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How Far Surface Treatment Protocols Can Affect the Color Stability of Direct Composite Resin Restorations?

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Abstract

Objectives: *To evaluate and compare the color stability of two esthetic restorative materials after surface finishing/polishing with different procedures.*
Materials and Methods: *A Teflon mold was used to fabricate 150 specimens of each composite type, covered with a transparent polyester strip and light cured. The specimens were then divided into five groups according to finishing/polishing technique.*
Surface roughness values (Ra) of each specimen were measured five times, and mean Ra values were determined. Baseline color measurements were made with a Vita Easy shadeV then the specimens were allocated into subgroups of five specimens each, and each specimen was stored for 7 days in 200 mL of distilled water, black coffee, or black tea. The specimens were then rinsed with distilled water for 5 min and blotted dry with absorbent paper before the second color measurement was performed.
Results: *No significant difference in surface roughness among the two types of composite resins regardless the method of finishing & polishing used. Additionally, no statistically significant correlation between the surface roughness and the color difference values.*
Conclusion: *Intra-orally, composite surface discoloration might happen with extremely smooth surface and not always related to the degree of surface roughness.*
Clinical Significance: Proper finishing and polishing of composite restorations will reduce but not totally prevent the color change caused by coloring beverages.

Keywords: *Composite restoration, Color stability, Finishing and Polishing, coloring beverages, surface roughness.*

Introduction

One of the greatest exciting tasks concerned with esthetic demands in dentistry is to create a restoration that matches the color and appearance of a natural tooth.

All esthetic restorative materials should copy the appearance of the natural tooth in color, and the success of an esthetic restoration depends first on the color match and then on the color stability of the material [1]. A critical property of esthetic restorative materials is their long-standing color stability. Unacceptable color match is a primary reason for replacement of composite resin restoration [2]. One of the greatest complications of composite restorations is their gradual color change and mismatch with the adjacent teeth over time [3].

Color changes could be classified into: first, intrinsic discoloration factors which are inherent to the material itself as a result of physico-mechanical reaction within the material [4] and second: extrinsic discoloration due to staining in the superficial layer of resin composite, water absorption, surface roughness, smoking, and diet. Consumption of certain beverages such as coffee and tea may affect the esthetic and physical properties of composite [5].

All composite restorative materials composed of two principal components; the resin matrix and filler particles which have different levels of hardness causing inconsistency in polishing efficiency. This inconsistency can lead to differences in surface roughness [6].

Additionally, particle size of the composite has a principal effect as larger particles are often associated with an important detachment of the fillers, and therefore to a higher porosity of the restoration [7]. That is the reason most operators use microfilled or nanofilled composites to

replace the enamel layer, these materials initially provide a relatively good surface smoothness and higher shine.

Appropriate surface finishing and polishing are essential clinical procedures, which improve esthetics and longevity of restorations. Polishing diminishes roughness and scratches created by finishing instruments [8,9]. A smooth surface is clinically important not only in minimizing plaque accumulation and gingival irritation, but also controls the esthetics and durability of the composite resin restorations [10,11].

Many studies have confirmed that the smoothest surface on composite resin restorations is accomplished using a clear matrix in contact with the composite surface during curing [12]. However, further contouring and finishing are usually required, so it is important to determine the finishing technique that will result in the smoothest restorative material surface under these clinical circumstances [13].

Among the widely used polishing devices are silicon carbide-coated and aluminum oxide-coated abrasive discs. Surface sealants also tried to fill the surface irregularities of composites in an attempt to improve the surface luster, marginal sealing and wear resistance [14,15]. Using of these sealants affects the absorption of pigments and color stability of composite restorations [16].

The aim of this in vitro study was to evaluate and compare the color stability of two esthetic restorative materials after surface finishing/polishing with different procedures. The null hypothesis of the study is that the finishing treatments used had no effect on the color stability of esthetic restorative materials tested.

Materials and Methods:

The composite resins and sealers used in this study are shown in Table 1.

