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Evaluating the colour stability of esthetic resin composite: A study of Neospectra ST under different staining conditions

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Abstract

Background: There is a burgeoning interest in the colour permanence of aesthetic restorations, although only a handful of studies have been documented thus far.
Aim: To investigate the impact of various common staining solutions on nanohybrid composite resin..
Materials and methods: Forty disk-shaped specimens (10 X 2 mm) were fabricated with Neo SpectraST composite material. The specimens were divided into four groups with 10 specimens (n=10) in each, based on the staining solutions, Group I: Turmeric, Group II: Coffee, Group III: Coke, and Group IV: Distilled water. Baseline measurements were taken using an ultraviolet spectrophotometer. Each sample group was immersed in their respective staining solutions, and the colour changes were recorded after 1, 7, and 14 days of immersion using the same spectrophotometer. The absorption values were recorded within the 300 to 800 nm range at baseline and after the immersion. The data was collected and subjected to statistical analysis.
Results: Neo spectra ST composite showed the maximum staining capacity with the turmeric group compared to other staining solutions. One-way ANOVA showed significant differences (p=0.000) among the staining solutions at different time intervals. Repeated measures ANOVA displayed significant differences within the staining solutions (Turmeric: p=0.005; Coffee: p=0.001; and Coke: p=0.001) at different time intervals.
Conclusion: The nanohybrid composite resin showed a significant colour change to turmeric compared to other staining solutions.
Keywords: Neo spectra ST composite, Spectrophotometry, Staining.

1. Introduction

Cosmetic dentistry provides people with the option to select dental restorations that match the colour of their natural teeth [1]. Because of their superior aesthetic qualities, composite resins are extensively utilized in cosmetic dentistry [1-2]. They vary in the type of resin matrix, as well as in the size, type, and quantity of filler particles [2]. The success of restoration depends on several factors, including adequate strength, high aesthetic appearance, diametral tensile and flexural strengths, compressive strength, polish retention, and resistance to wear and fracture [3-4].

Furthermore, aesthetic materials should mimic the appearance of natural teeth, which is closely linked to the material's colour stability. However, despite recent advancements, the colour stability of composite resins after prolonged intraoral use continues to be a concern for dentists [5]. Due to the polymerization reaction and their interaction with the oral environment, these resins undergo a series of physical changes [6], leading to the softening of the resin matrix and reduced stain resistance [7]. Discoloration of tooth-coloured resin-based materials can be attributed to both intrinsic and extrinsic factors, as well as the interface between the matrix and fillers [7-8]. Extrinsic factors, such as the adsorption or absorption of stains, not only lead to discolouration but also impact the structure of the composite and its fillers [9]. The type of polymerization system and the conditions under which polymerization occurs are crucial factors that determine the colour stability of composite materials [2]. In addition, the colour stability of composites is also affected by the conversion of matrix monomers. A high-intensity light polymerization unit has been developed to achieve superior properties in direct resin composites [10]. The staining of tooth-coloured composite materials is a primary reason for replacing restorations in visible areas [11]. Several in vitro studies have examined the colour stability of various aesthetic restorative materials [12-14].

Staining can be assessed both visually and through instrumental methods such as spectrophotometry and colourimetry. Visual colour evaluations are often unreliable because of varying colour perception among observers. In contrast, instrumental measurements remove the subjectivity inherent in visual colour comparisons [15]. The most frequently employed methods for measuring the colour change in dental materials are colourimeters and spectrophotometers [16-17].

Spectrophotometers offer greater accuracy than colourimeters because they include monochromators and photodiodes that measure the reflectance curve of a product's colour at intervals of 10 nm or less [18]. A study assessed the colour stability of various composites in different drinking media and found that water caused the least colour change, while red wine resulted in the greatest colour change. Cola, tea, and coffee produced moderate colour changes [19].

Neo Spectra ST composite, introduced by Dentsply Sirona in 2020,[20] is a universal nanohybrid composite material. It features Sphere TEC™ filler technology, which involves spherical, pre-polymerized fillers that enhance handling, strength, and esthetics. This innovative technology improves the composite's adaptability and sculptability, making it easier to place and contour. Neo Spectra ST provides excellent polishability, wear resistance, and natural-looking aesthetics, making it suitable for both anterior and posterior restorations. Its optimized filler content ensures a balance between strength and workability, offering reliable performance for various restorative procedures. However, very limited literature available on the physical, mechanical, and optical properties of Neo Spectra ST composite. Hence, this study aimed to evaluate the colour stability of Neo Spectra ST composite exposed to different staining solutions at different time intervals.

