Effect of Children’s Drinks on Color Stability of Different Dental Composites: An *in vitro* Study

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Aim: *To assess the effect of four different children’s drinks on color stability of resin dental composites.* ***Study design:*** *A total of one hundred and twenty specimens were prepared from Grandio SO, Filtek Z350 XT and Filtek Z250 XT (forty specimens each). Specimens were thermocycled, then each group was further subdivided into four subgroups (n=10) according to the immersion media which were chocolate milk, mango juice, orange fizzy drink, and water (control). The initial color parameters of each specimen were recorded before immersion (baseline) and color change values were recorded three and seven days after immersion in each solution using a digital spectrophotometer. Atomic force microscope was used to measure the surface roughness in randomly selected samples after one week immersion in children’s drinks.* ***Results:*** *All the children’s drinks produced color changes in the examined resin dental composites, yet there was no statistical significant difference between the effects of tested drinks on the color changes (mean ΔE) of the three different dental composites (P>0.05).* ***Conclusions:*** *All tested children’s drinks caused clinically unacceptable color changes of the tested resin dental composites. Immersion in chocolate milk and orange fizzy led to the highest color changes in the tested resin dental composites.*

Key words: *Children’s drinks, Color stability, Dental composites.*

INTRODUCTION

Trauma to anterior teeth is a common phenomenon in young children and adolescents. Coronal fracture to permanent teeth has an intense effect not only on the patient’s appearance but also on function and speech. Management of children with anterior tooth fracture is challenging to the pediatric dentists both from functional and aesthetic perspectives[1,2,3].

Due to the high esthetic demand, the use of dental composite resin has become increasingly popular and an important reality in restorative dentistry. Manufacturers have introduced new innovations in tooth-colored restorative materials to simulate the appearance of natural tooth by achieving optimum material’s color match and color stability[4,5,6,7,8].

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Color change in dental composites after the consumption of colored beverages is among the problems commonly encountered in restorative dentistry[6,9]. Color instability is attributed to intrinsic and extrinsic factors; intrinsic discoloration is due to inherent properties of the restorative material [4,9] while extrinsic color change is attributed to the bonding or penetration of different coloring agents in consumed foods or drinks to the restoration surface[1,6,9,10].

Advancements in dental composite restorative materials technology has improved their physical and aesthetic properties by introducing new filler concepts and matrix changes to allow their use for anterior restorations with optimum durability and color stability[4,8,11].

Thus, this study was conducted to assess the effect of four different children’s drinks on color stability of resin dental composites.

MATERIALS AND METHOD

A total of one hundred and twenty specimens were prepared from Grandio SO (Voco, Cuxhaven-Germany), Filtek Z350 XT (3M ESPE, St. Paul, Minnesota, USA), and Filtek Z250 XT (3M ESPE, St. Paul, Minnesota, USA) resin dental composites (Table 1), forty specimens per each material. The specimens were prepared in cylindrical Teflon molds ten millimeters in diameter and two millimeters thick. The mold was placed over a celluloid strip on glass slab and filled with the tested resin composite then covered with another celluloid strip and pressed by placement of another glass slab above the Teflon mold to eliminate air entrapment and voids.

Each specimen was light-cured from both sides using a LED source (bluephase C5 Ivoclar Vivadent, Schaan, Liechtenstein) for 60 seconds. Immediately after light curing, specimens were removed from the Teflon molds and stored in distilled water at 37°C for 24 hours to allow completion of polymerization. All samples were subjected to 500 thermocycle rounds between 5 and 55^{0}C with 20 seconds dwell time before immersion in the storage media.

Each group was divided to four sub-groups according to storage media (n= 10); chocolate milk, mango juice, orange fizzy drink, and water (control). The pH of the four immersion media was measured using a pH meter (pHep, HANNA instruments, Padova, Italy) and were found to be 6.25, 5.8, 3.5, and 5.6 respectively .The specimens were immersed in their corresponding solutions, kept in closed containers in an incubator at 37°C. The immersion media were daily renewed.

