ORIGINAL RESEARCH

Effect of Different Beverages and Brushing on Color Stability of Two Different Dental Resin Composites

Lamia M Elmalawany[1], Dina A El-Refai[2], Ghada A Alian[3]

Abstract

Aim: To evaluate the effect of different beverages, with and without brushing, on the color stability of a nanohybrid resin composite and an ormocer.

Materials and methods: Two dental resin composites were used: Admira Fusion (ormocer) and Grandio (nanohybrid resin composite). Four beverages were used: Nescafe Classic, red wine, Pepsi Cola, and artificial saliva. Eighty specimens from each composite were prepared, divided into brushing and non-brushing groups, and further subdivided according to the used beverage. The baseline color measurements were done after 24 hours. For the non-brushing group, the specimens were immersed in the different beverages for 5 minutes three times daily. For the brushing group, the same procedure was done, in addition to brushing the specimens for 5 seconds 1 hour after the last immersion cycle. The color measurements were repeated after 30 days. The one-way analysis of variance and independent *t*-tests were used for statistical analysis.

Results: Nescafe Classic yielded the highest ΔE while artificial saliva yielded the least. Both Nescafe Classic and red wine produced ΔE of more than 3.3. Brushing tended to decrease ΔE. Admira Fusion exhibited less ΔE than Grandio in all tested beverages.

Conclusion: Both restorative materials used were susceptible to staining by commonly consumed beverages.

Clinical significance: Commonly consumed beverages cause undesirable color changes to different resin composites.

Keywords: Beverages, Brushing, Color stability, Laboratory research, Nanohybrid resin composite, Ormocer.

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Introduction

Dental resin composite restorations are widely used to cope with the increased esthetic demands among adults and even children.[1] Among the main success reasons of esthetic restorations is the accuracy in shade selection, as well as the ability of the restoration to maintain that shade.[2] Staining of resin composite restorations is the main esthetic challenge affecting color stability of these restorations after long-term use.[3] Many factors contribute to staining of composite resin restorative materials either intrinsic or extrinsic.[4] Composite resin restorations having high surface smoothness and low surface porosity will have lower adherence of dental biofilms, tobacco, and food colorants that usually cause color changes.[5]

Studies in the literature in terms of color stability of dental restorations have proven that different common drinks, like coffee, tea, and soft drinks, in addition to mouth rinses cause different levels of discoloration to the various restoration.[6] These drinks are widely consumed by the public and can cause discoloration of resin composites.

Brushing and polishing though might remove material from the composite, they tend to remove the superficial staining partially or even completely. Thus, it enhances the color stability of dental resin composite restorations.[7,8]

Dental resin composites had been modified through different changes in filler technology, resin matrices, and the filler/matrix bonding. Several attempts had been made to increase the filler content of posterior composites in order to obtain a strong restoration that can withstand the masticatory forces.[9]

Hence this work was carried on to assess the effect of different beverages and brushing on the color stability of dental resin composites having different matrix formulations.

[1–3]Biomaterials Department, Faculty of Dentistry, Ain-Shams University, Cairo, Egypt

Corresponding Author: Lamia M Elmalawany, Biomaterials Department, Faculty of Dentistry, Ain-Shams University, Cairo, Egypt, Phone: +002-01003391908, e-mail: lamia.elmalawany@asfd.asu.edu.eg

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Materials and Methods

Two dental resin composites were used: Admira Fusion (nanohybrid ormocer-based) and Grandio (nanohybrid resin-based). Four beverages were used: Nescafe Classic (instant coffee), red wine (alcoholic drink), Pepsi Cola (soft drink), and artificial saliva (as control) shown in Table 1. Eighty specimens from each composite type were prepared, divided into brushing and non-brushing groups, and further subdivided according to the used beverage.

