Article published online: 2021-11-01

ORIGINAL ARTICLE

Effect of aggressive beverage on the color stability of different nano-hybrid resin based composite

Hicham Oday Nuaimi, Hala Maher Ragab[1]

Department of Conservative, Faculty of Dentistry, Ishik University, Erbil, Iraq, [1]Department of Operative and Esthetic Dentistry, Faculty of Dentistry, Beirut Arab University, Beirut, Lebanon

Address for correspondence:
Dr. Hicham Oday Nuaimi,
Department of Conservative,
Faculty of Dentistry, Ishik
University, Erbil, Iraq.
E-mail: dr.hichamnuaimi@gmail.com

ABSTRACT

Background: The purpose of this study was to evaluate the color stability of different types of nano-hybrid resin based composite restorative materials upon exposure to aggressive staining solutions (coffee and tea) over time. The color of all specimens before and after storage in the solutions were measured by a spectrophotometer based on CIE Lab system that is recommended by the American Dental Association and the color differences thereby is calculated. **Materials and Methods:** The color differences of three nano-hybrid composites after immersion for 30 days in tea and coffee as aggressive beverage solutions. **Results:** Within the limitations of the study, Venus Diamond was found the most color stable in tea, while Ceram X was shown the most color stable in coffee. There were statistically significant differences between Filtek 350 XT in tea and coffee storage ($P < 0.005$), but there weren't statistically significant in tea and coffee in both Ceram X, and in Venus Diamond ($P > 0.005$). **Conclusion:** Staining solutions are significant factors that affect color stability of composite resins.

Key words
Color stability, nano-hybrid resin based composite, storage media

INTRODUCTION

Composite resins have been widely used as direct anterior and posterior restoration.[1] The great advances in material composition; physical and mechanical properties have made these materials a treatment of choice as direct composite veneers.[2] Although ceramic veneers are highly esthetic and have advantage of color stability, limitations still exist in using ceramic veneers in all clinical situations.[3-5]

Many researchers have proven that true nano-fill and nano-hybrid composites have high color stability and can retain high surface luster.[6-8]

However, color stability in the oral environment and under effect of strong coloring beverages is still questionable. Therefore, the objective of this study is to evaluate the color stability of different types of nano-hybrid resin based composite restorative materials upon exposure to aggressive staining solutions (coffee and tea) over time.

Access this article online	
Quick Response Code:	Website: www.ejgd.org
	DOI: 10.4103/2278-9626.141666

The hypothesis of this study was that the staining capacity of the resin composite materials is related to the type of the staining solution used and resin matrices.

MATERIALS AND METHODS

Methods

Sample preparation and grouping

Thirty-disc (n = 10) were prepared from three different composite resins of A2 shade, that marketed for esthetic restorations (Group I: Filtek Z 350 XT [3M ESPE, St. Paul, MN, USA], Group II: Ceram X Duo [Densply Caulk, Milford, DE, USA], and Group III: Venus Diamond [Heraeus Kulzer, Germany]). The compositions of the resin matrices and fillers of these composite resins are listed in Table 1. Composite resins were injected into Teflon moulds (8 mm in diameter and 2 mm in depth) and placed over Mylar strip on a glass plate. Finger pressure was applied to the glass plate to expel excess materials and create a smooth surface. The composite resins were then polymerized using a LED light-curing unit (Elipar S10, 3M ESPE, St. Paul, MN, USA) for 40 s to allow thorough polymerization. The discs were

Table 1: Illustrate the restorative materials that were used in this study

Nano-hybrid RBC	Manufacturer	Resin matrix	Filler	Filler, weight/volume
Ceram X Duo	Densply Caulk	ORMOCER, DM ethyl1-4 (dimethyl lamino) benzoate	Barium-aluminum-borosilicate Filler size: (2.3-2.5 nm)-glass (1.1-1.5 μ), SiO_2-nanofiller (10 nm)	76/57
Venus diamond	Heraeus Kulzer	TCD-DI-HEA, UDMA	Filler particle size: 5 nm-20 μm Barium-aluminum fluoride glass Highly discrete nanoparticles	81/64
Filtek Z 350 XT	3M ESPE	TEGDMA, UDMA, BIS-EMA	Combination of nonaggregated 20 nm silica, nonaggregated 4-11 nm zirconia, and aggregated zirconia/silica cluster filler	78.5/59.5

RBC – Resin based composite; UDMA – Urethane dimethacrylate; BIS-EMA – Bisphenol A ethoxylated dimethacrylate; TEGDMA – Triethylene glycoldimethacrylate

removed from the moulds, stored in deionized water for 24 h to complete polymerization, and then polished with Sof-Lex (3M ESPE, St. Paul, MN, USA) polishing discs in four sequences from coarse to superfine following the manufacturer's instruction. The descriptions of the grouping are shown in Table 2.

