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Impact of Colored Beverages on the Color Stability of Single-Shade Composite Restorative Materials- An In-Vitro Study

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Abstract:- In dentistry, resin dental composite materials are frequently employed as tooth-colored direct cosmetic restorative solutions. The chameleon effect, which enables resin-based restorative materials to attain a shade that resembles the color of the surrounding tooth structure, is a term used to describe the blending effect, color induction, and color assimilation effects of resin composite. This study aimed To compare and evaluate the absorption of two different composite restorative materials. 32 extracted premolar samples were collected for the investigation. A rubber index was made to retain the class 5 tooth preparation measurements on the buccal surface, and the measurements were checked with a digital caliper. The tooth was split into two groups of sixteen each, 1-3M FILTEK Z350XT and 2- VITTRA APS UNIQUE. The teeth of each group were further divided into two groups, i.e., subgroups 1.1 and 2.1 for colored beverages, and 1.2 and 2.2 for carbonated beverages, before being submerged in tea and coke for 24 hours and 72 hours, respectively, to simulate one month and three month of beverage use. After this the color parameters were analyzed using a Spectrophotometer and color changes were compared. Different materials had no statistically significant interaction between material, media, and time, according to a three-way ANOVA (p <0.005).

Keywords:- *Single Shade Composite, Color, Staining Media.*

I. INTRODUCTION

In dentistry, resin-based dental composite materials are frequently employed as tooth-colored direct cosmetic restorative solutions. Clinicians must work to replicate the color of natural teeth in light of the growing cosmetic demands[1]. Composite resins aim to replicate tooth color while preserving gloss and color over time [2]. The color match and the material's capacity to hold color over time are the primary factors determining how successful an aesthetic restoration will be[3]. Color instability caused by prolonged use in a hostile oral environment is a significant drawback of resin composites. It could result in the restoration failing, necessitating a replacement restoration[4]. The chameleon effect, which enables resin-based restorative materials to attain a shade that resembles the color of the surrounding tooth structure, is a term used to describe the color induction, blending effect, and color assimilation effects of resin composite[5,6]. There are three main categories of discolorations. (I) External discoloration is brought on by plaque buildup and surface stains (extrinsic stain). (II) Surface or sub-surface color change, which denotes superficial deterioration or light staining agent penetration and reactivity inside the top layer of composite resins (absorption). (III) Body or intrinsic discoloration, which results from physicochemical processes in the more substantial part of the repair [7]. The characteristics of the resin matrix and the size of the filler particles may both contribute to an explanation for the staining susceptibility[8]. Certain beverages consumed by the general public, such as coffee, tea, and juices, have a larger ability to alter the color of composite resins[9]. Tea is a widely consumed beverage with a high potential for staining both tooth structure and resin materials due to its water-soluble pigments and polyphenol content, which includes tannin, caffeine, and caffeic acid[10]. CO2 dissolves in a liquid to produce fizz or efflorescence in carbonated beverages. In the technique, which is carried out under high pressure, CO2 is frequently employed[11] . Several investigations have demonstrated that carbonated beverages can aid in discoloration by weakening the resin matrix of composites[12]. Because of their high titratable acidity and low pH, soft drinks are frequently ingested, which damages teeth and causes non-carious cervical tooth loss (NCTL). These beverages' sugars are broken down by plaque microbes to produce organic acids, which cause demineralization and tooth cavities. Universal composites in single or group colors contain fewer hues than older composite resins due to properties known as color adjustment potential. Composite resins work with dentin and enamel to reduce color variations[13]. With Vittra APS Unique, direct restorations can be completed with just one composite material[14]. This reduction in the shade of colors facilitates achieving nearly undetectable restorations with single shades. With universal composites, restorations can be completed quickly and with excellent polish ability. Nevertheless, it has been noted that several universal composite resins on the market have less than optimal color stability[15]. This In-vitro study's objective is to assess and contrast the color stability of single-shade restorative materials, Vittra APS Unique composite, and 3M FILTEK Z350XT composite, following contact with staining agents, like tea and coke.

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II. MATERIAL AND METHODOLOGY

The study was conducted at K.V.G Dental College & Hospital, Sullia, D.K.

For the study's protocol, 60 freshly extracted human premolars were gathered. The use of extracted human teeth in an anonymous form was subjected to permission from the institutional Ethics Committee. For this study, premolar teeth with undamaged surfaces were removed for orthodontic or periodontal reasons (non-carious). Using an ultrasonic scaler calculus deposit and/or soft-tissue debris was removed, and all teeth were polished with prophylaxis paste.

