The influence of finishing/polishing time and cooling system on surface roughness and microhardness of two different types of composite resin restorations

Raja Rajeswari Kaminedi, Narendra Varma Penumatsa[1], Tulasi Priya[2], Kusai Baroudi

Department of Restorative Dental Sciences, Al-Farabi College, Riyadh, [1]Department of Pedodontics, College of Dentistry, Salman Bin Abdul Aziz University, Alkharj, Kingdom of Saudi Arabia, [2]Department of Conservative and Endodontics, Mamatha Dental College, Khammam, Telangana, India

Corresponding author (email: d_kusai@yahoo.co.uk>)
Dr. Kusai Baroudi, Department of Restorative Dental Sciences, Al-Farabi College, Riyadh - 11691, PO Box 85184, Kingdom of Saudi Arabia

Abstract

Objective: The aim of this study was to evaluate the effect of finishing time and polishing time on surface roughness and microhardness of nanofilled and hybrid resin composites. **Materials and Methods:** Hundred disk composite specimens from micro hybrid composite and nanohybrid composite were prepared, 50 for each type of composite. The specimens were divided into five groups according to the time of finishing and polishing (immediate, 15 min, 24 h and dry). Composite under the Mylar strip without finishing and polishing was taken as the control group. Surface roughness was measured with environmental scanning electronic microscope (ESEM) and microhardness was determined using Vickers Microhardness Tester. Data collected were statistically analyzed by *t*-test and one-way analysis of variance (ANOVA) followed by Turkey's *post hoc* test. **Results:** Smooth surface with low hardness was obtained for the group under Mylar strip without finishing and polishing. The highest roughness was recorded for delayed finishing and polishing for both composites. Immediate finishing and polishing increased the surface hardness more than that in the control group in both types of composites. Dry finishing reduced the hardness significantly for micro hybrid composite, but resulted in the highest surface hardness for nanofilled composite. **Conclusion:** Immediate finishing and polishing under coolant resulted in the best surface smoothness and hardness values in micro hybrid composite; however, immediate dry finishing and polishing gave the best smoothness and hardness values in nanohybrid composite.

Key words: *Microhardness, resin composite, roughness*

INTRODUCTION

In recent years, the usage of composite as a choice of restoration has increased incredibly because of its unique combination of aesthetics, affordability, and conservation. The aesthetic appearance of the composite resin is based upon the shape, color, and gloss of the restoration achieved by finishing and polishing procedure.[1]

Finishing refers to the contouring, shaping, and smoothing of the restoration to give anatomical contours and to remove excess material at the interface. Polishing is a step performed after finishing when the surface gains a high luster and enamel-like texture.[1]

A smooth surface finish is clinically necessary because the presence of surface irregularities from poor finishing and polishing can lead to staining, plaque, gingival irritation, recurrent caries, abrasiveness,

Access this article online	
Quick Response Code:	Website: www.jispcd.org
	DOI: 10.4103/2231-0762.146211

wear kinetics, and tactile perception by the patient.[2] Therefore, polishing procedures help to maintain longevity of restoration[3] and preserve good oral health.[4]

Polishability of resin-based composites relies on the filler particle size and morphology,[5] the filler loading, the type of filler,[6] and on the polishing method and instruments.[7] Therefore, the finishing and polishing procedures are both affected by the technique and are material sensitive.[8,9]

The softer surface resins may retain the scratches created by the finishing procedures, which can affect the fatigue strength of restoration leading to premature failure.[10] Surface hardness is an important mechanical property that can predict the wear resistance and its ability to abrade or be abraded by opposing dental structures or materials.[11] The timing of polishing might affect the physical properties of the composite and might increase the risk of premature failures.[12]

As the resin composite is a bad conductor of heat, it retains the heat produced by the polishing procedures in the outer layer of material and raises the temperature above the glass transition temperature, making the surface hard such that it can increase the mechanical properties of restoration such as microhardness and abrasion resistance.[13] Nevertheless, dry finishing and polishing may produce considerable heat that affects the interface between the tooth and adhesive bond; interestingly, it also affects the bond between the particles and the surrounding matrix. It is recommended to polish the resin under water coolant to reduce the detrimental effects of dry finishing and polishing;[14] therefore, polishing dry or with coolant affects the physical properties of the composite.

