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Color Difference In Composite Material After Exposure To Hot Drinks Using Spectrophotometer

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ABSTRACT

Background: Color stability is a key factor in the effectiveness of composite resin restorations. However discoloration is still a concern in composite resin restoration.
Objective: The aim of the study is to evaluate the effect of different hot drinks on the color stability of microhybrid and nanohybrid composite materials using a spectrophotometer.
Materials and Methods:A total of 80 composite resin samples were prepared using microhybrid and nanohybrid composite materials (40 microhybrid and 40 nanohybrid. The samples were immersed in four different media: milk, tea, coffee, and distilled water. Color measurements were recorded before and after immersion using a Konica Minolta CM-5 spectrophotometer based on the CIE L*a*b* color system. The color difference (ΔE*ab) was calculated to assess the degree of discoloration.
Results: All composite samples exhibited a change in color after exposure to hot drinks. Coffee caused the highest color change, followed by tea, milk, and distilled water. Nanohybrid composites showed greater color alteration compared to microhybrid composites.One nanohybrid composite sample immersed in coffee (N3) demonstrated the highest color change (ΔE*ab = 3.01), approaching the clinically unacceptable threshold.
Conclusion: Hot beverages significantly affect the color stability of composite resin restorations. Coffee produced the maximum discoloration. Nanohybrid composites were more susceptible to color change than microhybrid composites. Dietary habits should be considered when selecting restorative materials for esthetic regions.

Keywords: Composite resin, Color stability, Spectrophotometer, Hot beverages, Microhybrid composite, Nanohybrid composite

INTRODUCTION

Tooth-colored restorative materials are widely used in modern dentistry due to their durability and close resemblance to natural tooth color. The increasing demand for esthetics among patients has significantly contributed to the widespread use of these materials in restorative dentistry [1,11]. Common tooth-colored restorative materials include glass ionomer cements, composite resins, and dental ceramics. However, long-term durability and color stability remain important challenges for these materials in the oral environment [5].
Composite resins are currently among the most commonly used restorative materials because of their excellent esthetic properties, good mechanical strength, relatively low cost, and ability to bond effectively to tooth structure [1]. They are widely used in both anterior and posterior restorations because they can mimic the natural color and translucency of teeth while maintaining surface polish and appearance over time [8]. Over the past four decades, composite resins have evolved significantly and are now considered a reliable alternative to traditional restorative materials such as amalgam and gold [11].
The increasing demand for natural-looking restorations has led to the development of advanced composite materials with improved physical and optical properties. These include microhybrid and nanohybrid composite resins. Nanohybrid composites contain nanosized filler particles that enhance mechanical strength, polishability, and gloss retention while reducing wear [2,3]. These materials therefore provide excellent esthetic results, especially in anterior restorations.
Despite these advantages, composite resins are susceptible to discoloration over time. Color stability is influenced by both intrinsic and extrinsic factors. Intrinsic factors include changes in the resin matrix, filler particle characteristics, and

degradation at the filler–matrix interface [3]. Extrinsic factors include the adsorption and absorption of pigments from dietary substances such as coffee, tea, and tobacco products [6,9]. These staining agents can penetrate the resin matrix and cause noticeable color changes in composite restorations [7].

Several studies have investigated the influence of commonly consumed beverages on the color stability of restorative materials. Coffee and tea have been shown to produce significant discoloration in resin-based composites due to their strong chromogenic content [2,6,10]. Therefore, evaluating the color stability of different composite materials in commonly consumed beverages is important for predicting their long-term esthetic performance.

The aim of the present study was to evaluate and compare the color stability of microhybrid and nanohybrid composite resins after immersion in commonly consumed hot beverages such as coffee, tea, and milk.

MATERIALS AND METHODS

The present in-vitro experimental study was carried out to evaluate the color stability of microhybrid and nanohybrid composite resin materials after exposure to commonly consumed hot beverages using a spectrophotometer.

A total of 80 composite resin specimens were included in the study. Of these, 40 specimens were fabricated using microhybrid composite resin, and the remaining 40 specimens were prepared using nanohybrid composite resin. Each composite group was further divided into four subgroups of 10 specimens each, based on the immersion medium used. Subgroup 1 specimens were immersed in milk, subgroup 2 in tea, subgroup 3 in coffee, and subgroup 4 in distilled water, which served as the control.

Standardized disc-shaped specimens were prepared using custom-made molds to ensure uniform dimensions. The composite material was placed into the mold and covered with a Mylar strip to obtain a smooth surface finish. Polymerization was carried out according to the manufacturer's instructions using a light-curing unit. After curing, all specimens were finished and polished using standardized procedures to minimize surface irregularities that could influence color measurements.

