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Original Research Article

Color Stability of Resin Composite Restorative Materials Finished/Polished with Different Systems

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ABSTRACT

Objective: To evaluate the effect of three different polishing systems on color stability of microfill, nanofill, and nanohybrid resin composites.
Materials and Methods*:* A total of 120 resin composite discs were prepared in split Teflon mold with dimension of 10 mm diameter and two mm thick. Specimens were equally divided into three groups according to restorative materials (microfill composite A, nanohybrid composite B and nanofill C); 40 specimens for each material (n=40). Ten specimens from each restorative material were remained without finishing/polishing and used as a control group. Color measurement of all specimens (unpolished, polished) were recorded before & after mechanical tooth brushing by spectrophotometer.
Results: There was statistically significant difference among the tested composite materials and polishing method ($P < 0.001$). The nanofilled resin composite and the liquid polisher presented the least ΔE values. After tooth brushing, mean ΔE values was increased for three tested resin composite.
Conclusion: Nanofilled composite and liquid polisher showed the least color change between the tested resin composites and polishing systems.

Keywords: Color stability, Nano-filled resin composite, Nano-hybrid resin composite & Finishing/Polishing.

INTRODUCTION

The esthetic appearance of tooth-colored restorations is of great interest to both dentist and patient. To reach the goal of restoring teeth with natural appearance, developments of restorative technology are evolved into two fold approaches. The first approach is development in filler size, while the second approach is development in finishing and polishing technology. [1-4]

Proper finishing and polishing of dental restorations are important aspects in clinical restorative procedures, regardless of the type and location of the restoration, because they enhance both esthetics and longevity of restored teeth. [5,6] Clinicians have their choice among a wide range of finishing and polishing instruments. With the ultimate goal of achieving a smooth surface of the composite restoration in fewer steps, current one-step systems appear to be as effective as multi-step systems for polishing dental composites. [5] The one-step polishing systems are appealing to the clinician. [7]

Liquid polishers (surface sealant) are low viscosity fluid resins that provide a gloss over composite resin restoration, prevent stain penetration and discoloration of composite resins and result in greater shade stability improving final esthetics and reducing microlekage at composite margin. [8-11]

The esthetic success of a restoration is directly related to its optical appearance. Surface roughness, surface gloss and color are among the important factors that dominate the perceived visual appearance of resin composite restorations. [12] Correlations among these factors might differ by resin composite and shade; however, information on such correlations is limited. [13] The color of an object depends on its surface spectral reflectance. [14] The reflectance of a surface is a sensitive function of its roughness and therefore the optical properties of the resin composites may be influenced by the surface changes occurring during restorative procedures of finishing and polishing. [15]

The aim of the present study was to evaluate the effect of three different polishing systems on color stability of microfill, nanofill, and nanohybrid composites resin. The null hypothesis was there was statistically significant difference among the tested composite materials and polishing method.

MATERIALS & METHODS

The composite restorative systems employed in this study were; microfill resin composite (Heliomolar); nanohybrid composite (Tetric N Ceram) and nanofill resin composite (Filtek Z350XT).Three different polishing systems were used for each restorative system; three steps system (Astropol), one step (Astrobrush) and liquid polisher (G-coat Plus), as listed in Table 1. Shade A_2 was used for all composites resin tested.

The restorative materials were used in accordance with manufacturer's instructions and only one operator performed all the procedures of specimen's preparation. A light emitting diode (LED) visible-light curing unit was used (bluephase C8, Ivoclar/Vivadent AG Schaan, Liechtenstein), and the power density of the light (800 mW/cm^2) was checked every 10 specimens with a digital readout dental radiometer (bluephase meter, IvoclarVivadent AG, Schaan, Liechtenstein).

Table 1: Restorative materials & polishing systems tested

Brand names	Specifications	Manufacture	Composition
Filtek™ Z350 XT	*Nano filled composite*	*3M ESPE St Paul, MN, USA*	*Matrix: Bis-GMA, UDMA, Bis-EMA,TEGDMA Filler: silica nanofiller (5−75 nm), zirconia/silica nanocluster (0.6−1.4 µm)*
Tetric N ceram	*Nano hybrid composite*	*IvoclarVivadent*	*Matrix: bisGMA, UDMA,T EGDMA, EthoxylatedBis-EMA. Filler:Barium glass, ytterbium trifluoride, mixed oxide, silicon dioxideprepolymers*
Helimolar	*Microfilled composite*	*IvoclarVivadent*	*Matrix: Bis-GMA, UDMA, Decandioldimethacrylate, Filler:silicon dioxide, Prepolymer, Ytterbium trifluoride*
A stropol F P HP	*Three step polishing system*	*IvoclarVivadent*	*Matrix:rubber Abrasive:siliconcarbid, aluminiumoxide, titanium oxide, ferrous oxide, diamond dust(HP)*
Astrobrush	*One step polishing system*	*IvoclarVivadent*	*Silicon carbide-impregnated polyamide bristle brush*
G-coat Plus	*Nano-filled self-adhesive light cured protective coating*	GCcorporation Tokyo, japan	*Urethane methacrylate, methyl methacrylate, camphorquinone, silicon dioxide, phosphoric ester monomers*

