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A Study to Compare the Efficiency of Different Finishing-Polishing Systems on Surface Roughness of Nanohybrid Composite Resin

Tay Hatem Kadhom
M.Sc. in aesthetic and conservative dentistry/Department of university healthcare /Al-Nahrain university, Iraq.

Abstract

Aim: This in vitro study was aimed to investigate the influence of various finishing and polishing systems on the surface roughness of nanohybrid (IPS Empress Direct) composite resin.

Materials and Methods: A total of 50 disc-shaped specimens were prepared in composite resin using standardized cylindrical metallic mold (10 mm × 2 mm). All the samples were randomly divided into five groups each containing 10 discs: Group I — Mylar strip, Group II — Sof-Lex polishing system, Group III — Super Snap polishing system, Group IV — Opti1Step polishing system and Group V — OneGloss polishing system. The average surface roughness (Ra) of each specimen was measured three times and the mean Ra values were determined using a surface profilometer.

Results: The obtained data were collected and statistically analyzed using the one-way analysis of variance (ANOVA) test. Surface roughness was found to be in the following order: Mylar strip < Super Snap polishing system < SofLex polishing system < Opti1Step polishing system < OneGloss polishing system. This difference in surface roughness of composite resin was statistically significant ($P < 0.05$) in all the five experimental groups.

Conclusion: Surface roughness of composite resin depends on the composition, number of steps and flexibility of the finishing and polishing system employed.

Keywords: Surface roughness, finishing and polishing, composite resin

Introduction

The use of resin composites has significantly expandedin clinical practice over recent years because of the increasing esthetic demands and advancement in composite technology.The introduction of nanoparticle-filled composites with improved mechanical, physical, optical properties and clinical performance made possible the use of such materials for both the anterior and posterior restorations**(Ereifej et al.,2013)**.

Surface roughness of direct composite resinsremains a striking problem associated with increased plaque retention which resulting in gingival inflammation, superficial discoloration, and secondary caries. Also, surface roughness has a major influence on the wear of opposing and adjacent teeth. Conversely, smooth, highly polished restorations are less susceptible to accumulation of plaque and external discoloration with improved mechanical properties **(Patel et al., 2016)**.

Surface roughness of a composite resin associated with the composition and porosity of the material, nature of the instruments, and the polishing procedures used. The resin matrix and filler particles have different hardness levels causing variations in elimination efficiency during polishing, which leads to differences in surface roughness. Because of composition variety, types of resin, differences in filler particles, and the size and nature of abrading particles in the polishing tools, it is of significant importance to pair a composite resin with a matching polishing system. Other factors influencing polishing outcome may include the amount of pressure used, orientation of the abrading surface, the amount of time spent with each abrasive instrument and geometry (discs, cups, cones) of abrasive instruments**(Sapra et al., 2013)**.

A wide diversity of finishing and polishing tools are available which include carbide and diamond burs, abrasive disks, strips, abrasive impregnated rubber cubs and points, and finishing and polishing pastes.Each of these instruments or devices leaves the surface of various restorative materials with varying degrees of surface roughness. Recently, one-step polishing systems such as Opti1Step® (Kerr) and OneGloss® (Shofu INC, Japan) are introduced by which contouring, finishing, and polishing can be completed using a single instrument in minimal clinical time **(Januset al., 2010) (Erdemir et al., 2013) (Patel et al., 2016)** .

Roughness can be measured in multiple ways, but the most commonly used one both in dentistry and engineering is the surface roughness (Ra) value. surface roughness (Ra) is the arithmetic mean of vertical departure of a profile from the mean. Mechanical profilometer, scanning electron microscopy, optical three-dimensional (3D) profilometer, etc., are some of the methods used for measuring the Ra value **(Uppal et al., 2016)**.

