Original Article

Evaluation of Surface Roughness of Different Direct Resin-based Composites

Nashaat Mohammed Magdy, Mohammed Zaheer Kola[1], Hamod Hussain Alqahtani, Mubarak Daghash Alqahtani[2], Abdullah Saud Alghmlas[3]

Department of Conservative Dental Science, [1]Department of Prosthetic Dental Sciences, College of Dentistry, Prince Sattam Bin Abdulaziz University, [2]Intern, College of Dentistry, King Khalid University, [3]General Dental Practitioner at Presidency of the Royal Guard, Kingdom of Saudi Arabia

ABSTRACT

Aims and Objective: To evaluate surface roughness of different resin-based composites.

Materials and Methods: Three resin composites, one nanohybrid, one nanoceramic, and one bulk-fill resin-based composite, were used in this study. Cylindrical Teflon mold and 8 mm in diameter and 2 mm in thickness disc specimens were prepared. For each composite material, 15 discs were fabricated, with a total of sixty discs were obtained (n = 60). A glass slide 1–2 mm thick was placed over the strip before curing with the light-curing unit to flatten the surfaces. The specimens were then cured for 40 s through the Mylar strip and the glass slide. Five specimens per each material received no finishing treatment after being cured under Mylar strips; these specimens served as a control. Ten specimens from each composite material were finished/polished with Eve discs at coarse, medium, fine, and superfine grits for 30 s (using stopwatch) each on the specimens. After polishing, the composite surfaces were assessed quantitatively by profilometry and qualitatively by scanning electron microscopy. Data were analyzed using SPSS software.

Results: Tetric Evo Ceram and Tetric Evo Ceram Bulk-Fill specimens polished with Eve revealed slightly the same surface appearance as the Mylar strip. Eve discs scratched and exposed fillers of Ceram-x. Eve discs for Z250 surfaces exposed and scratched the filler particles but less than occurred with Ceram-x.

Conclusion: Bulk-Fill and nanohybrid resin composites exhibit smoothest surfaces compared with nanoceramic and microhybrid resin composites after polishing.

Keywords: *Bulk-fill composite, nanohybrid composite, scanning electron microscopy, surface roughness, tooth-colored restorative*

Received : 22-02-17.
Accepted : 05-04-17.
Published : 22-05-17.

Introduction

The continuous development of esthetically acceptable adhesive restorative materials has made a variety of tooth-colored materials available for clinical use.[1] Currently, the clinician has resin composite, polyacid-modified resin composite, resin-modified glass ionomer, and traditional glass ionomer restoratives as options for direct restorations.[2] In addition, resin composite materials are available with a variety of filler types that affect both their handling characteristics and physical properties. The ultimate esthetics of these tooth-colored restoratives are strongly influenced by the final surface polish.[3,4]

The proper finishing and polishing of dental restoratives are critical clinical procedures that enhance the esthetics and longevity of restorations.[5] The surface texture of dental materials has a major influence on plaque accumulation, discoloration, wear, and esthetical appearance of direct and indirect restorations.[6] Furthermore, a smooth surface adds to the

Access this article online

Quick Response Code:

Website: www.jispcd.org

DOI: 10.4103/jispcd.JISPCD_72_17

Address for correspondence: Dr. Nashaat Mohammed Magdy, College of Dentistry, Prince Sattam Bin Abdulaziz University, Al Kharj, KSA.
E-mail: nashaatmagdy1@gmail.com

How to cite this article: Magdy NM, Kola MZ, Alqahtani HH, Alqahtani MD, Alghmlas AS. Evaluation of surface roughness of different direct resin-based composites. J Int Soc Prevent Communit Dent 2017;7:104-9.

patient's comfort, as a change in surface roughness of 0.3 μ can be detected by the tip of the tongue.[7]

Early studies have shown that smoothest surface of a restoration is attained when the resin is polymerized against an appropriate matrix strip. When such a matrix is not used, polymerization of the outer layer is inhibited, resulting in a surface layer rich in organic binder, which has a sticker, softer consistency.[8] Since such a finish cannot be maintained, further contouring and finishing are required.[9] Finishing is the gross contouring of a restoration to obtain desired anatomy, whereas polishing refers to the reduction of the roughness and removal of scratches created by finishing instruments.[10] Research has been done to develop new monomers for resin matrix and studies that focus on loading, particle size, and silanation have been conducted on the filler content.[11-13]

In recent years, efforts have been made to analyze the suitability of numerous systems available for the finishing and polishing of composites. The effect of polishing systems on surface finish has been reported to be material dependent, and the effectiveness of one-step systems was mostly material dependent.[14] To date, little information is available on how to finish and polish nanostructured resin composites. With the development of nanocomposites, update evaluations of polishing procedures and their impact on bacterial adhesion are necessary.