Abbreviations: bis-GMA, bisphenol-A glycidyl methacrylate; UDMA, urethane dimethacrylate; TEGDMA, triethylene glycol dimethacrylate; DMA, dimethacrylate; Bis-EMA, Bisphenol A polyethylene glycol diether dimethacrylate

Cylindrical split mold (50 mm diameter and 2 mm thick) was constructed from Teflon. In the center of the mold a circular recess (10 mm diameter) was constructed and used for preparing the composite specimens. [16] Three groups of specimens were prepared, one from each material (n=40). Each restorative material was placed in bulk pack technique in the mold using Optra Sculp modeling instrument (Ivoclar/Vivadent, AG Schaan, Liechtenstein) over a transparent, 0.051 mm thick Mylar strip (Universal strip of acetate foil) and a glass slide. Black paper was placed between the glass slide and Mylar strip to prevent reflection of light during polymerization. [17]

Every effort was made to prevent the inclusion of air voids while inserting the material in the mold. Another Mylar strip and a glass slide were placed over the inserted material. A 500 gm stainless steel weight was applied for 30 s over the specimen, allowing the composite to flow in order to obtain a smoother and standardized surface. After removal of the stainless steel weight, curing was performed according to manufacturer's instructions. The distance between light source and specimen was standardized by curing through the glass slide. The tip of the light curing unit was in contact with the covering glass slide. Finally the specimens were removed from the mold. The specimens were immediately finished and polished to simulate the clinical condition. [18]

All the specimens were notched on their reverse side to serve as an orientation aid for the finishing procedures; each disc was notched at two locations 180^0 apart to ensure consistent orientation of specimens during polishing procedures (double notch at one edge; single notch at the opposite edge), which were carried out perpendicular to the notch. [18]

Ten specimens from each restorative material were remained without finishing/ polishing after removal of Mylar strip used as a control group. Specimens were finished and polished immediately after curing, following the routine clinical procedure. Specimens were finished with fine grit diamond instrument to simulate clinical condition for 30 s with a high-speed handpiece under water cooling; a new finishing bur was used for every five specimens. [19] Specimens were equally divided into three groups according to restorative materials (microfilled composite A, nanohybrid composite B and nanofilled C); 40 specimens for each material. Each group further subdivided into three sub groups according to polishing system (n=10).

In subgroups A1,B1,C1 the specimens were finished and polished with three steps silicon system, following a decreasing sequence of abrasiveness (the Astropol F; Finishing), the Astropol P (Polishing) and the Astropol HP (High Polishing) polishing discs using a low-speed hand piece at approximately 10,000 rpm in conjunction with water spray. Uniform light pressure and a planar motion 10 s for each abrasive step were used to polish the specimens. After each polishing step, the specimen was rinsed with water spray and blow dried with an air syringe. [20]

The second subgroup was polished using Astrobrush for 30 s (one-step system) which was mounted on a low speed handpiece attached to an electrical motor to fix the speed at 10000 rpm in conjunction with water spray. Each brush was removed after single use. The third subgroup, the specimens were coated with liquid polisher after finishing with diamond instruments.

After the finishing/polishing procedures, the specimens were washed with air-water spray for 5 s and examined under a stereomicroscope (Nikon model SMZ-IB, Tokyo, Japan) for grinding debris or surface defects. If voids were present, the specimen was discarded and replaced with another then stored in distilled water at room temperature for 24 hours to complete the polymerization. [21]