Coloring beverage preparation

Two different beverages were used in this experiment: (1) Coffee (Nescafe Classic, Nestle, Switzerland) and (2) tea (Lipton, Yellow Label Tea, Lipton, Rize, Turkey). A 3.6 g of coffee powder was dissolved in 300 ml of boiling distilled water as the reference's recommendation. After 10 min of stirring, the solution was filtered through a filter paper. Tea solution was prepared by immersing two prefabricated tea bags (2 g × 2 g) into 300 ml of boiling distilled.[2]

Methods

The color values were recorded using a digital spectrophotometer (Vita Easyshade, Compact, Vita, Zahnfabrik, Bad Sackingen, Germany). Positioning the specimens on a white background to prevent potential absorption effects performed color measurements. Three measurements were taken with the active point of the spectrophotometer in the center of each disc. The instrument automatically averaged the three readings, and this average reading was subsequently used for data analysis. Initial color measurements were taken after polishing discs, which represent the (baseline) measurement, and then subdivided them into two different subgroups one immersed in tea and the other in the coffee for 30 days. The color measurements were done before immersion (baseline) and after 30 days immersion. Each specimen was dried using blotting paper before color measurement. The color difference (ΔE) was calculated for each sample using the following equation.[9,10]

$$\Delta E = ([\Delta L^*]^2 + [\Delta a^*]^2 + [\Delta b^*]^2)\ 1/2$$

Before each series of measurements, the spectrophotometer was calibrated according to the manufacturer recommendations where "L" namely white-black, "a" red-green, "b" yellow-blue.

Table 2: Color changes (DE) (mean values and SDs) for composites with staining solutions after 30 days immersion

Composite resins	Tea staining mean (SD)	Coffee staining mean (SD)
Filtek Z350XT	11.83819355 (2.075)*	15.20 (1.026)*
Ceram X due	5.40 (1.379)	4.81 (0.660)
Venus diamond	4.68 (1.234)	5.60 (0.344)

*Statistic significant

Statistical analysis

One-way analysis of variance (ANOVA) was used to evaluate the effects of material type and staining agent on color change, including the possibility of interaction between the two factors using statistical software (SPSS for Windows, Version 20, SPSS Inc., Chicago, IL, USA). Using paired *t*-test for analysis for comparing samples in the same subgroup. In the present study, $P \leq 0.05$ was considered as the level of significance.

RESULTS

Mean, standard deviation and test of significance of mean values of color change between different subgroups for Group I (Filtek Z350XT), Group II (Ceram X) and Group III (Venus Diamond) are shown in Table 2. All results shows that the amount of ΔE in all groups was >3.3, which indicates that the storage of specimens in different color media during 30 days of immersion. There were statistically significant differences between Filtek 350 XT in tea and coffee storage ($P < 0.005$), but there weren't statistically significant in tea and coffee in Ceram X, and in Venus Diamond ($P > 0.005$). In tea staining media Venus Diamond restorative material was found to be the most color stable (ΔE = 4.68 ± 1.234) followed by Ceram X (ΔE = 5.40 ± 1.379), and Filtek Z350 XT (ΔE = 11.83 ± 2.075), while Ceram X was shown the most color stable in coffee Staining (ΔE = 4.81 ± 0.660), then Venus Diamond (ΔE = 5.60 ± 0.344) and Filtek Z350 XT (ΔE = 15.20 ± 1.026). ANOVA showed significant differences among various groups. In addition, the staining solution with maximum staining potential was coffee then tea for all tested resin composite, except for Venus Diamond, tea-staining solution was maximum potential than coffee as shown in Figures 1 and 2.

DISCUSSION

One of the qualities that should be experimented over time is the color stability of the composites. For this purpose, the composite resins were used for 30 days of immersion in aggressive solution that where common in our region of the world. Currently, spectrophotometers have been instructed and used to measure discoloration of restorations using the CIE Lab system.[11,12] This system inherits the advantage of being repeatable, sensitive, objective, universally accepted, and can measure small color differences. In this study, ($\Delta E \geq 3.3$) was taken as perceptible color change and therefore clinically unacceptable. Discoloration in resin composites can be extrinsic discoloration, or intrinsic (subsurface) discoloration.[13,14] Extrinsic staining occurs mostly due to either picks up stains or absorbs the stain, while the intrinsic staining occurs due to dispersion of stain into the resin materials followed by a chemical reaction. The staining ability of the composite is related to resin matrix,[14] percentage of filler particles,[15] adsorption and absorption of stains,[16] type of staining solution, and chemical interactions between composites and the stains.

