Original Research Paper

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Effect of Preheating on the Color Stability of a Giomer Composite Immersed in Different Beverages – An In-vitro Study

Abstract:

Background: Composite resins are among the most commonly used materials for aesthetic dental restorations due to their ability to closely resemble natural teeth. However, achieving long-term color stability remains a persistent challenge. Various measures has been taken recently to improve the color stability of composites.This study aims to investigate the impact of preheating a giomer composite resin on its color stability after exposure to different beverages.

Material and Method :60 composite disks were prepared. The samples were divided into two groups: one prepared at room temperature and the other at 68 °C. After curing, all samples were immersed in distilled water at 37 °C for 24 hours. The initial color (t0) of the samples was measured using a spectrophotometer following the CIE-Lab* system. Each group was then subdivided into three subgroups, which were immersed in distilled water, coffee, or tea for 30 days. Subsequently, the final color (t1) was measured. Statistical analysis was conducted using ANOVA followed by Tukey's post hoc tests.

Results: The preheated composites exhibited significantly less staining in the coffee solution compared to the room-temperature composites. However, in the tea solution, the preheated composites displayed greater staining than those at room temperature.

Conclusion: The findings of this study revealed that preheating composite resin is effective in reducing color changes after immersion in a coffee solution.

Key-words: color stability, composite, preheating, Beautifil II

Introduction:

Composite resins replicate the natural color of teeth, making them the preferred restorative material due to their excellent physical and mechanical properties, along with outstanding aesthetic qualities.[1] Despite substantial advancements in the composition and properties of composite resins, they continue to encounter various challenges in the oral environment, such as pH fluctuations and temperature variations.[2]

Color stability is a crucial property of composite resin that impacts its long-term clinical performance. Color changes can be triggered by various factors; extrinsic discoloration may result from staining in the resin composite's surface layer, water absorption, surface roughness, smoking, or dietary habits. Intrinsic discoloration, on the other hand, can occur due to physicochemical reactions within the material itself.[3]

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The long-term success of esthetic restorations depends largely on the material's resistance to different stains.[4]

Giomer represents a relatively new and innovative filler technology in resin composites.[5]These materials incorporate pre-reacted glass ionomer cements as fillers and are

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characterized by a significantly higher fluoride release compared to other composites.[4] In place of applying traditional glass or quartz fillers, giomers utilize inorganic fillers that range in size from 0.01 to 5 mm.[5]

The degree of discoloration in composite resins is directly influenced by factors such as the type of resin matrix, the volume and size of filler particles, and the depth of polymerization.[7] The hydrophilic nature of this restorative material is attributed to its chemical composition, specifically the monomers, which influence the absorption of water and colored beverages.[8] The unreacted dual carbon bonds not only make the material susceptible to destructive reactions that diminish color stability and release chemicals like formaldehyde and methacrylic acid, but also enable solvents from the oral environment to infiltrate the polymer network, leading to the breakdown of newly formed chains.[9]

Preheating composite resin prior to photo polymerization not only reduces its viscosity but also enhances its mechanical properties, such as increasing the conversion rate and surface hardness. Additionally, preheating improves the resin's flowability, promoting better adaptation to cavity walls, which ultimately reduces microleakage and extrinsic staining of the restoration.[6]

Although preheating composite resins is often assumed to influence color stability, there are relatively few studies on this topic.Some studies report positive effects, while others find no significant impact.[9] Thus, the aim of this study is to evaluate the effect of preheating of a giomer composite resin on the color stability of the resin when it was exposed to different beverages. The null hypothesis was color stability of preheated composite has no effect on immersion of tea and coffee solution.

Procedure:

Preparation of Sample:

This study was conducted using a giomer composite resin (Beautifil II, Shofu, Kyoto, Japan), a fluoride-containing nanohybrid composite. G power software, version 3.1.9.7 (Heinrich-Heine-Universitat Dusseldorf, Dusseldorf, Germany) was used. A power analysis was conducted before the experiment to determine the necessary sample size for accurately detecting significant effects. Based on the power analysis 60 disk (10 per group) samples with a diameter of 10 mm and thickness of 1 mm were prepared using a silicon mold. Specimens were divided into 2 groups according to the temperature of preparation (n=30). The samples from each group were randomly allocated into three subgroups (n=10).

Samples of sub- group 1,2 and 3 were respectively immersed in distilled water, coffee and tea.

Group 1- The composite is removed from the refrigerator and were placed at room temperature (25° C) for at least 10 minutes. The composite was interplaced between two glass slides and pressed, allowing for a smooth surface and no gap formation. The specimens were polymerized from both sides for 40 sec using an LED light curing unit at 1365 mW/cm2

Group 2- Composite were placed in a compule and then it was then inserted in the compule gun. Further the compule were placed in a heating instrument. After heating at 68°C, the composite was immediately inserted in the silicon mold and then curing is done from both sides as that of group 1 for 40 sec. To reduce heat dissipation, the maximum time between the removing of the composite from the heater and placing it in the cavity was 10 seconds.