Baseline color measurement of all specimens (unpolished, polished) were recorded before mechanical tooth brushing with ShimazuUV-3101PC (UV-VIS-NIR scanning spectrophotometer (Shimadzu corporation, Kanda-Nishikicho-chome, Chiyoda-ku, Tokyo 101-8448, Japan) using CIE (Commission Internationale de l'Eclairage) L*a*b*. [22] L*refers to the lightness coordinate, and with value ranges from zero (black) to 100 (white). The values, a*and b*are chromaticity coordinates in the red-green axis and the yellow-blue axis, respectively. Positive a*values indicate a shift to red, and negative values indicate a shift to green. Similarly, positive b* values indicate the yellow color range, and negative values indicate the blue color range. Measurements were repeated 3 times for each specimen and the mean values of the L*, a*, and b* data were calculated. Before each measurement session the spectrophotometer was calibrated according to manufacture recommendation using the supplied white calibration standard. [23]

The calculation of the color variation ΔE* between the two color measurements of unpolished specimens (control) and polished specimens was done using the following equation: [24, 25]

$$\Delta E = [(L1^* - L0^*)^2 + (a1^* - a0^*)^2 + (b1^* - b0^*)^2]^{1/2}$$

After baseline color measurements, all specimens were exposed to mechanical tooth brushing. The specimens were rinsed with distilled water for 5 min and blotted dry with tissue paper before color measurement. At this point, color readings were made using the spectrophotometer in the same manner described for baseline readings.

The calculation of the color variation ΔE* between the two color measurements (after tooth brushing and baseline) in the 3-dimention L*a*b*color space was done: $\Delta E = [(L2^* - L0^*)^2 + (a2^* - a0^*)^2 + (b2^* - b0^*)^2]^{1/2}$. All data were collected and were statistically analyzed.

RESULTS

The color change (ΔE) mean values and standard deviation of each material after polishing with either three step system, one step system or liquid polisher were obtained through the analysis of spectrophotometer reading are shown in table (2). Statistical evaluation of the data was performed with two ways ANOVA to evaluate the effect of different polishing methods, different types of dental resin composite tested, and their interaction on color change. It was found that there was a significant effect of finishing method and material type on color change. In addition, there was no significant interaction between polishing method and material. Least significant difference (LSD) test was conducted to detect any significance between different dental resin composite tested within every finishing method tested.

Regarding to polishing methods tested, a significant difference was observed among polishing procedures. The lowest ΔE was recorded with liquid polisher for nanofill, nanohybrid, microfill respectively, to be followed by three step system for nanofill, nanohybrid, microfill respectively. The highest ΔE values were recorded for all the restorative materials polished with one step system for nanofill, nanohybrid, microfill respectively.

When the dental resin composite resins were evaluated regardless of polishing systems, the final overall ΔE mean values for nanofill; liquid polisher, three step, one step respectively, were lowest than that for nanohybrid; liquid polisher, three step, one step respectively. While the highest values recorded with microfill for liquid polisher, three step, one step respectively, with significant difference between microfill, nanofill and nanofill, nanohybrid and no significant difference between nanohybrid, microfill

Table 2: mean ΔE and standard deviation for the tested composites and finishing /polishing systems evaluated before tooth brushing.

Materials	Three-step system	One-step system	Liquid polisher	LSD	P value
Microfilled	2.70 ± 0.27^{aA}	3.05 ± 0.17^{bB}	1.9 ± 0.04^{cC}	.169	<.0001
nanohybrid	2.50 ± 0.35^{aA}	2.80 ± 0.35^{bB}	1.8 ± 0.35^{cC}	.321	<0.0001
Nanofilled	2.07 ± 0.28^{a}	2.4 ± 0.35^{b}	1.39 ± 0.264^{c}	.275	<0.0001
LSD	0.321	0.2626	0.2626		
P value	0.0534	0.0055	0.0492		

Means with the same small superscripted letters in the same row and the same capital superscripted letters in the same column demonstrated no statistically significant differences ($p > 0.05$).

After tooth brushing, the mean ΔE values for all tested groups were increased (table 3). Two way ANOVA statistical analyses were used to evaluate the effect of material and polishing system on color stability. It was found significant effect of material on color stability. No statistical significant effect of polishing systems on color stability.

LSD test was used to compare between different restorative materials and different polishing systems tested. The nanofill was the lowest mean ΔE values for liquid polisher, three step system, one step system respectively, followed by nanohybrid for liquid polisher, three step system, one step system respectively, and microfill recorded the highest ΔE values for liquid polisher, three step system, one step system respectively. There was significant difference between nanofilled, microfilled. There was significant difference between nanofilled, nanohybrid. There was significant difference between microfilled, nanohybrid.