Materials	Lot Number	Manufacturer	Composition
Microhybrid Composite resin	6647356	Herculite Classic Kerr Italia	79 % inorganic filler (by weight) 59% by volume with an average particle size of 0.6µm -trimethyl-dioxo-dioxa- -diazahexadecane- Bismethacrylate -hexanediyl bismethacrylate -ethylenedioxydiethyl dimethacrylate -hexamethylene diacrylate -trimethoxysilylpropyl methacrylate
Nanohybrid Composite resin	6119059	Herculite XRV Ultra Kerr Italia	71% Three fillers—prepolymerized filler (PPF), silica nanofillers (20 – 50 nm), and Barium glass (0.4 micron). trimethyl-dioxo-dioxa -diazahexadecane- -diylbismethacrylate -bis(acryloyloxymethyl) butyl acrylate -trimethoxysilylpropyl methacrylate
Polishing Paste		Dental Town® Mansoura Egypt	Aluminum Oxide 2.5 gm
Polishing Discs	01616112	Tor W Ltd Moscow Russia	No 1.071 Diameter 14 mm
Sealer	1802221	GC corporation Tokyo, Japan	Equia Coat Nanofilled self- adhesive light- cured protective coating

Table 1: The composite resins and sealers used in this study

An A1 color shade was selected for both composite resins.

Thirty disk-shaped specimens from each group (150 specimens in total), 9 mm in diameter and 2 mm in depth, were prepared using a Teflon mold. The materials were handled according to the manufacturers' instructions. To decrease irregularities and voids in the specimens, the composite specimens were condensed during processing.

The specimen was covered with two glass slides on its upper and lower surface that prevented the oxygen inhibition layer formation during light polymerization for 40 seconds on both sides A nylon thread was embedded into the specimen so that the specimen could be suspended in the solutions. The mold with the composite resin was held between 2 glass slides, each covered with a transparent polyester strip (Mylar; Henry Schein, Melville, NY), and the microscope slides were gently pressed together to remove excess material. Specimens were polymerized by a conventional halogen light polymerizing unit (ESPE Elipar Trilight; 3M ESPE, St. Paul, Minn) with light intensity of 450 mW/cm^2, using 40 seconds of exposure to top and bottom surfaces, respectively. The distance between the light source and specimen was standardized by the use of a1-mm glass slide. The end of the light guide was in contact with the cover glass during the light-polymerization process. Afterward, all specimens were removed from the mold and immersed in double-distilled water at 37^{o}C for a day before finishing procedures. All preparation, finishing, and polishing procedures were performed by the same operator, to reduce variability.

Specimens from each material group were examined for obvious voids, and randomly separated into five treatment groups, each containing 15 specimens.

Group I (control group, Mylar strip group) contained specimens which received no finishing or polishing treatment.

In group II, the Mylar strip finished surface of each sample was polished with medium, fine, and superfine polishing discs for 30 seconds each on a rotary slow speed handpiece rotating at a maximum of 15,000 rpm (Strong 204 Saeshin Precision Co, Daegu, Korea) with light hand pressure.

In group III, specimens were sequentially polished with medium, fine, and superfine abrasive disks with aluminum oxide paste for 30 seconds. After each polishing step, specimens were thoroughly rinsed with water for 10 seconds to remove debris, air-dried for 5 seconds, and then polished with another disk of finer grit for the same period of time until final polishing.

In group IV, specimens were sequentially polished with medium, fine, and superfine abrasive disks for 30 seconds, as described for group II, then protected by sealer (Equia Coat, GC) and light cured for 20 seconds.

In group V, specimens were polished with medium, fine, and superfine abrasive disks with aluminum oxide-paste for 30 seconds, then protected by sealer and light cured for 20 seconds.

For each specimen, a new polishing disk was used and discarded after each use. Sealer was placed and cured following manufacturers' recommendations. All groups are mentioned in table 2.

