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Influence of polishing systems on surface roughness of four resin composites subjected to thermocycling aging

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ABSTRACT

Background: Surface smoothness considered to be a significant part of the appearance and success of the restorative materials. The aim of this study was to assess the influence of four different polishing systems on surface roughness of four resin composite materials when subjected to thermocycling.

Materials and Methods: This research was designed as a comparative study. Four resin composites were used which are: Nanofill composite (Filtek Supreme XT), nanohybrid composite (Tetric EvoCeram), microfill composite (Renamel Microfill), and microhybrid composite (Filtek Z250). Sixty disk-shaped specimens of each resin composite were prepared then divided into four groups according to the polishing system ($n = 15$); which were Sof-Lex Spiral, Diatech Shapeguard, Venus Supra, and Astropol. The specimens of each group were polished following the manufactures' instructions, then surface roughness, R_a values in μm were measured initially and after the specimens subjected to thermal cycling. The influence of resin composites, polishing systems, thermocycling, and their interaction effects on surface roughness (R_a mean values) was statistically analyzed mainly by using the repeated measures two-way analysis of variance test, whereas the Bonferroni''s *post hoc* test was applied for pair-wise comparisons. $P \leq 0.05$ was used as the significant level.

Results: The results of this study revealed that Filtek Supreme XT recorded significantly the lowest mean surface roughness (R_a) of 0.2533 ± 0.073 μm ($P < 0.001$). The Sof-Lex Spiral polishing system revealed significantly the lowest mean surface roughness (Ra) of 0.2734 ± 0.0903 μm ($P = 0.004$). Regardless of composite type and polishing system, there was a statistically significant increase in mean surface roughness values (R_a) in μm after thermocycling (0.2251 ± 0.0496 μm and 0.3506 ± 0.0868 μm, respectively) ($P < 0.001$).

Conclusion: Resin composite type, polishing method, and thermocycling aging significantly affected the surface roughness of composites; Nanofill composite and Sof-Lex Spiral polishing system provided the lowest values of surface roughness which increased after thermocycling.

Key Words: Composite resins, dental polishing, surface properties, thermocycling

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INTRODUCTION

Over the last few decades, composite resin materials have become more popular in restorative dentistry.[1,2] Surface texture or smoothness considered to be a significant part of the appearance, success, and longevity of these materials, as rough surface may allow plaque accumulation, gingival irritation, and promoting recurrent caries occurrence. Surface roughness also negatively influence the restorations' esthetics as whilst making it more susceptible to exterior staining, and its glossy and ability to reflect light are also decreased,[3-5] and moreover, the smooth finished and polished restorative surface maintain mechanical properties by increasing the resistance against abrasion.[6]

Surface roughness of a dental restoration below 0.2 µm is regarded an ideal feature since it protects the surfaces from common species bacteria retention[5,7] while, 0.3 µm is the threshold at which patients would notice the different.[1,8]

The main factors that affect the smoothness of the resin composite restoration are the intrinsic properties of the material used for restoration and the finishing and polishing procedures adopted.[9,10]

Roughness of the restoration is affected by the heterogeneous composition of resin composite materials; resin matrix and filler particles do not wear down similar due to varied hardness, producing irregularities on the restoration's surface.[9,11] Furthermore, according to the literature, the particle filler, which includes the type, shape, size, quantity, and interparticle spacing, is the most key impact factor that determines resin composites smoothness; using finer particle sizes leads to reduced interparticle spacing, which protects the softer resin matrix and decreases filler plucking.[12-14]

Megafill, macrofill, midifill, microfill, and nanofill are the particle size classification for composites, as the highest particle size range is utilized to identify the hybrid type (e.g., minifill hybrid).[15] Nano-filled and nanohybrid composites have lately been introduced to provide a material having excellent mechanical properties, with high initial polishing, and great polish, and gloss retention. While nano-filled composite use nearly uniform nanometric particles throughout the resin matrix, with the capacity to produce nanoclusters as secondary fillers; nanohybrids are composed of particles of different sizes, including micrometric and nanometric ones, this characteristic is similar to micro-hybrid composites.[7,16,17]

