Original Article

DOI: 10.7860/JCDR/2023/64563.18705

Dentistry Section

Determination of the Impact of Various Commonly Consumed Beverages on the Colour Stability of Universal Nanohybrid, Nanofilled, and Microhybrid Composite Resins: An In-vitro Spectrophotometric Study

SHREYA MODI[1], CHINTAN JOSHI[2], MONA SOMANI[3], AASHRAY PATEL[4], ANISHA PARMAR[5], KRUTI JADAWALA[6]

ABSTRACT

Introduction: The challenge in restorative dentistry is related to changes in the colour of composite over time when exposed to a variety of common beverages, which necessitates additional expenses for the patients.

Aim: To compare the colour changes of various composites currently available on the market after exposure to commonly consumed beverages.

Materials and Methods: This in-vitro study was conducted from May 2022 to December 2022 in the Department of Conservative Dentistry and Endodontics at Karnavati School of Dentistry in Gandhinagar, Gujarat, India. A total of 120 disc-shaped composite pellets, with 40 specimens for each type of composite (nanohybrid, nanofilled, and microhybrid), measuring 6×2 mm, were prepared and divided into four subgroups based on the beverages used (Distilled water, coca-cola, Tea, and Coffee). The samples were submerged in the respective beverages and kept at 37°C for seven days. Colour assessment was performed using a spectrophotometer before and after immersion. The obtained Commission International de l Eclairage (CIE) ∆E values were recorded after measuring the CIE L*a*b* values. Data analysis was conducted using Statistical Package for Social Sciences (SPSS) software version 20.0, utilising a paired t-test, post hoc Tukey's test, and one-way Analysis of Variance (ANOVA). A significance level of $p<0.05$ was used.

Results: Among all the beverages, the nanofilled composite showed the highest mean colour change, while the nanohybrid composite exhibited the lowest. Overall, the greatest colour change was observed with tea, followed by coffee, coca-cola, and the least with distilled water. In tea, coffee, and coca-cola, the nanohybrid composite and nanofilled composite showed a statistically significant difference in mean colour change: 16.74 ($p<0.001$), -7.29 ($p<0.001$), and -1.02 ($p=0.018$), respectively. However, the difference between the nanohybrid and microhybrid composite was statistically insignificant.

Conclusion: The nanohybrid composite demonstrated the least mean colour change, followed by the microhybrid composite, while the nanofilled composite exhibited the highest colour change.

Keywords: Aesthetic, Blending, Colour matching, Optical properties, Storage media, Staining

INTRODUCTION

The demand for long-lasting restorations that are both functional and aesthetically beautiful has increased among patients as a result of societal economic changes and media influences. However, one of the main issues contributing to clinical failure of restorative materials is discolouration. Several intrinsic and extrinsic conditions can cause composite resin to become discoloured. Intrinsic factors such as the composite resin matrix and its solubility, filler type and amount, degradation of resin-filler bond, and incomplete polymerisation affect the colour stability of composite restorations. Extrinsic influences include the patient's hygiene practices, smoking habits, eating habits, chemical reactions, surface roughness, and absorption of colourants from external sources [1]. The nature, type, and quantity of the polymeric matrix material, as well as the size and distribution of the filler particles, have an impact on the surface changes of composites [2].

Studies have shown that coloured solutions like tea, coffee, and other beverages can cause discolouration of composite restorative materials [3-5]. According to the Tea Board of India, tea consumption accounts for 80% of its domestic production [5]. With a stronger brew, the staining chemicals in tea, such as tannins, aflavins, and anthocyanins, may become even more concentrated [4]. The younger generation consumes more carbonated drinks like coca-cola, with India being the third-largest consumer worldwide [5]. Recent research has shown that acidic liquids like soft drinks (orange juice and cola) can cause erosion of resin composites. These surface abrasions can affect the gloss, which may subsequently worsen extrinsic stains [6]. Immersion in coffee is considered an acceptable test procedure to determine the susceptibility of resin-based materials to discolouration due to its strong staining potential [7,8].

Recently, NeoSpectra™ST (DentsplyDeTrey, Konstanz, Germany) is a nanohybrid universal resin composite made with SphereTEC technology. The company claims that manufacturing microscaled, spherical prepolymerised fillers' shape and size distribution enhance chameleon blending ability with excellent stain-resistant lustre [9]. FiltekZ350XT (3M ESPE, Minnesota, USA) is a nanofilled composite. The true nanotechnology provides superior wear resistance and gloss retention. According to the manufacturer, it has better polish retention and improved fluorescence [10]. Polofil Supra (Voco, Cuxhaven, Germany) is a microhybrid composite based on the proven VOCO sintra glass multifiller system. It has superb aesthetics and outstanding physical properties [11].

