Effect of Tea and Cola on the Color Stability of a Nano-Filled and a Nanohybrid Composite an In-vitro Study.

Running Title: Effect of beverages on the color stability of two nanocomposites.

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Abstract:

Introduction: Shade stability is one of the criteria for success of an aesthetic restoration. The current study assessed the effect of two beverages on the color stability of two nano-composites.

Methods: Thirty disk shaped samples (8 x 2 mm) of Filtek Z 350 XT and Ceram X Duo were fabricated in a customized metal mold and immersed in beverages (tea and cola) and distilled water for one week. Baseline and post immersion color measurements were recorded using reflectance spectrophotometer. The data was assessed using SPSS 20 software. Data among the groups was compared by one-way ANOVA and multiple comparisons of mean values by Tukey HSD test (<0.05).

Results: Both the nano-composites showed maximum color change when immersed in tea after a week. In Filtek, the highest (ΔE) value was seen in tea (1.21) and least in cola (0.38) after one week ($p < 0.01$), whereas the color change in Ceram X group was statistically insignificant.

Conclusion: The nano-composites showed color change in both beverages and distilled water within the clinically acceptable range (ΔE <3.3), however the samples immersed in tea showed maximum color change.

Keywords: Beverages, CIE *L*a*b**, Color, Nanocomposites, Spectrophotometer.

Introduction

Advancements in composite resins aimed at improving their physical, mechanical as well as esthetic properties. They were intended to replicate the natural teeth in appearance as much as possible. An aesthetic restoration should simulate natural tooth in color as well as finish while continuing to maintain it throughout their functional lifetime. Color stability plays an important role while restoring anterior teeth.

Discoloration of the composite restorations is one of the primary reasons for their failure and subsequent replacement.[1] Discoloration may be due to intrinsic or extrinsic causes.[2] Intrinsic causes could be discoloration of the resin matrix, alteration of the resin matrix and the interface between the matrix and fillers. In addition, filler size and distribution may also contribute to the discoloration.[3] Extrinsic causes could be staining due to adsorption or absorption of coloring pigments from exogenous sources. Studies have reported color instability of composites, when exposed to red wine, coffee, cola and tea.[4]

The CIE l*a*b* system was introduced by the International Commission on Illumination (CIE) in 1976. It denotes color as three variables - L* denotes the value of color from black (0) to white (100), a* denotes color along the red-green axis and b*along the yellow-blue axis. These values correspond to the same amount of visually perceived change. This system is used extensively while evaluating the color change in materials used in dentistry.

The current study assessed the color stability of a nano-hybrid and a nano-filled composite after immersing in tea, cola and distilled water for one week. The color change was evaluated using reflectance spectrophotometer based on the CIE L*a*b* system. The null hypotheses stated that the color stability of the composites was not affected by the type of composite, the type of beverage or the immersion time.

Materials and Method

Sample preparation

Thirty-cylindrical blocks of each nanocomposite (Filtek Z 350 XT, 3M ESPE Universal Restorative and Ceram X Duo, Sirona Dentsply) (n = 60) were made by compacting them into a customized metal mold of dimensions 8 x 2 mm. All the samples were polymerized using Bluephase NMC LED dental curing light (Ivoclar Vivadent, Schaan, Liechtenstein) with 1,200 mW/cm^2 intensity, by placing a Superdent mylar strip - (4" x 3/8" x .002", DuPont mylar*, USA) against the composite resin in the metal mold. Each sample was

polished with a full sequence of polishing discs (Sof-Lex 3M ESPE, St. Paul, MN, USA) and stored in distilled water for one day before immersing in the test solutions.

The composition of the two composites used has been shown in **Table1**.

