ORIGINAL ARTICLE

The effect of preheating on the color stability of microhybrid composite resin after immersion in carbonated beverages and black tea: an experimental study

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ABSTRACT

Introduction: Composite resin is commonly used in restorative dentistry due to its pleasing aesthetics. However, this material tends to experience discoloration, a vital standard reflecting the restoration's success. Studies show that preheating is effective in maintaining the color stability of other types of composite resin; nevertheless, the effect on microhybrid composite resin is not fully understood. This study aimed to analyze the effect of preheating on the color stability of microhybrid composite resins after immersion in carbonated beverages and black tea. **Method:** Twenty-four Z250 shade A2 composite resin discs, each with a diameter of 7 mm and a thickness of 2 mm, were divided into four groups (n=6). While groups I and II underwent a preheating process at 68°C before being soaked in carbonated drinks and black tea, groups III and IV were prepared at room temperature (25°C) without preheating and soaked in carbonated drinks and black tea. The discoloration of the samples was determined utilizing a UV-Vis spectrophotometer according to CIEL*a*b* color space. Data were analyzed using one-way ANOVA followed by the Least Significant Difference (LSD) test. **Result:** Preheating increased the color stability of composite resins. Preheated composite resins experienced significantly lower discoloration than composite resins at room temperature after soaking in carbonated drinks and black tea ($p<0.05$). **Conclusion:** preheating can minimize the color change of microhybrid composite resin after immersion in carbonated beverages and black tea.

KEYWORDS
Composite resin, carbonated drinks, black tea, discoloration, preheating.

INTRODUCTION

Composite resin is a commonly used restoration material in dentistry. This is due to its good physical and mechanical properties, high aesthetics, non-toxicity like amalgam,[1,2] minimal preparation and manipulation, and ability to restore anterior and posterior teeth.[3] A commonly used type of composite resin is microhybrid composite resin. Microhybrid composite resin has a combined filler of microfine particles (0.04-0.2 µm) and fine particles (0.1-3 µm).[4] Composite resins are subject to discoloration caused by their ability to absorb water and coloring agents. Intrinsic factors and extrinsic factors can influence discoloration. The extrinsic factor that can cause discoloration of composite resins is the consumption of beverages, such as tea and carbonated drinks.[5]

Discoloration of the composite resin matrix results from the caramel dye and the acidic pH of cola (pH 2.5), accelerating the degradation process of the composite resin matrix.[6] Also, black tea contains tannin, which can cause the composite resin restoration material discoloration. The tannin content in black tea is the highest among oolong and green tea.[7] Tannins are polyphenolic compounds with a brownish-yellow color, which can cause discoloration in composite resin.[8,9]

Resistance to discoloration is a vital standard reflecting the success of composite resin restorations; therefore, the color stability of composite resins should be improved. One method to overcome discoloration in composite resins is preheating. Preheating is done by heating the composite resin in a composite warmer before polymerization.

This method can improve composite resin's mechanical and physical properties, including color stability.[10,11] Increasing the temperature of the composite resin will result in a better degree of conversion in the composite resin.[12,13] Composite resins with efficient polymerization and a reasonable degree of conversion tend to experience lower water absorption and solubility and better color stability. [14,15]

Some studies have been conducted on how preheating affects the color stability of other types of composite resins.[13,16] However, its effect on the color stability of microhybrid composite resin is still unknown, specifically after immersion in two different solutions: black tea and carbonated drinks. Hence, this in vitro study aimed to analyze the effect of preheating on the resin's capacity to maintain color after exposure to a carbonated drink and black tea solution. This study aimed to analyze the effect of preheating on the color stability of microhybrid composite resins after immersion in carbonated beverages and black tea.

METHODS

This experimental study utilized 24 Z250 shade A2 composite resin disks, each with a diameter of 7 mm and a thickness of 2 mm, molded using a metal mold. The samples were divided into four groups based on temperature and immersion solution. Groups I and II were preheated for 40 minutes at the highest setting of 68°C using a composite warmer (Sinole, China). Meanwhile, groups III and IV were placed at room temperature (25°C). Within 45 seconds after removal from the heating device, each preheated resin composite was placed into the mold, which was positioned on a glass plate and coated with Vaseline.