Materials and Method

In the present study, the esthetic restorative material used was nanohybrid composite resin-IPS Empress Direct (Ivoclar-Vivadent, Schaan, Liechtenstein). Detailed information about the material is shown in Table 1. The finishing and polishing systems tested were Sof-Lex XT Pop-On (SL) discs (3M ESPE, St Paul, USA), Super-Snap Rainbow (SS) discs (Shofu INC., Kyoto, Japan), Opti1Step (OS) polishers (KerrHawe, Bioggio, Switzerland) and OneGloss (OG) polishers (Shofu INC., Kyoto, Japan). The composition and manufacturers of the evaluated polishing systems shown in Table 2.

Preparation of specimens

A total of 50 disc-shaped samples were prepared in composite resin using standardized cylindrical metallic molds (10 mm in diameter and 2 mm in height). The samples were fabricated by placing the restorative material directly into the mold in one increment using optrasculpt pad hand instrument. The mold was slightly overfilled with the material, covered on each side with matrix strip, and placed between two microscopic glass slides (1 mm thick each) and a constant pressure (1 kg weight) was applied for 20 seconds to extrude the excess material and forming a flat surface.

The restorative material was polymerized for 40 seconds each, from both sides, using LED curing light operating in standard mode and emitting no less than 600 mW/cm^2. The intensity of the polymerization light was measured frequentlywith a dentalradiometer placed on the curing unit before initiating the polymerization. The tip of the light curing unit was positioned perpendicular (at right angle) and in contact with the surface of the glass slide to keep a standard distance between the light curing unit and the specimen as 1 mm. Immediately after light curing, the polymerized specimens were removed from the mold and immersed in a container with distilled water at 37°C for 24 hours in an incubator prior to the finishing procedures.

Grouping of samples

After storage, all the specimens were randomly divided into five groups each containing 10 discs according to the polishing procedure as follows:

- Group I (n = 10) — Mylar strip
- Group II (n = 10) — Sof-Lex polishing system
- Group III (n = 10) — Super-Snap polishing system

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- Group IV (n = 10) — Opti1Step polishing system
- Group V (n = 10) —OneGloss polishing system

Finishing of samples
Except for the Mylar strip group, the specimens in all groups were surfaced with a fine diamond finishing burs, applied with light pressure for 15 seconds, using high-speed handpiece under water cooling to simulate a clinical initial finishing procedure. The finishing procedure was carried out in a single direction that was previously traced onto the sample surface. Care was taken to maintain parallelism during preparation of specimens. After application on five samples, a newfinishing bur was used.

Polishing of samples
The five groups were polished according to their respective manufacturer's instructions as follows:

Group I (Control group, Mylar strip group): No finishing or polishing treatment were carried out after polymerization against the Mylar strip.

Group II (Sof-Lex group): the specimens were polished with the medium grit aluminum oxide-impregnated discs at 10,000 rpm for 20 seconds and then with the fine and superfinegrit aluminum oxide-impregnated discs each for 20 seconds at 30,000 rpm under dry conditions. After each polishing step, the specimens were thoroughly rinsed with water for 10 seconds to remove debris, air-dried for 5 seconds, and then polished with another disc of lower grit for the same period of time until final polishing.

Group III (Super-Snap group): the samples were polished with the medium grit silicon carbide-impregnated discs at 10,000 rpm for 20 seconds and then with the fine and superfinegrit aluminum oxide-impregnated discs each for 20 seconds at 10,000 rpm under dry conditions. After each polishing step, the specimens were thoroughly rinsed with water for 10 seconds to remove debris, air-dried for 5 seconds, and then polished with another disc of lower grit for the same period of time until final polishing.

Group IV (Opti1Step group): the specimens were polished with diamond-impregnated disc-shaped One-step finisher and polisher, first with heavy pressure and then with light pressure at 10,000 rpm for 20 seconds under dry conditions. After polishing step, the specimens were thoroughly rinsed with water for 10 seconds to remove debris and then air-dried for 5 seconds.

Group V (OneGloss group): the samples were polished with aluminum oxide-impregnated disc-shaped One-step finisher and polisher, first with heavy pressure and then with light pressure at 10,000 rpm for 20 seconds under dry conditions. After polishing step, the specimens were thoroughly rinsed with water for 10 seconds to remove debris and then air-dried for 5 seconds.

