10.21608/ADJC.2023.186942.1234 Advanced Dental Journal
Volume 5 (2023) | Issue 1| Pages 59 - 66

Original Article

Color Stability of Different Resin Composites Under Moisture and Chemical Stimulants and Changes.

Hala Mohammad Fares [1]

[1]Associate Professor of Restorative Dentistry – Faculty of Dentistry – Pharos University - Egypt

Abstract

Resin composites are very successful and widely used esthetic restorative materials. However, their color stability is a challenging issue that has to be investigated and assessed. In this study we assessed the color stability of three different types of resin composites ; a nano-filled resin composite, a nano-hybrid one and a micro-hybrid one using Reflective Spectrophotometry. 90 specimens were used . They were divided into three groups of 30 to represent the three types of composites ; then each group were further subdivided into three subgroups to represent the three types of immersion solutions. The results showed the nano – hybrid composite to undergo the least color changes in comparison to the other two resin composites with different immersion solutions.

Key words: Resin composites ; color ; Spectrophotometer

Introduction

Resin composites are becoming the standard esthetic restorative materials for both anterior and posterior teeth. This is attributed to their easy reproduction of the tooth anatomical landmarks, excellent esthetics compared to other restorative materials, appropriate mechanical properties, conservation of tooth structure, reduction of microleakage at the restoration tooth interface and contribution to favorable distribution of forces (1-4). However the susceptibility of resin composites to staining is a problem and is the reason why some dentists resolve to ceramic – based restorations instead of resin composites. Despite the fact that color stability is a key factor for long-term esthetic success , there is a lack of information provided by the manufacturers regarding the staining susceptibility of resin composites (2-11). Discoloration of resin composites may be due intrinsic or extrinsic factors. Intrinsic factors include physical and chemical discoloration reactions in the resin composite surface matrix and deep layers. Physical trigerring factors include heat , humidity and ultraviolet irradiations. Chemical discoloration has been attributed to oxidation reactions in the amine accelerator, the structure of the polymer matrix, and the unreacted pendant methacrylate groups (12, 13). Meanwhile, extrinsic factors are attributed to surface adsorption of staining agents from exogeneous sources or due to accumulation of plaque or superficial degradation of the restorative material. Incomplete polymerization reaction has been reported to be one of the major factors resulting in staining of resin composite restorations. Also, the composition of the resin composite material as well as the characteristics of its particles, play a major role regarding the staining susceptibility of resin composites. In addition, it has been reported that the smoother the surface of the resin composite restoration the less the staining susceptibility (12-15). In this study, we set up a comparison among three types of resin composites ; a nano-filled resin composite, a nano-hybrid one and a micro-hybrid one after immersion of the specimens in two different mouth rinses as well as distilled water as a control in order to simulate moisture and chemical stimulants and changes that occur intraorally.

Materials and methods

A total of 90 specimens were used in this study. They were divided into three groups of 30. Each of the three groups represented a different type of resin composites. The resin composites used were ; a nano-filled one (Filtek Z 350 XT) ; a nano-hybrid one (Filtek Z 250 XT) ; and a micro-hybrid one (Cavex).

Their compositions and manufacturers are listed in Table 1

Thirty disc-shaped samples of each tested composite were constructed (discs thickness was 2 mm and diameter was 10 mm). Each sample of tested composite materials was controlled according to the manufacturer's instructions.

Samples' preparation:

A standardized brass mold measuring 10 mm thickness x 2 mm diameter was used to produce the nano and hybrid resin composite specimens. A clear Mylar strip (Mylar Uni-strip, Caulk/ Dentsply, Milford, DE,USA) was placed on top of clean glass slab. The composite resin was packed in the mold using a plastic instrument. A clear Mylar strip and a 1-mm thick glass slide was placed on top of the specimen and then gently pressed to remove excess material on the mold. To prevent the formation of an oxygen inhibited layer and ensure smooth and flat surfaces, Mylar strips were placed on either side of the mold during curing. Each specimen was light cured using light emitting diode(LED) for 40 seconds(Demi Plus, Kerr, Orange Co., CA,USA) with a spectral range of 450-470 nm wavelength and 1200mW/cm2 intensity and then it was extruded from the mold by applying positive pressure using a pestle of 9.5 mm diameter to allow equal distribution of pressure.The guide of the light curing unit was kept perpendicular to surface and the distance between the unit and the sample was standardized using a 1 mm thick glass slide. All the samples were stored in distilled water for 24h at 370C to ensure complete polymerization. The samples were finished with 400-grit SiC paper and were polished with OptiDisc (Kerr, Orange,CA, USA) polishing discs.The samples were kept in distilled water for 24h before baseline color measurements were taken.