Extensive research has been conducted on the colour stability of dental composites. Numerous studies have investigated the effects of composition alterations, filler changes, and the impact of various beverages, among other factors [2,8,11]. Thermal stress and water sorption can lead to expansion, surface deterioration, and microcracking, which can allow colourants to permeate [11]. Extrinsic discolouration is the main factor affecting colour stability, emphasising the need for dental researchers and material scientists to develop new resin-based materials for aesthetic restorations that are more resistant to discolouration [1]. Very few studies [9,12] have compared the colour stability of the recently marketed nanohybrid composite in commonly consumed beverages.

Therefore, the aim of the proposed study was to evaluate the colour stability of the universal nanohybrid composite, along with previously tested nanofilled and microhybrid composites, when submerged in the most popularly consumed beverages.

MATERIALS AND METHODS

An in-vitro study was conducted from May 2022 to December 2022, at the Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Gandhinagar, Gujarat, India.

Sample size calculation: The study considered information from a prior study [1] on the evaluation of colour stability of three composite resins in mouthwash. Based on this, a sample size of 10 discs per group was used in the current investigation to achieve data with 95% power and 5% significance using statistical power analysis.

Study Procedure

The proposed study followed a 3×4 factorial design, including three groups and four subgroups, to assess two variables: resin-based composites. Group 1 consisted of NeoSpectra™ ST (Shade A2), Group 2 included FiltekZ350XT (Shade A2E), and Group 3 consisted of Polofil Supra (shade A2) [Table/Fig-1]. The staining conditions included Distilled water (Das Enterprise, Ahmedabad, India), coca-cola (PepsiCo India private limited, Gurugram, India), Tata tea premium (Tata Consumer Products, Maharashtra, India), and Nescafe coffee (Nestle, Maharashtra, India) [Table/Fig-2].

Materials	Shade	Manufacturer	Content
Nanohybrid composite (Neo Spectra™ ST)	A2	DentsplyDeTrey, Konstanz, Germany	Organically modified ceramic-Methacrylate modified polysiloxane dimethacrylate resins, Ethyl-4 (dimethylamino) benzoate, and Bis (4-methyl-phenyl) iodonium hexafluorophosphate. Filler load: 78-80% by weight Spherical, prepolymerised SphereTEC fillers (d3,50≈15 μm), non agglomerated barium glass, and ytterbium fluoride (≈0.6 μm).
Nanofilled composite (Filtek Z350 XT)	A2	3M ESPE, Minnesota, USA	bis-GMA, UDMA, TEGDMA, bis-EMA (6) resins Filler load: 76.5% by weight non agglomerated/ non aggregated 20nm silica filler, non agglomerated/non aggregated 4 to 11 nm zirconia filler, aggregated zirconia/silica cluster filler (comprised of 20 nm silica and 4 to 11 nm zirconia particles) and ytterbium trifluoride filler consisting of agglomerated 100 nm particles.
Microhybrid composite (Polofil Supra)	A2	Voco, Cuxhaven, Germany	Bis-GMA, TEGDMA, UDMA, HEMA Filler load: 76.5% by weight Sintraglass multifillers, Microfillers-0.05 μm, Macrofillers-0.5 and 2 μm.

[Table/Fig-1]: Composites used in the study [4].

Material	Manufacturer
Distilled water	Das Enterprise, Ahmedabad, India
Coca-Cola	PepsiCo India Private Limited, Gurugram, India
Nescafe coffee	Nestle, Maharashtra, India
Tata tea premium	Tata Consumer Products, Maharashtra, India

[Table/Fig-2]: Beverages used in the study.

Acrylic moulds with a thickness of (2±0.1 mm) and an interior diameter of (6.0±0.1 mm) were used to create a total of 120 disc-shaped specimens, with 40 specimens for each composite [Table/Fig-3]. To minimise oxygen exposure, the resin composite was carefully packed into the moulds and coated with a Mylar sheet. A glass slide was placed on top to extrude any excess composite and achieve a smooth surface while avoiding the creation of bubbles. Pressure was applied for 30 seconds [1,9,10]. Polymerisation was performed using a BlueShot (BS) (Shofu, Kyoto, Japan) light curing unit with a light intensity of 1200 wM/cm^2 for 30 seconds. The tip of the curing light was brought into contact with the glass slide to standardise the distance between the light and the specimen. The light was positioned perpendicular to the specimen surface to deliver a homogeneous light beam with minimum light attenuation [13,14].

