, Cohen's kappa was used to assess inter-rater agreement between the observers. This coefficient was measured by scoring 20 specimens twice and was calculated to be 0.694. The acceptable rate for this coefficient in medical literature is more than 0.6. Therefore, the reliability of our data was confirmed.

Table 2. Color Changes of the Three Composites Following Each Immersion Period in the Tea Solution (Kruskal-Wallis Test)

Time/Material	Mean Rank	P Value
First day (2 hours)		1.000
Spectrum TPH	8.00	
Denfil	8.00	
Filtek Z250	8.00	
Second day		1.000
Spectrum TPH	8.00	
Denfil	8.00	
Filtek Z250	8.00	
Third day		1.000
Spectrum TPH	8.00	
Denfil	8.00	
Filtek Z250	8.00	
Fourth day		0.368
Spectrum TPH	9.00	
Denfil	7.50	
Filtek Z250	7.50	

4. Results

Comparisons of the color changes of composites following each immersion period in the tea solution using the Kruskal Wallis test revealed no statistically significant difference in color change among the three composites (Table 2).

As seen in Table 3, a comparison of the color changes of composites following each immersion period in the coffee solution revealed no statistically significant difference between the three composites after the first (two hours) and third days of immersion ($P > 0.05$). However, the color change among the three composites was significantly different following the second and fourth days of immersion ($P = 0.026$ and $P = 0.014$, respectively) (Table 3).

A comparison of the color change among the three composites at the first (two hours) and fourth days of immersion in the tea solution revealed no significant differences ($P > 0.05$). Color changes among the three composites at the first (two hours) and fourth days of immersion in the coffee solution revealed significant differences ($P = 0.014$) (Table 4).

Pairwise comparisons of the color changes of the three composites after the first (two hours) and fourth days of immersion in tea and coffee solutions revealed that the color change in Spectrum TPH was significantly greater than that observed in Denfil and Filtek Z250 ($P = 0.032$ and $P = 0.016$, respectively). However, the color change in Denfil and Filtek Z250 was not significantly different ($P > 0.05$)

Table 3. Color Changes of the Three Composites Following Each Immersion Period in the Coffee Solution (Kruskal-Wallis Test)

Time/Material	Mean Rank	P Value
First day (2 hours)		1.000
Spectrum TPH	8.00	
Denfil	8.00	
Filtek Z250	8.00	
Second day		0.026
Spectrum TPH	11.50	
Denfil	7.00	
Filtek Z250	5.50	
Third day		0.727
Spectrum TPH	8.50	
Denfil	8.50	
Filtek Z250	7.00	
Fourth day		0.014
Spectrum TPH	12.30	
Denfil	6.40	
Filtek Z250	5.30	

Table 4. Comparison of the Color Stability of Composites at the First and Fourth Days of Immersion in Tea and Coffee Solutions (Kruskal-Wallis Test)

Solution/Time/Material	Mean Rank	P Value
Tea		.368
First day-fourth day		
Spectrum TPH	9.00	
Denfil	7.50	
Filtek Z250	7.50	
Coffee		.014
First day-fourth day		
Spectrum TPH	12.30	
Denfil	6.40	
Filtek Z250	5.30	

(Table 5).

A comparison of each composite brand and each solution following the immersion periods revealed that none of the three brands experienced any color change during the four days of immersion in the tea solution ($P > 0.05$). However, all three brands experienced color changes following immersion in the coffee solution, and the color change in the Spectrum TPH sample was significantly higher than that in the remaining two composites ($P < 0.001$). Denfil and Filtek Z250 showed almost similar,

Table 5. Pairwise Comparisons of the Color Stability of the Three Composites at the First and Fourth Days of Immersion (Mann-Whitney U Test)

Time/Material	Mean Rank	Sum of Ranks	P Value
First day-fourth day			0.032
Spectrum TPH	7.60	38.00	
Denfil	3.40	17.00	
First day-fourth day			0.016
Spectrum TPH	7.70	38.50	
Filtek Z250	3.30	16.50	
First day-Fourth day			0.690
Denfil	6.00	30.00	
Filtek Z250	5.00	25.00	

and less significant, color change compared to Spectrum TPH ($P < 0.001$) (Table 6).

5. Discussion

This study was carried out to assess the color stability of three popular composite resins after immersion in tea and coffee solutions for specific periods.

