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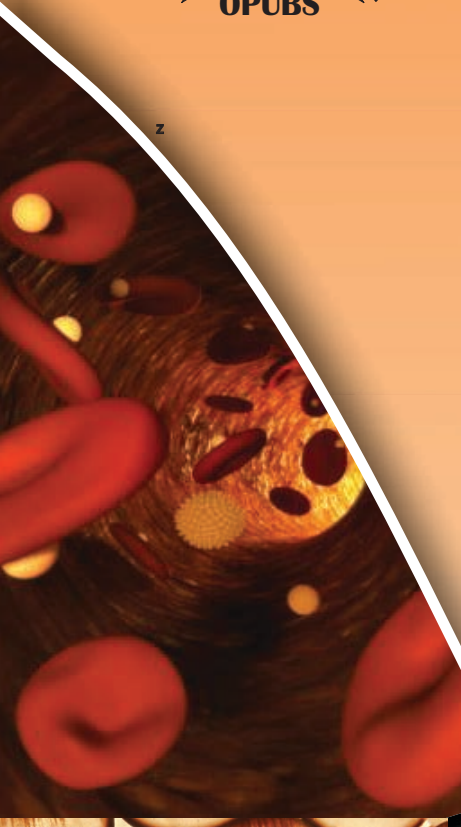



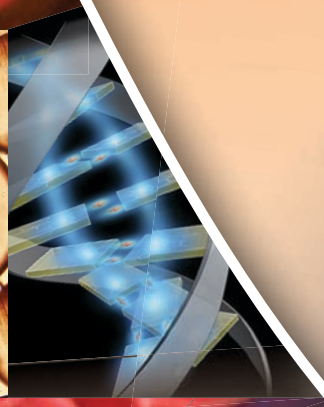



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Original Article

Color Stability Assessment of Two Different Composite Resins with Variable Immersion Time Using Various Beverages: An *In vitro* Study

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Abstract

Purpose of the Study: The aim of the study was to evaluate the difference in the color of microhybrid (MH) and nanofilled (NF) composite resins after 24 and 48 h in beverages such as red wine (RW), Coca-Cola, and distilled water. The specific objective of this study was to investigate the cumulative effect of the colorant solutions on the dental composites. **Materials and Methods:** MH and NF composite resins (A2 shade) were used in this current study. Sixty disk-shaped material specimens (10 mm in diameter × 2 mm in thickness) were prepared using a fiber mold (ring), with the desired dimensions. The specimen surfaces were polished using super-snap polishing system. Sixty specimens were divided into two groups of 30 each (Group I: MH resin composite; Group II: NF resin composite). Both the groups divided into six subgroups (Subgroup I: RW for 24 h [RW-24]; Subgroup II: RW for 48 h; Subgroup III: Coca-Cola for 24 h [CC-24]; Subgroup IV: Coca-Cola for 48 h [CC-48]; Subgroup V: Distilled water for 24 h [DW-24]; Subgroup VI: Distilled water for 48 h [DW-48]). All the samples were immersed in respective drinks for a period of 24 h, and color differences were measured using ultraviolet spectrophotometer. Once again, all the samples were immersed for another 24 h in the same drinks. After 48 h, the color change of the samples was measured. Measurements were made according to the CIE L × a × b × color space relative to the CIE standard illuminant D65. The color changes of the specimens were evaluated using the following formula: $\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$ Statistical analysis was performed. The data were analyzed using the one-way ANOVA and *t*-test at a significance level of 0.05. **Conclusion:** Color stability of MH composite resin was found to be inferior than the NF resin composite irrespective of immersion medium and time. In RW, the color change observed was maximum for both composite resins followed by Coca-Cola. Immersing the resin composites in distilled water for 24 and 48 h had negligible color change. A 48-h immersion of both composite resins in all three immersion mediums showed greater color change than 24 h immersion.