[Table/Fig-3]: Composite pellets formed using an acrylic mould.

After curing, the specimens were removed from the moulds. The samples were then polished following the manufacturer's instructions using four different abrasive discs (SHOFU Super-Snap Rainbow Technique Kit, Kyoto, Japan). These discs were mounted in a slow-speed handpiece. During the polishing procedures, the specimens were firmly set inside an acrylic mould. The specimens were then immersed in an ultrasonic device for 15 minutes to remove remnants from the polishing procedure. The final thickness of the discs was determined using a vernier calliper (Global Delivery Centres, Hoshiarpur, India) [Table/Fig-4]. All specimens were stored for 24 hours at 37°C in distilled water to ensure adequate rehydration and polymerisation. The initial colour values of all samples were assessed using the Commission Internationale de l'Éclairage L*a*b* (CIELAB) system [1,15] with Vita Easyshade (Vita Zahnfabrik, Germany) [Table/Fig-5]. Before each specimen measurement, calibration was performed by placing the probe tip on the machine's built-in calibration port (one calibration standard). The mean values of L0*, a0*, and b0* were recorded after each measurement was carried out three times. L* represents lightness, a* represents the degree of redness or greenness, and b* represents the degree of yellowness or blueness [16,17].

These 40 samples of each composite were then immersed in four different beverages (10 specimens each) for seven days at 37°C.

Staining conditions: For the Coffee beverage, 2 g of coffee and 236.6 mL of boiling water were combined. Since a cup of coffee typically takes 15 minutes to drink and 2 to 3 cups are usually consumed daily, the samples were submerged in coffee for seven days at 37°C. Thus, the 7-day immersion period in the proposed

[Table/Fig-4]: The dimension of the pellets was measured with a vernier calliper.

[Table/Fig-5]: Colour value assessed by Vita Easyshade.

study was equivalent to 7.4 months of clinical coffee consumption and its effects on composite restorations [18]. Tea solutions were prepared by dissolving 4 g of measured tea in 300 mL of hot water for 10 minutes [19]. Samples were submerged in the tea solution for seven days at 37°C after the tea solution had cooled for five minutes. Samples were also stored in coca-cola at 37°C for seven days [Table/Fig-6].

Spectrophotometric analysis: After a week, the samples were removed, cleaned with distilled water for five minutes, and dried on blotting paper. The same spectrophotometer (Vita Easyshade, Vita Zahnfabrik, Germany) was used to measure the secondary colours.

The colour difference (ΔE) between the two values obtained values was calculated using the following formula:

ΔE={(L1*-L0*) 2+(a1*-a0*) 2+(b1*-b0*)2}½ [15].

STATISTICAL ANALYSIS

For statistical analysis, data were compiled in an Excel spreadsheet, and SPSS (version 20.0; SPSS Inc., Chicago, IL, USA) was used. Descriptive statistical analysis was performed to determine the means and standard deviations. One-way analysis of variance (one-way ANOVA) was conducted for numerical data to evaluate the means of three or more groups of samples, using the F distribution.

[Table/Fig-6]: The pellets were immersed in beverages and kept in an incubator at 37°C temperature for 7 days.

To determine which of the three groups was significantly different from the others, a posthoc Tukey test was employed. A paired t-test was conducted to assess differences in mean between the various groups. Statistical significance was considered at $p<0.05$.

RESULTS

After immersion, colour changes were observed in all the samples. The highest mean colour change was seen with tea, followed by coffee, coca-cola, and distilled water, with values of 25.14±4.44, 16.50±3.95, 2.94±0.36, and 2.82±1.35, respectively [Table/Fig-7].

When comparing the two composite groups, the nanofilled composite (FiltekZ350XT) showed the highest mean colour change value across all beverages, while the nanohybrid composite (NeoSpectra™ST) showed the least. The nanofilled composite (FiltekZ350XT) exhibited the highest colour change in tea (25.14±4.44), while the least colour change was seen with the nanohybrid composite (NeoSpectra™ST) in distilled water (1.81±1.02) [Table/Fig-7,8] and [Table/Fig-9] for the one-way ANOVA test, which demonstrates that the groups differ significantly from each other.