In this study, disk-shaped polishers were used in order to obtain direct contact with the surfaces of the specimens. For all polishing systems, a slow-speed handpiece was used in a single direction that was previously traced onto the specimen surface with light hand pressure. For each sample, a new polishing disc and a new polisher were used and discarded after each use. samples were placed on a small bench vice with double-sided adhesive tape to obtain standardized constant position, facilitating the finishing and polishing procedures. Same operator carried out all specimen preparations, finishing and polishing procedures in order to reduce variability.

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Table 1: Properties of the composite resin tested

Composite Resin	Type	Composition	Shade	Filler Loading wt (%)	Lot #
IPS Empress Direct (Ivoclar-Vivadent, Schaan, Liechtenstein)	Nanohybrid	**Matrix**: Dimethacrylate **Filler**: Barium glass filler (0.4 µm), mixed oxide (150 nm) and Ba-Al-fluorosilicate glass	A2E	78.1	V14185

Table 2: The composition and manufacturers of theevaluated polishing systems

Polishing Systems	Composition	Manufacturers
Sof-Lex Extra Thin (XT) Pop-On (SL) Discs	Aluminum oxide-coated Discs Medium (30 µm) Fine (30 µm) Superfine (3 µm)	(3M ESPE, St. Paul, MN, USA)
Super-Snap Rainbow (SS) Discs	Silicon Carbide- / Aluminum oxide-coated Discs Medium (30 µm) Fine (20 µm) Superfine (7 µm)	(Shofu INC., Kyoto, Japan)
Opti1Step (OS) Polishers	Diamond-impregnated Polishers	(KerrHawe, Bioggio, Switzerland)

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OneGloss (OG) Polishers	Silicon with integrated Aluminum oxide abrasive Polishers	(Shofu INC., Kyoto, Japan)

Measurement of surface roughness

After polishing procedure, the polished specimens were washed, allowed to dry and stored in 100% humidity for 24 hours before measuring the average surface roughness values (Ra). The average surface roughness (Ra) of each sample was measured three times and the mean Ra values were determined with a cut-off value of 0.25 mm and a tracing length of 5 mm near the center of each specimen using a surface profilometer (TR 200, Germany). Average Surface Roughness is the arithmetic average height of roughness component irregularities from mean line measured within the sampling length and is expressed in microns (μm).

Statistical analysis

Descriptive statistics including: minimum, maximum, mean and standard deviation were calculated for the surface roughness (Ra) values (μm) of each group. The data were collected and analyzed using Statistical Package for Social Sciences (SPSS) software version 23. One-Way Analysis of Variance (ANOVA) test and Least Significant Difference (LSD) test were used to determine whether there is a statistical difference among the groups. In the above tests, P values more than 0.05 considered as statistically non-significant, whereas P values less than or equal to 0.05 regarded as significant and P values less than 0.01 considered as statistically highly significant.

Results

Mean values and standard deviations (±SD) of the surface roughness (Ra, μm) for all groups are listed in Table 3 and presented graphically in Figure1. Results of the one-way ANOVA demonstrated that among all the experimental groups, surface roughness was found to be in the following order: Mylar strip < Super Snap polishing system <SofLex polishing system < Opti1Step polishing system < OneGloss polishing system. This difference in surface roughness was statistically significant ($P < 0.05$) in all the fiveinvestigated groups.