Groups	Microhybrid composite Group A	Nanohybrid Composite Group B
Control Group I 30 specimens	Group AI Cured against Mylar strip	Group BI Cured against Mylar strip
Subdivision according to different media	Group AI i Immersion in distilled water	Group BI i Immersion in distilled water
	Group AI ii Immersion in instant coffee	Group BI ii Immersion in instant coffee
	Group AI iii Immersion in black tea	Group BI iii Immersion in black tea
Group II polishing protocol 30specimens	Group AII Polished with successive discs grits	Group BII Polished with successive discs grits
Subdivision according to different media	Group AII i Immersion in distilled water	Group BII i Immersion in distilled water
	Group AII ii Immersion in instant coffee	Group BII ii Immersion in instant coffee
	Group AII iii Immersion in black tea	Group BII iii Immersion in black tea

Group III polishing protocol 30 specimens	Group AIII Polished with successive discs grits and Al2O3 polishing paste	Group BIII Polished with successive discs grits and Al2O3 polishing paste
Subdivision according to different media	Group AIII i Immersion in distilled water	Group BIII i Immersion in distilled water
	Group AIII ii Immersion in instant coffee	Group BIII ii Immersion in instant coffee
	Group AIII iii Immersion in black tea	Group BIII iii Immersion in black tea
Group IV polishing protocol 30 specimens	Group AIV Polished with successive discs grits and protected by sealers	Group BIV Polished with successive discs grits and protected by sealers
Subdivision according to different media	Group AIV i Immersion in distilled water	Group BIV i Immersion in distilled water
	Group AIV ii Immersion in instant coffee	Group BIV ii Immersion in instant coffee
	Group AIV iii Immersion in black tea	Group BIV iii Immersion in black tea
Group V polishing protocol 30 specimens	Group AV Polished with successive discs grits Al2O3 polishing paste, then protected by a sealer layer	Group BV Polished with successive discs grits and Al2O3 polishing paste, then protected by a sealer layer
Subdivision according to different media	Group AV i Immersion in distilled water	Group BV i Immersion in distilled water
	Group AV ii Immersion in instant coffee	Group BV ii Immersion in instant coffee
	Group AV iii Immersion in black tea	Group BV iii Immersion in black tea

Table 2: Grouping of specimens according to types, finishing protocols and storage media.

Surface roughness test

After polishing, specimens were washed, allowed to dry, and stored for 7 days in double-distilled water before measuring the mean surface roughness (Ra) values. Ra values of each specimen were measured five times, and mean Ra values were determined with a cut-off value of 0.8 mm, and a stylus speed of 0.5 mm/s near the center of each specimen using a surface profilometer (Mitutoyo Surftest SJ-210 Surface Roughness Tester, Japan) which was calibrated against a standard specimen before each new measuring session[17].

Base line color testing

Composite resin specimens were air-dried and measured with a Vita Easy shadeV (Vita Zahnfabrik, D-79713 Bad Säckingen, Germany) against a white background using CIE LAB color space relative to CIE standard illuminant D55 at baseline, and after staining. The color differences (ΔE_{ab} *) between the 2 measurements were calculated as follows:

$\Delta E_{ab} = [(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2)]^{1/2}$ where L* is lightness, a* is green-red (-a*=green; +a*= red), and b* is blue-yellow (-b*=blue; +b*=yellow).

A perceptible discoloration that is ΔE_{ab} * 1.0 will be referred to as acceptable up to the value ΔE_{ab} *=3.3 in subjective visual evaluations made in vitro under optimal lighting conditions [2,18].

Color stability

After baseline color measurements were made, specimens will be allocated into subgroups of five specimens each, and each specimen was stored for 7 days in 200 mL of distilled water, black coffee, or black tea in a separate polypropylene container. The pH of the solutions was not measured.

Coffee solution used as a colorant was prepared by mixing (15 g) of instant coffee powder without cream and sugar (Grandos, café Gold, Hamburg, Germany) and 200 mL hot distilled water in accordance with the recommendations of the coffee manufacturer. After being cooled to nearly 45 °C, the specimens were immersed in this solution in light-proof containers by wrapping in aluminum foil. For this purpose, each group was placed in a holder keeping the specimens in vertical position. The solution was refreshed daily up to 7 days [19].

Tea solution was prepared by immersing black tea packet 2g (Ahmad Tea, Hampshire, England) in 200 ml boiling water in accordance with the recommendations of the manufacturer. After 7 days of immersion, the specimens were rinsed with distilled water for 5 min and blotted dry with absorbent paper before the second color measurement was performed.