When comparing the NeoSpectra™ST and FiltekZ350XT groups, there was a statistically significant mean difference in coca-cola, tea, and coffee, with values of -1.02 ($p=0.018$), -16.74 ($p<0.001$), and -7.29 ($p<0.001$), respectively [Table/Fig-10]. However, when comparing the NeoSpectra™ST and Polofil Supra groups, no statistically significant difference was found in any of the beverages [Table/Fig-10].

Except for the comparison between distilled water and coca-cola, all three composite groups showed statistically significant differences in colour change comparisons between all four beverages.

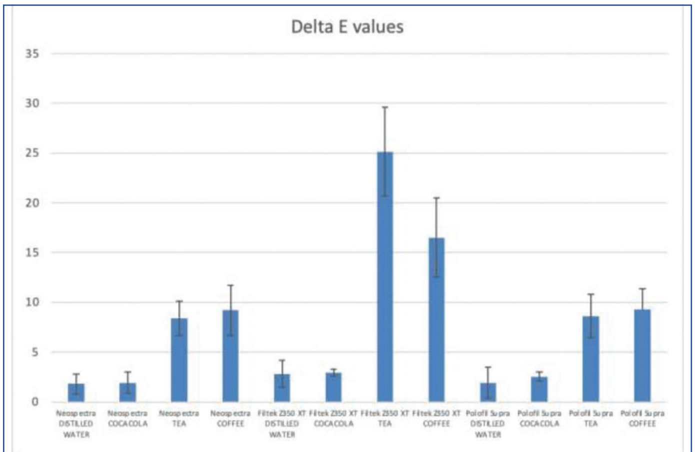
The comparison between distilled water and coca-cola did not show any statistically significant difference in any of the three composite groups (nanohybrid, nanofilled, and microhybrid), with values of 0.999, 1, and 0.836, respectively [Table/Fig-11]. The p-values for the nanohybrid and microhybrid composites were 0.703 and 0.797, respectively, indicating that there was no statistically significant difference between tea and coffee in terms of colour change [Table/Fig-11].

DISCUSSION

Insufficient light intensity and exposure time can result in incomplete polymerisation of composites, which can contribute to early colour

Groups	Number	Mean	Standard deviation	Standard error	95% Confidence interval for mean		Minimum	Maximum
					Lower bound	Upper bound		
Nanohybrid composite (Neo Spectra™ ST) Distilled water	10	1.811000	1.0192639	0.3223195	1.081863	2.540137	0.6700	3.5600
Coca-Cola	10	1.926000	1.0645938	0.3366541	1.164435	2.687565	0.5400	4.1500
Tea	10	8.400000	1.7015810	0.5380871	7.182762	9.617238	6.5500	10.7900
Coffee	10	9.216000	2.5134182	0.7948126	7.418009	11.013991	6.9200	13.2400
Nanofilled composite (Filtek Z350 XT) Distilled water	10	2.822000	1.3579216	0.4294125	1.850601	3.793399	1.2200	5.7000
Coca-Cola	10	2.946000	0.3621295	0.1145154	2.686948	3.205052	2.4500	3.6300
Tea	10	25.136000	4.4443827	1.4054372	21.956680	28.315320	20.3000	34.4400
Coffee	10	16.502000	3.9545889	1.2505508	13.673058	19.330942	10.8000	24.4300
Microhybrid composite (PolofilSupra) Distilled water	10	1.921343	1.5611392	0.4936756	0.804571	3.038115	0.5196	5.3842
Coca-Cola	10	2.553023	0.4522482	0.1430134	2.229504	2.876541	1.7944	3.2156
Tea	10	8.632654	2.1567157	0.6820134	7.089833	10.175476	5.6436	11.5624
Coffee	10	9.323810	2.0241788	0.6401015	7.875800	10.771820	5.5669	11.9721
Total	120	7.599152	7.1952874	0.6568369	6.298550	8.899755	0.5196	34.4400

[Table/Fig-7]: Mean values of colour change (Delta E) following beverage immersion for various composite resin groups.



[Table/Fig-8]: The mean colour change of different composites in different beverages is distributed in the graph.

	Sum of squares	df	Mean square	F	p-value
Between groups	5619.612	11	510.874	101.934	<0.001**
Within groups	541.275	108	5.012		
Total	6160.887	119			

[Table/Fig-9]: ANOVA for colour stability.
Actual p-value $9.14259738767505\times10^{-52}$
df: Degrees of freedom; F: F statistics; P: Probability value

changes due to water absorption and solubility [20]. In the proposed study, the polymerisation times of all specimens were adequate and comparable to ensure proper polymerisation.

