

Original Article

The Effect of Different Polishing Methods and Storage Media on Discoloration of Resin Composites

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Abstract

Statement of Problem: Accumulation of plaque and staining due to a rough surface, and penetration of colourant agents from food and beverages in to the resin composite results in an incomplete polymerization. There is a little information on the effect of finishing and polishing techniques on the discoloration of nanohybrid and microhybrid composites when exposed to staining solutions.

Objectives: To determine the degree of surface staining of nanohybrid and microhybrid composites after polishing and immersion in distilled water and two commonly used staining solutions.

Materials and Methods: A nanohybrid (Ice; SDI) and microhybrid (Gradis direct; GC) composites were used. Disc-shaped specimens were prepared and treated with either a matrix finish or polished using Sof-Lex discs (3M/ESPE) and Enhance point (Dentsply). After 24 h immersion in distilled water at 37°C the specimens were polished and colour coefficients (CIE L* a* b*) was measured by a spectrophotometer. All specimens were immersed in 37°C distilled water in an incubator for 7 days and colour coefficients were measured again. The colour change (ΔE) was calculated using the following formula: $\Delta E = [(\Delta a)^2 + (\Delta b)^2 + (\Delta L)^2]^{1/2}$. The data were analyzed using three-way ANOVA, one-way ANOVA/Tukey HSD and Student's *t*-test.

Results: There was a significant interaction between resin composites, polishing systems and staining solutions ($p < 0.05$). ANOVA and Tukey's tests showed that Ice had a significantly lesser colour change than Gradia direct and matrix finish revealed the smoothest surface followed by Sof-Lex discs and Enhance point. Distilled water and cola caused no perceptible colour change ($\Delta E < 3.3$). The effect of surface polish on staining was statistically significant ($p < 0.05$).

Conclusions: Sof-Lex discs in comparison to Enhance point stimulated greater staining resistance for both composites. The nanohybrid exhibited less colour change than microhybrid composite. Coffee was the only storage media that induced a perceptible colour change ($\Delta E > 3.3$) compared to cola and distilled water.

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Introduction

The majority of patients desire that tooth-coloured materials used in their restorative to be long lasting, withstand harsh oral environments and hence have high colour stability. This is especially significant for the anterior teeth. New amendments in resin composites and bonding systems targeted a better aesthetics as well as function authorizing these materials to be used for anterior and posterior restorations [1,2].

To improve physical and mechanical properties of resin composites, the size of filler particles incorporated in the resin matrix has been gradually decreased over the years [3,4]. The most recent developed resin composites contain only nanoparticles called nanofill composites. However, most manufacturers produce nanohybrid composites which mostly contain nanoscales particles and less pre-polymerized resin fillers. These materials are used for most anterior and posterior applications due to their combination of strength and polishability [5,6].

Colour change of aesthetic materials can be affected by several factors such as accumulation of plaque, penetration of staining agents (food and beverages), incomplete polymerization, water sorption, dietary and smoking habits, exposure to chemical, and surface smoothness of the restoration [1,2,7,8]. Heavy drinkers of alcohol and/or soft drinks with tooth-coloured restoratives predispose their restorations to discoloration affecting the clinical outcome and colour stability of the restorations. The effect of aging, beverages and food stimulating solutions on the colour stability of resin composites has been widely studied and various degrees of staining have been reported [9-13].

Additionally, surface characteristics and material's composition such as filler particles' shape and sizes may influence the discoloration of the composites [14]. Finishing and polishing techniques are reported to have a great influence on the discoloration of tooth-coloured restorative materials [15-17]. High finished and polished surface improves the aesthetics and the longevity of the restorations, while rough surfaces accumulate plaque and staining; hence, discoloration of the composite restoration occurs [18,19]. Therefore, the smooth surface contributes to aesthetics by prevention of staining and plaque retaining [20].

There are controversial reports on the effect of surface polish, foods and beverages on the colour

change of the nanocomposites. Nasim *et al.* [2] found significant differences among microfill, microhybrid and nano composites after storage in tea, carbonated drink and distilled water for 30 days. Microfill composite exhibited the most colour change and microhybrid the least. Malhotra *et al.* [1] in their study on the effect of three indigenous food stains (tea, tobacco, and turmeric) on microhybrid, and nanofill composites revealed that all of the tested groups showed clinically perceptible colour change. Moreover, Gönülol and Yılmaz [16] studied the effect of finishing and polishing techniques on the colour stability of two nanohybrids (Grandio/Voco and Aelite/Bisco) and found a significant difference between colour change of these two materials. A recent study [21] found no significant difference in the colour stability of the nanofill composite after immersion in different media. They also reported that the finishing and polishing procedures did not have any influence on the colour stability of the nanofill composite [21].