Statistical Analysis:

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). Surface roughness (Ra) data showed non-parametric distribution while color change (ΔE) data showed parametric distribution. Data were presented as mean and standard deviation (SD) values. For non-parametric data; Kruskal-Wallis test was used to compare between more than two groups. Dunn's test was used for pair-wise comparisons. For parametric data; three-way Analysis of Variance (ANOVA) test was used to study the effect of composite type, surface treatment, immersion medium and their interaction on (ΔE). Bonferroni's post-hoc test was used for pair-wise comparisons when ANOVA test is significant. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

Results

Average Roughness between both composite types:

When using Mylar strip for finishing composite there was no statistically significant difference between Micro- and Nano-hybrid composites. After immersion in distilled water and coffee; Micro-hybrid composite showed statistically significantly lower mean (Ra) than Nano-hybrid composite. After immersion in black tea; there was no statistically significant higher mean (Ra) than Nano-hybrid composite. After immersion in distilled water and in coffee; there was no statistically significant difference between Micro- and Nano-hybrid composites. After immersion in black tea; Micro-hybrid composite showed statistically significantly lower mean (Ra) than Nano-hybrid composite.

When using successive disks with polishing paste for polishing composite, after immersion in distilled water or black tea; there was no statistically significant difference between Micro- and Nano-hybrid composites. After immersion in coffee; Micro-hybrid showed statistically significantly lower mean (Ra) than Nano-hybrid composite.

When using successive disks then applying sealer for polishing composite, after immersion in distilled water or black tea; there was no statistically significant difference between Micro- and Nano-hybrid composites (Ra). After immersion in coffee; Micro-hybrid showed statistically significantly lower mean (Ra) than Nano-hybrid composite.

When using successive disks with polishing paste then applying sealer for polishing composite, after immersion in distilled water; there was no statistically significant difference between Micro- and Nano-hybrid composites. After immersion in coffee or black tea; Micro-hybrid composite showed statistically significantly higher mean (Ra) than Nano-hybrid composite, as mentioned in Table (3).

Surface treatment	Immersion medium	Micro-hybrid		Nano-hybrid		*P*-value	Effect size *(d)*
		Mean	SD	Mean	SD		
Mylar strip	Distilled water	0.118	0.018	0.271	0.133	0.006*	2.928
	Coffee	0.104	0.057	0.209	0.058	0.035*	1.636
	Black tea	0.209	0.049	0.140	0.049	0.076	1.357
Successive discs	Distilled water	0.253	0.065	0.144	0.084	0.076	1.357
	Coffee	0.196	0.122	0.197	0.065	0.465	0.475
	Black tea	0.169	0.031	0.335	0.134	0.012*	1.926

Successive discs + Polishing paste	Distilled water	0.175	0.088	0.211	0.131	0.808	0.141
	Coffee	0.215	0.082	0.461	0.163	0.011*	2.419
	Black tea	0.272	0.075	0.415	0.227	0.273	0.700
Successive discs + Sealer	Distilled water	0.522	0.107	0.517	0.177	0.855	0.110
	Coffee	0.309	0.146	0.651	0.073	0.004*	3.000
	Black tea	0.387	0.110	0.580	0.215	0.223	0.751
Successive discs + Polishing paste+ Sealer	Distilled water	0.525	0.178	0.661	0.157	0.150	0.915
	Coffee	0.982	0.146	0.580	0.105	0.006*	2.928
	Black tea	0.801	0.148	0.553	0.106	0.014*	1.736
*: Significant at P ≤ 0.05							

Table 3: The mean, standard deviation (SD) values and results of Mann-Whitney U test for comparison between (Ra) values of the two composite types

Average Roughness between different surface polishing protocols after immersion:

In Micro-hybrid composite: after finishing by using Mylar strip; black tea group showed statistically significantly higher mean value. There was no statistically significant difference between distilled water and coffee; both showed lower mean (Ra). After polishing using successive discs, there was no statistically significant difference in surface roughness between the three-immersion media. There was also no statistically significant difference between the three-immersion media when using successive discs and polishing paste for polishing the specimen. Using successive discs then applying sealer showed no statistically significant difference between coffee and black tea; both showed the statistically significantly lowest mean (Ra). Using successive discs and polishing paste then applying sealer, immersion in coffee showed statistically significantly highest mean (Ra). Black tea showed statistically significantly lower mean (Ra). Distilled water showed the statistically significantly lowest mean (Ra).