Group W_1 – Sample was prepared at room temperature, immersed in distilled water.

Group W_2 – Sample was prepared at temperature 68° C, immersed in distilled water.

Group C_1 – Sample was prepared at room temperature, immersed in coffee solution.

Group C_2 – Sample was prepared at temperature 68° C, immersed in coffee solution.

Group T_1 - Sample was be prepared at room temperature, immersed in tea solution.

Group T_2 – Sample was be prepared at temperature 68° C, immersed in tea solution.

All samples were unmolded and placed in 37° C distillated water for 24 h until the polymerization is completed. All specimens were then polished using a series of grid abrasive finishing discs (Shofu Super Snap Dental India Private Limited, New Delhi, India), following a sequence of decreasing abrasiveness with intermittent motion, while maintaining constant water cooling. Polishing procedure was kept to minimum time 10 sec for each step to avoid microcrack formation.

Staining Protocol:

To prepare the coloring solutions of coffee, 3.6 gr of coffee powder was dissolved in 300 mL of boiling water and boiling was done for 10 minutes, for the tea solution, two tea bags (2 × 2 g) (Yellow Label Tea, Lipton, London and Turkey) were suspended in 300 ml boiling water by immersion for 10 min.

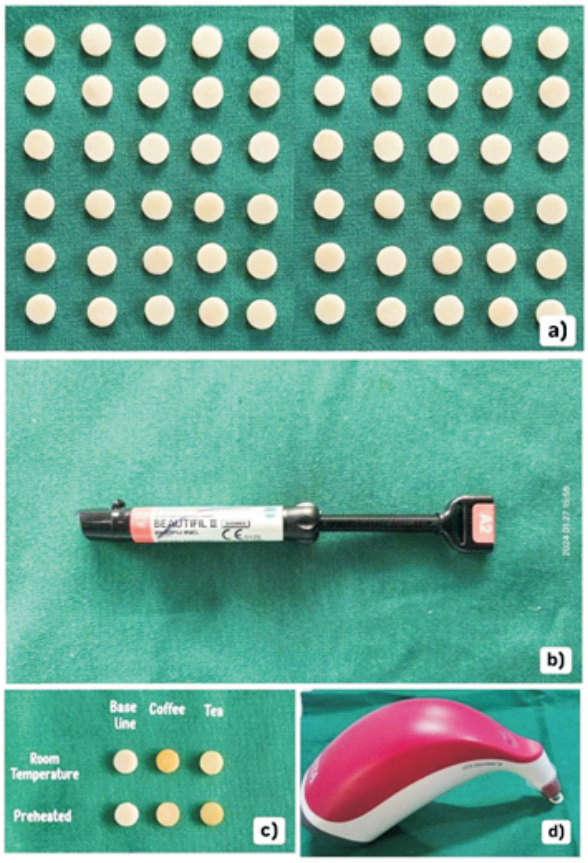
After that the samples were immersed in the solutions and placed in an incubator at 37°C for 7 days. The solutions were changed daily, and the samples were washed and brushed for one minute to eliminate any debris.The average time for drinking of a cup of coffee and the amount of drink have been reported about 15 minutes and 2-3 cups per day respectively, thus this was taken as reference.[20]

Color Evaluation:

The color assessment of the samples was performed using a VITA Easy shade compact spectrophotometer. The samples were previously dried with moisture absorbent paper and initial colors was measured (t0). Color evaluation was performed using CIE-L*a*b*system (Commission International De I'Eclairage). The values of L* (lightness), a* (green-red axis), and b* (yellow-blue axis) was determined in each color reading. The color change (ΔE) was calculated as follow:

$$\Delta E = [\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}]^{1/2}$$

The statistical analysis was carried out using SPSS (Statistical Package for Social Sciences) IBM version 25



.a) Sample; b) Beautifill II;c) Photographs of representative stained specimens; d) Spectrophototmeter (Vita Easyshade)

Results:

The table 1 shows mean and standard deviation of the distilled water, tea and coffee staining of composite at both room temperature and preheated. The tea group has shown highest staining and distilled water has shown least staining. This is seen in both room temperature and preheated. The mean and standard deviation is as follows: Room temperature – distilled water = 2.47±0.70, tea = 9.77±0.40, coffee = 7.60±0.38; Preheated – distilled water = 2.18±0.16, tea = 11.47±0.87, coffee = 7.89±0.51. The least staining was observed in distilled water of preheated composite followed by room temperature then coffee at room temperature followed by coffee at preheated composite, the same was seen for tea where preheated composite had more staining then distilled water.