For the preparation of the specimens, a split Teflon mold having a central circular hole of dimensions 10 mm diameter and 2 mm thickness[6] was utilized. The material was condensed as a single increment in the mold, which was placed on a celluloid strip resting on a microscopic slide. It was further covered by a celluloid strip and a second slide. A weight of 500 gm was used for 1 minute to ensure a flat void-free surface. Then the specimen was photo-cured for 20 seconds as instructed by the manufacturers by a LED light cure of 1200 mW/cm^2 output (Elipar S10, 3M ESPE, Germany)

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Table 1: Materials used in the study

Brand name	*Description*	*Composition*	*Manufacturer*	*Lot no.*
Dental resin composites used				
Admira Fusion (A3)	Universal nanohybrid ormocer.	100% ormocer monomer with C = C groups matrix. 84 wt% inorganic filler loading.	VOCO GmbH, Cuxhaven, Germany	1706603
Grandio (A3)	Universal nanohybrid resin composite.	Bis-GMA, TEDGMA, UDMA matrix. 87 wt%/71.4 Vol.% inorganic filler loading.	VOCO GmbH, Cuxhaven, Germany	1705400
Beverages used				
Artificial saliva		4.1 mM KH_2PO_4, 4.0 mM Na_2HPO_4, 24.8 mM $KHCO_3$, 16.5 mM NaCl, 0.25 mM $MgCl_2$, 4.1 mM citric acid, and 2.5 mM $CaCl_2$. The pH of the artificial saliva solution was adjusted to 6.7 with 10 N HCl[99]	Laboratory of the pharmaceutical industry.	
Nescafe Classic	Instant coffee	100% pure soluble coffee made of robusta coffee beans through spray drying technique.	Packed by Nestle, Egypt. Made in Spain.	
Red wine	Alcoholic drink	Sugar-free red wine, alcohol content 12.5% vol.	Gianclis vineyards, Egypt.	
Pepsi Cola	Soft drink	Carbonated water, Sugar or Fructose syrup, Color (caramel), Phosphoric acid, Caffeine, Emulsifier (gum Arabic), Natural flavor.	Pepsi Cola, Egypt.	
Dentifrice used				
Signal complete 8		Sodium Fluoride (1450 ppm Fluoride), Zinc Citrate, Aqua (water), Sorbitol, Hydrated Silica, PEG-32, Sodium Lauryl Sulfate, Aroma (flavor), Cellulose Gum, Perlite, Sodium Fluoride, Sodium Saccharin, Mica, Glycerin, CI 74160, and CI 77891.	Unilever Mashreq, Egypt.	ABN07

through the microscopic slide. The LED light cure was periodically checked by a curing radiometer (Model 100, Kerr, USA). The prepared specimens placed in artificial saliva were kept in an incubator at 37°C for 24 hours. A spectrophotometer (Cary 5000 spectrophotometer, Agilent technologies, USA) was utilized to measure the baseline color. One of the surfaces of each specimen was labeled to ensure measurements were repeatedly done on the same surface. CIE Lab color values for each sample were then calculated by using the color software application, which is available through the Cary WinUv instrument and supports the extensive color calculations and standards.

For the non-brushing groups, specimens were then immersed in their respective beverages for 5 minutes three times daily with a time interval of 5 hours. In between the cycles, the specimens were returned to the artificial saliva and placed in an incubator (Titanox, Italy) kept at 37°C. The beverages were used according to the recommended temperature of consumption, i.e., Pepsi Cola 4 ± 1°C (kept in a refrigerator), red wine 25 ± 1°C (kept at an incubator), and Nescafe was prepared by adding 5 gm of powder weighed using a balance to 250 mL of boiling distilled water and stirred for 1 minute using Cappuccino mechanical stirrer and cooled to 70 ± 1°C.[4] A digital thermometer was used to monitor the temperature. Freshly prepared beverages were used for each immersion cycle. Following each cycle, washing of the specimens with distilled water for 1 minute was done, then blot dried, and returned to the artificial saliva. The artificial saliva was replaced daily, and the procedure was repeated for 30 days.