2. Materials and methods

This study was conducted at GSL Dental College and Hospital, Rajahmundry, Andhra Pradesh, India. This in vitro study evaluated the influence of three different staining solutions, turmeric, coffee, and cola, on the colour stability of nanohybrid composite resin, NeoSpectra™ ST (Dentsply Sirona, USA), at three different immersion periods, 1, 7, and 14 days.

2.1 Sample preparation

A total of forty disk-shaped specimens were made using a nanohybrid composite, Neo Spectra™ ST. A stainless-steel mould with an inner diameter of 10 mm and a thickness of 2 mm was used to fabricate the composite specimens. The metal mould was placed over the glass slide, and the composite resin with A1 shade was condensed into it. The surface of the composite was covered with Mylar strips (Samit products, New Delhi, India) and another glass slide was placed over it. Then, the composite was cured on both sides for 40 seconds using a Blue LEX LED light curing unit (Monitex GT 1200, Taiwan) with a wavelength of 450-470 nm and a lamp intensity of 600 mW/cm2 in a normal mode. After curing, the specimens were retrieved from the mold and then stored in distilled water at 37°C for 24 hours to ensure complete polymerization. Specimens were polished using polishing disks (Sof-lexTM, 3M ESPE). Then, the baseline colour values were recorded using an ultraviolet spectrophotometer (Shimadzu, Japan) and absorption values were recorded at 300 to 800 nm.

2.2 Staining solutions preparation

Composite disks were prepared and exposed to various staining solutions—coffee, turmeric, and cola—over time intervals of 1, 7, and 14 days. A total of 40 samples were fabricated and divided into four groups (Figure 1) of 10 samples each (n=10) according to the staining solution used (Table 1). The turmeric solution (Group I) was made by dissolving 4 g of turmeric powder (Sakthi, Mallampati, India) in 200 ml of water. For Group II, the coffee solution was prepared by mixing 4 g of instant coffee powder (Hindustan Unilever Ltd, Maharashtra, India) into 200 ml of boiling water, stirring for one minute, and then filtering through a paper filter. Group III used 200 ml of commercially available Coca-Cola (Hindustan Coca-Cola Beverages Pvt Ltd, Thiruvallur, India), while Group IV used distilled water. The nanohybrid composite disks were immersed in their respective solutions (Figures 2a-d) and evaluated for colour stability using a spectrophotometer at specified time intervals. All solutions were freshly prepared and replaced daily.

Figure 1. Composite Samples

2.3 Color stability evaluation

A spectrophotometer with a visible range of 300 to 800 nm was used to observe the amount of absorbance of colour (stain) of the samples. After removing the samples from their respective staining solutions, they were thoroughly washed under running water, dried with absorbent paper, and then placed in a viewing port for colour measurement in a spectrophotometer. The amount of absorbance was recorded at 300, 350, 400, 450, 500, 550, 600, 650, 700, 750 and 800 nanometres the value at 400-450nm wavelength was taken [21] (because it is in the visible light spectrum and is within the absorption range of many chromophores, which are molecules that absorb light at specific wavelengths) as standard value for each sample and compared to calculate the mean of colour change for every sample. These mean values were recorded on the 1st, 7th, and 14th days of an experiment to notice the colour changes. Hence, the percentage of absorbance of colour was selected as a criterion of colour change in a particular sample.

Table 1: Materials tested in the study

Material	Product	Composition	Manufacturer
Resin-based Composite	Neo Spectra™ ST	Organically modified ceramic- Methacrylate modified polysiloxanedimethacrylate resins, Ethyl-4 (dimethylamino) benzoate and Bis(4-methyl-phenyl) iodonium hexa-fluoro-phosphate. Filler load: 78–80% by weight Spherical, pre-polymerized Sphere TEC fillers (d3,50 ≈ 15 µm), non-agglomerated barium glass and ytterbium fluoride (≈0.6 µm)	DentsplyDeTrey, Konstanz, Germany
Staining Solutions	Sakthi Turmeric	Turmeric	Sakthi, Mallampati, India
	Coffee	Caffeine, melonoides, chlorogenic acids, N-methylpyridinium, diterpenes (cafestol and kahweol). Other components Crylamide, Furan, Ochratoxin-A.	Hindustan Unilever Ltd., Maharastra, India
	Cola	Carbonated water, sugar, acidity regulator, caffeine with natural coloring agents	Hindustan Cola-Cola Bevarages Pvt. Ltd, Thiruvallur, India