In literature, polishing methods or procedures are well documented,[15-18] but the timing, i.e. immediate or delayed finishing, and polishing under dry or wet conditions affecting the physical properties of the resins remain a controversial topic. In this light, this study was conducted to investigate the best timing of polishing and finishing and the best method of polishing, whether dry or wet, affecting the surface hardness and surface smoothness of two types of resin composite materials.

MATERIALS AND METHODS

Two different tooth-colored restorative materials were used in the study: A hybrid resin composite Filtek Z250 (3M ESPE, USA) and a nanohybrid resin composite Filtek Z350 (3M ESPE, USA).

Materials used were of A2 shades. Teflon molds (4 mm in diameter and 2 mm thickness) were used to prepare 50 specimens from each of the restorative materials. To prepare each specimen, the mold was placed on a Mylar strip covered with glass slide and the uncured resin composites were packed inside the molds. Another Mylar strip was then placed over the mold and the material was compressed with a glass slide. The specimens tested were exposed to a load of 200 g for extrusion of any excess resin composite and forming a flat surface. The specimens were polymerized with a tungsten halogen light (Hilux, Benlioglu, Turkey) for 40 s at both sides of the specimen at a light intensity of 550 mW/cm^2.

A total of 100 specimens of the composite resin were prepared and divided into two groups, 50 specimens for each type of composite. Each group was subdivided into five subgroups, each of which had 10 specimens, according to the type and time of finishing and polishing as follows:

- Group 1: Control group; no finishing and polishing procedures were applied
- Group 2: The specimens were immediately finished and polished
- Group 3: The specimens were finished and polished after 15 min
- Group 4: The specimens were finished and polished after 24 h
- Group 5: The specimens were dry finished.

Finishing was performed with 30 µm diamond finishing burs (Diatech, Diatech Dental AC, Switzerland) with a high-speed hand-piece at 40,000 rpm under water cooling. The application time was limited to 10 s. A new finishing bur was used for every five specimens. In group 5, the specimens were finished without water cooling.

Medium to super-fine aluminum oxide disks (sof-lex 3M ESPE, USA) were used for polishing. The aluminum oxide disks were discarded after each use. Each disk was used in a circular motion applying light pressure for 20 s with a slow-speed hand piece (NSK Ti-Max electric hand piece, Japan). The revolutions per minute were set to 5000. To control the variability, one investigator, blinded to which material was being processed, performed all the finishing sand polishing procedures in a randomized order. All groups were stored in saline at 37°C before analysis.

Measurement of surface roughness

The surface roughness of each specimen was recorded using the environmental scanning electronic microscope (ESEM) (Quanta 200, the Netherlands) by a second operator who was also blinded to the restorative materials and finishing/polishing procedures.

The average surface roughness (Ra, μm) was measured using XT document software which has the ability to convert the 2D captured image by ESEM into 3D image with a magnification of 1000×. Each peak of the images was marked and then the peak height (*z*-axis), the peak length (*x*-axis), and the peak width (*y*-axis) were measured. All the measurements were recorded in an Excel data sheet in micrometers [Figure 1].

Measurement of surface microhardness

Surface microhardness of the specimens was determined using Digital Display Vickers Microhardness Tester (Model HVS-50; Laizhou Huayin Testing Instrument, China) with a Vickers diamond indenter and a 20x objective lens. A load of 200 g was applied to the surface of the specimens for 15 s. Three indentations were equally placed over a circle of 1 mm diameter at the middle third of the specimens. The diagonal length of each indentation was measured by a built-in scaled microscope and three Vickers values were taken for each specimen. The average of three Vickers values was calculated and taken as Vickers hardness number for each specimen.

Statistical analysis

Means and standard deviations were calculated for surface roughness and surface hardness. Data were analyzed by *t*-test to compare the means of two different composites and by one-way analysis of variance (ANOVA) to know the difference between different finish protocols for each composite, followed by Tukey's *post hoc* test. All statistical analyses were conducted at a significance level of $\alpha = 0.05$.