Various finishing and polishing systems were used in the past, including carbide and diamond finishing burs, abrasive strips, polishing pastes, etc., and to overcome the drawback of these systems such as formation of roughness, generation of friction heat and creation of tensile and shear stress on restorations, newer generations finishing and polishing agents like silicon carbide-coated or aluminum oxide-coated abrasive discs, impregnated rubber or silicon discs, wheels, cups, and points etc., are being used recently.[8,18]

Lately many manufacturers have offered single and two-step instruments and methods as these should ideally be little time-consuming and less expensive while still achieving similar esthetic outcomes.[2,5,19]

According to several studies, the roughness of some resin-based materials might change by teeth brushing and thermocycling procedure,[7,13] which emphasize the importance of studying the maintenance of the surface smoothness of resin composite restoration after subjected to the oral environment. Various studies revealed that, the surface roughness of the resin and ceramic materials was adversely impacted by the *in vitro* thermocycling procedure.[7,13,20,21]

Therefore, the aim of this study was to assess the influence of four different (two-step) polishing systems on surface roughness of four resin composite materials (Naofill, Nanohybrid, Microfill, and Microhybrid) when subjected to thermocycling aging. The null hypothesis tested was that there would be no difference in surface roughness among the polished resin composites or among the different polishing systems when subjected to thermocycling.

MATERIALS AND METHODS

Preparation of resin composite specimens

This research was designed as a comparative study. Table 1 summarizes the resin composites utilized in this study and their compositions; all the resin composite materials were of shade A2. For each resin composite type sixty disk-shaped specimens (2 mm in height and 10 mm in diameter) were made by putting the composite in round split teflon molds and covering them with Mylar strips (Hawe Transparent Strip, Kerr Hawe, Switzerland) at both the bottom and the top of the molds, compressed between

Table 1: Resin composite types, details and composition

Resin composite	Manufacture	Classification	Composition
Filtek Supreme XT	3M ESPE, USA	Nanofill	Matrix: BisGMA, TEGDMA, UDMA, and BisEMA Filler: Agglomerated zirconia/silica nanocluster 0.6–1.4 µm with primary particle size of 5-20 nm, nonagglomerated nanosilica filler 20 nm; (filler content is 78.5% by weight)
Tetric Evo Ceram	Ivoclar Vivadent, Liechtenstein	Nanohybrid	Matrix: UDMA, catalysts, additives, pigments and stabilizers Filler: Glass of barium, mixed oxide, ytterbium trifluoride and prepolymers. The inorganic fillers have a particle size range of 40-3000 nm, with a mean particle size of 550 nm; (filler content is 75.5% by weight)
Renamel Microfill	Cosmedent, UAS	Microfill	Matrix: BisGMA and BisEMA Filler: 0.02-0.04 µm pyrogenic silicic acid filler (filler content is 60% by weight)
Filtek Z250	3M ESPE, USA	Microhybrid	Matrix: BisGMA, BisEMA and UDMA Filler: Zircon/silica (0.01-3.5 µm), oxide; (filler content is 78% by weight)

TEGDMA: Triethylene glycol dimethacrylate; BisGMA: Bisphenol A-glycidyl methacrylate; UDMA: Urethane dimethacrylate; BisEMA: Bisphenol A ethoxylated dimethacrylate

two glass slabs and photocured using LED curing unit (Bluephase, Vivadent; Schaan, Liechtenstein) for 20 s at 1200 mW/cm^2 through each side. The prepared specimens were stored in distilled water at 37°C for 24 h, then on a rotary polisher, they were wet finished with 600-grit silicon carbide abrasive paper (Automata unit for grinding and polishing, Jean Wirtz, Dusseldorf, Germany) for 30 s.

Polishing procedures

The prepared specimens of each resin composite after that, were divided randomly into four groups based on the polishing system (n = 15). Four commercially available two-steps polishing kits for resin composite were selected for this study as mentioned in Table 2.