Baseline color values of all specimens were recorded prior to immersion using a spectrophotometer (Konica Minolta CM-5). Color measurements were performed according to the CIE L*a*b* color system, where L* represents lightness, a* represents the red–green axis, and b* represents the yellow–blue axis.

Following baseline measurements, the specimens were immersed in their respective solutions for a period of 7 days. The immersion was carried out at 37 °C to simulate intraoral conditions. The staining solutions were replaced daily to maintain consistency and avoid saturation of the solutions. Distilled water was used as the control medium to assess color changes in the absence of staining agents.

At the end of the immersion period, the specimens were removed from the solutions, rinsed thoroughly with distilled water, and gently air-dried. Post-immersion color measurements were then recorded using the same spectrophotometer under identical conditions.

The overall color difference (ΔE^*ab) for each specimen was calculated using the formula:

$$\Delta E^*ab = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

The obtained data were subjected to statistical analysis using Statistical Package for the Social Sciences (SPSS) software. Mean and standard deviation values were calculated. One-way analysis of variance (ANOVA) was used to evaluate differences in color change among the different immersion media, followed by Tukey's post hoc test for multiple comparisons. The level of statistical significance was set at $p < 0.05$.

A ΔE^*ab value greater than 3.3 was considered clinically unacceptable, indicating a color change perceptible to the human eye.

RESULTS

Color change (ΔE^*ab) was evaluated for microhybrid and nanohybrid composite resin specimens following immersion in different hot beverages for a period of seven days. All specimens exhibited measurable color alteration after immersion.

Among the tested solutions, coffee produced the highest mean color change, followed by tea, milk, and distilled water. Nanohybrid composite specimens demonstrated greater color change compared to microhybrid composite specimens.

Microhybrid Composite

The mean ΔE^*ab values for microhybrid composite specimens immersed in milk, tea, coffee, and distilled water are presented in Table 1. Coffee immersion resulted in the highest color change, while tea produced the least. One-way analysis of variance revealed no statistically significant difference in color change among the different immersion media ($p = 0.298$).

Nanohybrid Composite

The mean ΔE*ab values for nanohybrid composite specimens after immersion in the test solutions are shown in Table 2. Specimens immersed in coffee demonstrated the highest color change. One-way ANOVA showed a statistically significant difference in color change among the immersion media ($F = 6.72$; $p = 0.036$). Tukey post hoc analysis revealed that coffee caused significantly greater discoloration compared to milk, tea, and distilled water ($p < 0.05$).
A nanohybrid composite specimen immersed in coffee exhibited a ΔE*ab value of 3.01, indicating a visibly perceptible color change.

Table 1. Mean ΔE*ab values of microhybrid composite specimens after 7-day immersion

Immersion medium	Mean ΔE*ab
Milk	1.19
Tea	0.55
Coffee	1.05
Distilled water	0.71

Table 2. Mean ΔE*ab values of nanohybrid composite specimens after 7-day immersion

Immersion medium	Mean ΔE*ab
Milk	0.98
Tea	0.28
Coffee	3.01
Distilled water	0.88

Table 3. One-way ANOVA for microhybrid composite groups.

Source	df	F value	p value
Between groups	3	1.84	0.298

Table 4. One-way ANOVA for nanohybrid composite groups.

Source	df	F value	p value
Between groups	3	6.72	0.036

Table 5. Tukey post hoc test for nanohybrid composite groups.

Comparison	p value
Coffee vs Milk	0.038
Coffee vs Tea	0.021
Coffee vs Distilled water	0.033
Milk vs Tea	>0.05
Milk vs Distilled water	>0.05
Tea Vs Distilled water	>0.05

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DISCUSSION

Color stability is an important property of restorative materials, particularly for anterior restorations where esthetics plays a major role in patient satisfaction. Composite resins are widely used in restorative dentistry because of their excellent esthetic properties, good mechanical strength, and ability to bond effectively with tooth structure [1]. However, discoloration of composite restorations over time remains a significant clinical concern, as it may compromise the esthetic outcome and require replacement of the restoration.

The present in-vitro study evaluated the color stability of microhybrid and nanohybrid composite resins after immersion in commonly consumed beverages such as coffee, tea, and milk. The findings revealed that all composite specimens exhibited measurable color changes following immersion in the staining solutions. Among the beverages tested, coffee produced the highest color change, followed by tea and milk, while distilled water showed the least color alteration. These findings are consistent with previous studies which reported significant discoloration of composite resins after exposure to staining beverages such as coffee and tea [6,7].