Table 1: Table shows mean and standard deviation of various groups

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Room temperature	Distilled Water	2.47	10	.702	.22208
	Tea	9.77	10	.401	.12705
	Coffee	7.60	10	.386	.12222
Preheated composite	Distilled Water	2.18	10	.160	.05060
	Tea	11.47	10	.874	.27654
	Coffee	7.89	10	.510	.16133

Table 2: Paired sample test comparing intragroup difference of mean ± sd

Paired Samples Test

		Paired Differences				
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference	
					Lower	Upper
Room temperature	Distilled Water - Tea	-7.29	.910	.287	-7.95038	-6.64762
	Distilled Water - Coffee	-5.13	.676	.213	-5.61374	-4.64626
	Tea - Coffee	2.16	.421	.133	1.86739	2.47061
Preheated composite	Distilled Water - Tea	-9.29	.836	.264	-9.89456	-8.69744
	Distilled Water - Coffee	-5.71	.468	.148	-6.05130	-5.38070
	Tea - Coffee	3.58	1.01	.322	2.85137	4.30863

The table 2 shows mean difference of various subgroups. The comparison was done between following pairs at room temperature: distilled water – tea (mean difference = 7.29, p=0.00), distilled water – coffee (mean difference = 5.13, p=0.00), tea - coffee (mean difference = 2.16, p=0.00); at preheated: distilled water – tea (mean difference = 9.29, p=0.00), distilled water – coffee (mean difference = 5.71, p=0.00), tea - coffee (mean difference = 3.58, p=0.00).

Discussion:

Surface discoloration of aesthetic restorative materials presents a major challenge to the durability and longevity of these restorations.[10] Discoloration of composite resin can result from external or internal processes involving the adsorption or absorption of colorant agents. Coffee and tea solutions are rich in yellow pigments with diverse polarities. Previous studies have demonstrated that preheating composite resin increases its degree of polymerization, which in turn enhances its resistance to discoloration.[11,12,13] According to Micali and Basting, effective polymerization and a higher degree of conversion contribute positively to the color stability of composite resins.[14] This is because remaining monomers causes the penetration of liquids such as colorant solutions to the polymeric network and also lead to hydrolytic destruction of newly formed chains that may results in the formation of color compounds.[15]

Giomer is a resin-based dental adhesive material with fluoride-releasing properties, consisting of PRG fillers. PRG fillers are fabricated by the acid-base reaction between fluoroalumino–silicate glass (FASG) and polyalkenoicacid (PAA) in the presence of water to form a wet siliceous hydrogel. Following freeze-drying, the dried xerogel was further milled and silanized to produce PRG fillers within a defined size range.[16,17] The advantages of S-PRG filler include the release of ions beyond fluoride, offering a variety of benefits: (i) fluoride release and recharge capability, (ii) development of an acid-resistant layer, (iii) strengthening of tooth structure, (iv) antiplaque properties, (v) promotion of dentin remineralization, (vi) acid buffering ability, and reduction of acid production by acidogenic bacteria.[20]

The null hypothesis tested in this study was partially rejected, as the preheated materials exhibited significantly lower discoloration when immersed in coffee. However, this reduction was not found to be significant in the tea solution. Some researchers suggest that the color change observed in composites exposed to coffee may be due to a combination of adsorption and absorption of yellow pigments. By preheating the composites, the degree of polymerization is increased, which in turn reduces the absorption and penetration of colorant solutions. Consequently, the discoloration of preheated composites in coffee solutions is significantly reduced. In contrast, tea contains pigments that attach to the surface of the material primarily through adsorption.[18] As a result, an increase in the degree of polymerization has a relatively smaller effect on minimizing the color change caused by tea.

In our study, all composite disks exhibited detectable staining ($\Delta E \geq 3.3$) after being stored in staining solutions, with the tea solution causing the most significant staining.The study by Bagheri et al. found that tea is one of the beverages responsible for causing more discoloration compared to others.[19] In this study, we observed color change of the composites in the distillated water (control group), however, it was not statistically significant. It seems water sorption itself and departure of soluble material can be cause of this discoloration. Furthermore, in this study, the preheated composites exhibited a greater degree of color change compared to those at room temperature, although this difference was not statistically significant.

This study has certain limitations, as it is an in vitro study. While efforts were made to simulate the clinical environment and replicate the conditions of the oral cavity, the simulation cannot be entirely precise. Further, more trials that are clinical are required to confirm the data obtained from this laboratory study and to evaluate the new composite resin materials under various clinical situations.

Conclusions:

Based on the parameters of the study, it can be inferred that preheating composite resin proves effective in mitigating color alteration subsequent to immersion in a coffee solution. In clinical practice, when choosing the most suitable restorative material, dentists should take into account the patient's drinking habits, oral hygiene practices, and factors that may influence the color stability of the restoration. Furthermore, patients should be made aware of the potential for staining of the restorations.

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