Color Assessment

The color was recorded after thermocycling process (base line), three days and one week after storage in the different storage media. Prior to color assessment specimens were removed from the storage media, placed in water container and shaken ten times, rinsed under tap water for five seconds, and blot-dried.

The color of the specimens was measured with a spectrophotometer (Vita Easyshade, Vita Zahnfabrik, Bad Säckingen, Germany). Color differences were demonstrated by Standard Commission International de L'Eclairage Color System (CIE). According to the CIE-Lab system recommended by the American Dental Association, all colors in nature are obtained from the mixture of three basic colors: red, blue and green. The L* represents the value (lightness or darkness). The a* value is a measure of redness (positive a*) or greenness (negative a*). The b* value is a measure of yellowness (positive b*) or blueness (negative b*). Colorimetric measurements of the specimens were performed according to the CIE L*a*b* color scale, recording the L*, a*, and b* values, which allows the determination of color in the three-dimensional space.

Color measurements were performed by positioning the specimens on a white background to prevent potential absorption effects on any of colors parameters. One examiner performed all the recorded data of the L*, a*, and b* values.

Three readings were performed with the active point of the spectrophotometer in the center of each specimen and a mean value for the L*, a*, and b* values was obtained for each specimen. The color difference (ΔE) between the color coordinates was calculated using Hunter's equation, $\Delta E= [(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2]^{1/2}$ [5].

The recorded color changes were described according to the values of ΔE. Values of ΔE less than 1 were considered imperceptible by the human eye, only instrumentally detectable, ΔE values between 1 and 3.3 were considered visually detectable by skilled operators but still clinically acceptable, while values of ΔE more than3.3 were considered detectable by untrained observers, thus regarded as clinically unacceptable[4,5].

Topography of randomly selected one specimen from each subgroup after seven days immersion in different drinks was examined by atomic force microscope (Auto Probe CP-Research Probe Head, manufactured by Thermomicroscope, Sunnyvale, California, USA). Each specimen's surface was scanned using nonconductive silicon nitride probe (manufactured by Bruker. Model: MLCT-MT-A.). One Hertz scan rate and 256 × 256 resolution were used to obtain topography on a 50 microns × 50 microns scanning area. Measured topography data was processed by proscan 1.8 software for controlling the scan parameters and IP 2.1software for image analysis. The average roughness (Ra) was recorded for the randomly selected specimens.

Statistical analysis

Data was statistically described in terms of mean, standard deviation (±SD), and checked for normality using D'Agostino-Pearson test. ΔE showed a normal distribution so three way-ANOVA was used to study the effect of children's drinks on mean ΔE. Statistical analysis was performed with IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 22 for Windows.

RESULTS

The results of this in-vitro study revealed that the four tested children's drinks possessed clinically unacceptable staining abilities on the three different resin dental composites (ΔE>3.3) , however, there were no significant difference between the color changes of the three different dental composites after three and seven days immersion periods (P>0.05) as shown in table (2).

When the staining abilities of different children's drinks were compared, chocolate milk and orange fizzy caused the maximum color change in Grandio SO after one week with mean ΔE=6.24±1.96 and 6.17±3.06 respectively, while the minimum color change was recorded after immersion of Filtek Z250 XT in distilled water for one week with mean ΔE= 2.77±1.70 (Table 2 and Figure 1).

In this study atomic force microscope was used to measure the average roughness in randomly selected samples from each subgroup after one week immersion in children's drinks. The results showed average roughness (Ra) after immersion in chocolate milk: 60.51 nanometers, 89.18 nanometers and 64.15 nanometers for Grandio SO, Filtek Z350 XT, and Filtek Z250 XT respectively. The recorded values for mango juice were 31.67 nanometers, 54.54 nanometers and 28.78 nanometers for Grandio SO, Filtek Z350 XT, and Filtek Z250 XT respectively. The average roughness (Ra) for the selected samples of orange fizzy drink were 23.31 nanometers, 37.32 nanometers and 36.81 nanometers for Grandio SO, Filtek Z350 XT, and Filtek Z250 XT respectively. For distilled water, the average roughness (Ra) values were 28.71 nanometers, 52.78 nanometers and 39.87 nanometers for Grandio SO, Filtek Z350 XT, and Filtek Z250 XT respectively (Figure 2).