For the brushing group, the same procedure was employed. Specimens were immersed in their respective beverages for 5 minutes three times daily with a time interval of 5 hours. Then brushing was done using an electric brush (Oral-B Vitality, Braun Gmbh, Germany) 1 hour after the last cycle. To ensure standardization, each specimen was held in a specimen holder and both the holder and the brush were fixed to the jigs of a universal testing machine (Lloyd Instruments Ltd., Hampshire, UK). The dentifrice was used in the form of a slurry by mixing the paste with distilled water in a ratio of 1:1 by volume,[10,11] then applied to the top surface of the specimen using a spatula. Then the brushing was carried out for 5 seconds[11] with a 200 gm vertical load.[11] New brush was used for each subgroup.

After 30 days, the color measurements were repeated and the change in color ΔE was obtained using this equation:

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

Statistical Analysis

Results were displayed as mean, standard deviation (SD), and standard error (SE) values. The Kolmogorov–Smirnov test of normality indicated that most of the data were normally distributed (parametric data) that is why the three-way analysis of variance (ANOVA) test was administrated to study the interaction of the three variables.

The one-way ANOVA test was administrated between subgroups within each group for each material. When the ANOVA test yielded a significant difference, Tukey's post hoc test was performed.

The independent *t*-test was used to compare corresponding subgroups of the two groups for each material and between corresponding subgroups for both materials together. The $p < 0.05$ significance level was used.

The statistical analysis was performed with SPSS 18.0 (Statistical Package for the Social Sciences, SPSS, Inc., Chicago, Illinois, USA) for Windows.

Results

The three-way ANOVA showed that regarding the color change in different beverages among the tested subgroups, of different materials and with/without brushing, a statistically significant difference ($p = 0.00$) was found among the tested groups.

Pre-immersion and post-immersion values of color coordinates ($L^*a^*b^*$) were recorded, and the change in the color (ΔE) was calculated for each specimen, dependent samples.

Means, SD, and SE of the change in color values (ΔE) for each type of dental resin composite after being subjected to different beverages used in the study with/without brushing were presented in Table 2 together with Figure 1.

The effect of different beverages within each group for each type of dental resin composite was compared by the one-way ANOVA test, followed by Tukey's post hoc test, when there was a significant difference.

Regarding Admira Fusion, in the non-brushing group, the highest ΔE mean value was recorded in the subgroup using Nescafe Classic (5.20), whereas the lowest mean value was recorded in the control subgroup (0.56). In the brushing group, the highest ΔE mean value was recorded in the subgroup using Nescafe Classic (4.11), whereas the lowest value was recorded in the control subgroup (0.48).

Regarding Grandio, in the non-brushing group, the highest ΔE mean value was recorded in the subgroup using Nescafe Classic (5.58), whereas the lowest value was recorded in the control subgroup (0.62). In the brushing group, the highest ΔE mean value was recorded in the subgroup using Nescafe Classic (4.86), whereas the lowest mean value was recorded in the control subgroup (0.51).

Table 2: Means, SD, and SE of the change in color values (ΔE) for each type of dental resin composite after being subjected to different beverages used in the study with/without brushing regarding the effect of different beverages

Material	*Group*	*Beverages*	*Mean*	*SD*	*SE*	*p-value*
Admira Fusion	Non-brushing	Artificial saliva (control)	0.56[d]	0.16	0.07	0.000*
		Nescafe Classic	5.20[a]	0.18	0.08	
		Red wine	3.69[b]	0.29	0.13	
		Pepsi Cola	2.25[c]	0.20	0.09	
	Brushing	Artificial saliva (control)	0.48[d]	0.11	0.05	0.000*
		Nescafe Classic	4.11[a]	0.33	0.15	
		Red wine	3.03[b]	0.20	0.09	
		Pepsi Cola	2.07[c]	0.10	0.05	
Grandio	Non-brushing	Artificial saliva (control)	0.62[d]	0.12	0.05	0.000*
		Nescafe Classic	5.58[a]	0.22	0.10	
		Red wine	3.96[b]	0.18	0.08	
		Pepsi Cola	2.41[c]	0.07	0.03	
	Brushing	Artificial saliva (control)	0.51[d]	0.11	0.05	0.000*
		Nescafe Classic	4.86[a]	0.25	0.11	
		Red wine	3.56[b]	0.16	0.07	
		Pepsi Cola	2.20[c]	0.07	0.03	