Keywords: *Color stability, composite, microhybrid, nanofilled*

Introduction

Dental composite resins consist of three main components: (1) organic resin (matrix phase), (2) inorganic filler particles (dispersed phase), and (3) the coupling agent that chemically bonds the inorganic filler to the resin matrix (surface interfacial phase).[1] The first classification system of composite resins was introduced by Lutz and Phillips.[2] This was based on the average size and the chemical composition of the filler particles. Early composites, which were chemically cured, required

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that the base paste be mixed with the catalyst, leading to problems with proportions, with the mixing process and color stability.

A composite resin classified as a hybrid contains colloidal silica particles of different sizes. Hybrid composites were created to overcome the inherent weakness of microfilled composites (lack of mechanical strength) and macrofilled composites (excessive wear and lack of esthetics). Although demonstrating good handling characteristics and initial high polishability, polish retention is rather poor due to the presence of substantially larger filler particles similar to the macrofillers.

Nanotechnology is the production of functional materials and structures that fall in the range of 0.1–100 nm by various physical or chemical methods. When inorganic phases in an organic or inorganic composite become nanosized, they are called nanocomposites. They are available as nanohybrid types containing milled glass fillers and discrete nanoparticles (40–50 nm) and as nanofill types, containing nanosized filler particles, called nanometers and agglomerations of these particles described as nanoclusters.

No available restorative can meet optical requirements. Factors affecting color of composite are light-curing unit, time of curing, immersion medium, time of immersion, filler particle size, organic matrix, aging, and polishing systems. Beverages such as alcoholic and nonalcoholic and time factors affect the color stability of composite resin.[3]

Numerous methods were available for the assessment of the color change. They are colorimeter, conventional photo spectrometer, and ultraviolet (UV) spectrophotometer. An advantage of the UV spectrophotometer is the fact that it can identify the exact levels of compounds within a particular spectrum sample. Each color and the saturation of the color are identifiable.

The aim of the current *in vitro* study was to investigate the cumulative effect of the colorant solutions on microhybrid (MH) and nanofilled (NF) dental composites.

Materials and Methods

Two visible light-cured MH (A2 shade-3M Filtek Z100) and NF (A2 shade-3M Filtek Z350) composite resins [Figure 1] were used in this study. A sum total of sixty disk (n = 60) specimens of 10 mm in diameter and 2 mm in thickness [Figure 2] were prepared using a fiber mold ring using both composites. The samples were broadly divided into two groups. In Group I, composite disks (n = 30) were made with MH, and in Group II, NF disks (n = 30) were made. The mold was placed on a glass plate. The composite material was delivered directly from

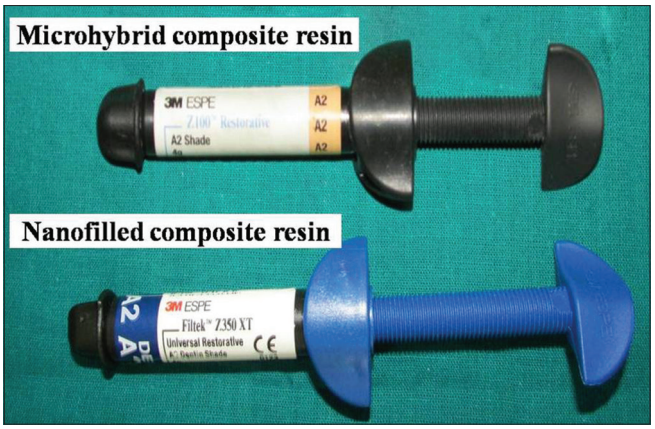

Figure 1: Composite materials

the syringe into the ring on top of the glass plate. The material was condensed using Teflon-coated composite filling instruments, and a mylar matrix cellulose strip was then placed onto the ring and pressed on the top surface of the material. The tip of a light-curing unit was positioned as close as possible without touching the material. The composites were cured for 40 s using a light-curing unit. To ensure adequate curing, the specimens were cured for another 20 s after the glass plate was removed. The composite disks were polished using super-snap polishing system. It was expected that polishing helped with creating conditions that were closer to the clinical circumstances. The colors of all the specimen disks were measured using UV spectrophotometer.