Table (1): The resin dental composites used in this study.

Material	Type	Manufacturing company	Shade	Filler content (wt %)
Grandio SO	Nanohybrid	VOCO (Cuxhaven-Germany)	A2	89%
Filtek Z350 XT	Nanofilled	3M ESPE (St. Paul, Minnesota,–USA)	A2	78.5%
Filtek Z250 XT	Nanohybrid	3M ESPE (St. Paul, Minnesota, USA)	A2	81.8%

Table (2): Color changes (mean and standard deviation of ΔE) after immersion in children’s drinks.

	Chocolate milk Mean SD		Beverages								
			Mango juice		Orange fizzy drink		Distilled water (Control)				*p*-value
			Mean	SD	Mean	SD	Mean	SD			
ΔE	Grandio SO	3 Days	5.27	1.75	4.57	2.42	6.02	2.21	5.04	1.46	0.439 NS
		1 Week	6.24	1.96	3.98	3.08	6.17	3.06	4.21	1.41	0.082 NS
	Filtek Z350 XT	3 Days	3.50	1.93	4.11	2.43	3.51	1.44	4.12	2.38	0.835 NS
		1 Week	2.81	1.07	4.83	2.31	3.27	2.64	3.86	1.41	0.138 NS
	Filtek Z250 XT	3 Days	3.12	1.92	3.95	1.31	3.65	2.07	4.95	2.43	0.224 NS
		1 Week	3.34	1.66	4.44	1.79	3.98	1.77	2.77	1.70	0.168 NS

*= Significant, NS=Non-significant

Figure (1): Histogram showing the mean of ΔE after immersion in four children’s drinks.