The findings of the current study showed that the coffee solution caused significantly greater color change, compared to the tea solution, which is in agreement with the results of Mundim et al. who evaluated the effect of coffee and cola drinks on the color stability of microhybrid (Filtek Z250) and hybrid (Surefil) composites and showed that coffee caused greater color changes in all composites (1). Um and Ruyter evaluated the staining of resin-based veneering materials due to exposure to coffee and tea solutions and reported that discoloration of materials due to immersion in tea solution was mainly due to the surface adsorption of colorants, while coffee caused discoloration due to adsorption and the absorption of coloring agents. They believed that penetration and absorption of coloring agents into the organic phase of veneering materials were due to the compatibility of the polymer phase with yellow coffee stains (22).

In this study, Spectrum TPH showed inferior color stability, compared to that of Denfil and Filtek Z250. This finding maybe due to a lower volume of filler particles in Spectrum TPH (77% by weight), as compared to the other two composites (Denfil = 80% by weight and Filtek Z250 = 82% by weight). According to a study by Tornavoi on color changes in composite resins (P60, Z100, and Charisma) subjected to accelerated artificial aging, Charisma (60% by volume) showed the greatest color change, compared to the other composites (P60 = 61% by volume, and Z100 = 71%

Table 6. Comparison of the Color Stability of Each Composite Following Different Immersion Periods, Based on the Type of Solution (Friedman Test)

Material/Solution/Time	Mean	P Value
Spectrum TPH		
Tea		1.000
First day	2.40	
Second day	2.40	
Third day	2.40	
Fourth day	2.80	
Coffee		0.000
First day	1.20	
Second day	2.40	
Third day	2.40	
Fourth day	4.00	
Denfil		
Tea		1.000
First day	2.50	
Second day	2.50	
Third day	2.50	
Fourth day	2.50	
Coffee		0.014
First day	1.60	
Second day	2.00	
Third day	3.20	
Fourth day	3.20	
Filtek Z250		
Tea		1.000
First day	2.50	
Second day	2.50	
Third day	2.50	
Fourth day	2.50	
Coffee		0.028
First day	1.90	
Second day	1.90	
Third day	3.10	
Fourth day	3.10	

by volume) (23). Also, in the study by Schulze et al. composite resins with lower percentages of inorganic particles showed significant color changes (24).

Another possible explanation for the inferior color stability of Spectrum TPH compared to Filtek Z250 is the presence of hydrophilic monomers in the composition of Spectrum TPH. The Spectrum TPH contains tri ethylene glycol dimethacrylate (TEGDMA), which is a hydrophilic monomer (25), whereas Filtek Z250 contains urethane dimethacrylate (UDMA), a hydrophobic monomer (26). According to Iazzetti et al. hydrophobic materials have greater color stability and stain resistance than hydrophilic materials, because of the greater solubility of hydrophilic materials (27), explaining the inferior color stability of Spectrum TPH compared to Filtek Z250 during the immersion period.

The lower color stability of Spectrum TPH compared to Denfil may be explained by its larger filler size. The distribution and size of filler particles are correlated with color stability. Composite resins with larger fillers (Spectrum 0.04 - 5 μm with 50% of particles being larger than 1.48 μm) have been shown to be more susceptible to color change following aging in water. Moreover, color perception is directly related to filler particle scattering. The filler-resin interface is the weakest point of composites, and it is highly sensitive to water sorption (28). Hydrolytic degradation of this area influences light scattering and color perception (29). Vichi et al. demonstrated that Z100, with the same composition of resin matrix as Denfil, had greater color stability compared to Spectrum TPH, which confirms our finding regarding the inferior color stability of Spectrum TPH (29).

The Lobene Stain Index was used to score the amount of stains on specimens in the current study. This index is widely used for the assessment of stainability of composite resins, and its reliability has been confirmed in many previous studies (30-35). However, this measure is subjective and may be considered a limitation of the current study. To eliminate the subjective interpretation of visual color comparison, using a spectrophotometer as a measuring instrument is recommended. Another limitation of this study was its lack of thermocycling or artificial aging procedures, to better simulate the clinical setting.

Similar studies are required involving thermocycling or other artificial aging procedures, to better simulate the clinical setting. The effect of longer exposure times on the color stability of composites needs to be investigated as well.

5.1. Conclusions

Within the limitations of this study, it can be concluded that the three microhybrid composites used herein exhibited different color stability upon exposure to coffee solutions. Coffee had the greatest effect on composites' color stability, and Spectrum TPH showed the greatest discoloration, compared to Denfil and Filtek Z250.

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Footnotes

Authors' Contribution: Study concept and design: Farkhondeh Raeisosadat and Maryam Abdoh Tabrizi; writing the manuscript: Afrooz Nakhostin; analysis and interpretation of data: Shaghayegh Hashemi Zonooz; critical revision of the manuscript: Fatemeh Raoufinejad, Bahar Javid ,Faeze Jamali Zavare.

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