The tested resin based composites were showed that the least color change was observed in Ceram X (ΔE tea = 5.40 ± 1.379), (ΔE coffee = 4.81 ± 0.660), whereas Filtek Z350 X T (ΔE tea = 11.83819355 ± 2.075), (ΔE coffee = 15.20 ± 1.026), and Venus Diamond (ΔE tea = 4.68 ± 1.234), (ΔE coffee = 5.60 ± 0.344) were showed higher color change with all the staining solutions. The composition of the resin materials and the relative amount of resin and filler content present (resin: Filler) have greatly influenced on the color change of a resin material. Resin materials that have less filler content and more resin content tend to absorb more water at the resin-filler interface leading to hydrolytic degradation of filler.[16,17] Thus resin based materials with lower filler contents have shown to have poor color stability.[18] Venus Diamond is a new nano-hybrid universal restorative system containing TCD-DI-HEA and urethane dimethacrylate (UDMA), with 63.5-65.1% by volume of barium aluminum fluoride glass fillers having size range of 5 nm-20 µm. Filtek Z350 XT is a universal nano-hybrid restorative system containing bisphenol A-glycidyl methacrylate (BIS-GMA), UDMA, triethylene glycoldimethacrylate (TEGDMA) and bisphenol A ethoxylated dimethacrylate with combination of nonaggregated 4-11 zirconia filler, aggregated zirconia/silica cluster filler that are loading of 59.5% by volume and particle size range of 0.6-10 µm. Ceram-X-duo (enamel) is a double translucent nano-hybrid resin composite has methacrylate modified polysiloxane and ethy 1-4 (dimethyl amino) with three different types of fillers, glass fillers, nano-fillers and organically modified ceramic nanoparticles which are loading 62% by volume. It has been noted that a composite with large filler particles are more prone to water the aging discoloration than a composite with small filler particles, which is in line with the hydrolytic degradation matrix filler interfaces. Thus, a composite with large filler particles has more color permeability than a composite with small filler particles. In this study, Ceram X and Venus Diamond showed less color change and higher filler content of Venus Diamond and Ceram X when compared with Filtek Z350 XT. In addition the difference of resin matrices of the different specimens also have effect on the color stability by which some types of resin matrices absorbed stain higher than the others so that it will influenced the degree of staining.[14,19]

In addition, resin matrix has capability of absorbing water. It is also capable of absorbing any other fluid, which

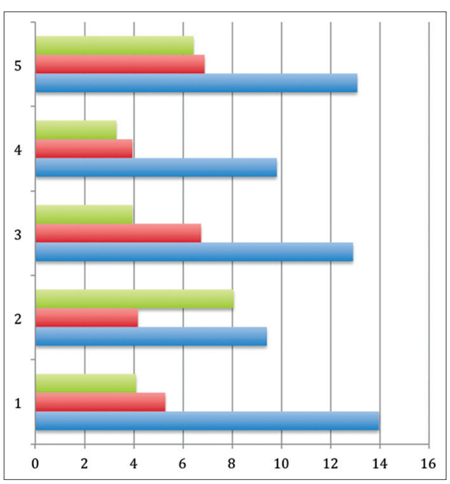

Figure 1: Delta E for specimens used in tea. Blue column represents DE of Filtek 350XT, the red column represent DE of Ceram X due, while green column represent DE of Venus Diamond

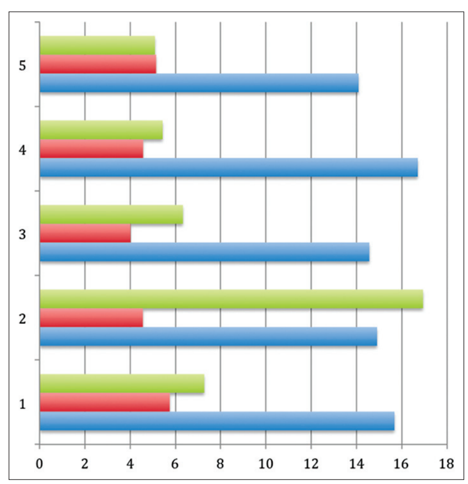

Figure 2: Delta E for specimens used in coffee, Blue column represent DE of Filtek 350XT, the red column represent DE of Ceram X due, while green column represent DE of Venus Diamond