Group I and II were randomly divided into 6 subgroups (n = 10) based on the immersion medium and time. The time durations of immersion used were 24 and 48 h. In subgroups I and II, samples were immersed in red wine (RW) for 24 and 48 h, respectively (RW-24 and RW-48). In subgroups III and IV, samples were immersed in Coca-Cola (CC) for 24 and 48 h, respectively (CC-24 and CC-48). In subgroups V and VI, samples were immersed in distilled water (DW) for 24 and 48 h, respectively (DW-24 and DW-48). All the samples in both MH and NF groups were soaked in respective drinks for a period of 24 h and then color change was measured using UV spectrophotometer. Once again, all the samples were immersed for another 24 h (totally 48 h) in the same drink and then the color change was measured. The specimen color change was measured using a UV spectrophotometer.

A white background was selected and measurements were made according to the CIE L × a × b × color space relative to the CIE standard illuminant D65. The color changes of the specimens were evaluated using the following formula:

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

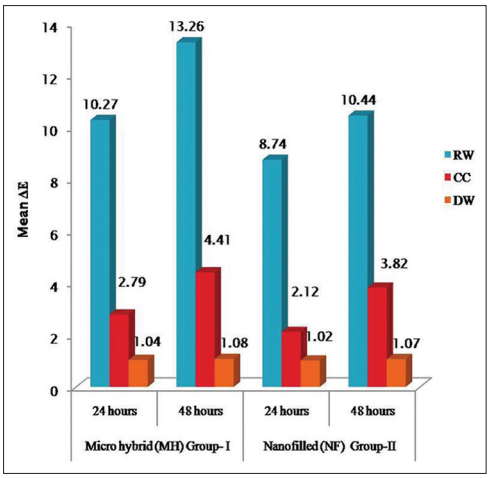

Figure 2: Mean delta E value for Group I and II

Statistical analysis was performed using Computer Software SPSS Version 14.0 (SPSS Inc. Chicago, USA), for each sample of each group. Descriptive statistics including the mean, standard deviation, median, minimum, and maximum values were calculated for each group. One-way ANOVA and *t*-test were used to test the data at a significance level of 0.05.

Results

Table 1 describes that the strong staining solution was RW for both MH (ΔE_{24} = 10.2, ΔE_{48} = 13.2) and NF (ΔE_{24} = 8.7, ΔE_{48} = 10.4), followed by Coca-Cola for MH (ΔE_{24} = 3.3, ΔE_{48} = 4.3) and NF (ΔE_{24} = 2.1, ΔE_{48} = 3.8) and finally distilled water for MH (ΔE_{24} = 1.04, ΔE_{48} = 1.09) and NF (ΔE_{24} = 1.01, ΔE_{48} = 1.07).

Describes the comparison of color stability between the two main groups of composite resins immersed in various solutions and at different time intervals. The samples of MH group immersed in RW-24 and RW-48 subgroups have a significant difference in color change ($P < 0.001$) when compared to the samples of NF. Similar pattern of color change difference ($P < 0.001$) was observed in CC-24 and CC-48, DW-24. Samples of both groups (MH and NF) immersed in DW-48 subgroup showed negligible color change, which was statistically insignificant ($P = 0.32$).

Describes the comparison of color stability based on time variability within the subgroups. The samples of MH group immersed in RW-24, CC-24, and DW-24 subgroups have a statistically significant difference in color change ($P < 0.001$) when compared to the samples of MH group of RW-48, CC-48, and DW-48 subgroups. A similar pattern of color change difference ($P < 0.001$) was observed in NF group.

Table 2 describes that the samples of MH and NF group immersed in RW-24 and RW-48 subgroups have a significant difference in color change ($P < 0.001$) when compared to the samples of MH and NF group of DW-24 and DW-48 subgroups. A similar pattern of color change difference ($P < 0.001$) was observed in CC-24 and CC-48 subgroups when compared to DW-24 and DW-48 subgroups.