When composites are cured against a Mylar strip, a resin-rich surface is formed initially, which is then finished to create a filler-rich surface with higher Knoop hardness values and reduced chemical solubility [21]. Therefore, in the proposed study, all specimens were finished consistently to achieve a uniform surface.

Colour is a subjective phenomenon that can vary between individuals and even within the same person over time. To minimise subjective inaccuracies, the Commission Internationale de l'Éclairage (CIE) L*a*b* colour scheme, spectrophotometers, and colourimeters were used to measure colour shifts [22]. Spectrophotometers, with their ability to measure reflectance curves at narrow intervals, provide more precise colour measurements compared to colourimeters [23]. Hence, spectrophotometers were used in this experiment.

In the proposed study, the specimens were immersed in different liquids for seven days. It has been shown that exposing dental materials to staining solutions for a short period, such as seven days, can lead to material discolouration [24]. According to Chan et al., stain penetration can reach up to five microns, and the majority of staining occurs within the first week [25].

A colour difference (ΔE) value between 1 to 3 is perceptible, and a value of 3.7 or higher is considered clinically unacceptable [26]. In the proposed study, both tea and coffee showed clinically unacceptable colour changes, while distilled water and coca-cola showed clinically acceptable colour changes. Furthermore, the samples exposed to tea exhibited the greatest overall colour change, followed by samples exposed to coffee and coca-cola.

Factors such as the type of drink, pigment amount, and pH level are known to contribute to colour to varying degrees [27]. Both tea and coffee contain distinct yellow colourants with different polarities. Coffee, with its lower polarity components, elutes later, while tea, with its higher polarity components, elutes earlier [5]. Additionally, both tea and coffee contain water, which has the potential to damage polymer materials. When polymer materials absorb water, hydrolysis can occur, leading to the breakage of chemical bonds between filler particles and the resin matrix. This can result in filler particles detaching from the material's surface, causing surface roughness and ultimately leading to discolouration [28].

Delta E	Neo Spectra™ ST (nanohybrid composite) (n=10)	Filtek Z350 XT (nanofilled composite) (n=10)	Polofil Supra (microhybrid composite) (n=10)	One-way ANOVA		Post-hoc Tukey test		
				F value (welch test)	p-value	Neo Spectra™ ST vs Filtek Z350 XT (p-value)	Neo Spectra™ ST vs Polofil Supra (p-value)	Filtek Z350 XT vs Polofil Supra (p-value)
Distilled water	1.81±1.02	2.82±1.36	192±1.56	1.734	0.196	0.224	0.981	0.301
Coca-cola	1.93±1.06	2.95±0.36	2.55±0.45	5.184*	0.018*	0.008	0.131	0.432
Tea	8.4±1.7	25.14±4.44	8.63±2.16	61.877*	<0.001*	<0.001	0.984	<0.001
Coffee	9.22±2.51	16.5±3.95	9.32±2.02	20.079	<0.001*	<0.001	0.996	<0.001

[Table/Fig-10]: Comparison of the groups using one-way ANOVA and posthoc Tukey test for the delta E values.
*The mean difference is significant at the 0.05 level
F: F statistics; P: Probability value

Delta E	Comparison group	Compared with	Std. Error	p-value
Nanohybrid composite (Neo Spectra™ ST)	Distilled water	Coca-Cola	0.754484	0.999
		Tea	0.754484	<0.001*
		Coffee	0.754484	<0.001*
	Coca-Cola	Tea	0.754484	<0.001*
		Coffee	0.754484	<0.001*
	Tea	Coffee	0.754484	0.703
Nanofilled composite (Filtek Z350XT)	Distilled water	Coca-Cola	1.366865	1
		Tea	1.366865	<0.001*
		Coffee	1.366865	<0.001*
	Coca-Cola	Tea	1.366865	<0.001*
		Coffee	1.366865	<0.001*
	Tea	Coffee	1.366865	<0.001*
Microhybrid composite (Polofil Supra)	Distilled water	Coca-Cola	0.754666	0.836
		Tea	0.754666	<0.001*
		Coffee	0.754666	<0.001*
	Coca-Cola	Tea	0.754666	<0.001*
		Coffee	0.754666	<0.001*
	Tea	Coffee	0.754666	0.797

[Table/Fig-11]: Intragroup comparison to study the effect of diff. types of beverages on different composites.