ultimately leads to discoloration. Water sorption is mostly due to direct absorption in the resin matrix. Glass filler particles cannot absorb water, yet they can contribute to water adsorption at the surface of the material. The level of water sorption is a function of the resin content of the material and the strength of the resin-filler interface. Extreme water sorption causes the expansion and plasticizing of the resin, which leads to reduced longevity of the composite resin and hydrolysis of saline, which in turn creates micro cracks. As a result, the micro-cracks or the interfacial gaps at the interface, between the filler and matrix, allow stain penetration and discoloration.[20] Several studies have shown that the presence of TEGDMA in materials cause a high amount of hydrophilic capacity and more sensation of BIS-GMA to tonality and water absorption in comparison to UDMA. UDMA is more resistant to stain than BIS-GMA.[2] In this study Filtek Z 350 XT showed lower color stability than Ceram X and Venus Diamond because of presence BIS-GMA in resin matrix in Filtek Z350 XT.

REFERENCES

1. Hickel R, Heidemann D, Staehle HJ, Minnig P, Wilson NH, German Scientific Association for Operative Dentistry, *et al.* Direct composite restorations: Extended use in anterior and posterior situations. Clin Oral Investig 2004;8:43-4.
2. Bagheri R, Burrow MF, Tyas M. Influence of food-simulating solutions and surface finish on susceptibility to staining of aesthetic restorative materials. J Dent 2005;33:389-98.
3. Sham AS, Chu FC, Chai J, Chow TW. Color stability of provisional prosthodontic materials. J Prosthet Dent 2004;91:447-52.
4. Archegas LR, Freire A, Vieira S, Caldas DB, Souza EM. Colour stability and opacity of resin cements and flowable composites for ceramic veneer luting after accelerated ageing. J Dent 2011;39:804-10.
5. Haselton DR, Diaz-Arnold AM, Dawson DV. Color stability of provisional crown and fixed partial denture resins. J Prosthet Dent 2005;93:70-5.
6. Janda R, Roulet JF, Kaminsky M, Steffin G, Latta M. Color stability of resin matrix restorative materials as a function of the method of light activation. Eur J Oral Sci 2004;112:280-5.
7. Mitra SB, Wu D, Holmes BN. An application of nanotechnology in advanced dental materials. J Am Dent Assoc 2003;134:1382-90.
8. Chen MH. Update on dental nanocomposites. J Dent Res 2010;89:549-60.
9. Ayad NM. Susceptibility of restorative materials to staining by common beverages: An *in vitro* study. Eur J Esthet Dent 2007;2:236-47.
10. Johnston WM. Color measurement in dentistry. J Dent 2009;37:e2-6.
11. Okubo SR, Kanawati A, Richards MW, Childress S. Evaluation of visual and instrument shade matching. J Prosthet Dent 1998;80:642-8.
12. Seghi RR, Gritz MD, Kim J. Colorimetric changes in composites resulting from visible-light-initiated polymerization. Dent Mater 1990;6:133-7.
13. Türkün LS, Türkün M. Effect of bleaching and repolishing procedures on coffee and tea stain removal from three anterior composite veneering materials. J Esthet Restor Dent 2004;16:290-301.
14. Villalta P, Lu H, Okte Z, Garcia-Godoy F, Powers JM. Effects of staining and bleaching on color change of dental composite resins. J Prosthet Dent 2006;95:137-42.
15. Reis AF, Giannini M, Lovadino JR, Ambrosano GM. Effects of various finishing systems on the surface roughness and staining susceptibility of packable composite resins. Dent Mater 2003;19:12-8.
16. Abu-Bakr N, Han L, Okamoto A, Iwaku M. Color stability of compomer after immersion in various media. J Esthet Dent 2000;12:258-63.
17. Schulze KA, Marshall SJ, Gansky SA, Marshall GW. Color stability and hardness in dental composites after accelerated aging. Dent Mater 2003;19:612-9.
18. Ferracane JL, Berge HX, Condon JR. *In vitro* aging of dental composites in water – effect of degree of conversion, filler volume, and filler/matrix coupling. J Biomed Mater Res 1998;42:465-72.
19. Lee YK, Lu H, Powers JM. Effect of surface sealant and staining on the fluorescence of resin composites. J Prosthet Dent 2005;93:260-6.
20. Ertas E, Güler AU, Yücel AC, Köprülü H, Güler E. Color stability of resin composites after immersion in different drinks. Dent Mater J 2006;25:371-6.

How to cite this article: Nuaimi HO, Ragab HM. Effect of aggressive beverage on the color stability of different nano-hybrid resin based composite. Eur J Gen Dent 2014;3:190-3.
Source of Support: Nil, **Conflict of Interest:** None declared.