Manufactures' instructions were followed during the polishing procedures as stated in Table 2. The composite discs in each group were polished using a slow-speed handpiece under minimal pressure in wet conditions; each specimen had only one side polished that marked by a 1 mm indentation. After polishing, all specimens were stored in distilled water at 37°C prior to surface roughness evaluation.

Surface roughness evaluation

The surface profile of the specimens was quantitatively analyzed to determine average roughness, R_a values in µm, using Taly-surf® tester (from Taylor Hobson Precision, Inc.). With a standard load of 0.7 mN and adjustable traverse speed down to 0.5 mm/s, a nominal 2 µm stylus was used. To confirm that the results were repeatable and reproducible, each test condition was repeated at least three times at distinct "new" locations on a rod bar surface. The "new" position was at least ± 200 µm away from the former one. The arithmetic average of the roughness profile is represented by the surface roughness values (R_a), which was the most utilized metric for this purpose.

Initial surface roughness measurements of all the specimens were performed, and then, the specimens were subjected to the thermocycling procedure[13] (5°C–55°C, 5000 cycles, 30 s each) in a thermal cycling tester (K178), Tokyo Giken Inc., Japan. After thermal aging, new surface roughness measurements were performed. Considering that all the contributors (operators) in this stage of surface roughness evaluation (during the testing procedures itself or data collection) were blinded and not aware about the samples data.

Statistical analysis

The distribution of numerical data was analyzed for normality, and normality tests were used (Kolmogorov–Smirnov and Shapiro–Wilk tests). The data were distributed in a normal (parametric) way. The mean and standard deviation values were used to present the data.

The effect of composite type, polishing system, thermocycling, and their interactions on mean R_a was assessed using the repeated measures two-way analysis of variance (ANOVA). When the ANOVA test was significant, Bonferroni's *post hoc* test was applied for pair-wise comparisons. $P \leq 0.05$ was used as the significant level. IBM SPSS Statistics for Windows, Version 23.0, Armonk, NY, USA: IBM Corporation was used to conduct the statistical analysis.

Table 2: Polishing systems used and protocol

Polishing system	Manufacture	Composition	Instructions (application directions)
Sof-Lex Spiral	3M ESPE, USA	The polishers (spirals) are made with either aluminum oxide or diamond abrasive particles impregnated in a thermoplastic elastomer matrix Consist of two spirals (beige and pink)	Sof-Lex spiral (beige) polisher, then the (pink) polisher for 10 s each in a slow-speed handpiece operating within 15,000-20,000 rpm and with water cooling
Diatech Shapeguard	Coltene, Switzerland	The polishers (spiral wheels) are made of diamond abrasive particles impregnated in a silicone matrix Consist of two spirals (purple and blue)	Diatech Shapeguard (purple) polisher for 10 s, then (blue) polisher for 10 s within speed 10,000-12,000 rpm under water cooling
Venus Supra	Heraeus Kulzer, Germany	The polisher tips made of synthetic rubber (urethane polymer) with impregnated microfine diamond powder and color pigments Consist of two polisher grits (red and grey) with different tip shapes	For 10 s each, use the Venus supra (red) polisher, then the second (grey) polisher, with the speed set at 7500-10,000 rpm and with water cooling
Astropol	Ivoclar Vivadent, Liechtenstein	The polisher tips are silicon carbide matrix and abrasive particles made of aluminum oxide, titanium oxide, and iron oxide. Diamond dust is also present in Astropol HP Consist of 3 polishing grits (coarse grey [F], fine green [P] and extra-fine pink [HP]) with different tip shapes	For 10 s each, use an Astropol P (green) polisher followed by an HP (pink) polisher with the speed set at 7500–10,000 rpm, with mild pressure and water cooling Note: Using of Astropol F (grey) polisher has been excluded as it is a prepolishing step

RESULTS

Effect of resin composites

Regardless of polishing system and thermocycling, there was a statistically significant difference between mean surface roughness (R_a) of different composite types ($P < 0.001$, Effect size = 0.454). Pair-wise comparisons demonstrated that Filtek Z250 showed the statistically significantly highest mean R_a (0.339 ± 0.1201 µm). There was no statistically significant difference between Renamel Microfill and Tetric Evo Ceram (0.2816 ± 0.084 µm and 0.2774 ± 0.072 µm, respectively); both revealed statistically lower mean values R_a. Filtek Supreme XT had the lowest statistically significant mean R_a (0.2533 ± 0.073 µm) [Table 3].