For each material different superscript letters indicate significant difference between subgroups ($P<0.05$)

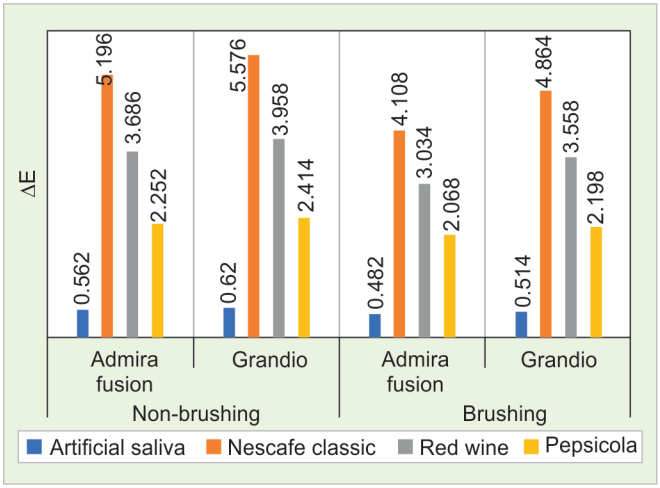

Fig. 1: A bar chart showing ΔE mean values of both types of dental resin composites after being subjected to different beverages used in the study with/without brushing

Brushing and non-brushing groups for each beverage for each type of dental resin composite were compared by the independent *t*-test.

Within all beverages, the highest ΔE mean value in Admira Fusion was recorded in the non-brushing group with a significant difference in subgroups using red wine and Nescafe Classic compared to the brushing groups.

Within all beverages, the highest ΔE mean value in Grandio was recorded in the non-brushing group with a significant difference between brushing and non-brushing groups in all beverages except the control subgroup.

The two dental resin composites for each beverage with/without brushing were compared using the independent *t*-test.

On using artificial saliva, in the non-brushing and brushing groups, the highest ΔE mean value was recorded with Grandio, with no significant difference between two materials. On using Nescafe Classic, in the non-brushing and brushing groups, the highest ΔE mean value was recorded with Grandio, with a significant difference compared to Admira Fusion. On using red wine, in the non-brushing group, the highest ΔE mean value was recorded with Grandio, with no significant difference between two materials. In the brushing group, the highest ΔE mean value was recorded in Grandio, with a significant difference compared to Admira Fusion. On using Pepsi Cola, in the non-brushing group, the highest ΔE mean value was recorded with Grandio, with no significant difference between two materials. In the brushing group, the highest ΔE mean value was recorded in Grandio, with no significant difference between two materials.

Discussion

Restorative resin composites are characterized by having excellent esthetic properties, good strength, ability to be bonded to dentine and enamel, and acceptable cost. This increased their popularity and enhanced their wide use in comparison to dental ceramics.[12]

One of the most determining factors regarding using a restorative material as an esthetic one is the ability to imitate the natural tooth appearance and to be color stable in various oral conditions. The color match of dental resin composites is found to

be satisfactory; however, the oral environment tends to discolor them.[12]

Thus, the conducted study aimed to assess the effect of different beverages, with/without brushing, on dental resin composite resistance to color change.

In this study, the composite samples were light cured in contact with a celluloid strip to eliminate the influence of the variability of finishing techniques on the results.[13] A standard weight was used during specimen preparation to eliminate voids and standardize the pressing force and packing load on the prepared specimen.

The esthetic and physical properties of resin composites are affected by the consumption of certain beverages, such as coffee, alcoholic drinks, and cola drinks, which can undermine the quality of the restoration.[14]

During food or drink consumption, they are in contact with the tooth surfaces for a very short time before being washed away by saliva. In most of the studies previously performed, the substrates usually were stored in beverages for a prolonged period, which has no resemblance to clinical realities and underestimates the washing role of saliva. That is why in this study, a cycle of 5 minutes immersion was used and repeated three times daily to resemble a natural situation.