Materials and Methods

The study was conducted in the Department of Conservative Dental Science, College of Dentistry, Prince Sattam Bin Abdulaziz University, KSA; wherein three resin composites, one nanohybrid, one nanoceramic, and one bulk-fill resin-based composite, were used in this study. The study was approved and cleared by the Institutional Ethical Committee vide approval letter no. EC 6426279S. The resin composites evaluated were Tetric Evo Ceram, Ceram-x, Tetric N Ceram Bulk-fill, and Z250 as a control. Table 1 shows the materials tested.

Surface roughness test

Cylindrical Teflon mold and 8 mm in diameter and 2 mm in thickness disc specimens were prepared. For each composite material, 15 discs were fabricated, with a total of sixty discs were obtained (n = 60). The composite materials were placed in the mold using OptraSculpt (Ivoclar Vivadent, Schaan, Liechtenstein) modeling instruments; the composite materials were covered with a Mylar strip. A glass slide 1–2 mm thick was placed over the strip before curing with the light-curing unit (Astralis, Ivoclar Vivadent, Schaan, Liechtenstein) to flatten the surfaces. The specimens were then cured for 40 s through the Mylar strip and the glass slide. After every five specimens, the light output was checked using a photometric tester (Radiometer/Dentek, Inc., Buffalo, NY, USA) that exceeded 400 mW/cm. The cured specimens were then stored in 100% humidity at 37 c for 24 h before finishing procedures.[12,15]

Five specimens per each material received no finishing treatment after being cured under Mylar strips; these specimens served as a control. The remaining forty specimens among the tested materials were ground wet with 320 grit silicon carbide (SiC) paper.[16,17] A slow speed handpiece rotating at a maximum 15,000 rpm was used with a constant moving repetitive stroking action to prevent heat buildup and the formation of grooves. A new polishing disc was used for each specimen and was discarded after each use.

Ten specimens from each composite material were finished/polished with Eve discs at coarse, medium, fine, and superfine grits for 30 s (using stopwatch) each on the specimens. After each step of polishing, all specimens were thoroughly rinsed with water and air-dried before the next step until final polishing.

After polishing, the composite surfaces were assessed quantitatively by profilometry (Surtronic 3+, Taylor-Hobson, England) and qualitatively by scanning electron microscopy (SEM). The Surtronic 3+ System includes display and traverse unit, pick-up and diamond stylus, calibration standard, carrying case, and battery. The system is usable handheld on horizontal, vertical, and inclined surfaces or bench mounted with accessories for batch measurement or laboratory applications. The pickup holder is mounted on a slide for vertical adjustment and can also be rotated to different measuring positions including right-angled measurements. Roughness is produced by the action of the cutting tool or machining process usually in the form of process marks. Surface roughness was described by the arithmetic mean of the absolute ordinate values (average roughness Ra, as per ISO 4287).[10]

Scanning electron microscopy evaluation test

For SEM evaluation, three specimens of each composite were randomly selected. The specimens were gold coated with the SCD 040 spattering device (Bal-Tec, Blazers, Liechtenstein). The SEM study was performed with JEOL JSM 6060 (JEOL JSM 6060, Tokyo, Japan) at a working tension of 25 kV. Photomicrographs of each surface were taken at ×2000 original magnification. Photo prints 16 cm ×12 cm in size were used. They were subdivided into 48 squares, with each square being assessed separately with respect to surface roughness, using four grading according to vision; smooth, homogenous surface or minor roughness or severe roughness or detrimental surface area.

During SEM examination, the type of composite was blind. After calibration in qualitative evaluation of roughness, assessment of the photomicrographs was carried out by two individuals.[15]

Statistical analysis

Ra values were distributed normally; statistical analysis was carried out using SPSS software (Version 21.0, SPSS Inc., Chicago, IL, USA). One-way ANOVA and *post hoc* tests (according to Scheffe's method) were employed.

