

INFLUENCE OF ADDITIONAL POLISHING ON THE SURFACE TEXTURE OF ESTHETIC RESTORATIVE MATERIALS IN DIFFERENT MOUTH RINSES: AN IN VITRO STUDY

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ABSTRACT

Purpose: This study evaluated the influence of additional polishing procedures on micro-hybrid and nano-hybrid resin composites immersed in two different mouth rinses. **Materials and methods:** Ninety specimens from each restorative material (Esthet.X HD, Dentsply, Filtek LS, 3M-ESPE, Beautiful II, SHOFU and Tetric N-Ceram Ivoclar Vivadent) were prepared and immersed in distilled water for 24 h. Baseline surface roughness was recorded using a Digital Microscope. Specimens from each material were divided into Group 1 (control) celluloid matrix; Group 2 polished by Kerr disks, and Group 3 polished by Kerr disks followed by silicon carbide brushes. Each group was subdivided into 3 subgroups (n=10) immersed in either artificial saliva, Listerine or Antiseptol and incubated for 24 h at 37°C. The post immersion surface roughness values were recorded for statistical analysis. **Results:** Control groups recorded significantly lower roughness ($p < 0.05$), while both polishing techniques gave similar roughness values. No significant difference was found between immersion media or between resin composites. However, nano-hybrid composites showed statistically higher roughness after polishing compared to control group. **Conclusions:** The surface texture of tested composites is neither influenced by polishing techniques nor rinses.

Keywords: Polishing- Mouth rinse- Surface texture- Micro-hybrid composite- Nano- composite

INTRODUCTION

Surface characteristics of esthetic resin restorations affect their clinical behavior and marginal quality. A perfectly smooth resin composite restoration surface is difficult to obtain as the resin matrix and the fillers have different hardness.

Thus, a degree of surface roughness is expected after finishing and polishing procedures, especially with larger filler size restorative materials.¹ The initial surface smoothness gained by a matrix strip cannot be easily achieved by any of the polishing procedures.² However, the matrix strip alone is not enough to reproduce tooth anatomy and contour.

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Additionally, the resin rich layer present on the surface of the restoration following the use of a matrix strip is esthetically unstable.³

Variability in the shape of finishing and polishing tools available commercially is present. The forms could either be as diamond stones, burs, rubber cups and wheels, abrasive discs, brushes, and strips.⁴ Highly flexible polyurethane discs coated with aluminum oxide are commonly used for polishing. However, these discs cannot reach the depth of narrow fissures on occlusal surfaces. Therefore, it was recently suggested to use silicon carbide brushes for additional polishing in posterior composites. Still, little information is known about their effect on the surface roughness of micro and nano hybrid composites.

Patients use mouth rinses due to therapeutic and cosmetic reasons. The main active ingredients in therapeutic mouth rinses are antimicrobial agents like chlorhexidine, cetylpyridinium or essential oils. In addition, detergents, emulsifiers, organic acids, dyes, water, salts and sometimes alcohol may be included.⁵ The different concentrations of substances in mouth rinses can affect their pH leading to increased roughness. Sarret et al, 2000,⁶ found that alcohol can plasticize the polymeric matrix, which makes the material more ductile. However, Yap et al, 2003,⁷ have demonstrated that not only alcohol can lead to changes in resins. For this reason, it may be of value to compare the effect of a chlorhexidine containing mouth rinse with an essential oil containing rinse on the surface texture of resin composites.

This study evaluated the influence of additional polishing procedures on micro hybrid and nano hybrid resin composites immersed in different mouth rinses. The first null hypothesis tested was that no significant difference would be found in surface texture of resin composites with different polishing procedures. The second null hypothesis tested was that different mouth rinses would have

no significant effect on surface texture of resin composites.

MATERIALS AND METHODS

Materials

Resin composites

Four esthetic restorative materials were selected for this study. The resin composites chosen were: Esthet.X HD Dentsply, Filtek LS, 3M-ESPE, Beautifil II, SHOFU and Tetric N-Ceram Ivoclar Vivadent. Table 1 shows the properties of the tested materials.

Mouth rinses

Artificial saliva as a positive control and two mouth rinses were tested in the study. Therapeutic mouth rinses tested were chosen to be of different types. Table 2 shows the types, composition, and pH of the immersion media.