In Nano-hybrid composite: after finishing by using Mylar strip; there was no statistically significant difference between the three-immersion media. After polishing using successive discs; black tea showed statistically significantly higher mean (Ra) while Coffee showed lower mean (Ra) value. Using successive discs and paste for polishing the specimen; coffee showed statistically significant highest mean (Ra). There was no statistically significant difference between the three-immersion media, when using successive discs then applying sealer; and also, when using successive discs and polishing paste then applying sealer, as mentioned in Table (4).

Composite type	**Surface treatment**	**Immersion**	**Distilled water**		**Coffee**		**Black tea**		**P-value**	**Effect size (Eta Squared)**
			Mean	SD	Mean	SD	Mean	SD		
Micro-hybrid	Mylar strip	Before	0.146	0.061	0.102	0.044	0.100	0.024	0.278	0.047
		After	0.118 ^{B}	0.018	0.104 ^{B}	0.057	0.209 ^{A}	0.049	0.021*	0.480
	Successive discs	Before	0.263 ^{A}	0.041	0.198 ^{B}	0.061	0.114 ^{C}	0.039	0.014*	0.545
		After	0.253	0.065	0.196	0.122	0.169	0.031	0.087	0.240

	Successive discs + Polishing paste	Before	0.227 A	0.060	0.123 B	0.042	0.128 B	0.011	0.036*	0.360
		After	0.175	0.088	0.215	0.082	0.272	0.075	0.151	0.148
	Successive discs + Sealer	Before	0.520	0.163	0.361	0.138	0.543	0.074	0.076	0.243
		After	0.522 A	0.107	0.309 B	0.146	0.387 B	0.110	0.046*	0.319
	Successive discs + Polishing paste+ Sealer	Before	0.468	0.178	0.611	0.157	0.414	0.100	0.200	0.087
		After	0.525 C	0.178	0.982 A	0.146	0.801 B	0.148	0.005*	0.617
Nano-hybrid	Mylar strip	Before	0.119 A	0.053	0.071 B	0.050	0.065 B	0.011	0.023*	0.370
		After	0.271	0.133	0.209	0.058	0.140	0.049	0.086	0.208
	Successive discs	Before	0.107	0.020	0.106	0.018	0.103	0.055	0.401	0.014
		After	0.144 C	0.084	0.197 B	0.065	0.335 A	0.134	0.016*	0.445
	Successive discs + Polishing paste	Before	0.309	0.154	0.159	0.080	0.193	0.101	0.099	0.155
		After	0.211 C	0.131	0.461 A	0.163	0.415 B	0.227	0.045*	0.264
	Successive discs + Sealer	Before	0.412 B	0.125	0.343 C	0.083	0.556 A	0.108	0.029*	0.462
		After	0.517	0.177	0.651	0.073	0.580	0.215	0.302	0.025
	Successive discs + Polishing paste+ Sealer	Before	0.510B	0.104	0.622A	0.133	0.243C	0.050	0.005*	0.708
		After	0.661	0.157	0.580	0.105	0.553	0.106	0.296	0.026
*: Significant at P ≤ 0.05, Different superscripts in the same row indicate statistically significant difference between immersion media										

Table 4: The mean, standard deviation (SD) values and results of Kruskal-Wallis test for comparison between (Ra) values in μm of different immersion media.

Color measurements results

In Micro-hybrid composite: Using Mylar strip; coffee showed the statistically significantly highest mean ΔE. Black tea showed statistically significantly lower mean value. Distilled water showed the statistically significantly lowest mean ΔE. Using successive discs, successive discs + polishing paste as well as successive discs + polishing paste + sealer; there was no statistically significant difference between coffee and black tea; both showed the statistically significantly highest mean ΔE values. Distilled water showed the statistically significantly lowest mean ΔE. Using successive discs + sealer; black tea showed the statistically significantly highest mean ΔE. Coffee showed statistically significantly lower mean value. Distilled water showed the statistically significantly lowest mean ΔE.