RESULTS

Surface roughness

The surface roughness (μm) results for both composite groups after different finish protocols are summarized in Table 1 and Figure 2. Among the nano-composite groups, it was found that the dry finish group recorded the highest surface roughness mean value (183.9 μm). The results of other groups were: 156.6 μm, 148.5 μm, and 142.9 μm for 24 h finish group, 15 min finish group, and immediate finish group, respectively. The non-finished group recorded the lowest surface roughness mean value (126.7 μm). This difference was statistically significant ($P < 0.05$).

Among the hybrid composite groups, it was found that 24 h finish recorded the highest surface roughness mean value (188.8 μm), followed by dry finish

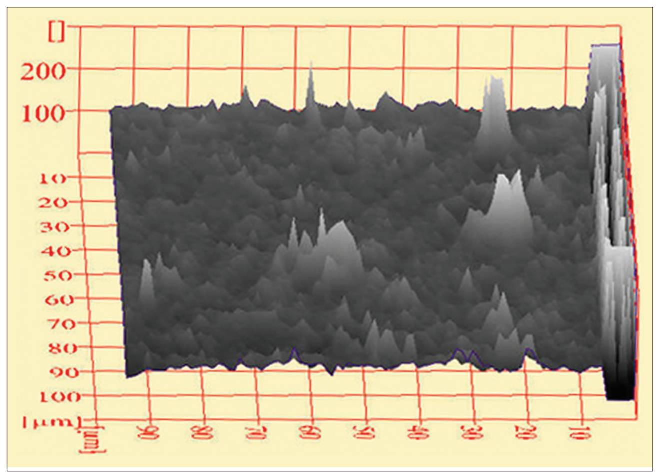

Figure 1: Scanned 3D image of surface roughness

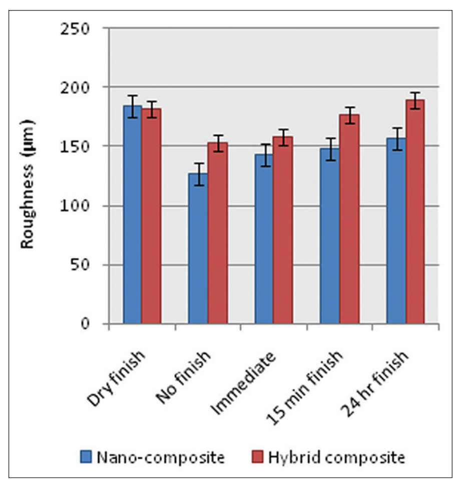

Figure 2: The mean values of surface roughness (μm) for both composite groups after different finishing protocols

Table 1: Surface roughness (mean±SD) for both composite types under different finishing protocols

	Dry finishing	No finishing	Immediate	15 min finishing	24 h finishing
Nano-composite	183.9±21.3	126.7±3.6	142.9±14.5	148.5±8.6	156.6±6.7
Hybrid composite	181.2±15.4	153.6±17.7	157.0±8.5	177.2±20.2	188.8±18.4

SD=Standard deviation

(181.2 μm), 15 min finish (177.2 μm), and immediate finish (157.7 μm) groups; however, non-finished group recorded the lowest surface roughness mean value (153.6 μm). Statistical analysis of the mean surface roughness revealed that the difference between different finish protocols for the hybrid composite group was significant ($P < 0.05$).

All the finish protocols in hybrid composite recorded a higher surface roughness mean value than in nano-composite (except dry finish) group ($P < 0.05$). No statistically significant difference in surface roughness was found between dry and 15 min finish groups ($P > 0.05$).

Vickers microhardness

Vickers microhardness (HV) results for both composite groups after different finish protocols are summarized in Table 2 and Figure 3.