Table 1: Composition of composites used in the study

RBC	Manufacture	Resin matrix	Filler	Filler, weight/volume
Filtek Z 350 XT universal restorative	3M ESPE	TEGDMA, UDMA, Bis-EMA	Combination of non-aggregated 20nm silica, non-aggregated 4-11nm zirconia and aggregated zirconia/ silica cluster filler	78.5 / 59.5
Ceram X Duo	Dentsply Caulk	ORMOCER, DM ethyl 1-4 (dimethyl amino) benzoate	Barium- aluminum-borosilicate. Filler size: (2.3-2.5nm)- glass (1.1-1.5 μ), SiO2 – nanofiller (10nm)	76 / 57
RBC – Resin based composite, UDMA – Urethane dimethacrylate, Bis- EMA – Bisphenol A ethoxylated dimethacrylate, TEGDMA - Triethylene glycol dimethacrylate				

Storage media preparation

The two beverages used in the study were freshly prepared daily for use. Distilled water (Thermo Fisher Scientific, U.S) served as the control group. Tea (Brooke Bond Red Label, Unilever, Mumbai, India) was prepared by freshly mixing 4 grams of tea powder, 100 ml of milk and 10 grams of sugar to 300 ml of water and the solution was boiled for 5 minutes every day. A fresh bottle of Coca-Cola (The Coca Cola Company, Atlanta, Georgia, U.S), a carbonated drink was freshly opened daily in order to maintain the accepted level of carbonic gas. Thirty composite blocks were then divided into three subgroups and were immersed in distilled water, tea and cola respectively for one hour a day for one week.

Color evaluation

Baseline color measurement was done for all the samples using X-Rite i1 Eye-One Pro Spectrophotometer before immersing in the test solutions. Before measuring, the machine

was standardized to the recommended values and the assessment was done at baseline (T0), one day (T1) and one week of immersion in test solutions (T7). All the specimens were dried and placed in the spectrophotometer view port. L *, a * and b * values of every sample was assessed thrice and the mean was noted. The mean change in color ΔE was derived from ΔL *, Δa *, Δb* (i.e. differences in L *, a * and b * values at different time intervals) using the following formula[5]:

$$\Delta E\ (L^* a^* b^*) = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]\ ½$$

Sample size selection and randomization

Based on the key article, the mean SD values were taken from the table 1 of the article.[6]Keeping an alpha error of 1%, power of the study 80% and the minimum difference in the values with clinically significant difference of 0.05 units, the sample size was selected to be 10 per group. The sample size was calculated using the below formula:

$$N = \frac{2(Z_{1-\alpha/2} + Z_{1-\beta})^2 \sigma^2}{d^2}$$

The samples from each composite group were numbered sequentially from 1-30 by the principal investigator. Random numbers were generated from 1-3 in an excel sheet to categorize them into tea, cola and distilled water sub groups. The examiner was blinded during the color evaluation and the statistician was blinded during the data analysis.

Statistical analysis

The collected data was assessed using SPSS 20. Software. Data among the groups was compared by one-way ANOVA and multiple comparisons between the mean values by Tukey HSD test ($p < 0.05$).

Results

The color change (ΔE) values with their standard deviation, have been shown in **Table 2.**

Table 2: Mean and standard deviation of the color change (ΔE) of the composites after one day and one-week immersion

COMPOSITE	**IMMERSION SOLUTION**	**(ΔE) 1 day**	**(ΔE) 7 days**

Filtek Z 350 XT	Distilled water	0.25 ± 0.57	0.08 ± 0.36 *
	Tea	0.53 ± 0.66	1.21 ± 0.59 *
	Cola	-.10 ± 0.69	-0.38 ± 1.49 *
Ceram X Duo	Distilled water	0.09 ± 0.46	0.44 ± 0.39
	Tea	0.07 ± 0.45	0.59 ± 0.38
	Cola	0.39 ± 0.53	0.49 ± 0.75
*indicates significant difference between the beverages for each composite (in columns) according to Tukey HSD test (*P<0.05*).			

Among the three test solutions, tea exhibited maximum discoloration in both the composites compared to cola and distilled water after one-week immersion.

In the Filtek group, following immersion in test solutions for one day, the highest mean color change value was observed in tea (ΔE_1 = 0.53 ± 0.66) and least in cola (ΔE_1 = -0.10±0.69) which was statistically insignificant. Post hoc Tukey tests comparing distilled water, tea and cola groups after one day showed statistically insignificant results with p value > 0.05.

After one-week, Filtek group showed the highest mean color change value in tea ($\Delta E_{7=}$ 1.21 ± 0.59) and least in cola ($\Delta E_{7=}$ -0.38 ± 1.49) which was statistically significant. Post hoc Tukey tests showed significant difference between distilled water and tea, tea and cola groups.

