

Effect of Finishing/Polishing Techniques on Surface Roughness of Three Different Resin Composite Materials: A laboratory Study

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Abstract:

Objective: To determine the changes in surface roughness of different resin based composite materials having spherical shaped fillers after finishing and polishing with different systems and various application steps either one, two or three-steps. **Materials and Methods:** A total of 120 disc-shaped specimens (10 mm diameter × 2 mm thickness) were prepared from three different RBC materials (n=40 discs/group): a Nano-fill resin composite (Omnichroma); a Nano-ceramic resin composite (Neo Spectra ST) and a Nano-hybrid resin composite (Charisma Topaz). Each group was subdivided into four subgroups (n=10) according to the finishing/polishing (F/P) system: control (without F/P), one-step system (Enhance); two-step system (Super Snap Rainbow); and three-step system (Soflex). The mean Ra was measured using the profilometer. To compare the surface roughness between RBC materials without and after F/P, the collected data were subjected to statistical analysis using two-way analysis of variance (ANOVA), Student's t-test and One-way ANOVA with Tukey's post hoc tests. The level of significance was seated $p < 0.05$. **Results:** The Nano-fill resin composite showed the lowest mean Ra while the Nano-ceramic resin composite showed the highest value. A statistically significant difference was found in Ra and without and after F/P for the three RBC materials ($p < 0.001$). **Conclusions:** The various finishing and polishing systems had a noticeable effect on the surface roughness of the RBCs. The Nano-fill resin composite had the lowest surface roughness. The two-step F/P system provided the best F/P protocol of resin based composites evaluated.

Introduction:

Resin-based composite restorations are highly used in restorative dentistry, mainly because of their esthetic quality and good physical properties. Varieties of dental resin composites are available for clinical use, presenting a wide range of organic and inorganic components that may affect both handling properties and clinical use. The introduction of well dispersed inorganic particles into a resin matrix has been shown to be extremely effective for improving the performance of resin composites.¹

Improvements are mainly concerned about reducing polymerization shrinkage and increasing both hardness and compressive strength, by introducing of newer resin formulations and filler content. Fillers in resin composites have numerous roles such as reducing polymerization shrinkage, coefficient of thermal expansion and water sorption. They reinforce the material to enable better initial finishing/polishing with polish retention, and to reduce wear during the masticatory forces.^{2,3}

The surface quality of resin composite restorations is one of the most important factors determining their clinical success in the oral cavity. The final esthetic of the restoration, improved mechanical properties, perception and comfort of the patient are highly correlated with surface properties. Moreover, Smooth and polished restorations are less susceptible to plaque accumulation.^{4,5}

Surface roughness property of the resin based

composites has long been considered as a parameter of high clinical relevance. The structures of resin matrix, coupling agent and the characteristics of filler particles have a direct effect on the surface roughness of resin composites. The most important factors that affect surface roughness of any restoration are filler component, the type of inorganic particles, and the size and shape (geometry) of the filler particles.⁶

Restorative resins are modified, from past to present, from macro-fill, micro-fill, hybrid, and micro-hybrid resin composites to recent nano-fill and bulk-fill resin composites. Materials with fillers of larger sizes generally demonstrate higher surface roughness than those with fillers of smaller sizes. The smaller filler particles can adhere to resin matrix thus providing smoother surface finish.⁷

Different composite series containing spherical, irregular and hybrid shape fillers; which are based on mono-, bi- or multimodal (trimodal) filler formulations, providing different surface roughness due to difference in shape. The monomodal spherical shaped show low surface roughness while multimodal irregular filler particles express high surface roughness. The concept of multimodal fillers enables the composites to obtain high filler loading and allows a strong integration of small particles into resin matrix that can be eroded by breaking off small individual particles rather than large ones.⁸

Optimal finishing and polishing of resin composites are essential for preserving esthetics and increase longevity of resin-based restorations. Smooth and polished restorations are less prone to plaque accumulation and extrinsic stains. It may also influence the physical and mechanical properties of the restorations and wear resistance of the restorations.⁹

The Null Hypothesis was no difference in the effect of finishing/polishing techniques on surface roughness of three resin composite materials.