Effect of polishing system

Regardless of composite type and thermocycling, there was a statistically significant difference between mean surface roughness (R_a) in µm of different polishing systems ($P = 0.004$, Effect size = 0.057). Pair-wise comparisons revealed that there was no statistically significant difference between Astropol, Venus Supra, and Shape Guard (0.2942 ± 0.0927 µm, 0.2934 ± 0.0814 µm, and 0.2904 ± 0.1109 µm, respectively); all showed statistically significantly higher mean R_a than Sof-Lex Spiral (0.2734 ± 0.0903 µm) [Table 3].

Effect of thermocycling

Regardless of composite type and polishing system, there was a statistically significant increase in mean surface roughness values (R_a) in µm after thermocycling (0.2251 ± 0.0496 µm and 0.3506 ± 0.0868 µm respectively) ($P < 0.001$, Effect size = 0.792) [Table 3].

Table 3: The mean, standard deviation values and repeated measures analysis of variance test results for comparison between surface roughness (R_a) in µm of the four composite types, the different polishing systems, before and after thermocycling irrespective of other variables

Study Variables	The mean±SD of surface roughness (R_a) µm	*P*	Effect size (partial η^2)
Renamel Microfill	0.2816^B±0.084	<0.001*	0.454
Filtek Z250	0.339^A±0.1201		
Filtek Supreme XT	0.2533^C±0.073		
Tetric Evo Ceram	0.2774^B±0.072		
Sof Lex Spiral	0.2734^B±0.0903	0.004*	0.057
Shape Guard	0.2904^A±0.1109		
Venus Supra	0.2934^A±0.0814		
Astropol	0.2942^A±0.0927		
Before thermocycling	0.2251±0.0496	<0.001*	0.792
After thermocycling	0.3506±0.0868		

*Significant at $P \leq 0.05$. Different superscripts are statistically significantly different. SD: Standard deviation

Interactions of variables

Tables 4-6 summarize the statistically analysis of the surface roughness results of the specimens in, respectively, as comparison between each of composite types, polishing systems and thermocycling individually with different interactions of other variables; all are represented in Figure 1 and Tables 4-6.

DISCUSSION

The main objective of the current study was to identify the effects of different two steps polishing systems on the surface roughness of four various resin composite materials.

Table 4: The mean, standard deviation values, and repeated measures analysis of variance test results for comparison between surface roughness (R_a) values in μm of the four composite types with different interactions of variables

Polishing system	Thermocycling	Mean±SD				*P*	Effect size (partial η^2)
		Renamel Microfill	Filtek Z250	Filtek Supreme XT	Tetric Evo Ceram		
Sof Lex Spiral	Before	0.2102±0.0447	0.2111±0.0386	0.19±0.0369	0.214±0.0456	0.441	0.012
	After	0.316^{B}±0.0488	0.435^{A}±0.0604	0.304^{B}±0.0456	0.307^{B}±0.0492	<0.001*	0.226
Shape Guard	Before	0.229±0.0492	0.215±0.0419	0.211±0.0369	0.226±0.0456	0.647	0.007
	After	0.3468^{B}±0.0556	0.53^{A}±0.0604	0.283^{C}±0.0395	0.282^{C}±0.0465	<0.001*	0.500
Venus Supra	Before	0.224^{B}±0.0377	0.279^{A}±0.0728	0.22^{B}±0.0369	0.236^{B}±0.0492	0.001*	0.068
	After	0.29^{B}±0.0529	0.354^{A}±0.0748	0.38^{A}±0.0421	0.364^{A}±0.0604	<0.001*	0.102
Astropol	Before	0.218^{B}±0.0386	0.28^{A}±0.0394	0.1987^{B}±0.0421	0.239^{B}±0.0483	<0.001*	0.108
	After	0.419^{A}±0.0438	0.408^{A}±0.0604	0.24^{C}±0.0421	0.351^{B}±0.0438	<0.001*	0.329