With a No. 56 fissure carbide bur, Class V cavities with standardized trapezoidal outlines were created on the buccal surfaces coronal to the cement-enamel junction, measuring 5 mm wide, 3 mm long, and 1.5 mm deep. To standardize the cavity size and preparation, a rubber index was created using the necessary measurements and to mark the cavity outline before preparation. [2]. The same person prepared all cavities and the final dimensions were verified using a digital caliper (Paquimetro Digital 150mm/6 316119 Mtx).

The teeth were divided into 2 groups. Group 1- 3M Filtek Z350XT(N=30), Group 2- Vittra APS Unique Composite(N=30). The teeth were then cleaned with water and allowed to air dry. Next, the cavities were acid-etched for 20 seconds using a gel containing 37% phosphoric acid. Finally, the teeth were rinsed with water spray for 5 seconds and gently dried using an air stream. An LED curing unit was used to light-cure the bonding compound (3M ESPE UNIVERSAL BOND ADHESIVE) for 20 seconds after it was applied, per the manufacturer's recommendations. Next, a celluloid strip was placed over the created cavities and the chosen resin composites were filled inside. They then underwent a 40-second light cure. The buccal surface of the tooth was restored either with 3M Filtek Z350XT composite (3M, N = 30) or Vittra APS Unique Composite (FGM, N=30)depending on the group they belong.

Before measuring color, the specimens were kept in distal water for a whole day. The International Commission on Illumination System (CIE L*a*b*), which uses a spectrophotometer to measure color parameters, represents color luminosity (white to black) as the L* coordinate, chromaticity (blue to yellow) as the b* coordinate, and green to red as the a* coordinate. The color shifts (ΔE*) were computed in this way: Δ= E[(L*) (a*) (b*)] 1/ 2 E + Δ + Δ + Δ 2222 . For three days, at 37°C, all samples were stored in distilled water to assess their color. Lastly, specimens were divided into two subgroups (n = 15 each) according to the immersion media. Following baseline measures of tooth color, teeth were then measured after being submerged in tea and coke for 24 and 72 hours, respectively, imitating one and three months of beverage consumption. Every 24 hours, new immersion solutions were prepared and replaced. For three days, the immersion regimens were carefully followed, with five minutes spent on each immersion. The restorations were thoroughly rinsed in 0.1 M phosphate-buffered saline (PBS pH 7.2) both prior to and following each immersion. They were kept in deionized water at room temperature when not subjected to the immersion regime. The tea solution was made by soaking two premade tea bags (2 g Taj Mahal Brooke Bond Tea Bag) in 300 mL of boiling distilled water for 10 minutes, while the carbonated drink will be Coke 300ml which is available in India. After which the color parameters were measured using a Spectrophotometer and color changes will be compared.

III. RESULTS

Table 1- Comparison of mean color for different groups

Material * Time * Media

Dependent Variable: Tooth_colour

Material	Time	Media	Mean	Std. Error	95% Confidence Interval	
					Lower Bound	Upper Bound
FGM	Baseline	Distilled water	88.174	.574	87.039	89.309
		Coke	85.988	.574	84.852	87.123
		Tea	85.631	.574	84.496	86.766
	24 hrs	Distilled water	.014	.574	-1.121	1.149
		Coke	1.218	.574	.082	2.353
		Tea	1.556	.574	.421	2.691
	72 hrs	Distilled water	5.875	.574	4.740	7.010
		Coke	4.835	.574	3.700	5.970
		Tea	6.339	.574	5.204	7.474
3M	Baseline	Distilled water	88.470	.574	87.335	89.605
		Coke	90.200	.574	89.065	91.335
		Tea	87.106	.574	85.971	88.241
	24 hrs	Distilled water	-.358	.574	-1.493	.778
		Coke	.914	.574	-.221	2.049
		Tea	.680	.574	-.455	1.815
	72 hrs	Distilled water	6.121	.574	4.986	7.256
		Coke	5.087	.574	3.952	6.223
		Tea	5.409	.574	4.274	6.544