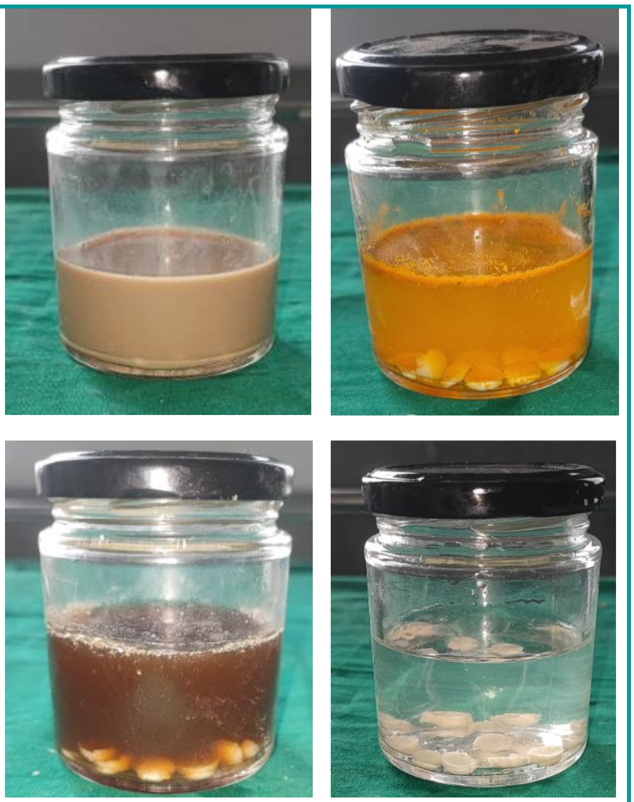

Figure 2. Composite Samples immersed in different staining solutions. Coffee (Top left), Turmeric (Top right), Coco-Cola (Bottom left), and Distilled water (Bottom right).

2.4. Statistical analysis

The obtained data was subjected to statistical analysis using the statistical package for social sciences (SPSS) 26.0 version, IBM, USA. One-way Analysis of variance (ANOVA) was used to compare the changes among the different staining solutions. Repeated measures ANOVA was used to compare among the different time intervals within each group, and Tukeys' test were performed at significance level of 0.05.

3. Results

The mean colour stability of the composite samples immersed in different staining solutions at different time intervals is presented in Table 2. The highest value of colour change was observed with the turmeric followed by coffee and Coke. The composite specimens stored in distilled water demonstrated the least colour changes compared to the other staining solutions. Maximum colour absorption on 1st day was seen in the turmeric followed by Coke and coffee, respectively. However, no significant colour absorption difference was observed after 7 and 14 days of immersion in turmeric and coffee. However, one-way ANOVA showed significant differences (p=0.000) among the staining solutions at different time intervals. Within each staining material, repeated measures ANOVA displayed significant differences (Turmeric: p=0.005; Coffee: p=0.001; and Coke: p=0.001) at different time intervals.

Table 3 presents the comparison between the different time intervals within each staining solution. In the turmeric group, 1-day immersion showed significant differences with the 7th day (p=0.028) and 14 days immersion (p=0.028). In the coffee group, significant differences were observed between all the time intervals (1- and 7-days: p=0.009; 1- and 14-days: p=0.013; and 7- and 14-days: p=0.013). Similarly, significant differences were also found in the Coke group between all the time intervals (1- and 7-days: p=0.013; 1- and 14-days: p=0.002; and 7- and 14-days: p=0.001).

Table 4 presents the intergroup comparison of colour changes between the different staining solutions at individual time intervals. After 1-day immersion, turmeric showed significant differences with the Coffee (p=0.001) and distilled water (p=0.000), and between Coke and distilled water (p=0.000). After 7 days of immersion, distilled water showed significant differences with the turmeric (p=0.000), Coffee(p=0.013) and Coke (p=0.000) staining solutions. Also, Coffee exhibited significant differences with the turmeric (p=0.006) and Coke (p=0.005). After 14 days of immersion, distilled water displayed significant differences with the turmeric (p=0.000) and Coffee (p=0.000) staining solutions. Also, significant differences were found between turmeric & coke (p=0.000); and coffee & coke (p=0.000).

Table 2. Comparison of absorption values during the different intervals

Groups	1st day Mean (SD#)	7th day Mean (SD#)	14th day Mean (SD#)	Repeated measures ANOVA
Turmeric	3.0188 (0.66)	1.9260 (0.09)	1.9260 (0.09)	F=11.4 p=0.005*
coffee	1.5840 (0.20)	1.884 (0.087)	1.88 (0.086)	F=19.7 p=0.001*
Coke	2.5140 (0.326)	1.930 (0.123)	1.40 (0.23)	F=39.7 p=0.001*
Control	1.28 (0.969)	1.28 (0.969)	1.28 (0.969)	
One-way ANOVA	F=20.23 P=0.000*	F=26.2 P=0.000*	F=28.07 P=0.000*	

#Standard Deviation

Table 3: Intra group comparison of absorption values among the different intervals