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Materials and Methods:

Materials:

Three different resin composite restorative materials were used in the current study. One of these materials is a Nano-fill resin composite with the supra nano spherical and rounded filler particle geometry, the other material is Nano-ceramic composite with spherical filler particle geometry, and the third one is Nano-hybrid composite with spherical filler particle geometry. They

were manipulated according to the manufacturers' recommendations. Their brand names, specifications, composition, manufacturers and batch numbers are listed in, (Table 1).

The finishing and polishing procedure was accomplished by three variable systems: one-step, two-steps, and three-steps finishing/polishing system. All of them were used as stated by the manufacturers' instructions. Their full description was mentioned in, (Table 2).

Table 1: Resin composite restorative materials used in the study

Brand name	Specification	Composition	Manufacturer	Batch No.
OMNICHROMA	Nano-fill with spherical and rounded fillers resin composite	Matrix: -UDMA/TEGDMA -Mequinol, Dibutyl hydroxyl toluene and UV absorber Filler Type: -supra-nano spherical zirconia-silica filler and round shaped composite filler Filler particle size: -0.2-0.6 μm mean 0.3 μm Filler Load: -79% by weight 68% by volume	Tokuyama Dental, Tokyo, Japan	014E49 014E59 014E60 014E61
Neo Spectra™ ST	Nano-Ceramic with spherical filler resin composite	Matrix: -Methacrylate modified polysiloxane (organically modified ceramic) -Dimethacrylate resins -Ethyl4 (dimethylamino)benzoate -Bis(4-methyl-phenyl)iodonium hexafluorophosphate Filler Type: -Barium glass, prepolymerized filler and ytterbium fluoride Filler Particle Size: -0.1-0.3 μm mean 0.2 μm Filler Load: -78-80 weight -% 60-62 volume-%	Dentsply Sirona, Charlotte, NC. United States	2010000764 2010000765 2010000766 2010000767
CHARISMA® TOPAZ	Nano-Hybrid with spherical filler resin composite	Matrix: TCD-DI-HEA and UDMA Filler Type: -Barium Aluminium Fluoride glass -Pre-polymerized filler - Highly discrete nanoparticles Filler particle Size:- 5 nm– 5 μm Filler Load:- 69% filler by weight, 59% by volume	Kulzer GmbH, Leipziger Straße 2 63450 Hanau, Germany	K010052 K010053 K010065 K010066

Table 2: Finishing/Polishing Systems used in the study

Material	Specifications	Composition	Manufacturer	Batch No.
Enhance® Finishing System	One-Step	-Polymerized Urethane Dimethacrylate Resin; -Aluminum Oxide; Silicon Dioxide	Dentsply LLC 38 West Clarke Avenue Milford, DE 19963 USA	00049937
Super-Snap Rainbow® System	Two-Step	-Silicon Carbide -Aluminum Oxide	Shofu Dental Corporation, 1225 stone drive, San Marcos, USA	0219021
Sof-Lex™ Finishing and Polishing System	Three-Step	-Aluminum Oxide	3M ESPE, St Paul, MN, USA	047025

Methods:

Specimens Preparation: One hundred and twenty disc-shaped specimens were classified into two equal groups (n=40 discs/group) according to used type of resin based composite material: Nano-fill RBC, Nano-ceramic RBC, and Nano-hybrid RBC.

A cylindrical plastic mold of 10 mm diameter × 2 mm depth, fabricated by laser cut technique to prevent the stickiness of the restorative material to the mold that was utilized for discs fabrication. The mold was placed above a microscopic glass slide, covered with a Mylar strip (SS white, USA), then resin composite was applied in one increment using the LM Arte Applicator instrument (LM Dental™, Norrbyn rantatie 8, FI-21600 Parainen, Finland) until the whole mold space was filled totally. Another microscopic glass slide was pressed on top of resin composite surface. A constant pressure was applied over the glass slide to extrude any excess material and to reduce voids within the disc.

Resin composite was cured for 20 seconds with a LED light curing device (RTA MINI S, Woodpecker, China) through the glass slide on the top of the mold after removal the weight. The light curing device was placed in a perpendicular direction to the specimen's surface and in direct contact with the glass slide. The light intensity was measured at 800mW/cm² and checked with a digital readout dental radiometer (Blue phase Meter, Ivoclar vivadent, Austria) after each 5 specimens. Another 20 seconds of light curing was done to both sides of each specimen after the removal of the microscopic glass slide. The mold was opened and disc shaped resin composite specimens were obtained. Any external flanges of the specimens were removed using a silicon carbide grinding paper (1200 grit).