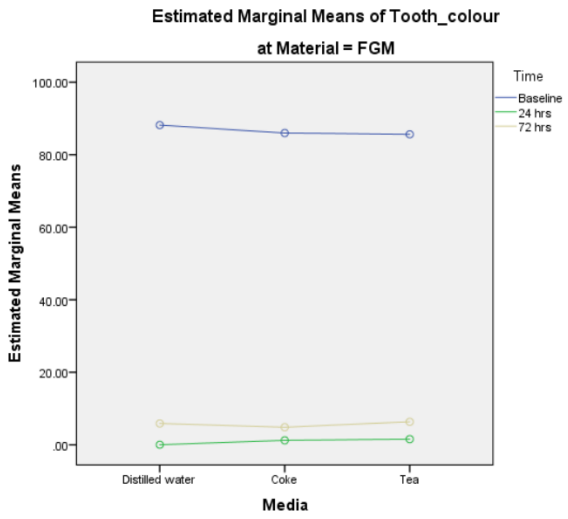

Fig 1- Estimated marginal means of tooth color for VITTRA APS UNIQUE at different timeline.

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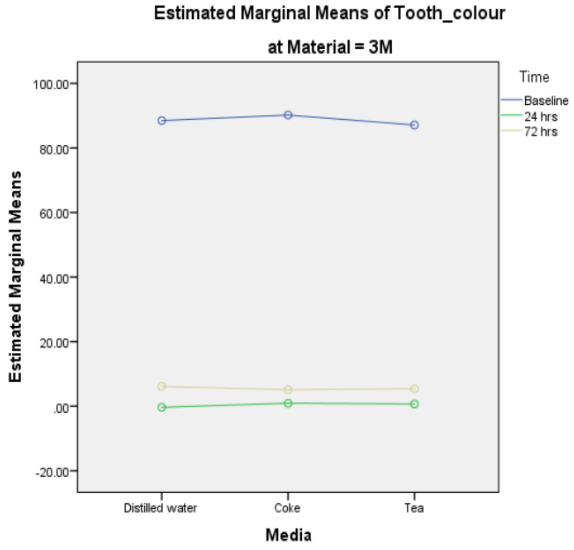

Fig 2-Estimated marginal mean of tooth color for 3M FILTEK Z350XT at different timelines.

Table 2-Significance of three-way ANOVA results for the tested variables

Tests of Between-Subjects Effects

Dependent Variable: Tooth color

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	228976.650[a]	17	13469.215	5117.713	.000	.999
Intercept	141004.631	1	141004.631	53575.597	.000	.998
Material	7.116	1	7.116	2.704	.103	.021
Time	228824.860	2	114412.430	43471.723	.000	.999
Media	2.131	2	1.065	.405	.668	.006
Material * Time	44.081	2	22.041	8.374	.000	.117
Material * Media	16.158	2	8.079	3.070	.050	.046
Time * Media	61.677	4	15.419	5.859	.000	.157
Material * Time * Media	20.628	4	5.157	1.959	.105	.059
Error	331.617	126	2.632			
Total	370312.898	144				
Corrected Total	229308.267	143				

a. R Squared = .999 (Adjusted R Squared = .998)

Table 3- Effect of time on color –VITTRA APS UNIQUE(FGM)

Multiple Comparisons

Dependent Variable: Toothcolour1

Tukey HSD

(I) Time1	(J) Time1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Baseline	24 hrs	86.92417*	.37796	.000	86.0289	87.8194
	72 hrs	81.98375*	.37796	.000	81.0885	82.8790
24 hrs	Baseline	-86.92417*	.37796	.000	-87.8194	-86.0289
	72 hrs	-4.94042*	.37796	.000	-5.8357	-4.0451
72 hrs	Baseline	-81.98375*	.37796	.000	-82.8790	-81.0885
	24 hrs	4.94042*	.37796	.000	4.0451	5.8357

*. The mean difference is significant at the 0.05 level.

Table 4-Effect of time on color-3M FILTEK Z350XT

Multiple Comparisons

Dependent Variable: Toothcolour2

Tukey HSD

(I) Time2	(J) Time2	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Baseline	24 hrs	88.18000*	.54816	.000	86.8670	89.4930
	72 hrs	83.05292*	.54816	.000	81.7399	84.3659
24 hrs	Baseline	-88.18000*	.54816	.000	-89.4930	-86.8670
	72 hrs	-5.12708*	.54816	.000	-6.4401	-3.8141
72 hrs	Baseline	-83.05292*	.54816	.000	-84.3659	-81.7399
	24 hrs	5.12708*	.54816	.000	3.8141	6.4401

*. The mean difference is significant at the 0.05 level.

Tables 1 and 2 and figure 1 and 2 provide the results of the color parameters and show how the color parameters have changed based on time and media. Different materials had no statistically significant interaction between material, media, and time, according to a three-way ANOVA ($p < 0.005$). There is a significant color variation with time i.e. at 24 hrs and 72hrs however at 24 hrs there is increased variation in color when immersed in tea in both the materials.