The Ceram X group after one-day immersion, showed the highest mean color change value in Cola (ΔE_1 = 0.39 ±0.53) and least in tea (ΔE_1 = 0.07 ±0.45) which was statistically insignificant.

Ceram X group after one-week immersion, showed the highest mean color change value in tea (ΔE_7 = 0.59 ± 0.38) and least in distilled water (ΔE_7 = 0.44 ± 0.39) which was statistically insignificant. Post hoc Tukey tests comparing distilled water, tea and cola groups also showed statistically insignificant results with a p value > 0.05.

Discussion

Daily intake of beverages has shown to affect the appearance and structural properties of composites, thus compromising the aesthetic quality.[7,8,9]The staining of composites depends upon the matrix phase, size of the fillers, adsorption and absorption of the stain, polymerization and color pigments.[10,11,12] The resin structure has a direct effect on its surface

properties and ability to stain. The composite samples were placed in tea, cola and distilled water for one hour every day for one week which denotes a medium frequency of intake of beverages.[13]

Color change was assessed using the CIE l*a*b* system. Here L* values are along the vertical axis and a* and b* values revolve on axes around L*. A (+) a* value denotes red and a (-) a* value denotes green. A (+) b* denotes yellow and (-) value denotes blue. The readings were recorded in L*a*b* coordinates to calculate the mean color change value (ΔE). According to this principle, if the material is color stable, there will be no change in color after immersion in the test solutions (ΔE = 0). The human vision cannot perceive ΔE < 1.5, thus it was measured using a spectrophotometer. The ΔE ≥ 3.3 was clinically perceptible, which is in accordance with the earlier studies.[6]

Among the three tested solutions, maximum color change was exhibited by Filtek composite samples in tea group compared to the cola and distilled water (control) groups, after one day and one week of immersion. This could be due to the tannic acid in the tea.[12]

Filtek composite samples also showed color change in the cola group after one week, however lack of yellow pigment in cola might have attributed to lesser color change compared to that in tea.[14, 15]As immersion time increased from one day to one week, the color change exhibited also intensified, which could be due to the interaction between the resin and the staining components of the test solutions resulting in subsequent penetration of the stain into the resin.[7]

Among the two composites tested, Filtek group exhibited maximum color change when immersed in tea after one week. The degree of water sorption determines the susceptibility to extrinsic discoloration and degradation of the resin.[16] According to Bagheri et.al[15] a composite that absorbs water, can also absorb other fluids, resulting in staining[17] and inferior mechanical properties due to matrix degradation.[18]The glass fillers do not absorb water into the material, but adsorb it on the surface. The remaining water decreases the life of composites by expanding and plasticizing the resin component, hydrolyzing the silane, causing microcracks or interfacial gaps, thus allowing stain penetration and discoloration.[15] The resin matrix can also contribute to the discoloration of composite. It was reported that UDMA is more resistant to stain and exhibited lower water sorption compared to Bis-GMA.[19, 20] Also, composites containing TEGDMA have shown more staining compared to those containing UDMA.[16]In the current study Filtek Z 350 XT showed more color change than Ceram X, which could have been due to Bis-GMA in its resin matrix.

Conclusion

Within the limitations of the study the following conclusions were drawn:

- Both Filtek Z 350 XT and Ceram X Duo have shown a color change when immersed in tea, cola and distilled water for one week, within the clinically acceptable range.
- Among the three solutions, the tea group has shown the highest amount of color change in both composites.
- The amount of color change varied with change in immersion time, in all three solutions.

Limitations

1. The current in-vitro study did not consider variables such as temperature of the beverage, concentration of the beverage, surface wear/roughness, resin matrix and filler content of the composite which may have influenced the color stability of the composites.
2. As the solutions tested in our study do not represent all clinical scenarios to which composites may be exposed in the oral cavity, further studies are needed to evaluate other factors that influence the color stability of the composite resins.

Legends

Table 1: The composition of the two composites used has been shown.

Table 2: The mean and standard deviation values of color change (ΔE) have been shown**.**

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