Methods

Preparation of resin composite specimens

A specially constructed Teflon mold (3 mm diameter X 2 mm height) was used to obtain 90 specimens from each resin composite. The mold was placed on a 1mm glass slide and a celluloid strip and packed with the restorative material. Another celluloid strip and glass slide were used on top of the mold. A 500 g weight was applied to the slide for 1 min, to extrude excess material and produce a flat smooth surface. The excess extruded material was carefully removed and the tip of the curing unit was placed directly on the glass slide, to standardize the curing distance. Specimens were cured using light emitting diode light cure (Elipar S10, 3M ESPE, D82229 Seefeld, Germany) at 1200 mW/cm² for 40 s. Samples were removed, marked on the bottom surface, and kept in distilled water in an incubator at 37°C for 24 h.⁸

TABLE (1): Properties of esthetic restorative materials used in the study

Brand	Type	Manufacturer	Composition	Lot. no
Esthet X HD (EHD) Shade (A2)	Micro-hybrid	Dentsply Caulk, Milford, DE, USA	Matrix: Bis-GMA adduct, BisEMA adduct, and TEGDMA, Camphorquinone (CQ), Photoinitiator, Stabilizer, Pigments. Fillers: Barium, Boron, Fluoroaluminosilicate glass. Filler size: 0.4-0.7 μm . Mean 0.6 μm	1201312
Filtek LS (FLS) Shade (A2)	Micro-hybrid	3M-ESPE, St Paul, MN, USA	Matrix: Siloxanes, Oxiranes, Camphorquinone, Iodine salt, Electron donor, Stabilizers, Pigments. Fillers: fine quartz particles and radiopaque yttrium fluoride. Average filler size: 0.47 μm	7AC
Beautiful II (BII) Shade (A2)	Nano-hybrid	Shofu Co, Kyoto, Japan	Matrix: Bis-GMA, TEGDMA, UDMA. Fillers: S-PRG, multifunctional Aluminofluoroborosilicate glass, DL camphorquinone. Filler size: 0,1-4 μm . Mean 0.8 μm	100872
Tetric N-Ceram (TNC) Shade (A2)	Nano-hybrid	Ivoclar Vivadent, Schaan, Liechtenstein	Matrix: Bis-GMA, UDMA, Ethoxylated Bis-EMA, Additives, stabilizers, catalysts, pigments, Prepolymers. Fillers: Barium glass, ytterbium trifluoride, mixed oxide, silicon dioxide. Filler size: 0.6-10 μm	L48183

TABLE (2): Immersion media used in the study

Mouth rinse	Manufacturer	Composition	pH
Artificial Saliva	Central Laboratory of Misr University for Science and Technology	0.4g NaCl, 0.4g KCl, 0.795g CaCl ₂ -2H ₂ O, 0.6 g NaH ₂ PO ₄ -H ₂ O, 1 g urea, 0.005g Na ₂ S-9H ₂ S, + 1L deionized water.	6.9
Listerine Total Care Zero	Johnson & Johnson, UK	Eucalyptol, Zinc Chloride, Menthol, Sorbitol, Methyl salicylate, Thymol, Sodium Benzoate, Benzoic acid, Sodium Fluoride (220 ppm F)	5.5
Antiseptol	Kahira pharmaceuticals and chemical Industries Co. Cairo-Egypt.	Chlorhexidinegluconate 0.1%	6.7

Surface roughness measurements at base line:

USB Digital microscope with a built-in camera connected with a personal computer (IBM compatible) was used in photographing the test specimens. The magnification used was fixed at $\times 200$, and images were recorded with a resolution of 1280 x 1024 pixels per image. Microsoft office picture manager was used to crop images 350 x 400 pixels to specify/standardize area of measurement.

Cropped images were analyzed using WSxM software.⁹ The software expresses the measurements in pixels. Therefore, the system was calibrated in order to convert the pixels into absolute real world units. For the purpose of calibration, a comparison between a ruler of known size and a scale generated by the software was done. For each specimen, three images (3D) of the surface profile were collected, in the central area and in the sides at an area of 10 \times

10 μm^2 . A software (WSxM) was used to calculate average surface roughness (Ra) from the average heights of every specimen, expressed in μm , which can be assumed as reliable indices of surface roughness.¹

Grouping of the specimens:

The 90 specimens from each composite were randomly divided into three equal groups. The control (celluloid matrix) group received no finishing or polishing, the specimens were directly immersed in one of the immersion media. Second group specimens were polished with Aluminum oxide optidiscs (Kerr, Orange, CA, USA). Third group specimens were polished with optidiscs followed by silicon carbide occluobrushes (Kerr, Orange, CA, USA). Each group was further subdivided into three subgroups (n=10) according to the immersion media: artificial saliva, Listerine total care zero or Antiseptol, as shown in Table 3.