There are few published studies comparing colour change of microhybrid and nanohybrid composites subjected to different polishing systems exposed to daily used staining beverages. Therefore, the aim of this study was to compare the colour change of a microhybrid and a nanohybrid composite after polishing by Sof-Lex discs or Enhance point versus Mylar strip after immersion in distilled water, cola and coffee for 7 days. The null hypothesis is that there is no difference between microhybrid and nanohybrid composites after immersion in those staining solutions, and that the polished or unpolished surfaces do not affect the colour change of these materials differently.

Materials and Methods

Two types of resin composite were selected; Ice (nanohybrid, SDI, Australia) and Gradia direct (microhybrid, GC, Japan). Three surface finish/polishes (matrix finish, Sof-Lex discs / 3M ESPE, and Enhance point / Dentsply) and three storage media (distilled water, cola and coffee) were used. Fifty-four disc-shaped specimens for each composite were prepared using a polyethylene mould of 10 mm diameter and 1 mm thickness. Resin composite was placed into the mould and sandwiched between two Mylar strips and glass slabs with slight hand pressure in order to extrude the excess material. The specimen was cured over the Mylar strip using an LED curing

unit [Radii plus LED, (wavelength of 440-480 nm/ output of 1500mW/cm², SDI, Bays water, Victoria, Australia). Thirty minute after curing, the specimen was removed from the mould and ground gently using 600 grit silicon carbide paper to make a smooth edges. All the specimens were stored in distilled water at 37°C for 24 h in an incubator.

The specimens were divided into three groups of 18; one group was designated 'matrix finish' and left without further polishing after removal of the Mylar strip. Specimens in the second group were polished using a sequence of four Sof-Lex (3M/ESPE, St Paul, MN, USA) discs (coarse, medium, fine and super fine) on a low speed hand piece. The third group was polished using Enhance Point (Dentsply, Detrey GmbH, Konstanz, Germany). Each group of 18 was then divided into 3 subgroups of 6 and immersed in either distilled water, cola or coffee for another 7 days at 37°C. The staining solution was replaced with fresh solution every 24 h during the storage period.

After 24 h, when the polymerization completed, before polishing the baseline L^* , a^* , b^* (CIE system) values of all specimens were measured using a spectrophotometer (Vita Easyshade, Ivoclar Vivadent AG, Schaan, Liechtenstein). Each specimen was measured at three areas, and then the mean values were calculated. The spectrophotometer was recalibrated when required.

After 7 days of immersion in the solutions, colour measurement was recorded again for all groups with the same method mentioned above. Before colour measurement, the specimens were dried with paper towel slowly. The second measurement was served as the treatment for each specimen to enable the calculation of colour change (ΔE) using the following formula:

$$\Delta E = [(\Delta a)^2 + (\Delta b)^2 + (\Delta L)^2]^{1/2}, \text{ where } \Delta a^* = (a^*_1 - a^*_0), \Delta b^* = (b^*_1 - b^*_0), \text{ and } \Delta L^* = (L^*_1 - L^*_0).$$

Zero represents the baseline reading, whereas 1 represents the colour reading after 7 days of immersion in the staining solutions or distilled water.

Statistical Analysis

Three-way ANOVA was used to assess the effect of different polishing methods, storage media and composites. Due to the significant interaction effects, subgroup analysis using one-way ANOVA/ Tukey HSD and Student's t -test were performed. SPSS version 18.0 (Chicago, IL, USA) was used for statistical analysis. A $p < 0.05$ was considered statistically significant.

Results

Results of Three-way ANOVA showed a significant interaction between two resin composites, storage media and polishing systems (all $p < 0.05$). Table 1 shows the statistical analysis within groups using one-way ANOVA and Tukey's test. Generally, Ice showed less colour change than Gradia direct in all storage media and all polishing systems (Figure 1). Matrix finish caused significantly less colour change than Sof-Lex discs and both less than Enhance point for both composites in all storage media. Among the storage media, coffee revealed significantly more colour change than cola and both more than distilled water for two tested composites and all polishing methods.