Table 3: Mean surface roughness (Ra, μm) values and standard deviations (±SD) for the polishing systems investigated

Polishing systems	**Number**	**Mean**	**Std. Deviation**
Mylar strip	10	0.0138	0.00132
Sof-Lex	10	0.3133	0.02431

Super-Snap	10	0.1860	0.01217
Opti1Step	10	0.3757	0.01181
OneGloss	10	0.7860	0.00776

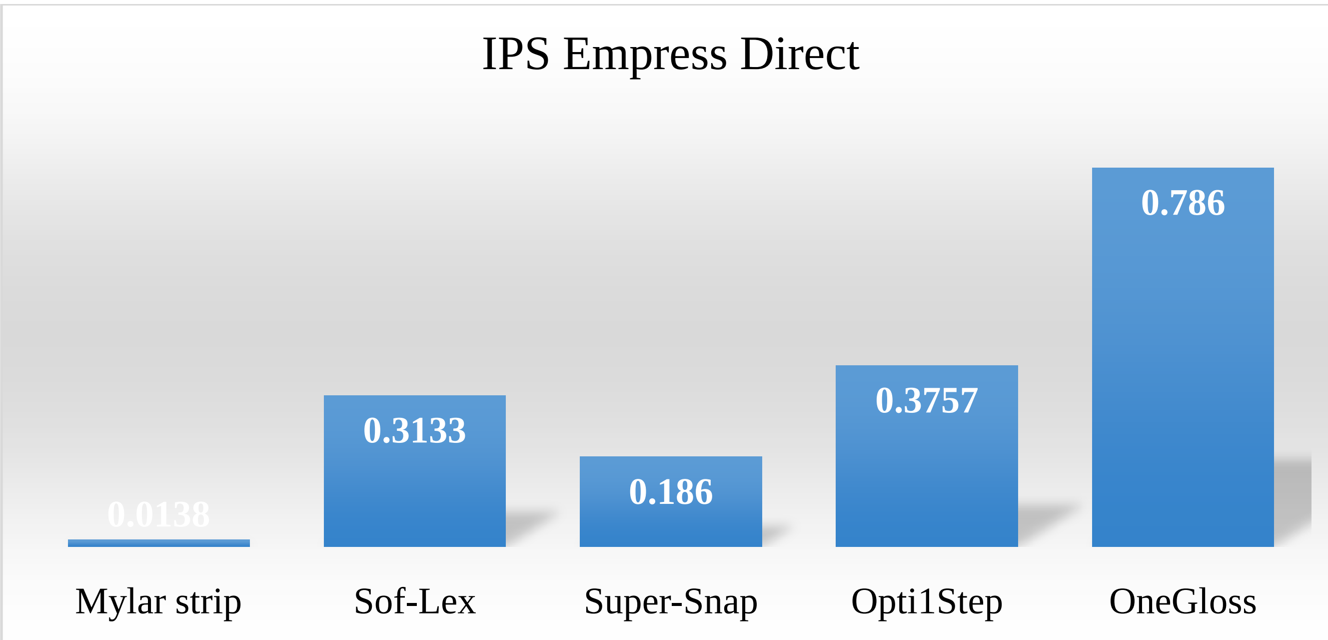

Figure 1. Surface roughness of the polishing systems tested.

Discussion

Finishing and polishing procedures of resin composite restorations are critical steps to enhance the esthetics and longevity of restored teeth. Finishing refers to the contouring of the cured restoration whereas polishing decreases the roughness created by finishing instruments. It is clinically important to determine the finishing technique that will result in the smoothest surface using minimum clinical time and instruments **(Korkmaz et al., 2008) (Dutta** and**Maria, 2012)**.Nanohybrid composite resin combines the desirable properties of polishability and strength and can be used as an anterior and posterior restoration **(Uppal et al., 2016)**.

In the present study, the mylar strip (control polishing group) exhibited significantly lower roughness values (smoothest surface) than the polishing systems ($p<0.05$). this finding in agreement with **Ereifej et al.** in**2013**. Although the surface obtained with a mylar matrix is perfectly smooth, it is rich in organic resin. Therefore, elimination of the outer-most layer of resin by finishing-polishing procedures would tend to produce a harder, more wear resistant and, hence, a more esthetically stable surface**(Korkmaz et al., 2008) (Erdemir et al., 2012)(Patel et al., 2016)**. This surface is also limited by the anatomy complexity and restorative procedures,

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being the functional occlusal adjustment is mandatory in almost every restoration **(Costa et al., 2007)(Schmitt et al., 2016)**. Several studies showed that the smoothest surfaces were obtained by curing nanohybrid resin composite materials against a matrix strip **(Ergücü** and **Türkün, 2007) (Senawongse** and **Pongprueksa 2007) (Endo et al., 2010) (Erdemir et al., 2012) (Schmitt et al., 2016) (Patel et al., 2016) (Uppal et al., 2016)**. Conflicting to the present study findings were reported by **Sapra et al.** in **2013**.This might be due to that in their study, baseline roughening of all the samples was done (including controls), whereas in this study, composite surfaces created by mylar strips considered as controls.