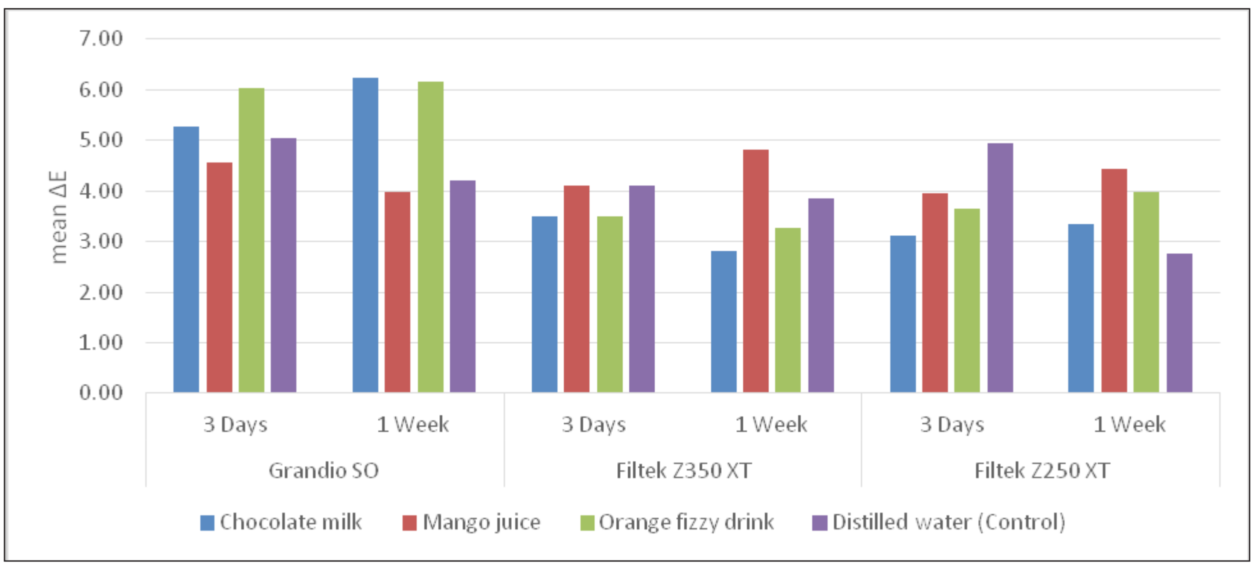
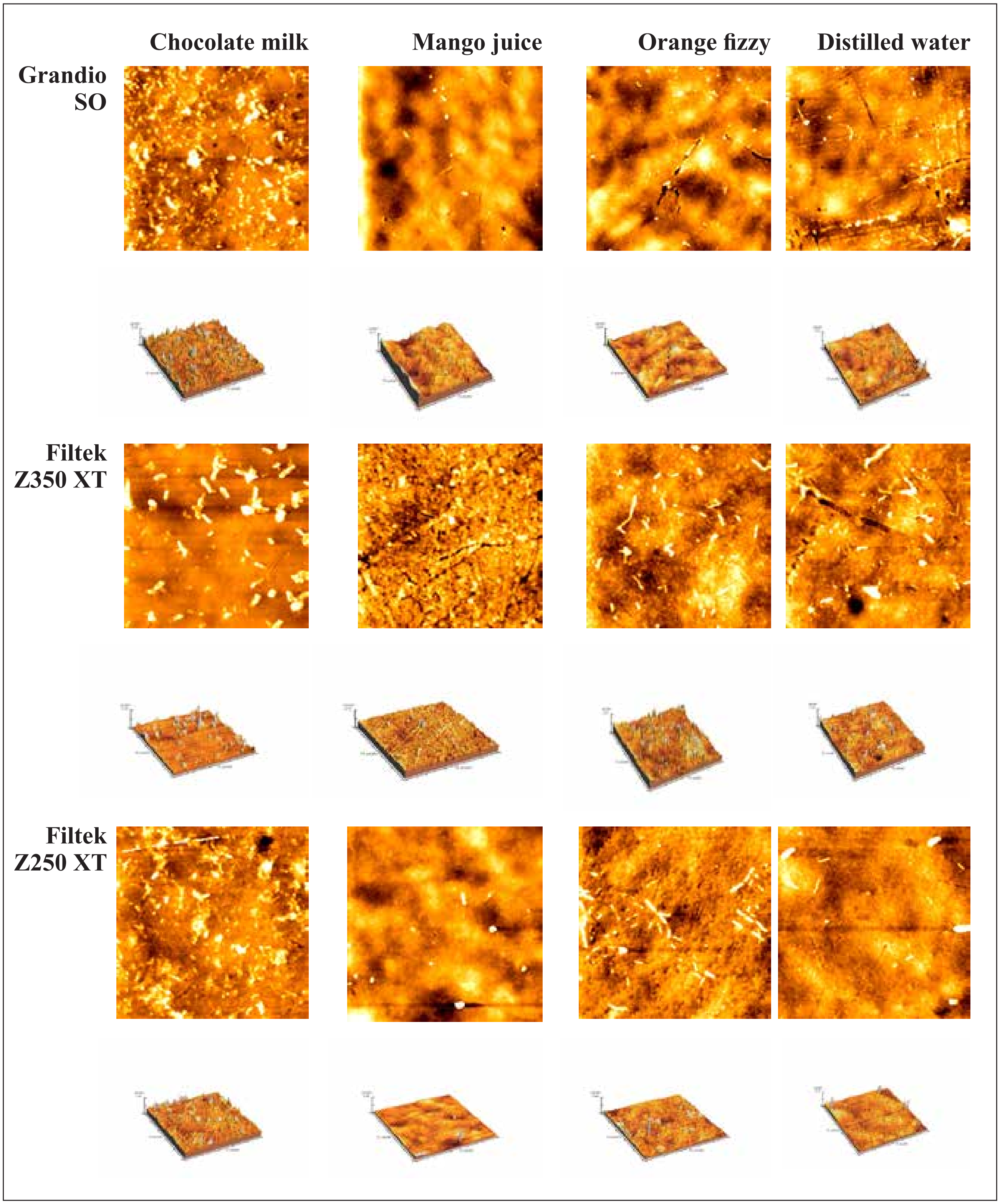


Figure (2): Surface roughness of specimens after one week immersion in four children's drinks.