Among the nano-composite groups, it was found that dry finish group recorded the highest microhardness mean value (69.04), followed by non-finished group, immediate finish group, and 24 h finish group (67.7 HV, 67.1 HV, and 65.9 HV, respectively), while 15 min finish group recorded the lowest microhardness mean value (61.3 HV). This difference was statistically significant ($P < 0.05$).

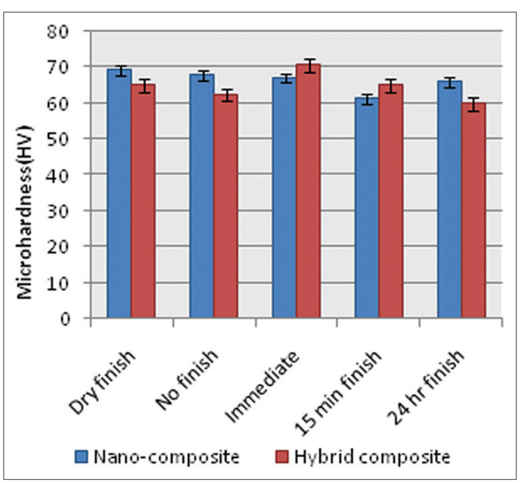

Figure 3: The mean values of microhardness for both composite groups after different finishing protocols

Among the hybrid composite groups, it was found that immediate finish group recorded the highest microhardness mean value (77.6 HV), followed by dry finish group, 15 min finish group, and non-finished group (65.4 HV, 63.6 HV, and 61.1 HV, respectively). However, 24 h finish group recorded the lowest microhardness mean value (59.8 HV). Statistical analysis of the mean microhardness by ANOVA revealed that the difference between different finish protocols for hybrid composite group was significant ($P < 0.05$).

All the finish protocols in the nano-composite group recorded a higher surface microhardness mean value than in the hybrid composite group (except dry finish) and the differences between both composite groups were statistically not significant ($P > 0.05$) except for non-finished and 24 h finish groups where the differences were statistically significant ($P < 0.05$).

DISCUSSION

It is the clinician's responsibility to deliver realistic restorations that closely mimic natural tooth structure. The finishing and polishing step is most important to maintain natural surface luster and contour.[19] It is recommended to perform finishing and polishing procedures immediately after curing.[4] This statement is based on the fact that hygroscopic expansion will improve marginal adaptation by closing the gap formed by polymerization shrinkage and finishing/polishing procedures.[4] Therefore, most dentists prefer to do the finishing and polishing step immediately after the light curing of the resin restoration, which is more acceptable and cost effective for the patient.

Contrary to the above recommendation, there are studies that recommend delayed polishing keeping in view that immediate polishing may lead to plastic deformation of resin which is cured 75% after 10 min.[20] It is also proposed to delay any finishing procedures until after hygroscopic expansion occurs because of the risk of fracture of the unsupported enamel surrounding the marginal gap.[14]

It is reported that the benefits of delayed versus immediate finishing were material and tooth structure dependent.[21]

Table 2: Vickers microhardness (mean±SD) for both composite groups after different finishing protocols

	Dry finishing	No finishing	Immediate	15 min finishing	24 h finishing
Nano-composite	69.0±7.1	67.7±4.5	67.1±3.5	61.3±3.2	65.9±5.6
Hybrid composite	65.4±7.8	61.1±5.4	77.6±7.5	63.6±5.1	59.8±5.7

SD=Standard deviation

In this study, two types of composite restorations were tested. The results showed that nanofilled composites had smoother surface under all conditions of finishing and polishing timings than micro hybrid composite. These results are in accordance with the study of Rai and Gupta.[22] It may be because of the combination of nanosized particles and the nanocluster formulations for nanofilled composite. The nanocluster filler particles consist of loosely bound agglomerates of nanosized filler particles. During abrasion, the primary particles (nanomer sized), and not the clusters themselves, can be worn away, rather than be plucked out; thus, smooth finish and higher gloss is retained over time. In the micro hybrid, the particle size is larger, leaving the surface rough due to pluck out of filler particles after wearing out of resin matrix during polishing.[21] Contrary to our study, Silikas *et al*.[23,24] compared the surface roughness of micro hybrid and nanohybrid and found no difference in surface roughness.