In Nano-hybrid composite: Using Mylar strip as well as successive discs + polishing paste + sealer; black tea showed the statistically significantly highest mean ΔE. Coffee showed statistically significantly lower mean value. Distilled water showed the statistically significantly lowest mean ΔE. Using successive discs as well as successive discs + sealer; there was no statistically significant difference between coffee and black tea; both showed the statistically significantly highest mean ΔE values. Distilled water showed the statistically significantly lowest mean ΔE. Using successive discs + polishing paste; coffee showed the statistically significantly highest mean ΔE. Black tea showed statistically significantly lower mean value. Distilled water showed the statistically significantly lowest mean ΔE.

Composite type	Surface treatment	Distilled water		Coffee		Black tea		P-value (Between media)	Effect size (Partial eta squared)
		Mean	SD	Mean	SD	Mean	SD		
Micro-hybrid	Mylar strip	1.38 ^{C}	0.26	7.63 ^{AD}	0.36	5.74 ^{BE}	0.73	<0.001*	0.710
	Successive discs	1.56 ^{B}	0.29	6.01 ^{AE}	0.65	5.77 ^{AE}	0.37	<0.001*	0.600
	Successive discs + Polishing paste	1.34 ^{B}	0.47	6.53 ^{AE}	0.13	5.82 ^{AE}	1.63	<0.001*	0.654
	Successive discs + Sealer	2.13 ^{C}	0.69	6.35 ^{BE}	0.33	7.42 ^{AD}	0.68	<0.001*	0.651
	Successive discs + Polishing paste+ Sealer	2.44 ^{B}	0.42	7.14 ^{AD}	0.26	7.08 ^{AD}	0.23	<0.001*	0.634
	P-value (Between surface treatments)	0.160		0.025*		0.002*			
	Effect size (Partial eta squared)	0.102		0.167		0.241			
Nano-hybrid	Mylar strip	2.13 ^{C}	0.24	4.67 ^{BE}	1.55	8.28 ^{AD}	1.11	<0.001*	0.695
	Successive discs	2.44 ^{B}	0.22	5.6 ^{AE}	0.66	6.61 ^{AE}	0.12	<0.001*	0.531
	Successive discs + Polishing paste	1.17 ^{C}	0.36	7.02 ^{AD}	0.41	5.07 ^{BF}	0.61	<0.001*	0.679
	Successive discs + Sealer	1.14 ^{B}	0.33	7.9 ^{AD}	0.14	8.73 ^{AD}	1.28	<0.001*	0.805

	Successive discs + Polishing paste+ Sealer	1.75 C	0.26	5.41 BE	0.51	6.73 AE	0.15	<0.001*	0.614
	P-value (Between surface treatments)	0.062		<0.001*		<0.001*			
	Effect size (Partial eta squared)	0.137		0.450		0.505			
[P-value for Effect of composite type, (Effect size)]		Distilled water		Coffee		Black tea			
Mylar strip		0.165 (0.032)		<0.001* (0.344)		<0.001* (0.277)			
Successive discs		0.100 (0.044)		0.441 (0.010)		0.117 (0.040)			
Successive discs + Polishing paste		0.749 (0.002)		0.354 (0.014)		0.163 (0.032)			
Successive discs + Sealer		0.066 (0.055)		0.005* (0.125)		0.016* (0.093)			
Successive discs + Polishing paste+ Sealer		0.195 (0.028)		0.002* (0.151)		0.510 (0.007)			

**: Significant at P ≤ 0.05*
A,B,C superscripts in each row indicate statistically significant difference between immersion media
D,E,F superscripts in each column indicate statistically significant difference between surface treatments

Table 5: The mean, standard deviation (SD) values and results of three-way ANOVA test for comparison between ΔE values of different interactions of variables.

Discussion

Discoloration of the resin composite surface is a multifaceted phenomenon that can involve several factors [20]. In the present study we tried to correlate several factors that may contribute to composite discoloration. One of these factors is surface roughness which is correlated the the filler size of the composite resins and pattern of finishing and polishing of their surfaces [1,21].

In this study, two types of composite resins were used representing the most commonly clinically used esthetic direct restorations; microhybrid and nanohybrid types.