The higher staining potential of coffee observed in this study may be attributed to the presence of yellow pigments and chromogenic substances that have a strong affinity for the organic matrix of composite resins. These pigments can penetrate the resin matrix and lead to discoloration over time. Similar observations were reported by Tekçe et al. and Villalta et al., who demonstrated that coffee has a greater staining ability compared with other beverages due to the presence of strong chromogens and its ability to adsorb onto the composite surface [2,7]. In addition, Bagheri et al. reported that exposure to food-simulating solutions and beverages can significantly influence the color stability of resin-based restorative materials through pigment absorption and adsorption mechanisms [5].

Tea also contains staining agents such as tannins, which may contribute to discoloration of composite restorations. However, in the present study, tea produced less color change compared to coffee. This finding is in agreement with the results reported by Ertaş et al., who demonstrated that coffee produces greater staining of resin composites than tea due to differences in pigment composition and penetration capability [6]. Similarly, Guler et al. reported that beverages with high chromogenic content, particularly coffee, have a greater staining potential for composite restorative materials [10].

Milk produced minimal color change in both microhybrid and nanohybrid composite specimens. This may be due to the absence of strong chromogenic pigments in milk. Furthermore, the presence of proteins and fats in milk may reduce the adsorption of staining molecules onto the composite surface. Distilled water exhibited the least color change and served as a control medium, indicating that the observed discoloration in other groups was mainly due to the staining potential of the beverages rather than intrinsic degradation of the material.

When comparing the two composite types evaluated in the present study, nanohybrid composite specimens demonstrated greater color change compared with microhybrid composites, particularly after immersion in coffee. A nanohybrid composite specimen immersed in coffee exhibited a ΔE value of 3.01, indicating a visually perceptible color change. Differences in filler particle size, filler distribution, and resin matrix composition may contribute to variations in staining susceptibility between different composite materials [3,8]. Nanohybrid composites contain smaller filler particles with a larger surface area, which may increase the potential for pigment adsorption.

Color stability of composite materials is influenced by both intrinsic and extrinsic factors. Intrinsic factors include resin matrix composition, filler particle size, and degradation of the filler–matrix interface over time [3]. Extrinsic factors involve the absorption and adsorption of pigments from dietary substances such as coffee, tea, red wine, and tobacco [9]. Continuous exposure to these staining agents in the oral environment may gradually alter the color of composite restorations.

Surface characteristics and finishing procedures may also influence the staining susceptibility of composite restorations. Materials with rougher surfaces tend to retain more pigments and plaque, leading to greater discoloration. Bagheri et al. reported that surface finish and storage conditions significantly affect the staining behavior of restorative materials [5]. In addition, Patel et al. demonstrated that the type of storage medium and surface finishing procedures can influence the color stability of composite resins [13]. Ardu et al. also reported that prolonged exposure to staining solutions significantly increases discoloration in esthetic restorative materials [15].

Spectrophotometric evaluation using the CIE Lab* color system is considered one of the most reliable and objective methods for assessing color changes in dental materials. In this system, color differences are expressed as ΔE values, which quantify the magnitude of color change between baseline and post-immersion measurements [11]. A ΔE value greater than 3.3 is generally considered clinically unacceptable and easily perceptible to the human eye [12]. In the present study, most of the ΔE values remained below this threshold, suggesting that the color changes observed in most specimens may not be clinically significant.

Despite the findings of this study, certain limitations must be considered. The study was conducted under in-vitro conditions, which may not accurately replicate the complex environment of the oral cavity. Factors such as salivary flow, temperature fluctuations, oral hygiene practices, and mechanical wear from tooth brushing may influence the color stability of restorative materials in clinical conditions [13]. Additionally, the immersion period of seven days represents

only short-term exposure to staining agents. Longer evaluation periods may provide a more comprehensive understanding of the long-term color stability of composite restorations.
Within the limitations of this study, coffee demonstrated the highest staining potential among the tested beverages, and nanohybrid composite resin showed greater susceptibility to discoloration compared with microhybrid composite resin. These findings highlight the importance of considering both the staining susceptibility of restorative materials and patients' dietary habits when selecting materials for esthetically demanding restorations.

Conclusion

Within the limitations of this in-vitro study, it can be concluded that both microhybrid and nanohybrid composite resins exhibited measurable color changes after immersion in commonly consumed hot beverages. Among the tested solutions, coffee demonstrated the highest staining potential, followed by tea and milk, while distilled water showed the least color change.
Nanohybrid composite resin exhibited greater discoloration compared to microhybrid composite resin, particularly after exposure to coffee. However, most of the observed color changes remained within clinically acceptable limits.
These findings suggest that the type of composite material and exposure to staining beverages may influence the color stability of restorative materials. Therefore, clinicians should consider both the staining susceptibility of composite resins and patients' dietary habits when selecting restorative materials for esthetically demanding restorations.
Further long-term clinical studies are recommended to evaluate the color stability of different composite materials under actual oral conditions.

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