Each group was subdivided into four subgroups (where n=10 discs/subgroup) according to the finishing and polishing technique used. Finishing and polishing process of each subgroup was performed according to the manufacturers' instructions and done under air/water spray to avoid heat generation. Low speed type handpiece (Sirona T2 Revo, Dentsply Sirona, Charlotte, NC, United States) was used at speed between 10,000-15,000 RPM according to the finishing and polishing system used. The handpiece was used in unidirectional movements to avoid any scratches formation.

Subgroup 1 (Control group): each specimen was fabricated using the Mylar strips only against the glass slide and left without finishing and polishing.

Subgroup 2 (one-step finishing and polishing system): each specimen was finished using the finishing discs (particle size 40µm) that impregnated with aluminum oxide and silicon dioxide particles. Then, it was polished using the fine and extra fine pastes. Discs were used with conventional speed (10000-15000 RPM) with intermittent pressure without water coolant. A new disc was used for each specimen.

Subgroup 3 (two-step finishing and polishing system): each specimen was finished using the discs in sequence started with the violet (medium) disc (safe side down,

double sided and safe side up silicon carbide disc) (particle size 30µm). After that, the surface was polished with the green (fine) disc (double sided aluminum oxide grit) (particle size 20µm) followed by the red (super fine) disc (double sided aluminum oxide grit) (particle size 7µm). The discs dimensions are 12mm x 8mm. All the discs were used at average speed (15000 RPM) with uniform, steady pressure for finishing and feather light pressure for polishing. They were used in a unidirectional movement to prevent formation of secondary scratches. Brand new discs were used for each specimen.

Subgroup 4 (three-step finishing and polishing system): each specimen was finished using the discs according to the instructions' sequence beginning with the black (coarse) disc (particle size 100µm) impregnated with aluminum oxide, then the blue (medium) disc (particle size 29µm), followed by the light blue (finishing) disc (particle size 14µm). Later on, it was polished using the sky blue (super fine) disc (particle size 5µm). The disc dimensions are 12.7mm x 9mm. During the finishing and polishing every specimen were rinsed with water and then dried between each disc. All the discs were used with light touches and in rotating motions covering the whole surface to prevent any white line marks. Every specimen was finished and polished with new discs.

Finally, the specimens of all four subgroups were stored in distilled water at 37±1°C for 7 days using incubator (DRAWELL, Chongqing, China) before they were used for surface roughness measurement.

Measurement of Surface Roughness (Ra)

The average surface roughness (Ra) of each subgroup was examined using a profilometer (Surftest SJ210, Mitutoyo Corp., Kawasaki, Japan) according to the ISO 4287-1997. For this purpose, the probe was placed in the middle of the specimen surface. Each specimen was scanned 5 times and the mean roughness parameter (Ra) was calculated in (µm). The tracing length was 0.8 mm, at a scanning speed 0.5 mm/s. The resolution of the recorded data was 0.01 µm. The device was set to read a wide line from the specimen. Scanning was done by a contact mode in a laboratory atmosphere under controlled temperature and dry condition.

Statistical analysis: After conduction of the surface roughness test, the data were collected, tabulated, and examined by Shapiro-Wilk test to identify the normal distribution. Results of Shapiro-Wilk test, (Table 3) showed that Ra data was parametric (met the normal distribution) and presented as mean±SD. The SPSS statistical package for social science version 25 (SPSS Inc., Chicago, IL, USA) was used for data analysis. Two-way ANOVA was used to compare Ra (dependent variable) among materials groups (Control, Nano-fill, Nano-ceramic and Nano-hybrid) and finishing and polishing techniques (One-step, two-step and three-step). Then, Tukey post hoc test was used for pair-wise comparisons, (Table 4). P value is significant if it was

less than .05 at confidence interval 95%. Graphical presentation of data was made using box plot with error bars representing confidence interval, (Figure).

Results:

According to the average Ra values, Tukey post hoc test showed no significance difference between RBC (control groups) made with Mylar strips and each other. The highest Ra values were recorded with the nano-ceramic composite, to be followed by the nano-fill and the nano-hybrid respectively.