*Significant at $P \leq 0.05$. Different superscripts in the same row indicate statistically significant difference between composite types. SD: Standard deviation

Table 5: The mean, standard deviation values, and repeated measures analysis of variance test results for comparison between surface roughness (R_a) values in μm of the four polishing systems with different interactions of variables

Composite type	Thermocycling	Mean±SD				*P*	Effect size (partial η^2)
		Sof Lex hhhhhSpiral	Shape gggGuard	Venus hhhhhSupra	Astropol		
Renamel Microfill	Before	0.2102±0.0447	0.229±0.0492	0.224±0.0377	0.218±0.0386	0.691	0.006
	After	0.316^{B}±0.0488	0.3468^{B}±0.0556	0.29^{B}±0.0529	0.419^{A}±0.0438	<0.001*	0.185
Filtek Z250	Before	0.2111^{B}±0.0386	0.215^{B}±0.0419	0.279^{A}±0.0728	0.28^{A}±0.0394	<0.001*	0.128
	After	0.435^{B}±0.0604	0.53^{A}±0.0604	0.354^{C}±0.0748	0.408^{B}±0.0604	<0.001*	0.283
Filtek Supreme XT	Before	0.19±0.0369	0.211±0.0369	0.22±0.0369	0.1987±0.0421	0.273	0.017
	After	0.304^{B}±0.0456	0.283^{B}±0.0395	0.38^{A}±0.0421	0.24^{B}±0.0421	<0.001*	0.200
Tetric Evo Ceram	Before	0.214±0.0456	0.226±0.0456	0.236±0.0492	0.239±0.0483	0.417	0.013
	After	0.307^{B}±0.0492	0.282^{B}±0.0465	0.364^{A}±0.0604	0.351^{A}±0.0438	<0.001*	0.096

*Significant at $P \leq 0.05$. Different superscripts in the same row indicate statistically significant difference between polishing systems. SD: Standard deviation

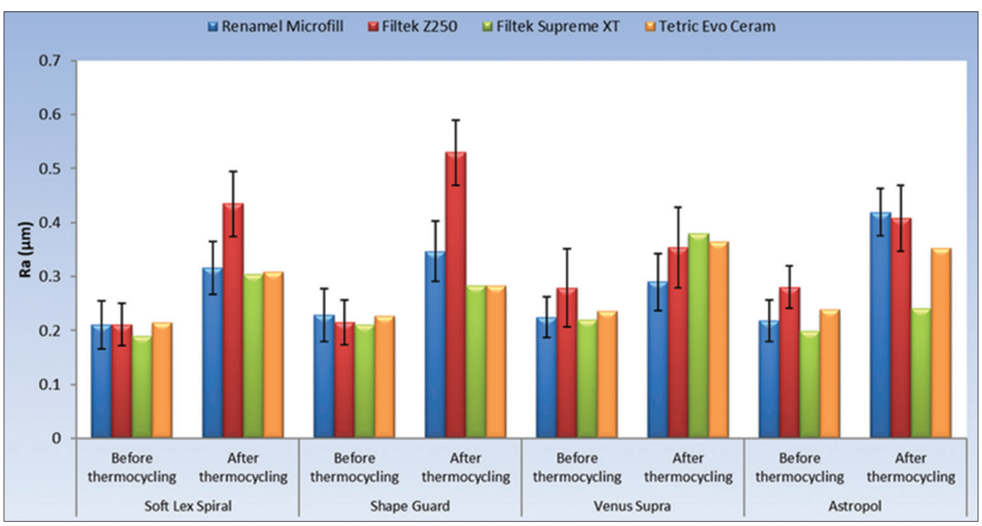

Figure 1: Bar chart representing mean and standard deviation values for surface roughness (Ra) in μm of the four composite types with different interactions of variables.