Immersion of samples in oral rinse solutions

To observe the color stability in various solutions after polishing, the 30 samples belonging to each group were , further , sub divided into three subgroups of 10 (n=10) based on the two types of mouth rinses and the distilled water(control), used. The samples of each group of resin composites were individually immersed in light-proof vials containing one of three ; 20 mL of ANTIPLACA 0% Alcohol, CLORHEXIDINA mouthwash or distilled water (Health Aqua, Alexandria, Egypt)) as shown in table (2). The vials were sealed to prevent the evaporation of the solutions and stored in an incubator (CBM.TorrePicenardi(CR), Model 431/V, Italy) at 37ºC for 12 hours which was considered equivalent to 1 year of 2 minutes daily use (17). By the end of the immersion period, samples were rinsed with distilled water, wiped with gauze and dried with absorbent paper. Color was then re-assessed.

Assessment of color using the Reflective Spectrophotometer

Color values (L*, a*, b*) of samples were measured with a Reflective Spectrophotometer (X-Rite, model RM200QC, Neu-Isenburg, Germany). The aperture size was set to 4 mm and the specimens were exactly aligned with the device. A white background was selected and measurements were made according to the CIE L*a*b* color space. All measurements were performed at the center of the resin composite discs and were repeated three times by one operator before (baseline) and after immersion in mouth rinses. The color difference ΔE was calculated from the mean ΔL*, Δa*, Δb* values for each spample using the following formula: $\Delta E=[(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2]^{1/2}$ where, ΔL*, Δa*, Δb* are the differences in L*, a*and b* values before and after immersion.

Results

The results were analyzed using Graph Pad Instat (Graph Pad, Inc.) software for windows. A value of $P \leq 0.05$ was considered statistically significant. Continuous variables were expressed as the mean and standard deviation. After homogeneity of variance and normal distribution of errors had been confirmed, one-way analysis of variance was performed followed by Tukey's post-hoc test if significance was revealed.Two-way analysis of variance ANOVA test of significance was done for comparing variables affecting mean values (resin composite groups and solutions). The sample size (n=30/group) was large enough to detect large effect sizes for main effects and pair-wise comparisons, with the satisfactory level of power set at 80% and a 95% confidence level.

Color change results

Color change (□E) results (Mean ± SD) for all resin composite groups as function of oral rinse solutions are summarized in table (3) and figure (1).

Regarding the *0% Alcohol* oral rinse solution, it was found that the *Nano-filled* composite (Filtek Z 350 XT) group, recorded the highest color change means value (3.889□E) ; followed by the *Hybrid* composite (Cavex) group (3.201□E) ; meanwhile the *Nano-hybrid* composite (Filtek Z 250 XT) group recorded the lowest means value (2.773□E). The difference between groups was statistically *significant* as indicated by the one way ANOVA test (p=0.0255<0.05). Pair-wise Tukey's post-hoc test showed *non-significant* (p >0.05) difference between the (*Hybrid* and *Nano-filled)* and the (*Hybrid* and *Nano-hybrid)* groups. Table (3)

Regarding the *Chlorhexidine* oral rinse solution, it was found that the *Hybrid* composite (Cavex) group recorded the highest color change means value (6.562□E) ; followed by the *Nano-filled* composite (Filtek Z 350 XT) group (4.138□E) ; while the *Nano-hybrid* composite (Filtek Z 250 XT) group ,recorded the lowest means value (3.086□E). The difference between groups was statistically *significant* as indicated by the one way ANOVA test followed by pair-wise Tukey's post-hoc test (p=<0.0001 <0.05). Table (3)

Regarding the *Distilled water* solution, it was found that the *Hybrid* composite (Cavex) group recorded the highest color change means value (4.434□E) ; followed by the *Nano-filled* composite (Filtek Z 350 XT) group (4.014□E) ; while the *Nano-hybrid* composite (Filtek Z 250 XT) group recorded the lowest means value (2.999□E). The difference between groups was statistically *significant* as indicated by the one way ANOVA test (p=0.0255 <0.05). Pair-wise Tukey's post-hoc test showed *non-significant* (p >0.05) difference between the (*Hybrid* and *Nano-filled)* groups. Table (3)