In the proposed study, coca-cola caused a modest colour change, which may be attributed to the change in sample roughness caused by the low pH of the solution, facilitating the adsorption of colour onto the surface. These findings support Patel et al., claim that coca-cola only slightly alters the colour of composite resins [29]. Mundim FM et al., also reported that coca-cola was ineffective in causing colour changes in composite resins [30].

The surface roughness of restorative materials is influenced by the amount and size of filler particles, which in turn is related to the external colour [31]. Various factors related to filler components, such as interparticle spacing, filler distribution, quality of filler bond to the matrix, and presence of filler agglomeration and clusters, affect the surface characteristics of the composite [32]. According to Ikejima I et al., the amount of inorganic content in composite resins increases their mechanical properties, and the structural arrangement of fillers plays a crucial role in this regard [33]. The filler percentages reported by the manufacturers for the composite resins examined in the proposed study are as follows: NeoSpectra™ST contains 78-80 wt% filler load, FiltekZ350XT has 76.5 wt%, and Polofil Supra incorporates 76.5 wt% [Table/Fig-1].

In the present study, FiltekZ350XT exhibited the highest colour change in all beverages. Additionally, there was a statistically significant mean difference in colour change between the NeoSpectra™ST and FiltekZ350XT groups in coca-cola, coffee, and tea. These differences between composites may be attributed to the smaller quantity and larger size of filler particles in FiltekZ350XT, which can result in higher surface roughness and increased discolouration. Nasim I et al., suggested that the porosity of the silica fillers and the porosity of aggregated filler particles in FiltekZ350XT may contribute to this effect [34].

On the other hand, NeoSpectra™ST showed the least mean colour change in all four beverages compared to the other composites. The could be attributed to the use of SphereTEC™ technology in manufacturing this material. The spherical prepolymerised fillers with their microgranulated structure provide excellent adaptability and sculptability, and they can bind more free resin compared to regular fillers. Additionally, the higher weight percentage of fillers in NeoSpectra™ST results in less material deterioration in different beverages. Restorations appear optically smooth if the surface roughness is less than 1 μm [35]. A recent study by Gurgan S et al., demonstrated that NeoSpectra™ST has acceptable roughness values for clinical efficacy, and a similar result can be observed for the mean colour change of the composite [9].

Microhybrid composites, such as Polofil Supra, contain filler particles of various sizes and distributions. These composites typically have a weight percentage of 77% microfillers ranging in size from 0.05 μm. The stability of the glass framework in these composites is crucial. On the other hand, nanofilled composites, like FiltekZ350XT, contain nanoclusters, which are aggregates of particles. These particles have higher water absorption capacities and are less resistant to discolouration compared to the sintraglass multifillers and macro/micron-sized fillers in microhybrid composites [36]. These research findings support the results of the current study, indicating that microhybrid composites have greater colour stability than nanofilled composites.

Finally, it is important to acknowledge that the oral cavity is a complex environment with various factors at play. Factors such as consumed foods, beverages, their temperature, salivary substances, and clinical circumstances can all influence the physical and aesthetic properties of composite materials.

Limitation(s)

The evaluation of colour stability in in-vitro experiments has inherent limitations. In order to predict the behaviour of materials in a clinical setting, authors tried to simulate the effects of long-term exposure over a shorter period of time in the present study. However, it is important to note that the effects of heat from hot food and drinks, saliva, and other fluids may be more pronounced in the oral cavity. Furthermore, the process of mastication can alter the surface roughness of the resin, allowing deposits and discolouring agents to adhere more strongly to rough surfaces. Additionally, there is intermittent interaction between dental structures, restorative materials, and staining agents, which can be exacerbated by mechanical wear.

CONCLUSION(S)

Overall, the results of this investigation demonstrated that all composite resins were susceptible to colour changes when exposed to various beverages. The nanohybrid composite showed higher colour stability, followed by the microhybrid composite, and the least stability was observed in the nanofilled composite. Among the beverages tested, tea caused the highest colour change, followed by coffee, coca-cola, and the least change was seen with distilled water. Based on these findings, it is not recommended to consume tea, coffee, or coca-cola immediately following composite repair.

The clinical significance of these findings is as follows:

1. Patients should be under dental supervision to minimise the negative effects of coffee and tea consumption on the aesthetic quality of restorations.
2. It is important to select the most appropriate restorative material for each clinical intervention and to use it in a manner that maximises its desirable qualities. Understanding the composition of the restorative material is crucial in this regard.