Aiming for standardization and to concentrate on the polishing system's, prepolishing step was done for all the resin composite specimens to create a uniform baseline.[1,22] In this research, to minimize difference in the applied force, only one operator applied and compressed the composite inside the molds, while time and speed of polishing were done following the manufacturers' guidelines.

Table 6: The mean, standard deviation values, and repeated measures analysis of variance test results for comparison between surface roughness (R_a) values in µm before and after thermocycling with different interactions of variables

Composite type	Polishing system	Mean±SD		P	Effect size (partial η^2)
		Before thermocycling	After thermocycling		
Renamel Microfill	Sof-Lex Spiral	0.2102±0.0447	0.316±0.0488	<0.001*	0.144
	Shape Guard	0.229±0.0492	0.3468±0.0556	<0.001*	0.173
	Venus Supra	0.224±0.0377	0.29±0.0529	<0.001*	0.062
	Astropol	0.218±0.0386	0.419±0.0438	<0.001*	0.378
Filtek Z250	Sof-Lex Spiral	0.2111±0.0386	0.435±0.0604	<0.001*	0.430
	Shape Guard	0.215±0.0419	0.53±0.0604	<0.001*	0.599
	Venus Supra	0.279±0.0728	0.354±0.0748	<0.001*	0.078
	Astropol	0.28±0.0394	0.408±0.0604	<0.001*	0.198
Filtek Supreme XT	Sof-Lex Spiral	0.19±0.0369	0.304±0.0456	<0.001*	0.164
	Shape Guard	0.211±0.0369	0.283±0.0395	<0.001*	0.072
	Venus Supra	0.22±0.0369	0.38±0.0421	<0.001*	0.278
	Astropol	0.1987±0.0421	0.24±0.0421	0.017*	0.025
Tetric Evo Ceram	Sof Lex Spiral	0.214±0.0456	0.307±0.0492	<0.001*	0.115
	Shape Guard	0.226±0.0456	0.282±0.0465	0.001*	0.045
	Venus Supra	0.236±0.0492	0.364±0.0604	<0.001*	0.198
	Astropol	0.239±0.0483	0.351±0.0438	<0.001*	0.159

*Significant at $P \leq 0.05$. SD: Standard deviation

Following finishing and polishing, the surface micromorphology (polishability) of composite restorations is affected by factors either related to the type of the composite itself or to the polishing techniques, the accessibility to the surfaces to be polished, the kind and severity of imperfections that remain after finishing or freehand application, as well as the influence of the oral environmental factors.[3,7,8,10] Taking that into consideration, previous researches reveal that each material behaves differently; the same finishing and polishing techniques used on different materials provide varied smoothness results.[9,23]

In general, in this study and irrespective to other factors, the polishability performance of the tested resin composites revealed that Filtek Supreme XT "nanofill" recorded the lowest mean surface roughness (R_a) of 0.2533 ± 0.073 µm. The factors related to the resin composite that influence its polishability includes the type, nature, amount (loading), shape, size, hardness, and distribution of inorganic filler particles beside the composition of the organic matrix; considering that polishing is complicated due to the heterogeneous nature of these dental materials (hard filler particles embedded in a relatively soft matrix).[3,7,8]

The results of this study were in accordance with many other studies.[5,9,13,14,19,24,25] These results could be explained and attributed to various factors as, the size of the glass filler particles as compared to nanofilled and microfilled composites, hybrid composites include larger filler particles and these large particles when compressed during polishing will leave bubbles and rough surface,[24,25] while fine particles are more wear-resistant because they are uniform and fewer filler particles are protruded over the surface.[12] Furthermore, smaller filler size led to a decreased interparticle spacing within the matrix leads to the organic resin matrix becomes highly protected and decreased filler pulling.[5,9,26]