IV. DISCUSSION

The durability of composite resin restorations is still a concern for dental professionals despite advancements in composite resins because these materials are susceptible to wear, tear, breakdown, and staining following exposure to different foods and drinks consumed in the mouth can lead to Restoration failure necessitating replacement[16]. Universal shade composites claimed to have a breakthrough in dentistry that has an impact on treating all these problems. The basic foundation for universal shade composites is structural color phenomena. The fundamental optical processes of diffraction, scattering, and interference lead to the creation of structure colors. Consequently, structural color was said to be more suitable and stable than conventional pigmented color, which results from the light absorption of pigments[17].

The methods used in this study were those of earlier investigations. A single operator carried out every attempt to guarantee that the methodology and all of the steps were standardized[2]. The human teeth that were extracted were utilized as research materials to determine how the environment affected the color of the teeth. Furthermore, because natural teeth have unique optical qualities, clinical conditions could be revealed by using them.

The preferred system was the Sof-lex line of polishing discs. Aluminum oxide discs have been proposed as a standard procedure because they may provide polished surfaces that are smooth, nondestructive, and less prone to chemical solubility[18]. Samples were exposed to popular drinks including tea and Coke in the current investigation. In

addition, water was used as a control storage medium, but no colour shift was observed. Water degradation of resin composites occurs immediately after storage due to the presence of residual monomer from polymerization; however, this effect is restricted to light transmission parameters rather than transparency and colour parameters, particularly after short-term water storage for up to 7 days[19].

In contrast to those studies that used incredibly long immersion regimes ranging from 15 minutes to 72 hours, the immersion regime used in our study was only about 5 minutes. This was done to establish an experimentally replicated more realistic consumption pattern that would resemble real-time exposure and aid in determining the true impact of soft drinks[20]. To mitigate the effects of Coca-Cola® and Tea after the recommended exposure period, the specimens were thoroughly rinsed in 0.1 M phosphate-buffered saline (PBS, pH 7.2) both before and following each immersion in the beverages. This was done to prevent the materials from being harmed for an extended period while they were being stored in the deionized water and to bring the pH back to neutral after the exposure was over[21,22,23]. Gallic acid, which is abundant in tea, may be the cause of these solutions' increased staining ability, as demonstrated by Kumari et al[24.] The physiological solution used as the control group in this investigation does not change colour. On the other hand, following immersion in tea and coke, all restorative materials displayed clinically noticeable colour variations.

Our findings are consistent with previous research showing that even though substances have similar colour parameters, some (like tea) may stain more severely than others (like cola). Furthermore, because tea's pH is lower than the critical point at which enamel demineralization occurs, it may make it easier for tannins to enter tooth enamel through the formed porosity, which could result in an elevated B*. The 3MFILTEKZ350XT group experienced a higher and more significant change in b* value during the 72-hour immersion than the VITTRA APS UNIQUE group. The discoloration of the surrounding structure to the restoration may account for the change in b* for 3MFILTEK Z350XT in the current study. While colour change is generally viewed as a drawback in aesthetic restorations, VITTRA APS UNIQUE's structural colour property is seen as a benefit because it makes it easier to blend the restoration in with the stained tooth structure. As a result, when the surrounding tooth or environment changes, the restoration colour will pseudo-fluctuate. Conversely, traditional composites get their colour chemically from the addition of pigment hues to the composite formulas.

The color parameters of VITTRA APS UNIQUE and 3M FILTEK Z350XT significantly changed when they were kept in various staining/coloring solutions. One likely explanation is that both restorations are made of direct restorative materials, which have incomplete outer layer polymerization. When cured in air, materials containing acrylic acid display a surface layer that is inhibited by oxygen. Applying Mylar strips can therefore remove the uncured layer from the surface and produce a smooth surface finish. Nevertheless, there is less polymerization visible in the resin composite's outer layer, which may result in more discoloration[25].

V. CONCLUSION

For tooth-colored restorations to maintain their aesthetic appeal over time, color stability is a critical component. Within the parameters of our investigation, we have concluded that VITTRA APS UNIQUE, which possesses structural color properties, can, in patients who exhibit a greater propensity for consuming colored food and beverages, compensate for color changes in the surrounding structure. With the use of intelligent chromatic material technology, a new generation of single-shade composite resin can simplify color selection without compromising aesthetic success. This makes it easier for the dentist to treat patients well and with less inventory.

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