Finishing and polishing procedures affect surface smoothness, which may be associated with early surface discoloration. Rough surfaces retain stains more than smooth surfaces [22,23]. A variety of polishing systems are now available, but none of them assure perfect surface smoothness as obtained by mylar strip. Polishing protocol followed in this study is the widely clinically used successive aluminum discs as recommended by a number of studies [24,25]. Use of polishing paste is also suggested to increase surface smoothness [26,27], however some scratches and micro gaps could be left on the polished surfaces of composite resin restoration.

The use of a thin layer of a low-viscosity resin has been studied to overcome this problem. The so-called surface-penetrating sealant or rebinding agent should be able to fill, by capillary action, the structural micro defects and micro fissures that are formed during the insertion technique and finishing/polishing procedures. This approach is expected to provide a more uniform and surface smoothness [28,29] Doray et al, reported that surface sealants could improve the resistance to staining of a composite resin provisional material [16].

However, in the present study, the surface sealant utilized on top of composite resin was not efficient on the protection against color alteration. This in accordance with Fernanda Valentini et al, who stated that the use of sealant dramatically increased the staining of the restorations immersed in coffee. This is probably related to the fact that, unlike the restorative composite, no filler particles are present in the resin sealant. The glass filler particles are generally inert and should not absorb fluids, the amount of water/colorant uptake being dependent on the resin content of the material. In addition, the presence of more hydrophilic comonomers in the resin sealant compared with the composite resin might also explain the decreased color stability [30].

The second factor related to composite discoloration is the adsorption and absorption of pigments into the organic

phase of resin-based materials [31]. As resin polymers and dietary colorants have different polarities, composite materials with a resin matrix that is compatible with the polarities of yellow colorants may facilitate the absorption of yellow colorants into the organic phase of the material [32].

Coffee and tea were used as coloring agents because of their frequent consumption in daily life. Low periods of immersion like 7 days are sufficient to produce staining and color changes to composite resins [33,34]. 24 h *in vitro* corresponds to about 1 month *in vivo*, which is considered sufficient for a long-term staining susceptibility evaluation [35].

According to Guler, et al. (2005), the average time for consumption of 1 cup of coffee is 15 min, and among coffee drinkers, the average consumption is 3.2 cups per day. Therefore, 7 days of storage simulated consumption of the drink over 6 months [27].

In this study significant differences in ΔE values were found among materials for both storage media. Coffee staining produced higher color changes in the specimens than those of water storage. coffee contains significant amounts of staining agents such as gallic acid, which facilitate staining [31], and according to Nasim *et al*., the staining ability of tea could be due to the presence of tannic acid [5].

In the present study, all groups showed higher Ra values than the mylar strip group, and there is no significant difference in surface roughness between microhybrid and nanohybrid composites resin materials cured against the Mylar strip.

Regarding $\Delta E*$ value, the use of mylar strip, both of microhybrid and nanohybrid composites resulted in more staining. This could be explained by the high percentage of matrices. Resin matrices tend to absorb more water and are more prone to staining, once water is the vehicle for dye penetration [13,36,37].

This finding is in accordance with Gönülol and Yılmaz [38]. Same results are also reached by de Costa *et al*. [39] Rough surfaces may be discolored by adsorption of stains, although there is not always a relationship between surface roughness and staining [20].

Visual assessment of minimal color change is not a precise quantitative evaluation, in addition to lack of reproducibility. Evolution in electronic optics and informatics makes the electronic techniques for color selection more adequate for daily usage [13,36]. In the present study, Vita Easy shadeV (Vita Zahnfabrik, D-79713 Bad Säckingen, Germany) was used for standardized evaluation.

Both composite resins showed decrease in $\Delta E*$ values in relation to the polishing procedures. The highest values were observed with sealer coated, followed by mylar strip and finally the successive discs polishing.

Conclusion

Within the limitations of this study, the following conclusions were obtained:

1. There was no significant difference among the composite resins in terms of surface roughness among used finishing & polishing systems.
2. There was no statistically significant correlation between the surface roughness and the color difference values.
3. Coffee produced the highest color changes in the specimens.
4. Intra orally composite surface discoloration will happen with extremely smooth surface and not always related to degree of surface roughness.

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