Discussion

This study was carried out to evaluate whether or not the consumption of beverages after placement of restoration, may cause changes in the composite color. It has been revealed that different beverages are the contributing factors to composite color stability.

Composite resins are used to replace missing tooth structure and modify tooth color and thus improving esthetics. Traditionally, certain composites have been improved for esthetics and others were manufactured for higher stress-bearing areas. More recently, nanocomposites were optimized for both excellent esthetics and high mechanical properties for stress-bearing areas.[4]

Composite resin discoloration is multifactorial, including factors such as intrinsic discoloration and extrinsic staining out of which extrinsic staining overwhelms the other.[5] Factors under extrinsic staining affecting color stability of the composites are the type of composite, type of beverages, time of immersion, light-curing system, curing time, method of polishing, size of the fillers, organic matrix, and aging. The discoloration of tooth-colored resin-based composite materials can be a reason for the replacement of dental restorations in esthetic areas.

MHs have good clinical wear resistance and mechanical properties which are suitable for stress-bearing applications. However, they lose their surface gloss with time becoming rough and dull. In the development of fillers, the latest advancement has been the use of nanotechnology. Nanofillers offer advantages not only in optical properties but also in mechanical properties. It is desirable to provide low visual opacity in unpigmented dental composites. This allows for the production of a wide range of shades and opacities that enhances the clinician to design a highly esthetic restoration.[4]

Several studies have reported that alcohol facilitates staining by softening the resin matrix of the composites. Bansal *et al.*[3] used whisky as immersion medium because of its high alcohol content. RW which is a dark burgundy and it contains 12% alcohol by volume which is comparatively lower than the whisky. Hence, RW caused the most severe statistically significant ($P < 0.001$)

Table 1: Mean (ΔE), standard deviation, "*F*" and "*P*" value for Group I and Group II

Material	Immersion time (h)	Immersion medium (subgroup)	*n*	Mean	SD	*F*	*P*
Microhybrid (Filtek Z100)	24	RW-24	10	10.27	1.07	2,534,366	0.001
Group I		CC-24	10	2.79	9.80		
		DW-24	10	1.04	8.56		
	48	RW-48	10	13.26	0.001	1111049	0.001
		CC-48	10	4.41	0.001		
		DW-48	10	1.08	0.002		
Nanofilled (Filtek Z350)	24	RW-24	10	8.74	0.0005	2,044,912	0.001
Group II		CC-24	10	2.12	0.001		
		DW-24	10	1.02	0.0007		
	48	RW-48	10	10.44	0.0007	121,981.9	0.001
		CC-48	10	3.82	0.007		
		DW-48	10	1.07	0.0006		

DW: Distilled water, RW: Red wine, CC: Coca-Cola, SD: Standard deviation

Table 2: Comparison of color stability of microhybrid and nanofilled composite resin at 24 and 48 h with red wine, Coca-Cola versus distilled water

Subgroups	Groups			
	MH		NF	
	t	*P*	*t*	*P*
RW-24 versus DW-24	21272.2	<0.001	2574.7	<0.001
CC-24 versus DW-24	423.6	<0.001	228.5	<0.001
RW-48 versus DW-48	1248.6	<0.001	2971.9	<0.001
CC-48 versus DW-48	342.45	<0.001	115.4	<0.001

MH: Microhybrid, NF: Nanofilled, DW: Distilled water, RW: Red wine, CC: Coca-Cola

discoloration results with MH (mean ΔE_{24} = 10.27; ΔE_{48} = 13.26) and NF (mean ΔE_{24} = 8.74; ΔE_{48} = 10.44) resin composite materials tested.