Usually toothbrushing is done for an average of 2 minutes, which means that each tooth surface receives only brushing for a fraction of this time. The estimation was done that a tooth may be brushed for 4 seconds each day.[15] The specimens in this study were brushed for 5 seconds.

During toothbrushing, dilution of the toothpaste occurs quickly by saliva. This effect was simulated in this study by using toothpaste:distilled water in a 1:1 volume ratio.[16]

Considering the shade selection techniques, in the digital technique of shade selection, color is quantified by CIE Lab, which uses *L**, *a**, and *b** values.

Newer formulas were developed, CIEDE 2000 for an example that shows more human perceptibility and acceptability of color differences between different shades.[17] But its main drawback is that it does not have an associated color space and is a very complicated formula.[18] Many studies presented the presence of a good to perfect correlation between the two different formulas (ΔEab and $\Delta E00$) used to calculate the color differences.[19,20] Owing to this fact, CIE Lab was used.

Spectrophotometers are known for being the most accurate, highly precise, simple, easy to use, and flexible instrument for color matching in dentistry.[21] They measure the spectral reflectance or transmittance of solids and liquids.

Regarding results, though the same, shade A3 was used for both materials yet they yielded different color coordinates.

The highest color changes were recorded upon immersing in Nescafe Classic and the least was in the control subgroup. Immersion in Nescafe and red wine produced ΔE of more than 3.3, which is considered clinically unacceptable, but immersion in Pepsi Cola produced color changes that were perceptible but lower than clinically acceptable.

In this study, it was found that although coffee and cola have similar color parameters, coffee might cause more severe discolorations.[22] Coffee discoloration is caused by the adsorption of pigment on the surface and further absorption in the subsurface layer. In addition to that coffee contains yellow colorants with high polarity compatible with that of the polymer matrix, so it penetrates the organic phase of the material.[23] Cola on the other side lacks the presence of a yellow colorant that might be why it had limited staining potential in this study.

The results of our study were in agreement with Ceci et al.[24] and Elrashid et al.[25] whom results showed that the highest color change for all materials used in their studies for specimens that were immersed in coffee. While results of the study performed by Llena et al.[26] showed that red wine produced more discoloration, followed by coffee and cola.

Recent studies showed that intrinsic discoloration was of minimized effect in well-polymerized resin composite materials. By immersing resin composites in water, the color differences were hardly perceptible and considered clinically acceptable, which proved that water sorption alone did not cause color changes of the resin composites to a considerable extent as saliva contains no pigment. Therefore, extrinsic discoloration could be considered the most determining factor for better color stability and esthetic success of dental resin composite restorations.

In the current study, brushing tended to decrease the color changes, yet clinically perceptible color changes remained. This was attributed to the ability to remove colorants adsorbed on material surfaces through vigorous brushing, but colorants absorbed into the matrices will stay and may require the replacement of the restorations. This result was in agreement with Bezgin et al.[8]

Admira Fusion exhibited less color changes in all tested groups that may be attributed to its high inorganic content, which is in agreement with the results of Ceci et al.[24] In 2017, Dall'orologio et al.[27] found that color stability of enamel and Admira Fusion was not significantly different after 3 years of clinical service. Llena et al.[26] found that Grandio was the second most intensely stained material in their study, and Ergücü et al.[28] reported that Grandio had the highest staining at the end of the first day of immersion in coffee. Grandio is based on a Bis-GMA oligomer that has greater hydrophilicity, which might account for its higher stainability. It has also been suggested that during polymerization of methacrylate-based resins, microcracks occur due to contraction. These microcracks allow the diffusion of fluids inside the organic matrix, resulting in more rapid changes inside the material.[29]

Conclusions

Aside from the limitations of *in vitro* studies, the following conclusions can be drawn:

1. Coffee had the highest staining ability among the tested beverages, followed by red wine, causing clinically unacceptable color changes.
2. Admira Fusion exhibited more color stability compared to Grandio.
3. Brushing for 5 seconds once daily was not enough to remove the stains caused by the used beverages.

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