REFERENCES

[1] Shree Roja RJ, Sriman N, Prabhakar V, Minu K, Subha A, Ambalavanan P. Comparative evaluation of colour stability of three composite resins in mouthrinse: An in-vitro study. J Conserv Dent. 2019;22(2):175-80.
[2] Shetty P, Purayil TP, Ginjupalli K, Pentapati KC. Effect of polishing technique and immersion in beverages on colour stability of nanoceramic composites. J Oral Biol Craniofac Res. 2021;11(1):53-56.
[3] Elsaka S, Taibah S, Elnaghy A. Effect of staining beverages and bleaching on optical properties of a CAD/CAM nanohybrid and nanoceramic restorative material. BMC Oral Health. 2022;22(1):96.
[4] Patil A, Muliya VS, Pentapati KC, Kamath S. Effect of green, tulsi, and areca teas on the colour stability of two composite resin materials-an in-vitro spectrophotometric analysis. Clin Cosmet Investig Dent. 2020;12:423-28.

[5] Chowdhury D, Mazumdar P, Desai P, Datta P. Comparative evaluation of surface roughness and colour stability of nanohybrid composite resin after periodic exposure to tea, coffee, and Coca-cola-An in-vitro profilometric and image analysis study. J Conserv Dent. 2020;23(4):395-401.
[6] Ceci M, Viola M, Rattalino D, Beltrami R, Colombo M, Poggio C. Discolouration of different esthetic restorative materials: A spectrophotometric evaluation. Eur J Dent. 2017;11(2):149-56.
[7] Malek Afzali B, Ghasemi A, Mirani A, Abdolazimi Z, Akbarzade Baghban A, Kharazifard MJ. Effect of ingested liquids on colour change of composite resins. J Dent (Tehran). 2015;12(8):577-84.
[8] Lauvahutanon S, Shiozawa M, Takahashi H, Iwasaki N, Oki M, Finger WJ, et al. Discolouration of various CAD/CAM blocks after immersion in coffee. Restor Dent Endod. 2017;42(1):09-18.
[9] Gurgan S, Koc Vural U, Miletic I. Comparison of mechanical and optical properties of a newly marketed universal composite resin with contemporary universal composite resins: An in-vitro study. Microsc Res Tech. 2022;85(3):1171-79.
[10] Backes CN, FranÇa FMG, Turssi CP, Amarl FLB, Basting RT. Colour stability of a bulk-fill composite resin light-cured at different distances. Braz Oral Res. 2020;34:e119.
[11] Nasoohi N, Hoorizad M, Tabatabaei SF. Effects of wet and dry finishing and polishing on surface roughness and microhardness of composite resins. J Dent (Tehran). 2017;14(2):69-75.
[12] Yaşın B, Bakır Ş. Effect of additional polymerization process on colour change in composite resins hold in different solutions. Journal of Dental Sciences and Education. 2023;28:41-48.
[13] Konerding KL, Heyder M, Kranz S, Guellmar A, Voelpel A, Watts DC, et al. Study of energy transfer by different light curing units into a class III restoration as a function of tilt angle and distance, using a MARC Patient Simulator (PS). Dent Mater. 2016;32(5):676-86.
[14] Diab RA, Yap AU, Gonzalez MAG, Yahya NA. Impact of light-curing distance on the effectiveness of cure of bulk-fill resin-based composites. Saudi Dent J. 2021;33(8):1184-89.
[15] Hafez R, Ahmed D, Yousry M, El-Badrawy W, El-Mowafy O. Effect of in-office bleaching on colour and surface roughness of composite restoratives. Eur J Dent. 2010;4(2):118-27.
[16] Knispel G. Factors affecting the process of colour matching restorative materials to natural teeth. Quintessence Int. 1991;22(7):525-31.
[17] Karaarslan ES, Bulbul M, Ertas E, Cebe MA, Usumez A. Assessment of changes in colour and colour parameters of light-cured composite resin after alternative polymerization methods. Eur J Dent. 2013;7(1):110-16.
[18] Garoushi S, Lassila L, Hatem M, Shembesh M, Baady L, Salim Z, et al. Influence of staining solutions and whitening procedures on discolouration of hybrid composite resins. Acta Odontol Scand. 2013;71(1):144-50.
[19] Emami Arjomand M, Hoorizad Ganjkar M, Ghamari R. Effect of tea on colour stability of enamel lesions treated with resin infiltrant. Front Dent. 2021;18:4.
[20] Unsal KA, Karaman E. Effect of additional light curing on colour stability of composite resins. Int Dent J. 2022;72(3):346-52.