Regarding to the one-step F/P system, there was a significant difference (p<0.05) between Nano-fill resin composite and the other two composites. While there was no significant difference between the Nano-Hybrid resin composite and the Nano-ceramic resin composite. The lowest surface roughness value was shown by the Nano-fill resin composite while the highest value was the Nano-hybrid resin composite.

For the two-steps F/P system, there was no significant difference between the three tested resin based composites. The lowest value was stated by Nano-fill resin composite, and the highest value was the Nano-hybrid resin composite.

According to the three-steps F/P system, there was also no significant difference between the three tested resin based composite. The Nano-ceramic demonstrated the lowest surface roughness value while the Nano-hybrid had the highest roughness value.

Regarding to the effect of finishing and polishing techniques within the Nano-fill composite group there was no significant difference between the control group, the one-step F/P and two-steps F/P groups, but there was a significant difference (p<0.05) between the three-steps F/P group and the other groups. The two-steps F/P

group had the lowest Ra value among this RBC followed by the control group, the one-step F/P group and finally the three-steps F/P group.

For the Nano-Hybrid composite group there was no significant difference between the control group and the two-steps F/P group. Also between the one-step F/P and three-steps F/P groups, while there was a significant difference (p<0.05) between the two-step F/P group with the one-step F/P and the three-step F/P groups. The lowest Ra value was demonstrated by the Control group, then the two-step F/P group, the one-step F/P group and finally the highest was the three-step F/P group.

Regarding to the Nano-ceramic composite there was no significant difference between the control group and the two-steps F/P group. Also between the one-step F/P group and the three-steps F/P group, but there was a significant difference (p<0.05) between the control group, the one-step F/P and three-steps F/P groups. The lowest Ra value was expressed by the two-steps F/P group, to be followed by the control group, the one-step F/P group and three-step F/P one in order.

Generally, between all the analyzed groups, the two-step F/P system showed the lowest surface roughness values followed by the one-step F/P while the three-step F/P system showed the highest surface roughness values.

Table 3: Two-way ANOVA test of Ra means (nm)

Source	F	Significance
Restoration Material	3.072	P=0.050
F/P System	138.967	P=0.00
Restoration X F/P	6.650	P=0.00

Table 4: Tukey post Hoc test showing Ra values of different restorative materials after finishing/polishing with different techniques

Restorative Material	Finishing and Polishing System			
	Control mean ±standard deviation	One-step mean ±standard deviation	Two-step mean ±standard deviation	Three-Step mean ±standard deviation
Nano-fill	0.3264±0.5935 ^{A,b}	0.4115±0.5282 ^{B,c}	0.2909±0.4016 ^{A,b}	0.5934±0.3317 ^{A,a}
Nano-hybrid	0.2637±0.3849 ^{A,b}	0.5394±0.5586 ^{A,a}	0.3494±0.5926 ^{A,b}	0.6051±0.09199 ^{B,a}
Nano-ceramic	0.3380±0.05369 ^{A,b}	0.5101±0.08474 ^{A,a}	0.3089±0.05365 ^{A,b}	0.5305±0.7914 ^{A,a}

Different upper case letters in the same column indicate significant differences between each two materials
 Different lower case letters in the same raw indicate significant differences between each two finishing & polishing techniques

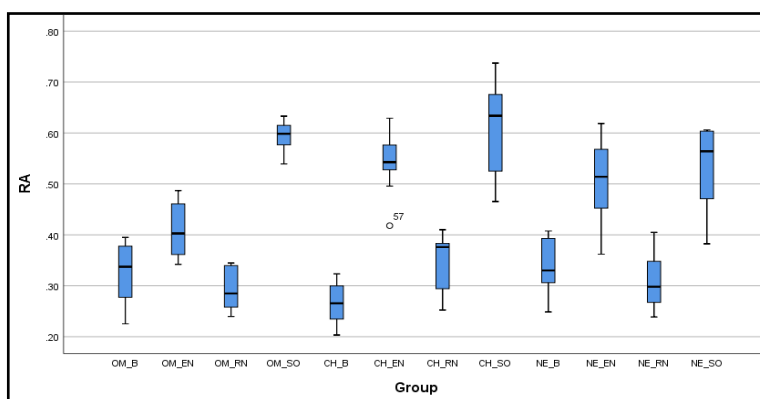


Figure: Box Plot showing the relation between RA and different groups

Discussion:

There are numerous methods for restoring destructed teeth and treating dental caries. The tooth-colored materials are in highly demand recently. Different types of the resin composite have been used in the clinic. Resin composite has many advantages over dental amalgam as it is less damaging to natural teeth, allows more conservative restorations, and better esthetic.¹⁰

The esthetic success of tooth-colored restorative dental materials is affected by several factors such as, surface roughness. Since the demand for improved esthetic of restorations is still increasing, esthetic restorations should reproduce the natural appearance and shape of the natural teeth. Surface smoothness has been viewed as vital property of resin composite.^{11,12}

Surface properties of resin composite have a crucial role in the clinical success of the restoration; smooth appearance is a result from adequate contouring, proper finishing and polishing which is mandatory for healthy oral tissues and marginal integrity.¹³

On the other hand, a rough surface has a negative effect on the esthetics. Moreover, plaque accumulation is significantly increases with rough surfaces causing a high pace of developing cariogenic biofilms which ends up with caries.¹⁴

The surface quality is affected by different factors either related to the material itself or to the F/P system being used. The polished surface of the restoration has a direct effect on the aesthetic appearance and the wear of the opposing teeth so, having a smooth polished surface enhance the oral hygiene and the durability of the restoration.¹⁵

Finishing and polishing procedures have a direct effect on the surface quality of the tooth colored restoration. Proper finishing and polishing procedures imply a complex combination of factors such as, the restorative material itself, the anatomy of the tooth being restored, the F/P system used, the operator's quality and ability to use the system. The manual finishing and polishing was used in this study because it simulates the clinical conditions.¹⁶

The size of the fillers are one of the most critical factors that determine the properties of the restoration surface, the Nano-fillers provide less inter-particle spaces which resulted in softer composite matrix, leading to the smoother restoration surface with decreased roughness.¹⁷

The finishing and polishing systems are available in different shapes including cups, discs and points to help in the application of different teeth anatomical forms, in this study the disc shaped was used for all the systems to decrease any variability and to ensure that the surface being uniformly finished and polished regardless the used system. Also it is mainly indicated to be used with the smooth surfaces like discs used in this study. In addition, point shaped was not used as it may cause scratches.

The surface roughness was measured quantitatively by using the profilometer device. The stylus type profilometer used in this study provides meanings of surface features on a scale size. The profilometer allows more surface area to be scanned and provides accurate roughness readings, consequently adequate comparison between the studied restorative materials and F/P systems.¹⁸

Results obtained from this study regarding to Mylar strip groups (control groups) which stated that the unfinished surface made with direct contact with a glass slap was more smooth than the finished and polished surfaces, came in agreement with the results of the study done by Korkmaz et al.¹⁹ who studied the influence of one-step polishing system on surface roughness of Nano-composites and found the same results regarding the surface roughness of the composite materials made with Mylar strips without finishing and polishing.

A smooth and glossy surface was obtained by using the glass slap and Mylar strip without any finishing and polishing procedures, this is not an accepted or applicable scenario in clinical and real life situations, the Mylar strip group has been used as a control group as recommended by different studies.¹⁹

However, F/P procedures are crucially required intra-orally, Also the smooth surface obtained from the glass slide and Mylar strip which directly contacted the restorative material, has a resin-rich layer on its top which needs to be removed. Accordingly; the removal of this outer most resin rich layer by F/P procedures allows production of a more wear resistant and glossy restorative surface.²⁰

The results obtained from this study showed that the lowest surface roughness values were recorded with the Nano-fill resin composite. This might be due to the clustered arrangement of its filler particles, the wear mechanism suggested was that the clusters of the particles wear off instead of taking out the whole particles; this is believed to be the reason for its polishability and polish retention.²¹ In the study done by Endo et al.²² similar results were obtained regarding to the roughness of Nano-fill composite as it may be usually higher than that provided by Nano-hybrid composite.

Another important factor that might explain these results is the filler particle shape. The spherical shaped particles of the Nano-fill resin composite showed lower surface roughness than the hybrid shaped particles. This might be due to that the irregular shaped filler particles can be subjected to more friction during the polishing process as they have sharp edges and corners that can be easily removed.²³

The findings of this study came in agreement with the study done by Cao et al.²⁴ who studied the filler morphology of different resin based composite materials and the surface properties and came with the conclusion that the spherical shaped fillers showed lower surface roughness than other different shapes.