For both composites in all 3 polishing groups, mean values of ΔE was significantly different between

Table 1: Mean colour change (ΔE values) \pm standard deviation of the materials for all polishing systems in all storage media

Composite	Storage Medi	Matrix finish	Sof-Lex	Enhance
Gradia direct	Distilled water	1.8 \pm 0.58 ^{a,A}	2.5 \pm 0.63 ^{a,AB}	2.9 \pm 0.73 ^{a,B}
	Cola	2.2 \pm 0.48 ^{a,A}	2.9 \pm 0.57 ^{a,AB}	3.1 \pm 0.60 ^{a,B}
	Coffee	4.1 \pm 0.48 ^{b,A}	6.2 \pm 0.46 ^{b,B}	6.5 \pm 0.44 ^{b,B}
Ice	Distilled water	1.1 \pm 0.50 ^{a,A}	1.8 \pm 0.40 ^{a,AB}	2.1 \pm 0.56 ^{a,B}
	Cola	1.6 \pm 0.36 ^{a,A}	2.1 \pm 0.67 ^{a,A}	2.3 \pm 0.38 ^{a,A}
	Coffee	3.2 \pm 0.42 ^{b,A}	5.5 \pm 0.49 ^{b,B}	6.1 \pm 0.38 ^{b,B}

Different upper case letters show significant differences in the colour change (ΔE) between different polishing systems (Tukey's HSD test)

Different lower case letters show significant differences in the color change (ΔE) between storage media (Tukey's HSD test)

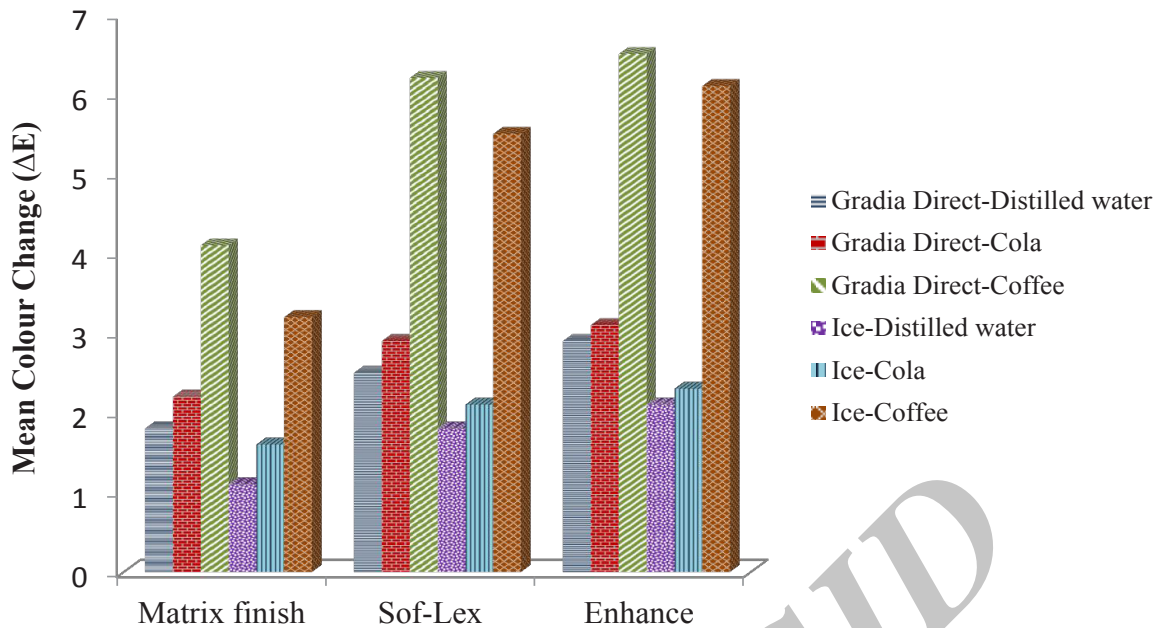


Figure 1: Mean colour change (ΔE values) of tested resin composites for all polishing systems in all storage media

coffee and distilled water or coffee and cola ($p < .05$), but no significant difference between distilled water and cola. Table 2 compares the differences between the ΔE values of all storage media for both composites. Only coffee produced clinically perceptible colour change ($\Delta E > 3.3$).