Finishing and polishing procedures:

All specimens except control group specimens were ground wet with 320 grit silicon carbide paper to simulate clinical finishing step.³ A low speed motor (STRONG, model no 204, Seoul South Korea) and a hand piece (MK-dent Germany, CE 0123, REF No.AM1014) were used. The second group specimens were polished with a sequence of different grit optidiscs in the following order (extra-coarse 80 μm ,

coarse/medium 40 μm , fine 20 μm , extra-fine 10 μm). Each disc was used for 15 s in one direction with air cooling using light pressure. To remove any residues the specimens were washed using air/water spray for 5 s. Specimens were then air dried before using the next grit disc. The disc was discarded and replaced with a new one every three specimens. Specimens assigned for the third group were polished similarly with optidiscs, followed by an additional polishing step using silicon carbide impregnated occluobrushes. The brush was used in low speed with air cooling for 30 s in one direction. All specimens preparation, finishing and polishing procedures were performed by the same operator.

Immersion in mouth rinses:

Initially, the pH of the three immersion media (artificial saliva- Listerine Total care zero-Antiseptol) was assessed. A pH meter (pH 213 microprocessor-based. HANNA instruments, USA) was first calibrated. The electrode tip was immersed till 4 cm was submerged in the immersion media and stirred. The pH was recorded when the electrode has stabilized. The specimens were then immersed in 20 mL of the respective immersion media in containers and kept in an incubator at 37°C for 24 h, which is equivalent to a cumulative time period of 2 yr for 2-min daily use of mouth rinse.¹⁰ After this period, specimens were removed, washed with water spray and surface roughness was measured again.

Table (3): Group distribution in each resin composite type

Polishing technique	Immersion media		
	Artificial saliva	Listerine	Antiseptol
Control (matrix)	G1	G2	G3
Optidisc	G4	G5	G6
Optidisc + Occluobrush	G7	G8	G9

Statistical analysis

The data were presented as means and standard deviation (SD) values. After checking the normality of the data, multifactorial analysis of variance ANOVA test of significance comparing the variables affecting roughness (Ra) mean values was done. Pair-wise Tukey’s post-hoc test was applied between subgroups when the difference was significant. One Way-ANOVA was used to study the effect of polishing techniques on different resin composite types regardless of the effect of mouth rinses. Statistical analysis was performed with IBM SPSS (SPSS, IBM Corporation, NY, USA) Version 20 for Windows. The relevant significance was approved at $p \leq 0.05$ in all tests.

RESULTS

Three way ANOVA test showed statistical significant differences between the unfinished control groups and the finished and polished

groups ($p= 0.001$), as the control groups recorded significantly lower Ra mean values. However, no statistical significance was found between different immersion media or between different tested resin composites as $p=0.363$ and $p=0.158$ respectively. Additionally, only the interaction between the finishing and polishing technique and the type of resin composite recorded significant differences as $p=0.001$. All the other interactions, between the immersion media and the type of composite or between the immersion media and the finishing and polishing technique, were not statistically significant as $p>0.05$. Table 4 shows the comparisons among groups. In table 5 significant increase in surface roughness of Beautifil II and Tetric N-Ceram after the polishing procedures was evident compared to the control matrix group as $p \leq 0.001$. However, no significant differences were observed for Esthet.X HD and Filtek LS.

Table (4): Surface roughness mean (Ra) in $\mu\text{m} \pm$ standard deviations (SD) of different composites in different groups