Smoothest surface was obtained under Mylar strip because of the resin layer at the surface.[25] In the current study, delayed finishing and polishing showed rougher surface on both types of composite restoration than immediate polishing and finishing. This may be related to the stress produced during the delayed polishing. These results are in accordance with the study conducted by Yazici *et al*.[15] and contrary to the study of Yap *et al*.[16,22] which concluded that the delayed finishing and polishing of polyacid-modified resins resulted in smoother surface.The authors attributed this result to the maturity of resin at the time of finishing and polishing.

In the present study, surface hardness was decreased in delayed finishing and polishing when compared to control, whereas hardness increased in immediate finishing and polishing for both resin groups. The decrease of hardness in delayed finishing was not significant in nanofilled composite, but it was significant in micro hybrid composite. This difference in the two resins may be because of the difference in matrix and filler component of resin.These results are in coincidence with the study of Cenci *et al*.[17] They attributed the decrease in hardness to the loss of surface properties after polymerization using a delayed polishing procedure.

On the other hand, another investigation proved that delayed finishing and polishing generally results in surface similar to or even harder than that obtained with immediate finishing and polishing.[26]

The dry finishing groups showed significant increase in the surface hardness of the nano-composite resin material and a non-significant increase of hardness of the surfaces of hybrid composite material. This result was expected due to the maturation of the resin matrix by the heat generated with no cooling system; however, this uncontrolled heat can create a lot of cracks and excessive roughness of the surface of the resin restoration,[18,27] which was clearly presented in the study.

CONCLUSION

- Smoother finish (nanohybrid- 126.7 µm and micro hybrid- 153.6 µm) was obtained under Mylar strip in all conditions
- Surface roughness was increased in delayed polishing procedures for both types of composites (nanohybrid- 156.6 µm and micro hybrid- 188.8 µm)
- Dry finish resulted in highest surface roughness in nanofilled (183.9 µm) and considerably high values in micro hybrid (181.2 µm) groups compared to the control group
- Surface hardness was decreased in delayed polishing procedure of both types of resin (nanohybrid- 65.9 VH, micro hybrid- 59.8 VHN) than the control group (67.7 VHN- nanohybrid and 61.1 VHN- micro hybrid)
- Immediate polishing and finishing increased the surface hardness than the control group in both types of composites (nanohybrid- 67.1 VHN, 77.6 VHN)
- Dry finish resulted in highest surface hardness for nanofilled composite (69 VHN).

Immediate finish under coolant resulted in highest surface hardness for micro hybrid resin (77.6 VHN).

Immediate polishing under coolant for micro hybrid resin composite is highly recommended. Dry and immediate finishing and polishing is also advised for nanohybrid resin composite to achieve the best physical properties.

REFERENCES

1. Jefferies SR. Abrasive finishing and polishing in restorative dentistry: A state-of-the-art review. Dent Clin North Am 2007;51:379-97, ix.
2. Lu H, Roeder LB, Lei L, Powers JM. Effect of surface roughness on stain resistance of dental resin composites. J Esthet Restor Dent 2005;17;102-9.
3. Koupis NS, Marks LA, Verbeeck RM, Martens LC. Review:

Finishing and polishing procedures of (resin-modified) glass ionomers and compomers in paediatric dentistry. Eur Arch Paediatr Dent 2007;8:22-8.
4. Yap AU, Ang HQ, Chong KC. Influence of finishing time on marginal sealing ability of new generation composite bonding systems. J Oral Rehabil 1998;25:871-6.
5. Remond G, Nockolds C, Philips M. Implications of polishing techniques in quantitative x- ray microanalysis. J Res Natl Inst Stand Technol 2002;107:639-62.
6. Kim KH, Ong JL, OkunoO. The effect of filler loading and morphology on the mechanical properties of contemporary composites. J Prosthet Dent 2002;87:642-9.
7. Setcos JC, Tarim B, Suzuki S. Surface finish produced on resin composites by new polishing systems. Quintessence Int 1999;30:169-73.
8. Jung M, Eichelberger K, Klimek J. Surface geometry of four nanofiller and one hybrid composite after one-step and multi-step polishing. Oper Dent 2007;32:347-55.
9. Cadenaro M, Biasotto M, Contardo L, Chiesa R, Di Lenarda R, Doringo E. Surface roughness of three resin restorative materials after finishing and polishing. Minerva Stomatol 2006;55:179-87.
10. Ferrancane JL, Mitchem JC, Condon JR, Todd R. Wear and marginal breakdown of composite with various degrees of cure. J Dent Res 1997;76;1508-16.
11. William JA. Wear and wear particles-some fundamentals. Tribiology International 2005;38:863-70.
12. da Silva JM, da Rocha DM, Travassos AC, Fernandes VV Jr, Rodrigues JR. Effect of different finishing times on surface roughness and maintenance of polish in nanoparticle and microhybrid composite resins. Eur J Esthet Dent 2010;5:288-98.
13. Davidson CL, Duysters PP, De Lange C, Bausch JR. Structural changes in composite surface material after dry polishing. J Oral Rehabil 1981;8:431-9.
14. Lopes GC, Franke M, Maia HP. Effect of finishing time and techniques on marginal sealing ability of two composite restorative materials. J Prosthet Dent 2002;88:32-6.
15. Yazici AR, Tuncer D, Antonson S, Onen A, Kilinc E. Effects of delayed finishing/polishing on surface roughness, hardness and gloss of tooth-coloured restorative materials. Eur J Dent 2010;4:50-6.
16. Yap AU, Sau CW, Lye KW. Effects of finishing/polishing time on surface characteristics of tooth-coloured restoratives. J Oral Rehabil 1998;25:456-61.
17. Cenci MS, Venturini D, Pereira-Cenci T, Piva E, Demarco FF. The effect of polishing techniques and time on the surface characteristics and sealing ability of resin composite restorations after one-year storage. Oper Dent 2008;33:169-76.
18. Ozgünaltay G, Yazici AR, Görücü J. Effect of finishing and polishing procedures on the surface roughness of new tooth-colored restoratives. J Oral Rehabil 2003;30:218-24.
19. Türkün LS, Türkün M. The effect of one-step polishing system on the surface roughness of three esthetic resin composite materials. Oper Dent 2004;29:203-11.
20. Asmussen E, Jorgensen KD. A microscopic investigation of the adaptation of some plastic filling materials to dental cavity walls. Acta Odontol Scand 1972;30:3-21.
21. Da Costa J, Ferracane J, Paravina RD, Mazur RF, Roeder L. The effect of different polishing systems on surface roughness and gloss of various resin composites. J Esthet Restor Dent 2007;19:214-26.
22. Rai R, Gupta R. *In vitro* evaluation of the effect of two finishing and polishing systems on four esthetic restorative materials. J Conserv Dent 2013;16:564-7.
23. Silikas N, Kavvadia K, Eliades G, Watts D. Surface characterization of modern resin composites: A multitechnique approach. Am J Dent 2005;18:95-100.
24. Mitra SB, Wu D, Holmes BN. An application of nanotechnology in advanced materials. J Am Dent Assoc 2003;134:1382-90.
25. Başeren M. Surface roughness of nanofill and nanohybrid composite resin and ormocer-based tooth-colored restorative materials after several finishing and polishing procedures. J Biomater Appl 2004;19:121-33.
26. Chinelatti MA, Chimello DT, Ramos RP, Palma-Dibb RG. Evaluation of the surface hardness of composite resins before and after polishing at different times. J Appl Oral Sci 2006;14:188-92.
27. Morgan M. Finishing and polishing of direct posterior resin restorations. Pract Proced Aesthet Dent 2004;16:211-8.

How to cite this article: Kaminedi RR, Penumatsa NV, Priya T, Baroudi K. The influence of finishing/polishing time and cooling system on surface roughness and microhardness of two different types of composite resin restorations. J Int Soc Prevent Communit Dent 2014;4:S99-104.

Source of Support: Nil, **Conflict of Interest:** None declared.