In this study, the SuperSnap polishing system showed significantly lower surfaces roughness values than the Soft-Lex polishing system. **Uppal et al.** in **2016** showed the same results innanohybrid composite (Filtek Z250XT). This might be attributed to differences in the composition between these polishing systems. In this context, **Rai** and **Gupta** in **2013** showed that Super-Snap polishing kit produces decreased surface roughness as compared to Sof-Lex polishing kit in Z350XT (Nanofilled composite) and Z250 (Microhybrid composite). These results are supported by **Barbosa et al.** in **2005** who observed smoother surfaces by Super-Snap system as compared to Sof-Lex system suggesting a better ability of Super-Snap discs to remove the scratches left by diamond burs.

The results of the present study showed that Sof-Lex and SuperSnap polishing systems produced significantly smoother surfaces than Opti1Step and OneGloss polishing systems. This might be assigned to the increased number of steps used and the time spent during finishing and polishing procedures with multi-step systems which promote even reduction of filler particles and organic matrix phases of composite resin.In this regard, **Sudha et al.**, in **2017** found that for nanohybrid composite resin (Tetric N-Ceram), diamonds (PoGo) abrasives gave a surface finish rougher than that produced by aluminum oxide (Super-snap) discs. In addition, **Schmitt et al.** in **2016** stated thatmultiple-step polishing procedure (Soft-Lex discs) produced lower surface roughness values than one-step polishing system (PoGo) for two nanohybrid composite resins: TetricEvo Ceram and Ceram X Duo. **Lainović et al.** in **2013** showed that multi-step polishing protocol (SuperSnap discs) produced significantly smoother surface and lower AFM surface texture parameters than one-step polishing protocol (OneGloss) for nanohybrid composite resin (Filtek Z550), they stated that the reasons for these results lay in the polishing mechanisms of differently designed polishers that multi-step finishers and polishers are elastic silicone sandpapers, with four successively reduced grits, consisting of silicone carbide (Black and Violet sandpaper) and aluminium-oxide particles (Green and Red sandpaper), whereas, OneGloss is a one-step, aluminium-oxide impregnated rigid silicone polisher which is designed with the idea to save clinical operative time, and to serve either for finishing, or polishing only by altering the contact pressure. Polishing with OneGloss tool causes greater microploughing of the material and dislodging of filler or resin particles.In disagreement with the current study results, **Ereifej et al.** in**2013** demonstrated that for nanohybrid composite resin (IPS Empress Direct), aluminum oxide discs used (OptiDisc and Kenda) resulted in poorer finish than one-step diamond polishers of Opti1Step and PoGo, this might be attributed to differences in the multiple-step polishing systems used, in addition to differences in samples finishing and method of measurement, the authors used sandpaper polishing (600 grit) and a noncontact optical interferometric profilometer.Nevertheless, the use of one-step polishers is recommended to save time and costs.

The results of thisin-vitro study showed that Opti1Step diamond polishers produced lower surface roughness values than OneGloss aluminum oxide polishers, this could be related to the composition and optimized flexibility of Opti1Step polisher so that it eliminates the scratches on the composite surfaces produced by the diamond burs during the finishing step better than OneGloss polisher. The efficiency of abrasive systems is related to flexibility of the backing material in which the abrasive is embedded, hardness of the abrasive, geometry of the instrument and how the instruments are used.For a composite resin finishing system to be effective, the abrasive particles must be relatively harder than the filler materials. Otherwise, the polishing agent will only remove the soft resin matrix and leave the filler particles protruding from the surface. These results supported by **Ergücü** and **Türkün** in **2007**, who showed that for nanohybrid composite resins (Tetric EvoCeram, Premise and CeramX), PoGo (diamond micro-polisher) created statistically significant smoother surfaces ($p<0.05$) than OneGloss. In addition, **Patel et al.,** in **2016** demonstrated that for nanohybrid composite resin (Tetric N-Ceram), PoGo polishing system provided smoother surface finish as compared to OneGloss polishing system.