The most common type of nonalcoholic beverage used in our day-to-day life is the Coca-Cola. In the present study, color change values for both MH (mean ΔE_{24} = 2.79) resin and NF (mean ΔE_{24} = 2.12) resin composite restorative materials in Coca-Cola were <3.3 after 24 h, but there was a significant ($P < 0.001$) color difference between the groups. This may due to the absence of yellow colorant, which is more abundant in coffee and tea.[6] However, the mean ΔE after 48 h is more than 3.3 for both resin composites. Both the resin composites showed greater color change after 48 h of immersion than 24 h of immersion. The staining capacity of Coca-Cola is less than the RW. Domingos *et al*.[7] concluded that Coca-cola was the medium that had the lowest influence on the color stability of the composite resins. Ruyter[8] demonstrated that Coca-Cola had the lowest pH and that might damage the surface integrity of the composite resins.

Distilled water which does not have any coloring agents served as control in the present study. In the present study, the mean ΔE in both 24- and 48-h immersion is < 3.3 for both MH (mean ΔE_{24} = 1.04; ΔE_{48} = 1.08) and NF (mean ΔE_{24} = 1.02; ΔE_{48} = 1.07) composite resins. For both the composite resins, immersing the samples in distilled water for 24 h had a significant ($P < 0.001$) color change but was insignificant ($P = 0.32$) when immersed for 48 h.

In the present study, with respect to the composite used and polishability, polished NF composite showed significantly superior color stability than polished MH composite. Toksoy-Topcu *et al*. studied the influence of different drinks on the color stability of polished MH and NF composite resins and concluded that there was a significant color change in the composite resin with all the types of drinks, and the highest value was recorded for MH composite.[9]

Khatri *et al*. studied the staining of polished conventional MH resin and a NF composite resin under various staining solutions and concluded that MH resin was more susceptible to color change.[10]

Al Kheraif *et al*. evaluated the effects of different staining solutions on the color stability of NF compared with MH resin. Unpolished samples were immersed in various staining solutions and concluded that NF composite showed significantly higher discoloration than MH composite.[11]

Awliya *et al*. studied the color stability of unpolished MH and NF composite resin immersed in various staining solutions and concluded that unpolished MH composite resin was more color stable than the other.[12]

Due to the large size and extreme hardness of the filler particles, the resin matrix tends to wear faster than the fillers. Clinically, this can give rise to a rough surface after polishing, wear from prolonged function, and increased susceptibility to discolorations.[13]

Microfilled composites, as their name implies, are composites that are filled with very small pyrogenic or colloidal silica particles with size averages in the order of 0.04 μm.[14] The small filler particles in the microfilled composite resins render the material highly polishable.

The initial gloss of many restoratives is quite good, but in hybrids, plucking of the larger fillers causes loss of gloss. In contrast, in the NF composite, the nanoclusters shear at the same rate as that of the surrounding matrix during abrasion. This allows the restoration to maintain a smoother surface for long-term polish retention.[4]

MH composite has small and large filler particles. Hence, after the finishing and polishing procedure, many voids are left on the composite surface, which affect its quality and also increase the external discoloration.

In this study, the composite resins were immersed for 24 and 48 h, because the composites remain in the oral cavity for a long time, with various staining substances, at different times and periods. The color changes of the samples were less for those immersed for 24 h than the 48-h immersion irrespective of the type of immersion solution used. Hasan *et al*. in their study used the immersion times of 48 and 96 h, and they found that the samples immersed for 96 h had a greater degree of color change and the 48-h immersion was lesser than the former.[15]

Conclusion

The stainability of two resin composite restorative materials was evaluated after 24 and 48 h of immersion in RW, Coca-Cola, and distilled water. Within the limitations of this study, the following conclusions were drawn:

1. Color stability of MH composite resin was found to be inferior than the NF resin composite irrespective of immersion medium and time
2. In RW, the color change observed was maximum for both composite resins followed by Coca-Cola
3. Immersing the resin composites in distilled water for 24 and 48 h had negligible color change
4. A 48-h immersion of both composite resins in all the immersion mediums showed greater color change than 24-h immersion.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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