The Nano-hybrid resin composite which has small fillers particles, and the resin matrix surrounds the filler particles which is the first thing that is worn out after abrasion of the composite, leading to the protrusion of the fillers, and formation of filler bumps on the outer surface of the resin based composite, also the quality of the matrix-filler silane bonding, all of these might be the reasons regarding to the results obtained by the profilometer analysis.²⁵

The Nano-ceramic composite showed the highest surface roughness, this may be attributed to its filler particles size which ranges from 0.1µm-0.3µm with filler load ranges from 78%-80% by weight and 60%-62% by volume which is larger relatively than the other composites used, also it doesn't seem to have the same mechanism as the Nano-fill composite, there are voids present due to the plucking out of the filler particles after the polishing, this would explain why the larger particles are not broken during the finishing and polishing procedures as the smaller particles but they are plucked out leaving voids.²⁶

A crucial factor that implies an important effect on the surface roughness of the resin composite is the finishing instruments used and the technique they were applied. The shape of the instrument used as well as the hardness of the abrasive particles play an important role during this step.¹⁸

The two-steps F/P was able to provide better surface roughness than the three-steps F/P this may be due to the silicon carbide composition of it coarse disc which doesn't produce initial deep scratches as the three-step F/P, and these scratches were easily removed by the consequence discs used, also, the aluminum oxide discs may have its own limitations in using because of its geometry. These results was approved by Da Costa.²⁷ and his colleges who compared different finishing and polishing systems including the same materials used in this study. In contrast a study by Rodriguez et al.²⁸ stated that the multistep discs provided better surface roughness than a two-step system used.

The two-step F/P system when compared to the one-step F/P system has produced relatively smoother surface among all the used composites, this might have been a result of the sequential decreasing of the particle size of the discs, the particles size of the two-step F/P system has decreased sequentially from 60µm to 7 µm, while the particles size of the one-step F/P system was 40 µm.

The one-step F/P used in this study produced lower surface roughness than the three-steps F/P among the used resin based composites, this may be due to its convenience and efficiency to produce smooth surface without switching between different discs or using of water coolant, without the need for wash and dry between every step that leads to the removal of the larger abrasive particles, the results was similar to the study done by Da Costa.²⁷ and her colleges who compared the effect of different finishing and polishing systems including one-step F/P and three-step F/P

systems, came with the results that the one-step system has lower surface roughness than the multi-step system.

Within the limitations of this study, the null hypothesis stated that there was no difference in the effect of finishing/polishing techniques on surface roughness on three resin composite materials, was rejected. Results showed that there was a significant difference between different finishing/polishing techniques on the surface roughness the different resin based composites.

Conclusions:

- Finishing and polishing with three different systems affected the surface roughness of the resin based composites.
- Nano-fill composite demonstrated lower surface roughness than the Nano-hybrid and Nano-ceramic resin based composite.
- The two-step F/P system provided the best F/P protocol of resin based composites evaluated.

References:

1. Jones CS; Billington RW; Pearson GJ. The in vivo perception of roughness of restorations. *Br Dent J.* 2004;196(1):42–45.
2. Beun S; Glorieux T; Devaux J; Vreven J; Leloup G. Characterization of nanofilled compared to universal and microfilled composites. *Dent Mater.* 2007;23(1):51–59.
3. Ikejima I; Nomoto R; McCabe JF. Shear punch strength and flexural strength of model composites with varying filler volume fraction, particle size and silanation. *Dent Mater.* 2003;19(3):206–211.
4. Bollenl CML; Lambrechts P; Quirynen M. Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention: a review of the literature. *Dent Mater.* 1997;13(4):258–269.
5. Brambilla E; Cagetti MG; Gagliani M; Fadini L; Garcia-Godoy F; Strohmenger L. Influence of different adhesive restorative materials on mutans streptococci colonization. *Am J Dent.* 2005;18(3):173.
6. Say EC; Yurdagüven H; Yaman BC; Özer F. Surface roughness and morphology of resin composites polished with two-step polishing systems. *Dent Mater J.* 2014;33(3):332–342.
7. Kim K-H, Ong JL, Okuno O. The effect of filler loading and morphology on the mechanical properties of contemporary composites. *J Prosthet Dent.* 2002;87(6):642–649.
8. Jaarda MJ; Wang R-F; Lang BR. A regression analysis of filler particle content to predict composite wear. *J Prosthet Dent.* 1997;77(1):57–67.