Table (1) Composition and manufacturer of the tested resin composite materials

Resin Composite	Composition	Manufacturer
Filtek Z350 XT Nano-filled composite	The resin contains Bis-GMA, UDMA, TEGDMA, and Bis-EMA. Fillers are a combination of non-agglomerated/non-aggregated 20 nm silica filler, non-agglomerated/non-aggregated 4–11 nm zirconiafiller, and aggregated zirconia/silica cluster filler (comprised of 20 nm silicaand 4–11 nm zirconia particles).The inorganic filler loading is about 78.5% by weight (63.3% by volume)	3M/ESPE, St. Paul, MN, USA
Filtek Z250 XT Nano-hybrid composite	The resin matrix AUDMA, UDMA and 1, 12-dodecane-DMA The filler: non-agglomerated/non-aggregated 20 nm silica filler, a non-agglomerated/non aggregated 4 to 11 nm zirconia filler, anaggregated zirconia/silica cluster filler(comprised of 20 nm silicaand 4 to 11 nm zirconia particles) and a ytterbium trifluoride filler consistingof agglomerate 100 nm particlesfiller load 76.5%wt(58.4%vol) Filler size 0.01 to 3.5 µm	3M/ESPE, St. Paul, MN, USA
Cavex hybrid composite	The resin matrix Bis-GMA, Bis-EMA , UDMA with small amount of TEGDMA Filler Silanized zirconia/silica particles Filler load 77% wt 57% vol Filler size:size range 0.01 to 3.5 µm, average size 0.6 µm	Cavex BV, Holland

Table (2) Composition and manufacturer of the tested oral rinse solutions

Oral rinse solution	Composition	Manufacturer
ANTIPLACA 0% Alcohol	Aqua,Propylene glycol, Hydrogenated Castor Oil, PEG 40, Citric acid, CetylpyridiniumChloride, Sodium Floride, SodiumSaccharin, SodiumBenzoate, CI 42090, CI18965, Cinnamal	Foramen SL Cantabria, Spain
CLORHEXIDINA Mouthwash	Aqua, Glycerin, PEG 40, Hydrogenated Castor Oil, Poloxamer407, Chlorhexidine Digluconate, Sodium Floride, SodiumSaccharin, Aroma, Allantoin, SodiumBenzoate, Alcohol, CI 16035, Limonene	Foramen SL Cantabria, Spain

Table (3) Color change(□E) results(Mean values± SDs)for all resin composite groups as function of immersion solution

Variable		***Immersion solution***			
		0% Alcohol	***Chlorhexidine***	***Distilled water***	***P value***
Resin composite	***Nano-filled***	$3.889^{A}_{a}\pm0.999$	$4.138^{A}_{b}\pm0.654$	$4.014^{A}_{a}\pm1.173$	0.8477 ns
	Nano-hybrid	$2.773^{A}_{b}\pm0.482$	$3.086^{A}_{c}\pm0.681$	$2.999^{A}_{b}\pm0.902$	0.6014 ns
	Hybrid	$3.201^{C}_{ab}\pm1.012$	$6.562^{A}_{a}\pm0.633$	$4.434^{B}_{a}\pm0.638$	<0.0001*
Statistics	***P value***	0.0255*	<0.0001*	0.0055*	

Different subscript small letter in the same column indicating statistically significant difference between composites (*p*< 0.05 Different superscript largeletter in the same rawindicating statistically significant difference between solutions (*p*< 0.05 *; significant (*p*< 0.05) ns; non-significant (p>0.05)

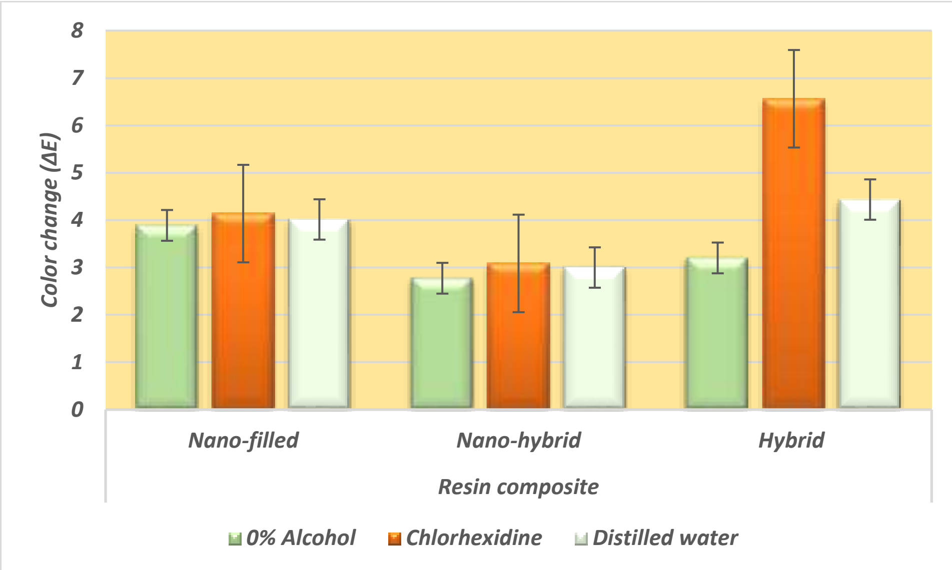

Fig. (1) Column chart of colour change means values for all resin composite groups as function of immersion solutions