While the results of our study were controversies with other researches.[2,3,4,7,11,14,16,19] The high polishability performance results of Filtek Supreme XT "nanofill" in this study were disagreed with other studies[13,18] who stated that, a clear relationship between filler size and composite surface roughness was not observed. Moreover, Kaizer *et al.*'s review[27] found no evidence to justify the use of nanofilled and nanohybrid resin composites over microhybrid resin composites for improve the surface quality. Therefore, filler size is not the only main factor as surface roughness might be related to the filler hardness, allowing it to abrade more evenly and create smoother surfaces[19] or to the composition of the resin composite material.[2]

There are many factors that can influence polishing efficiency of the polishing systems mainly its composition and this involves the abrasive particles' hardness, size, and form, attachment of such particles to the matrix material, flexibility and imbedding matrix's physical features, the instruments, and their geometry (cusp, discs, and cones), pressure, and time. The abrasive particles should be harder than the composite filler and should not detach during polishing.[5,7,23,28] There are some other factors such as the application method, polishing medium, and polishing technique.[3,7,8]

In general, and regardless to other factors, the Sof-Lex Spiral polishers in this study recorded good polishing performance, revealed the lowest mean surface roughness (R_a) of 0.2734 ± 0.0903 µm. The four polishing tested systems are two-step polisher of similar composition contain diamond abrasive particles impregnated in silicon matrix. The results difference could be attributed to the type of the abrasive particles as although the four types contain diamond particles, the Sof-Lex Spiral and Astropol systems contains also aluminum particles and other factor might be the shape of the polisher as Sof-Lex Spiral and Diatech Shapeguard were spiral in shape while Venus Supra and Astropol were points.[5,7,23]

The results of this research were in agreement with other studies.[1,11,19,29,30] As Wheeler *et al*. study,[1] who found that Diatech Shapeguard and Komet Spiral recorded the lowest surface roughness values of 0.23 µm and 0.26 µm, respectively and were statistically different from all other groups. Although the similarity in polishing systems composition "diamond particles, impregnated in silicone matrix," the authors speculated that the disparity in findings might be due to the way by which the abrasive particles are bound within the silicone matrix or the silicone matrix's composition.

Diamond particles, owing to their hardness, may produce smoother surfaces than aluminum particles. During polishing, the polishing material's particle hardness must be sufficient enough to achieve a uniform reduction in both the resin matrix and the filler particles of resin composites, otherwise, the polisher only removes the matrix and soft elements, leaving the fillers projecting on the surface.[2,24]

As mentioned in addition to the diamond abrasive particles both of Sof-Lex Spiral and Astropol polishers that used in our study contain aluminum oxide hard particles which might be an explanation of the good polishing performance Sof-Lex Spiral polishing system;[1] similar results were found in previous studies Dhananjaya *et al*. and Abzal *et al*.[11,29]

The polishing performance affected also by the polishers' design and shape, polishers with elastomeric bristles uniformly impregnated with abrasives particles could fit easily to all surface portions in the restoration, this will perform better polishing and minimize heat formation and unwanted pressure;[31] which could be an explanation in our study to the good polishing performance of Sof-Lex and Diatech Shape Guard which are spiral in shape compared with Venus Supra and Astropol which are points in shape. These were in consistent with other researchers[1,5] that revealed the best polishing performing systems were Polishettes and Diatech Shape Guard Spiral that has a flexible wheel form with elastic bristles. In contrast to our results Daud *et al*., study[3] who revealed that PoGo system which is points in shape polisher was provided to create a surface with a statistically significant higher gloss than the Sof-Lex system which is discs polisher. The authors attributed the discrepancy to the research's methodological variations, particularly the type of profilometer pick-up device used (mechanical vs. optical profilometry) and suggested that standardization of methodologies could help eliminate such conflicting.

Regardless of composite type and polishing system**,** there was a statistically significant increase in mean surface roughness values (R_a) in µm after thermocycling (0.2251 ± 0.0496 µm and 0.3506 ± 0.0868 µm respectively).