Composite resin was applied using a plastic filling instrument and then condensed. Celluloid strips were then placed on the surface of the composite resin and cured for 20 seconds using an LED light curing unit. After curing, the composite resin was removed from the mold. All samples were immersed in artificial saliva at 37°C for 24 hours, after which the initial color (ΔE1) was measured using a UV-Vis spectrophotometer.

Storage solutions used in this research were black tea, SariWangi 100% Teh Asli (SariWangi AEA, Indonesia), and Coca-Cola (The Coca-Cola Company, US). The tea solution was prepared by steeping the bags in 200 mL of 100°C water for 3 minutes. After that, the pH of all solutions was measured. The samples were immersed in the soaking solutions for seven days, with the solution replaced every 24 hours. The soaking duration of 7 days (168 hours) is equivalent to consuming beverages for seven months.[17] After seven days, the samples were thoroughly rinsed under running water for 30 seconds and dried using paper towels.

The color change was evaluated by measuring the initial color (ΔE1) and final color (ΔE2) before and after soaking in the storage solution, respectively, utilizing a UV-Vis spectrophotometer (Shimadzu Corporation UV-2401-PC, Japan). The color change (ΔE) was then calculated with the formula as follows: $\Delta E = [\Delta L^*2 + \Delta a^*2 + \Delta b^*2]½$ with ΔE: discoloration; ΔL: black-white (L2 – L1); Δa: color differences from red-green (a2 – a1); Δb: color differences from yellow-blue (b2 – b1)

The research data were analyzed using a Statistical Package for the Social Sciences 25.0 (SPSS for Macbook; SPSS, Chicago, IL, USA). The significance of differences between groups was evaluated by one-way ANOVA, and the Post Hoc Least Significant Difference (LSD) test at a significance level of p<0.05 with a 95% confidence interval was used to perform multiple comparison tests.

RESULTS

Based on the color change measurements, all groups of the microhybrid composite resins experienced a color change, as can be seen in Figure 1.

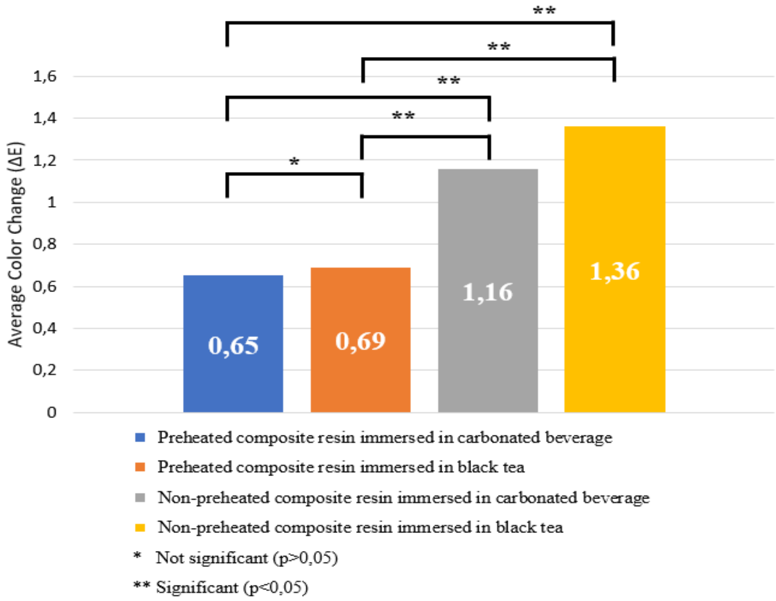

Figure 1. Color change value

Figure 1 illustrates that after immersion, the average color change (ΔE) in Group I was 0.65, Group II was 0.69, Group III was 1.16, and Group IV was 1.36. Based on the one-way ANOVA, these results are significantly different (p<0.05).

LSD test also showed significant results between some treatment groups (p<0.05), as depicted in Table 1.