For both *Nano-filled* and *Nano-hybrid* composite groups, immersion solutions of subgroups affected by color change; means values were *non-significant* as indicated by one way ANOVA test(p >0.05) where (*Chlorhexidine ≥Distilled water ≥0% Alcohol*). Table (3)

For the *Hybrid* composite group, immersion solutions of subgroups affected by color change ; means values were *significant* as indicated by one way ANOVA test (p=<0.0001<0.05) where (*Chlorhexidine > Distilled water > 0% Alcohol*). Table (3)

<u>Total effect of materials groups ;</u> *regardless of the immersion solutions, there were significant differences among resin composite groups as indicated by two way ANOVA test(p=<0.0001<0.05) where (Hybrid > Nano-filled > Nano-hybrid).*

<u>Total effect of immersion solutions ;</u> *regardless of the resin composite groups, there were significant differences among* immersion solutions *as indicated by two way ANOVA test(p=<0.0001<0.05) where (Chlorhexidine ≥Distilled water ≥ 0% Alcohol).*

Discussion

Resin composites are esthetically appropriate, appreciated and widely used restorative materials. Regarding the issue of esthetic dentistry, the color seems to be a strong influencing factor. Therefore, color stability is consistently becoming a very demanding issue. Inside the oral cavity, resin composites are, continuously subjected to such a repeated and cyclic contact with various staining agents. That process is multimodal as numerous factors do influence the discoloration process of resin composite restorations by such staining agents. Among these factors are ; incomplete polymerization, water sorption, surface roughness, oral hygiene and staining food and beverages(14). This study for measuring the color stability of different types of resin composites, was conducted invitro for standardization of the different setup parameters included in this study. Such parameters could include ; the type of food, frequency of intake, the type of beverages, tooth brushing, oral hygiene, general health and certain individual habits. Our samples were meticulously polished as previous studies have reported a higher discoloration potential of unpolished samples in comparison to the polished ones (14). Also, all the samples in this study were stored in distilled water for 24 hours at 37 o C, before finishing and polishing, to ensure complete polymerization. The immersion solutions used in this study included two different types of mouth rinses (to assess the effect of chemical agents on staining) ; as well as distilled water (as a control). The vials containing the samples were placed in an incubator for 12 hours at 37 o C which was reported as being equivalent to one year of two minutes daily use (17). The Reflective Spectrophotometer used in this study is considered a precise and reliable method for measuring color (5, 18, 19). The Spectrophotometer could, even, detect color values below the human eye perceivable level of perceptibility threshold (14). The results of this study were statistically significant. It was revealed that the nano-hybrid resin composite (Filtek Z 250 XT) exhibited the least color change means value ; followed by the nano-filled resin composite (Filtek Z 350 XT) ; while the micro-hybrid resin composite (Cavex) demonstrated the highest color change means value. Those differences could be attributed to the fillers type, volume and percentages, size as well as the fillers loading levels. Also, there is a possible influence of the filler charge percentage by weight and by volume. In addition to all that, comes the chemical composition and the different monomer quantities of the resins included in the structure of these composites. The increase in the resin content results in greater water sorption and thus increased staining susceptibility. Also, TEG-DMA could enhance the surface hardness, the elastic modulus and the degree of polymerization in comparison to Bis-EMA (14) . Both the nano-hybrid resin composite (Filtek Z 250 XT) and the nano-filled resin composite (Filtek Z 350 XT) had similar percentage volume of filler particles ; however, the nano-hybrid resin composite (Filtek Z 250 XT) exhibited higher filler loading levels which accounted for its significant less color change means value and greater wear resistance. The micro-hybrid resin composite (Cavex) contained no nano particles and had the least filler loading levels compared to the other two resin composites. That accounted for the results that showed the micro-hybrid resin composite significantly demonstrating the highest color change means value. On the other hand, it has to be stated that the degree of polarity of the immersion solutions influenced their depth of penetration through the resin composite materials and, thus, the staining susceptibility. In the end, it has to be mentioned that the chemical composition, the different fillers types and sizes and the monomer quantities of resin composites are not often disclosed, in details, by the manufacturers. That, if happened, could have pointed the way for further explanation and discussion.