These results agreed with many other studies,[7,20,21,32] who studied the effects of thermocycling on composite restoration microhardness, roughness, and color. Dos Santos *et al*.[32] observed that thermocycling (3000 cycle) raised the resin composites surface roughness, however after 10,000 thermal cycles, there was a pattern toward decreasing surface roughness values.

Also in consistence, another study[13] measured the surface roughness using four finishing and polishing systems (Sof-Lex Pop On, Super Snap, Flexidisc, and Flexidisc + Enamelize) on six resin composite materials (Filtek Z250, Point 4, Renamel Nanofill, Filtek Supreme Plus, Renamel Microfill, and Premise). The results of that study revealed that, the surface roughness of the resin materials was adversely impacted by the *in vitro* thermocycling procedure, with an increase in value after 5000 thermal cycles.

The adverse effect of thermocycling on resin composite surface roughness could be explained by the temperature fluctuations resulting in thermal stress and microcracks in the matrix, as well as failures at the filler/matrix boundary. Furthermore, exposure to water may cause hydrolytic deterioration of a filler's silane coating or resin matrix water absorption (dissolution). Variation in filler particles exposure following thermocycling is most likely because of matrix breakdown, causing the filler particles to be exposed and hence increasing the roughness rates.[7,32]

Composites containing triethylene glycol dimethacrylate (TEGDMA) have been demonstrated to be more liable to degradation due to their hydrophilicity, which allows water to penetrate the material more easily,[13] which could explain the bad polishability performance (high R_a values) of Filtek Supreme XT in our study after thermocycling despite of its initial (before thermocycling) low R_a values as it was the only resin composite materials out of the four tested materials that contain (TEGDMA).

In the other hand, the result of this study is contradictory to the findings of a previous study[33] that reported that, the 14 days of artificial aging did not promote significant changes in R_a or gloss values, except for R_a in the unpolished Proviplast microhybrid composite resin subgroup, indicating excellent performance of the materials**.**

In this study aiming to overcome the limitations of the *in vitro* studies, all the specimens subjected to 5000 thermal cycles to simulate the influence of long-term oral cavity exposure in a short time to expect the polishability efficacy of resin composites clinically. However, although of this, there still many other dynamic oral environmental influencing factors as water and saliva content, occlusal loading, food abrasion, and pH level; all are factors to consider. Importantly, the specimen surfaces in this study were flat, while resin-based composite restorations in clinical applications include a variety of geometric forms with convex and concave surfaces**.**[1,7,18]

Many literatures found good correlation and consistence between profilometric observations regarding surface roughness which used in this study and scanning electron microscope (SEM) images.[1,34] On the other hand, although the highest frequent roughness parameter measurement in numerous studies is (R_a) which is well accepted as a parameter to estimate the surface quality of resin-based materials, however it has major limitation in identifying a surface's topography.[5] Consistency Aytac *et al*.,[7] concluded that, profilometric results of surface roughness and SEM images of these samples did not agree in a satisfactory manner.

CONCLUSION

With the study limitations, it could be concluded that:

- Resin composite type, polishing method, and thermocycling aging significantly affected the surface roughness of composites
- Nanofill composite (Filtek Supreme XT) significantly showed the lowest surface roughness values, followed by Nanohybrid and Microfill composites (Tetric Evo Ceram and Renamel Microfill), while Microhybrid composite (Filtek Z250) significantly demonstrated the highest surface roughness values
- Sof-Lex Spiral polishing system significantly showed the lowest surface roughness values among all the tested polishing systems as Astropol, Venus Supra, and Shape Guard polishing systems recorded higher surface roughness values without significant difference between them
- Thermocycling has a negative effect on composites' surface roughness as regardless of composite type and polishing system**,** there was a significant increase in surface roughness values after thermocycling
- Comparing the surface roughness values between each of composite types, polishing systems, and thermocycling individually with different interactions of other variables revealed significantly various results.

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Conflicts of interest
The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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