Composite Group	EHD	FLS	BII	TNC
G1	0.2379 ^{ab} ± 0.0009248	0.2367 ^{ab} ± 0.0006569	0.2375 ^{ab} ± 0.0003951	0.2360 ^{cd} ± 0.0009867
G2	0.2374 ^{ab} ± 0.0008139	0.2365 ^{bc} ± 0.0007939	0.2378 ^{ab} ± 0.0003350	0.2362 ^{cd} ± 0.0008858
G3	0.2383 ^{ab} ± 0.00008819	0.2369 ^{ab} ± 0.0007311	0.2372 ^{ab} ± 0.0004256	0.2359 ^{cd} ± 0.001176
G4	0.2365 ^{ab} ± 0.0007847	0.2365 ^{bc} ± 0.0008152	0.2377 ^{ab} ± 0.0003652	0.2379 ^{ab} ± 0.0005984
G5	0.2370 ^{ab} ± 0.0005786	0.2364 ^{bc} ± 0.001129	0.2380 ^{ab} ± 0.0003164	0.2390 ^a ± 0.0004484
G6	0.2363 ^{cd} ± 0.0006298	0.2364 ^{bc} ± 0.0008162	0.2366 ^{ab} ± 0.0004458	0.2380 ^{ab} ± 0.0006991
G7	0.2378 ^{ab} ± 0.0009756	0.2380 ^{ab} ± 0.0007893	0.2383 ^{ab} ± 0.00009755	0.2381 ^{ab} ± 0.0004562
G8	0.2381 ^{ab} ± 0.0005876	0.2382 ^{ab} ± 0.0006105	0.2389 ^a ± 0.0004702	0.2379 ^{ab} ± 0.0005054
G9	0.2376 ^{ab} ± 0.001118	0.2382 ^{ab} ± 0.001119	0.2391 ^a ± 0.0006304	0.2382 ^{ab} ± 0.0003199

Different letters indicating statistical significance according to Tukey’s test ($p < 0.05$)

TABLE (5) Mean Surface roughness (Ra) in μm and standard deviations (SD) of different polishing techniques regardless the effect of mouth rinses

Resin composite	Polishing techniques						p-Value
	Control (matrix)		Optidisc		Optidisc+ Occlubrush		
	Mean	SD	Mean	SD	Mean	SD	
EHD	0.2371	0.0015	0.2379	0.0017	0.2366	0.0025	0.071NS
FLS	0.2367	0.0021	0.2382	0.0027	0.2364	0.0023	0.054 NS
BII	0.2375 ^b	0.0011	0.2383 ^a	0.0013	0.2390 ^a	0.0015	$\leq 0.001^*$
TNC	0.2356 ^b	0.0029	0.2385 ^a	0.0017	0.2380 ^a	0.0012	$\leq 0.001^*$

Means with different letters within each row are significantly different according to One way ANOVA test at $p < 0.05$.

*=significant, NS=Insignificant

DISCUSSION

Surface texture of resin composite restorations contributes greatly in esthetic appearance and health of periodontal tissues. Within this context, finishing and polishing procedures are recommended to improve esthetics and achieve long term stability.¹¹ In the study by Jones et al, 2004,¹² patients distinguished between surface roughness levels within the range of 0.25–0.5 μm . They concluded that restorations should be finished with a maximum roughness of 0.5 μm to render the restoration tolerable and undetectable by a patient's tongue. All surface roughness values gained in this study were below this level.

In a study by Lu et al, 2003,¹³ it was found that the best choice for providing minimal surface roughness for composite restorations was flexible aluminum oxide discs. The efficiency of finishing systems increases when it contains hard abrasive particles to remove both resin matrix and filler particle of resin composites.¹⁴ The hardness of aluminum oxide is generally significantly higher than most of the filler particles used in resin composite formulations.¹⁵ This difference may lead to equal abrasion of the filler particles with the resin

matrix, leaving a smooth surface.¹⁶ On the other hand, silicon carbide brushes hold more abrasive components as their fibers have in built silicon carbide particles. This makes each bristle work as a polishing instrument, which may result in smoother surfaces of resin composite restorations. This was the rationale for selecting aluminum oxide optidiscs and silicon carbide occlubrushes for the finishing and polishing procedures in this study.

Surface roughness is more commonly described by Ra as a parameter. Surface roughness of a restoration should be equal to or lower than the surface roughness of enamel-to-enamel occlusal contact areas (Ra=0.64 μm).¹⁷ Most of surface roughness researches on restorative materials analyze the roughness pressed against transparent matrices. This is done to ensure very smooth surfaces, which is representative of the clinical situation when matrices are used. The results of this study have shown that the smoothest resin composite surfaces were obtained with celluloid matrix control groups. This came in accordance with the studies by Ergüçü and Türkün, 2007;¹⁸ Janus et al, 2010;¹⁹ Yazici et al, 2010;²⁰ Erdemir et al, 2012,² who found that the lowest surface roughness was achieved with mylar matrix. Contrary to this came the findings by Olievira et al,

2010,²¹ who found that matrix strips caused the highest surface roughness. Nagem Filho et al, 2003,²² also stated that polyester strip and Soflex discs produced the same surface roughness. Based on the results, the first null hypothesis that there would be no significant differences in surface texture between the two polishing systems for each composite was accepted as no significant difference in surface roughness was noticed between the two polishing techniques. Significant differences were only recorded between the control matrix groups and the polished groups. These similar results suggests that using silicon carbide brushes can improve polishing in areas that are difficult to access with aluminum oxide discs.