Conclusion

Surface roughness of composite resin depends on the composition, number of steps and flexibility of the finishing and polishing system employed.

References

1. Ereifej NS, Oweis YG, Eliades G. The Effect of Polishing Technique on 3-D Surface Roughness and Gloss of Dental Restorative Resin Composites. Operative Dentistry 2013; 38(1):9-20.
2. Sapra V, Taneja S, Kumar M. Surface geometry of various nanofiller composites using different polishing systems: A comparative study. J Conserv Dent 2013; 16:559-63.
3. Patel B, Chhabra N, Jain D. Effect of different polishing systems on the surface roughness of nano- hybrid composites. J Conserv Dent 2016; 19:37-40.
4. Erdemir U, Yildiz E, Eren MM, Ozsoy A, Topcu FT. Effects of polishing systems on the surface roughness of tooth-colored materials. Journal of Dental Sciences 2013; 8:160-169.
5. Janus J, Fauxpoint JG, Arntz Y, Pelletier H, Etienne O. Surface roughness and morphology of three nanocomposites after two different polishing treatments by a multitechnique approach. dental materials 2010; 26:416–425.
6. Uppal M, Arora, Kataria P. Profilometric Analysis of Nanohybrid Composite Surface Polished with Three Polishing Systems: An in vitro Study. International Journal of Oral Care and Research 2016;4(4):255-258.
7. 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; 33:44-50.
8. Dutta S, Maria R. The Effect of Various Polishing Systems On Surface Roughness of Nano and Microhybrid Composite Restoratives: An in Vitro Surface Profilometric Study Indian Journal of Basic & Applied Medical Research 2012; 3(1):214-220.
9. 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.
10. Erdemir U,Sancakli HS, Yildiz E. The effect of one-step and multi-step polishing systems on the surface roughness and microhardness of novel resin composites. Eur J Dent 2012; 6:198-205.
11. 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

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 9709 - 9717
Received 25 April 2021; Accepted 08 May 2021.

Restor Dent 2007; 19: 214-226.
12. Schmitt VL, Nahsan FPS, Naufel FS Vaez SC, de Andrade CS, Baseggio W, Sinhoreti MAC, Puppin-Rontani RM. Polishing techniques effect on microhybrid, nanohybrid and nanofilled composites color and surface roughness stability. Biosci. J., Uberlândia 2016: 32(1): 262-271.
13. Ergücü Z, Türkün LS. Surface Roughness of Novel Resin Composites Polished with One-step Systems. Operative Dentistry 2007; 32(2):185-192.
14. Senawongse P, Pongprueksa P. Surface Roughness of Nanofill and Nanohybrid Resin Composites after Polishing and Brushing. J Esthet Restor Dent2007; 19:265–275.
15. 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.
16. Barbosa SH, Zanata RL, Navarro MF, Nunes OB. Effect of different finishing and polishing techniques on the surface roughness of microfilled, hybrid and packable composite resins. Braz Dent J 2005; 16:39-44.
17. Sudha K, Hanisha RK, Seema RO,Laxmana RC, Leela NPT, Sravana LP. Effect of different polishing systems on the surface roughness of nano-hybrid composites: A profilometric study. Annals and Essences 2017; 9(4):1-4.
18. Lainović T , Blažić L , Vilotić M , Kakaš. Effect of diamond paste finishing on AFM surface texture parameters and topography of dental nanocomposites polished by two different procedures. IJIRSET 2013; 2(12): 7353-7359.