Groups	Intervals		p - value
Turmeric	1st day	7 days	0.028*
		14 days	0.028*
	7 days	14 days	-
Coffee	1st day	7 days	0.009*
		14 days	0.013*
	7 days	14 days	0.013*
Coke	1 day	7 days	0.013*
		14 days	0.002*
	7days	14 days	0.001*
Control	1 day	7 days	---
		14 days	---
	7 days	14 days	---

*Significant difference

Table 4: Inter group comparison of absorption values among the different intervals

Intervals	Groups		Mean Difference	Significance
After 1 day	Turmeric	coffee	1.1348	0.001*
		Coke	0.504	0.187 (NS)
		Distilled water	1.7388	0.000*
	coffee	Coke	0.63	0.07 (NS)
		Distilled water	0.604	0.09 (NS)
	Coke	Distilled water	1.23	0.000*
After 7 days	Turmeric	coffee	0.342	0.006*
		coke	0.004	1.000 (NS)
		Control	0.646	0.000*
	coffee	coke	0.346	0.005*
		control	0.304	0.013*
	Coke	control	0.65	0.000*
After 14 days	Turmeric	coffee	0.046	0.708(NS)
		Coke	0.526	0.000*
		Control	0.646	0.000*
	coffee	Coke	0.480	0.000*
		control	0.600	0.000*
	Coke	control	0.12	0.53 (NS)

*Significant difference, NS: No significant difference.

4. Discussion

Composite restorative materials are susceptible to colour change upon exposure to saliva, beverages, and food stains [22]. Compared to clinical studies, laboratory studies are easy to perform, could yield results at a faster rate, and help in predicting the colour changes in composite specimens [23]. Hence, this study assessed the colour change in dental resin materials by exposing them to turmeric, Coffee, Coke, and distilled water. Different studies have reported varying thresholds for colour difference values at which a colour change becomes perceptible to the human eye. These thresholds have been noted as ΔE values ranging from 1 [24] to between 2 and 3 [25], as well as greater than or equal to 3.3 [25] and 3.7[15]. Specifically, ΔE values between 0 and 2 are imperceptible, those from 2 to 3 are barely noticeable, values from 3 to 8 are moderately noticeable, and values above 8 are significantly noticeable [26]. A ΔE value of 3.7 or lower is generally considered clinically acceptable [15-23].

The staining of composites by all the immersion media used in this study can be explained by the staining susceptibility of composite resins, which may be related to their water sorption level and the hydrophilicity of the matrix resin [27]. Staining of resins by coloured fluids and beverages occurs due to the adsorption or absorption of colourants by the resins [17]. Composite resins that can absorb water are also capable of absorbing other pigmented fluids, leading to discolouration. It is believed that water serves as a vehicle [28] for stain penetration into the resin matrix. Conjugated diarylheptanoids, such as curcumin, are responsible for the orange colour and high staining potential of turmeric solution.[29] Coffee's staining is attributed to tannic acid and its discolouration results from both surface adsorption and absorption of colourants. This may explain why coffee tends to be less colour-stable compared to tea [17]. Despite containing phosphoric acid, cola drinks do not seem to significantly impact the colour change of composites. Different acids affect the dissolution and erosion of materials in various ways. Additionally, the phosphate ions present in Coca-Cola® may inhibit dissolution, as these ions have been shown to decrease the rate of calcium phosphate dissolution from teeth [30,31].

The stain resistance of the resin matrix is influenced by its degree of conversion [32] and water uptake [33]. In Bis-GMA-based composite resins, water uptake increases from 3% to 6% as the proportion of TEGDMA rises from 0% to 1% [34] UDMA appears to be more resistant to staining than Bis-GMA. Under standard curing conditions, UDMA-based composite resins show lower water sorption [35] and better colour stability.

The results of this study were consistent with the studies conducted by various researchers on the colour stability of dental composites. Like the present study, Stober et al. [36]also demonstrated that turmeric solution and red wine caused the most severe discolouration (ΔE >10) compared to tea, coffee, and mouth rinse over periods of 4 and 8 weeks. Scotti et al. [37] found that synthetic saliva and coffee caused more significant darkening than tea and artificial saliva over 10 and 30 days. Yannikakis et al. [38] used coffee and tea as staining agents and observed that coffee-stained provisional resin restorative materials more than tea. In a study by Fontes et al. [39], the authors evaluated colour changes at baseline and one week after storage in coffee, yerba mate, and grape juice. They found no significant difference in ΔE values from the baseline, except for grape juice.

The present in vitro study investigated the colour stability of composite resins exposed to different staining solutions over various time intervals. However, it did not fully replicate the complexities of the oral environment. Additional studies are necessary to achieve a thorough understanding of the colour stability of composite resin materials under real oral conditions.

5. Conclusion

The current study revealed that among the staining solutions tested, turmeric caused the most significant discoloration of Neo Spectra ST, followed by coffee and cola.

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