DISCUSSION

The overwhelming demand for esthetic dentistry has been met with rapid development of new restorative materials to achieve optimum color match and sustained color stability. However, these materials are continuously exposed to challenging oral environment, thus it is important to determine their susceptibility to color change overtime. This study was conducted to assess the effect of four different children's drinks on color stability of resin dental composites.

In this study, the drinks chosen to assess the color change of dental resin composites are among those commonly consumed by children[1].

Celluloid strips were used for external surface shaping of the discs to obtain extremely smooth surfaces and to standardize the surface properties of all specimens as finishing and polishing procedures may result in different surface textural changes and subsurface defects[12,13].

All specimens were subjected to thermocycling and kept at 37° Celcius constantly in incubator throughout the entire study in order to simulate oral cavity fluctuations and average temperature respectively[14].

The present study used a spectrophotometer for color measurements to eliminate potential subjective errors in color assessment. During color measurement, both the actual color of the material surface and the lighting condition under which the surface is measured affect the measured color. Thus, a standard illuminant against a white background was used. As color change evaluation was the focus of this study, the choice of illuminant was not important [1,4,5,15].

The value ΔE was used to compare the color changes that occurred due to immersion in the four children's drinks, it represents relative color changes that an observer might report for the materials. Thus ΔE is more meaningful than the individual L*, a*, b* values [4,5,10,16].

The results of this study showed that the color changes of the three different composites upon three and seven days immersion in the four children's drinks were clinically unacceptable ($\Delta E > 3.3$). This intense behavior of the resin dental composites towards the four immersion media may be related to the exposure of the specimens to thermocycling before immersion. The aging process can induce changes in the surface microstructure, matrix chemical composition, and also at the interface between organic matrix and filler particles[17,18,19] .

It was assumed that thermocycling weakens chemical bonds in the organic polymer creating pores within the resin matrix as well as exposure of filler particles, thereby contributing to the color changes in resin dental composites. Surface deterioration creates microcracks within the material that facilitate the penetration of stains[17,19,20].

Though statistically insignificant, the highest ΔE values were recorded due to the effects of chocolate milk and orange fizzy drink on Grandio SO (Voco). Chocolate milk staining effect may be due to its organic components and greasy nature, thus readily adsorbed to the resin surface interacting with the organic matrix leading to its discoloration. The pronounced effect on Grandio SO (Voco) may be related to the hydrophilic nature of its organic matrix giving rise to higher sorption[13,21].

The color change occurring upon immersion in orange fizzy may be attributed to its low pH (3.5) which affected the composite resin surface increasing pigment absorption. The acidic pH can induce surface roughness (as confirmed with atomic force microscope) thus enhancing accumulation of residues and dyes, diminishing the gloss of the restoration, giving rise to discoloration and staining[22,23].

The comparable staining effects of the four immersion media on Filtek Z350 XT (3M ESPE) and Filtek Z250 XT (3M ESPE) may be due to the similarity in their organic matrix structure. The majority of TEGDMA (triethylene glycol dimethacrylate) in their organic matrix has been replaced with a blend of UDMA (urethane dimethacrylate) and Bis-EMA (Bisphenol A polyethethyleneglycol dietherdimethacrylate) which are of high molecular weight, and therefore have lesser double bonds per unit of weight. This results in less shrinkage, decreased aging, and a slightly softer matrix. These resins impart a greater hydrophobicity which may limit water uptake and consequently, color variations induced by the absorption of the staining solutions[4,14].

The color changes developed due to distilled water immersion may be due to water penetration into the matrix or filler-matrix interface. The presence of microcracks in the resin matrix as a result of swelling and plasticizing effects, along with interfacial gaps created between the filler and resin matrix can lead to color changes[5,9,10].

CONCLUSIONS

1. All tested children's drinks caused clinically unacceptable color changes of the tested resin dental composites after three and seven days immersion period.
2. Chocolate milk and orange fizzy led to highest color changes in the tested resin dental composites after seven days immersion period.
3. The microstructure of the resin dental composites affects the degree of the color change.

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