Table 3: Mean ΔE and standard deviation for the tested composite and finishing /polishing procedures evaluated after tooth brushing:

Materials	Three-step system	One-step system	Liquid polisher	LSD	P value
Microfilled	3.502 ± 0.026^a	3.6 ± 0.35^a	3.4 ± 0.35^a	.295	.394
nanohybrid	3.1 ± 0.35^b	3.30 ± 0.35^b	3.0 ± 0.35^b	.321	.168
Nanofilled	2.50 ± 0.35^c	2.7 ± 0.35^c	2.40 ± 0.35^c	.321	.168
LSD	0.3208	0.3208	0.3208		
P value	<.0001	0.0002	<.0001		

Means with the same small superscripted letters in the same row demonstrated no statistically significant differences ($p > 0.05$).

DISCUSSION

Alteration of filler component remains the most significant development in the evolution of composite resins. In terms this alteration in filler size and loading that is responsible for the composite resin performance for both polishability and wear and fracture resistance. [26]

The present study compared the color stability of two different nanocomposite resin restorative materials; nanofill (Filtek Z350XT), nanohybrid (Tetric N Ceram), and a microfill resin composite (Helimolar) after finishing/polishing with different systems. These restorative materials were selected on the basis of filler load and filler size. Also, the different polishing systems investigated in this study were selected to compare and evaluate the effectiveness of one step polishers compared to multistep polisher.

Color change can be assessed both visually and by specific instruments. The methodology used in the present study was in accordance with previous studies that used spectrophotometry and the CIE L*a*b* coordinate system, which is a recommended method for dental purposes. The CIE L*a*b* coordinate system was chosen to evaluate the color variation (DE) because it is well suited for the determination of small color changes and has advantages such as repeatability, sensitivity, and objectivity. [23]

These systems are more precise, according to the literature, in comparison with measurements obtained from colorimeters, once they are not influenced by the environment luminosity. ΔE values can be used to represent color alterations of restorative materials undergoing determined treatment or certain periods of time. [27]

Values of ΔE that observed in the present study revealed that the lower the roughness after polishing, the greater the resistance to color changes of the composite resins. When the ΔE values were compared, significant differences were found among composite resin materials (which had different particles sizes and different amounts of filler content) and among polishing techniques. ΔE values obtained with different polishing techniques in this study were ranked in an ascending order:

liquid polishing followed by three step polishing cups followed by one step silicon brush. A significant decrease was observed in the ΔE values by the application of a glaze material.

Optical properties of dental composite resins are directly affected by surface roughness. An increasingly roughened surface will reflect the individual segment of the specular beam at slightly different angles. Therefore; different polishing methods of finishing dental composite resin restorations influence the resistance to color and brightness alterations of the restoration. [28]

In the present study, the application of the glaze material decreased surface roughness and color change. However, even though the glaze material is resistant to function, tooth brushing, and staining, initially; some investigations demonstrated a degradation of the glaze material as it ages. [11] If the surface configuration had a matte finish, there would be an excessive amount of light reflected at surface level and a reduction of light transmission through the material. Surface texture controls the degree of scattering or reflection of the light striking on the natural tooth or the material. [28] For this reason, clinicians experience problems in establishing harmony of the shade obtained with the original shade that was selected using a shade guide, especially after finishing and polishing procedures. [28]

The color differences among three tested composite resin materials and three polishing methods tested were found to be between 1.39 and 3.05 in this study. Although polishing methods showed statistically significant color differences, these differences are within a clinically acceptable level, as they are below 3.7. [29] The arrangement of ΔE values in ascending order is nanofill, microfill, and nanohybrid composite resins with no significant difference between microfill and nanohybrid, which is similar in order to the inorganic filler particle sizes.

It was reported that increased particle size resulted in lower amounts of color changes due to a decrease in the proportion of organic filler matrix, resulting in a decrease in the rate of fluid absorption. [30] In this study, fluid absorption or dissolution was not considered, as the composite resin specimens were not stored in any type of fluid. Only the effects of polishing procedures on color stability were investigated. The degree of surface roughness after polishing increases with the increase in filler particle size, and the amount of light reflection also changes accordingly. Consequently, an increase in the size of filler particles would result in surface irregularities, causing a difference in color. [31]

After tooth brushing, ΔE was increased for all restorative material with least values recorded with nanofill and this may be explained by increasing of surface roughness which had strong effect on color stability.

CONCLUSION

Based on the findings of this study, the following conclusions can be found:

1. Nanofilled composite showed the least color change between the tested composites.
2. Liquid polisher exhibited the least color change among the tested polishing systems but still worse than Mylar strip.

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