Table 1. Post Hoc test (LSD) on all groups' average color change (ΔE)

	Group I	Group II	Group III	Group IV
Group I	-	.865	.027*	.003*
Group II	.865	-	.038*	.005*
Group III	.027*	.038*	-	.355
Group IV	.003*	.005*	.355	-

Note: *Significant result (p<0,05)

Based on the results of the LSD test between groups, significant differences (p<0.05) were found in Group I compared to Group III, Group I compared to Group IV, Group II compared to Group III, and Group II compared to Group IV.

DISCUSSION

Results in Figure 1 showed a significant increase in color stability in the preheated microhybrid composite resin groups. The preheating groups in black tea and carbonated drinks showed a lower ΔE than the non-preheating groups. This finding follows the research conducted by Darabi et al., which concluded that preheating effectively improves the color stability of composite resins.[13] Preheating of the composites minimizes the penetration and absorption of the colorant liquid by increasing polymerization. Specifically, the increase in temperature of the composite resin during the preheating process causes a decrease in viscosity and increases thermal vibrations, leading to better marginal adaptation. This process optimizes the mobility of free radicals and monomers, thereby raising the composite resin's conversion degree.[15]

The degree of conversion is the amount of change in the double carbon bond (C=C) of the monomer to a single bond in the composite resin. Ideally, all monomers are converted into polymers; however, the degree of conversion in composite resins generally only reaches 55-75%.[18] If the degree of conversion of a monomer is insufficient, there will be many unconverted monomers in the polymer. Unconverted monomers can dissolve and form microcracks in the polymer bond of resin and filler particles, accelerating the penetration and extrinsic staining.[16]

Result of the research were slightly different from research performed by Mary et al. discovered that the preheated composite resins boosted the degree of conversion by 18% to 74.61% compared to non-preheated ones, which was 63.22%.[12] Composite resins with efficient polymerization and good conversion degrees tend to experience lower water absorption and solubility, thus increasing the color stability of the composite resin.[13,14]

Water absorption and pigments in beverages can lead to discoloration in composite resins.[19-22] In this study, black tea caused more discoloration than carbonated drinks. This is due to the adsorption of polar coloring agents onto the composite resin material's surface.[13] One of those colorants is tannin, which has a yellow-to-brownish color.[8] This finding supports the previous study carried out by Daokar et al., which found that tea causes the greatest color change of preheating and non-preheating composite resins compared to other beverages.[23]

Carbonated beverages also affect the color change of microhybrid composite resins. Some commercial carbonated drinks contain caramel coloring and have an acidic pH that can accelerate the degradation process of composite resin polymers.[16] The acid content, with its abundance of H+ ions, dissolves the material, increasing its solubility. This process enhances water absorption in the composite resin, thereby reducing its color stability.[6]

The carbonated drink product we used in this study has a lower pH than black tea, which resulted in lower discoloration. This finding could be due to the polarity of the caramel colorant and the lack of yellow pigment in its composition. The polarity of the dye can impact the penetration of the color. Pigments with lower polarity can penetrate matrix polymers more easily than higher polar pigments, such as those in commercial carbonated drinks.[24,25]

Our in vitro study showed that preheating can improve the color stability of microhybrid composite resin after soaking in two different beverages by increasing the conversion degree and marginal adaptability. This mechanism can lower residual monomers, non-converted double-carbon bonds, and microleakage. This finding is aligned with and supports other previous studies.[13,15]

The limitation of this study is that it has yet to represent all actual clinical conditions. Evaluating color stability should consider the impact of oral environmental factors; hence, in vivo and clinical research is necessary.

Additionally, this study is limited to two types of drinks, and future research should include a broader range of drinks and colorant solutions.

CONCLUSION

Preheating significantly reduced the color change of microhybrid composite resin after immersion in carbonated beverages and black tea. Moreover, the latter showed the greatest color change in both the preheating and non-preheating groups, followed by carbonated drinks. However, the ΔE of all groups was below 3.3, which was clinically acceptable. The implications of this research indicate that preheating affects the color stability of microhybrid composite resin after exposure to black tea and carbonated drinks. This information is valuable for both practitioners and patients. Practitioners must pay close attention to the preheating stage when preparing restorative materials to maintain their aesthetic qualities. This finding can also help patients become more mindful of their food and beverage intake while using microhybrid composite resin.

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