9. Takanashi E; Kishikawa R; Ikeda M; Inai N; Otsuki M; Foxton RM, et al. Influence of abrasive particle size on surface properties of flowable composites. *Dent Mater J.* 2008;27(6):780–786.
10. Roberson T; Heymann HO; Swift Jr EJ. *Sturdevant's art and science of operative dentistry.* Elsevier Health Sciences; 2006.
11. Marghalani HY. *Resin-Based Dental Composite Materials* 13. 2016;
12. Yildiz E; Karaarslan ES; Simsek M; Ozsevik AS; Usumez A. Color stability and surface roughness of polished anterior restorative materials. *Dent Mater J.* 2015;2014–344.
13. Attar N. The effect of finishing and polishing procedures on the surface roughness of composite resin materials. *J Contemp Dent Pract.* 2007;8(1):27–35.
14. Da Costa J; Adams-Belusko A; Riley K; Ferracane JL. The effect of various dentifrices on surface roughness and gloss of resin composites. *J Dent.* 2010;38:123–128.
15. Antonson SA; Yazici AR; Kilinc E; Antonson DE; Hardigan PC. Comparison of different finishing/polishing systems on surface roughness and gloss of resin composites. *J Dent.* 2011;39:9–17.
16. Yap AUJ; Lye KW; Sau CW; others. Surface characteristics of tooth-colored restoratives polished utilizing different polishing systems. *Oper Dent.* 1997;22:260–265.
17. Kaizer MR; de Oliveira-Ogliari A; Cenci MS; Opdam NJM; Moraes RR. Do nanofill or submicron composites show improved smoothness and gloss? A systematic review of in vitro studies. *Dent Mater.* 2014;30(4):41–78.
18. Bansal K; Gupta S; Nikhil V; Jaiswal S; Jain A; Aggarwal N. Effect of different finishing and polishing systems on the surface roughness of resin composite and enamel: An In vitro profilometric and scanning electron microscopy study. *Int J Appl Basic Med Res.* 2019;9(3):154.
19. Korkmaz Y; Ozel E; Attar N; Aksoy G. The influence of one-step polishing systems on the surface roughness and microhardness of nanocomposites. *Oper Dent.* 2008;33(1):44–50.
20. Uctasli MB; Arisu HD; Omurlu H; Eliguzeloglu E; Ozcan S; Ergun G. The effect of different finishing and polishing systems on the surface roughness of different composite restorative materials. *J Contemp Dent Pr.* 2007;8(2):89–96.
21. Borges BCD; Bezerra GVG; Mesquita J de A; Silva TRSF; Alves-Júnior C; Pinheiro IV de A; et al. Filler morphology of resin-based low-viscosity materials and surface properties after several photoactivation times. *Acta Odontol Scand.* 2013;71(1):215–222.
22. Endo T; Finger WJ; Kanehira M; Utterodt A; Komatsu M. Surface texture and roughness of polished nanofill and nanohybrid resin composites. *Dent Mater J.* 2010;29(2):213–223.
23. Tamura Y; Kakuta K; Ogura H. Wear and mechanical properties of composite resins consisting of different filler particles. *Odontology.* 2013;101(2):156–169.
24. Cao L; Zhao X; Gong X; Zhao S. An in vitro investigation of wear resistance and hardness of composite resins. *Int J Clin Exp Med.* 2013;6(6):423.
25. Malavasi CV; Macedo EM; Rego GF; Schneider LF; Cavalcante LM; others. Surface Texture and Optical Properties of Self-Adhering Composite Materials after Toothbrush Abrasion. *J Contemp Dent Pract.* 2015;16(10):775–782.
26. Mahmoud SH; El-Embaby AE; AbdAllah AM. Clinical performance of ormocer, nanofilled, and nanoceramic resin composites in Class I and Class II restorations: a three-year evaluation. *Oper Dent.* 2014;39(1):32–42.
27. Da Costa J; Adams-Belusko A; Riley K; Ferracane JL. The effect of various dentifrices on surface roughness and gloss of resin composites. *J Dent.* 2010;38:123–128.
28. Rodrigues-Junior SA; Chemin P; Piaia PP; Ferracane JL. Surface roughness and gloss of actual composites as polished with different polishing systems. *Oper Dent.* 2015;40(4):418–429.