Discussion

The results of this study showed that the null hypothesis was rejected, i.e. nanohybrid and microhybrid composite performed differently when subjected to different finishing and polishing

Table 2: Comparison between two composites for each storage media in all polishing methods, using Student's *t*-test

Polishing Methods	Storage Media	<i>p</i> value
Matrix finish	Distilled water	0.051
	Cola	0.038*
	Coffee	0.007*
Sof-Lex	Distilled water	0.045*
	Cola	0.051
	Coffee	0.031*
Enhance	Distilled water	0.061
	Cola	0.022*
	Coffee	0.122

*:Significant difference ($p < 0.05$) (Tukey's HSD test)

procedures. Immersion in storage media also showed diverse effects on the colour change of the two tested materials. The nanohybrid composite (Gradia direct) showed significantly greater colour change than the microhybrid (Ice) in matrix finish and polished groups in all storage media (Table 1). This different performance of the two composites supports the effect of material's composition as intrinsic factors in their colour change. Ice with filler loading of 61vol% and particle sizes range of 0.04 -3 μm contains UDMA/Bis-EMA/TEGDMA showed less discoloration than Gradia having 59 vol% and average particle sizes of 0.85μm contain mainly UDMA. The differences could be related to the resin phase of the composite [10] or filler volume, sizes or the porosity of the aggregated filler particles [22]. The degree of conversion has been mentioned as a prominent factor on the discoloration of resin composites.

However, Al Kheraif *et al.* [23] examined the effect of coffee, tea, cola and distilled water on colour stability and degree of conversion of nanofill and microhybrid composites. They found that nanofill composite with greater ΔE values when exposed to coffee despite having a higher degree of conversion compared to microhybrid composite [23].

Besides material composition, mechanical and chemical elements such as finishing and polishing procedures, and exposure to staining solutions might also result in surface roughness, thus high stainability [24,25]. In the present study, in contrast to distilled

water (pH = 6.8) and cola (pH = 2.47), immersion in coffee (5.41) for both composites and two polished groups resulted in clinically perceptible colour change ($\Delta E > 3.3$). Results of other studies [9,23] on the effect of food colourants on the discoloration of resin composites showed results similar to ours. Although cola had the lowest pH that might damage the surface integrity of the materials, it did not produce as much discoloration as coffee which may be due to the lack of a yellow colourant in cola. It is concluded that discoloration by coffee might be due to adsorption and absorption of colourants by materials. This sorption of colourants into the organic phase of the materials was probably due to the porosity of polymer phase with the yellow colourants of coffee [9].

Another explanation for more discoloration due to immersion in coffee would be alteration in the surface hardness of the resin composite. Karaman *et al.* [26] studied the influence of cola and coffee on the colour stability of silorane and methacrylate-based composites. Immersion in coffee caused a significant discoloration for all the composites tested, showing a lower colour change in silorane-based than that of methacrylate-based composite. Immersion in coffee caused the most changes in the surface hardness of methacrylate-based composite [26].

In the current study, the specimens polymerized under Mylar strip without receiving further polishing treatment (matrix finish group) had the lowest ΔE values followed by Sof-Lex discs. Enhance point showed the most colour change in both nanohybrid and microhybrid composites that could be due to the defect and scratches created by the polishing procedure on the surface of the materials make them more disposed to staining [27]. Previous studies [28-30] also reported similar results that the roughest surface is generated by using Enhance polishing systems in comparison with Mylar strip and Sof-Lex discs. A current study investigated the effect of polishing systems on stain susceptibility and surface roughness of nanocomposites, reporting that staining susceptibility depends mainly on material composition and on the polishing procedures. It has been shown that polishing improved the staining resistance of the resin composites; and nanocomposites exhibited similar staining resistance or surface roughness to microhybrid composite [31]. However, it is shown that the smoothest surface was not necessarily the most stain resistant [32], which may support the hypothesis that discoloration is not exclusively dependent on the surface roughness but exposure to

the staining media may change the surface quality and predispose the materials to discoloration [9]. In our study, coffee and cola were used as colourant agents, due to their frequent intake in daily life and having different pH levels. The results indicated that coffee induced the most colour change in both materials in matrix finish and two other polished groups, which is in agreement with other studies [12,23,33].

Conclusions

Within the limitations of this in vitro study, the following conclusions were drawn. Multiple-step polishing technique (Sof-Lex discs) in comparison to one-step (Enhance Point) stimulated greater staining resistance for both composites. The nanohybrid exhibited less colour change than microhybrid composite. Stain susceptibility altered not only due to the composition of the material, but also the polishing techniques and storage media. Therefore, the practitioners should try to minimize discoloration of the composite restorations by adopting excellent polishing techniques and educating patients on the staining effects and erosive potential of the soft drinks if consumed heavily.

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