Conclusion

Chemicals, staining agents and moisture, increase the staining susceptibility of resin composite restorations.

The nano-hybrid resin composite materials exhibit high filler loading levels and, consequently, significantly less staining susceptibility in comparison to other resin composite materials.

References

1 - Kramer N, Reinelt C, Frankenberg R. Ten-year clinical performance of posterior resin composite restorations. J Adhes Dent 2015 ; 17 : 433- 441

2- Acar O, Yilmaz B, Altintas SH, Chandrasekaran I and Johnston WM. Color stability of CAD/ CAM and nano composite resin materials. J Prosthet Dent 2016 ; 115: 71 – 75.

3- Heinze SD, Rousson V,and Hickel R. Clinical effectiveness of direct anterior restorations----a meta-analysis. Dent Mater 2015 ;31: 481-495

4-Kareem SA, Al-Maaroof AG, and Fadhil NH. Color stability of different aesthetic resin composite materials : A digital image analysis. Ind J Forensic Med Toxicology 2020 ; 14 (1) : 1210 – 1215.

5- Tekce N, Tuncer S, Demirci M, Serim ME and Baydemic C. The effect of different drinks on the color stability of different restorative materials after one month. Restor Dent Endod 2015 ; 40 : 255 – 261.

6- Kumari RV, Nagaraj H, Siddaraju K and Poluri RR. Evaluation of the effect of surface polishing ,oral beverages and food colorants on color stability and surface roughness of nanocomposite resins. J Int Oral Health 2015 ; 7 : 63 – 70

7- Yildiz E, Karaarslan E, Simsik M, Ozsevik AS and Usumez A. Color stability and surface roughness of polished anterior restorative materials. Dent Mater J 2015 ; 34 : 629 – 639

8- Bezgin T, Ozer L, Fulga OZ and Ozcan P. Effect of tooth brushing on color changes of esthetic restorative materials. J Esthet Restor Dent 2015 ; 27 : 65 – 73.

9- Karaman E, Tuncer D, Firat E, Ozdemir OS and Karahan S. Influence of different staining beverages on color stability, surface roughness and microhardness of silorane and methacrylate based composite resin. J Contemp Dent Pract 2014 ; 15 : 319 – 325.

10- Tan BL, Yap AU, Ma HN, Chew J and Tan WJ. Effect of beverages on color translucency of new tooth colored restoratives. Oper Dent 2015 ; 40 : 56 – 65.

11- Harorli OT, and Barutcigil C. Color recovery effect of commercial mouth rinses on a discolored composite. J Esthet Restor Dent 2014 ; 26 : 256 – 263.

12- Ertas E, Gueler AU, Yuecel AC, Koeprueleu H and Gueler E. Color stability of resin composites after immersion in different drinks. Dent Mater J 2006 ; 25(2) : 371 – 376.

13- Catelan A, Briso ALF, Sundfeld RH, Goiato MC and Santos PH. Color stability of sealed composite resin restorative materials after ultraviolet artificial aging and immersion in staining solutions. J Prosthet Dent 2011 ; 105 (4) : 236 – 241.

14- Ardu S, Duc O, Di Bella E, and Krejci I. Color stability of recent composite resins. Odontology 2017 ; 105 : 29 – 35.

15- Alharbi A, Ardu S, Bortolotto T and Krejci C. Stain susceptibility of composite and ceramic CAD/ CAM blocks versus direct resin composites with different resinous matrices. Odontology 2017 ; 105 (2) : 162 – 169.

16- Ardu S, Braut V, Di Bella E, and Lefever D. Influence of back ground on natural tooth coordinates : an invivo evaluation. Odontology 2011 ; 102 :267 – 271.

17- Akalin T, Genc G, Ceyhan Y, and Bozkurt FT. The effect of mouth rinses on the color stability of sonicfill and a nano-hybrid composite. J Istanbol Univtac Dent 2016 ; 50 (2) : 17 – 23.

18- Leloup G, Holvoet PE, Bebelman S, and Devaux J. Raman scattering determination of the depth of cure of light activated composites : influence of different clinically relevant parameters. J Oral Rehabil 2002 ; 29 : 510 – 515.

19- Ardu S, Gutemberg D, Krejci I, Feilzer AJ, Di Bella E and Dietschi D. Influence of water sorption on resin composite color and color variation amongst various composite brands with identical shade code : an in