Micro-hybrid composites can be finished to a very smooth surface²³ with a surface roughness average varying from 0.12 to 0.25 μm due to their small filler particle size and arrangement. The filler particles average size is ranging between 0.01 and 2.0 μm for micro-hybrid resin composites. Generally, it is hard to differentiate between micro-hybrids and nano-hybrids, as nano-hybrids also contain a range of filler sizes.²⁴ Decreasing the filler particles size and increasing the filler content will lead to a decrease in resin composite surface roughness.¹⁹ An explanation could be due to the less inter-particle spacing resulting from finer filler size, thus more protection of the softer resin matrix and less filler plucking occurs.²⁵ However, this current study had revealed that both tested nano-hybrid composites showed significant increase in surface roughness after the polishing procedures. On the other hand, no significant changes were found in surface roughness for both micro-hybrid resin composites. A possible explanation could be the non-uniform abrasion of the resin matrix and the fillers of the nano-hybrids, especially BII that contain irregular glass fillers, which were exposed with polishing and caused this difference in roughness.²⁶ Additionally, the abrasion of the softer resin matrix may result in a lack of support

of the fillers, leading to further filler debonding and roughening of the surface. This result is in agreement with the result of Gönülol and Yılmaz, 2012,²⁷ who stated that nano-hybrids exhibited similar or rougher surfaces compared to a micro-hybrid composite using seven different polishing systems. Additionally, Say et al, 2014,⁸ showed that one micro-hybrid composite yielded significantly lower roughness values than nano-hybrid for two polishing systems. While the other micro-hybrid exhibited significantly smoother surfaces than the nano-hybrids only with one of the polishing systems.

The second null hypothesis tested was accepted as different mouth rinses did not cause significant changes in surface texture of tested resin composites. From a clinical point of view, the influence of mouth rinses on resin composites is not similar. It is affected by many factors like food habits, oral hygiene products, and the acquired biofilm.²⁸ Low pH mouth rinses with high alcohol content could lead to softening and biodegradation over time of resin composites. Moreover, Ferracane et al, 2006²⁹ affirmed that polymer chain molecules is affected by the chemical composition of immersion media and the duration of exposure.

The results of this study was consistent with the findings of Oliveira et al, 2010²¹ Truath et al, 2012³⁰ and Urbano et al, 2014³¹ who revealed that surface roughness was not dependent on the type of mouth rinse used. They explained this by the time to which the resin composites were exposed to mouth rinses, as it could have been insufficient to cause alterations in composite surfaces. Attin et al, 2006,³² found that the acidic pH of the mouth rinses may have contributed to the degradation of resin composite surfaces. It is important to emphasize that the Listerine used in this study was alcohol free and of higher pH (5.5) than other Listerine types used in many other studies. Antiseptol, the Chlorhexidinegluconate based mouth rinse is characterized by having a relatively high pH (6.7).

This could formulate another explanation for the similar roughness results between artificial saliva and the two types of mouth rinses.

In the study by Almeida et al, 2010,³³ the mouth rinse exposure time was for 2 minutes twice daily for seven days and promoted surface degradation and increase in sorption and solubility. Miranda et al, 2011²⁸ found significant increase in surface roughness of composites immersed in different mouth rinses compared to distilled water when increasing the immersion time. Festuccia et al, 2012,³⁴ also stated that significant differences in surface roughness were found between composites when immersed in Listerine compared to Plax alcohol-free. In the light of the findings of the present study, it is possible to assume that prescribing any of the mouth rinses by the dentist will not affect the surface texture of resin composite restorations.

CONCLUSIONS

Based on the applied methodology and the obtained results, it may be concluded that:

- 1- Additional polishing procedures can achieve smooth restoration surfaces.
- 2- Tested mouth rinses have no detrimental effect on surface texture of esthetic restorations.
- 3- It is suggested that micro-hybrid composites, is preferred to nano-hybrid composites for anterior restorations due to their lower surface roughness after polishing procedures.

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