[21] Kocaagaoglu H, Aslan T, Gürbulak A, Albayrak H, Taşdemir Z, Gumus H. Efficacy of polishing kits on the surface roughness and colour stability of different composite resins. Niger J Clin Pract. 2017;20(5):557-65.
[22] Garg SA, Chavda SM. Colour masking white fluorotic spots by resin infiltration and its quantitation by computerized photographic analysis: A 12-month follow-up study. Oper Dent. 2020;45(1):01-09.
[23] Chittem J, Sajjan GS, Varma Kanumuri M. Spectrophotometric evaluation of colour stability of nano hybrid composite resin in commonly used food colourants in Asian countries. J Clin Diagn Res. 2017;11(1):ZC61-ZC65.
[24] Barakah HM, Taher NM. Effect of polishing systems on stain susceptibility and surface roughness of nanocomposite resin material. J Prosthet Dent. 2014;112(3):625-31.
[25] Chan KC, Fuller JL, Hormati AA. The ability of foods to stain two composite resins. J Prosthet Dent. 1980;43(5):542-45.
[26] Barry TN, Bailey CW, Ashcraft-Olmscheid D, Vandewalle KS. Effect of a new bleaching gel on tooth whitening. Oper Dent. 2017;42(5):559-66.
[27] Ozkanoglu S, G Akin EG. Evaluation of the effect of various beverages on the colour stability and microhardness of restorative materials. Niger J Clin Pract. 2020;23(3):322-28.
[28] Tanthanuch S, Kukiattrakoon B, Siriporananon C, Ornprasert N, Mettasitthikorn W, Likhitpreeda S, et al. The effect of different beverages on surface hardness of nanohybrid resin composite and giomer. J Conserv Dent. 2014;17(3):261-65.
[29] Patel SB, Gordan VV, Barrett AA, Shen C. The effect of surface finishing and storage solutions on the color stability of resin-based composites. J Am Dent Assoc. 2004;135(5):587-94; quiz 654.
[30] Mundim FM, Garcia Lda F, Pires-de-Souza Fde C. Effect of staining solutions and repolishing on color stability of direct composites. J Appl Oral Sci. 2010;18(3):249-54.
[31] Ferooz M, Bagheri R, Jafarpour D, Burrow MF. Physical properties of nanohybrid and microhybrid resin composites subjected to an acidic environment: A laboratory study. Oper Dent. 2020;45(3):E105-13.
[32] Kyoizumi H, Yamada J, Suzuki T, Kanehira M, Finger WJ, Sasaki K. Effects of toothbrush hardness on in-vitro wear and roughness of composite resins. J Contemp Dent Pract. 2013;14(6):1137-44.
[33] Ikejima I, Nomoto R, McCabe JF. Shear punch strength and flexural strength of model composites with varying filler volume fraction, particle size and silanation. Dent Mater. 2003;19(3):206-11.
[34] Nasim I, Neelakantan P, Sujeer R, Subbarao CV. Colour stability of microfilled, microhybrid and nanocomposite resins-an in-vitro study. J Dent. 2010;38(Suppl 2):e137-42.
[35] Chung KH. Effects of finishing and polishing procedures on the surface texture of resin composites. Dent Mater. 1994;10(5):325-30.
[36] Meshki R, Rashidi M. Effect of natural and commercially produced juices on colour stability of microhybrid and nanohybrid composites. BDJ Open. 2022;8(1):11.

PARTICULARS OF CONTRIBUTORS:

1. Postgraduate, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India.
2. Professor and Head, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India.
3. Associate Professor, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India.
4. Assistant Professor, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India.
5. Postgraduate, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India.
6. Postgraduate, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Shreya Modi,
Postgraduate, Department of Conservative Dentistry and Endodontics,
Karnavati School of Dentistry, Gandhinagar-382422, Gujarat, India.
E-mail: shreyahm2210@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Apr 14, 2023
- Manual Googling: Aug 05, 2023
- iThenticate Software: Aug 25, 2023 (11%)

ETYMOLOGY: Author Origin

EMENDATIONS: 5

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for the present study? Yes
- Was informed consent obtained from the subjects involved in the study? No
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Apr 07, 2023**
Date of Peer Review: **Jul 17, 2023**
Date of Acceptance: **Aug 28, 2023**
Date of Publishing: **Nov 01, 2023**