Results

Surface roughness evaluation

Univariate analysis of variance with 4 × 4 factorial randomized design models was used for statistical analysis, with a significance level at 0.05. When there was an interaction between the resin composites and polishing system, one-way ANOVA was used. The homogeneity of variances was checked with Levene statistic (P = 0.05). The F-test and *post hoc* Duncan's tests were used when the variances were homogeneous. When the variances were not homogeneous, differences between the groups were checked using Welch test and *post hoc* Dunnett C-test.

Table 2 summarizes the average surface roughness values, standard deviations, and standard error. A Mylar strip was used as the control, and the surface roughness values for all tested resin composites were compared to that of the Mylar test.

Scanning electron microscopy evaluation

Qualitative assessment of the SEM photomicrographs accorded well with the quantitative results. SEM analysis of the Tetric Evo Ceram and Tetric Evo Ceram Bulk-Fill specimens polished with Eve revealed slightly the same

Table 1: Restorative materials investigated

Resin composite	Composition	Manufacturer	Filler content (percentage by weight)
Tetric N Ceram Bulk-Fill: Bulk-fill resin composite	Matrix: Dimethacrylate Filler: Barium glass, ytterbium trifluoride, mixed oxide, additives, catalysts, stabilizers, and pigments	Ivoclar Vivadent, Schaan, Liechtenstein	75-77
Tetric Evo Ceram: Nanohybrid resin composite	Matrix: Dimethacrylates, additives, catalysts, stabilizers, pigments Filler: Barium glass, ytterbium trifluoride, mixed oxide, prepolymers, 68% content by volume	Ivoclar Vivadent, Schaan, Liechtenstein	82.5
Ceram-x: Nanoceramic resin composite	Matrix: Methacrylate modified polysiloxane, dimethacrylate resin Filler: Barium-aluminum-borosilicate glass (0.04-1.2 um), silicon dioxide Ormocer, fluorescent pigment, UV stabilizer	Dentsply/Caulk, Milford DE, USA	69.5
Z250: Microhybrid resin composite	Matrix: BisGMA, TEGDMA Filler: Zirconia-silica (0.04-3.5 um), 66% content by volume	3M Dental Products, St Paul, MN, USA	66

UV=Ultraviolet

Table 2: Mean roughness values (um), standard deviations, and standard errors for the various materials evaluated

Restorative materials	Polishing systems	*n*	Mean roughness values	SD	SE
Tertric N Ceram Bulk-Fill	Mylar	10	0.066	0.014	0.006
	Eve	10	0.204	0.023	0.007
Tetric Evo Ceram	Mylar	10	0.112	0.030	0.013
	Eve	10	0.181	0.068	0.022
Ceram-x	Mylar	10	0.180	0.020	0.008
	Eve	10	0.451	0.040	0.013
Z250	Mylar	10	0.092	0.020	0.008
	Eve	10	0.292	0.061	0.019
*P**	<0.001				

$P<0.001$ - significant difference at $P<0.05$. n=Number of specimens, SD=Standard deviation, SE=Standard error

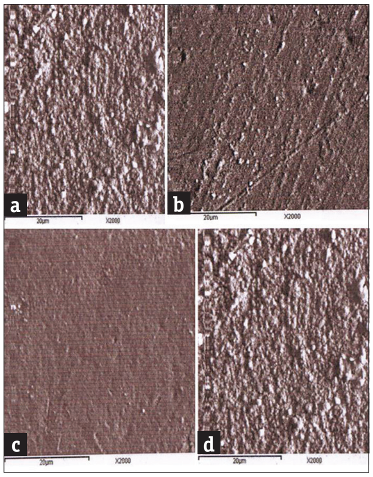

Figure 1: Scanning electron microscopy analysis after polishing; (a) Z250, (b) Tetric Evo-Ceram, (c) Tetric Evo-Ceram bulk-fill, and (d) Ceram-x

surface appearance as the Mylar strip. Eve discs scratched and exposed fillers of Ceram-x. Eve discs for Z250 surfaces exposed and scratched the filler particles but less than occurred with Ceram-x as shown in Figure 1.

Discussion

Proper finishing of restorations is desirable not only for esthetic considerations but also for oral health. The primary goal of finishing is to obtain a restoration that has good contour, occlusion, healthy embrasure forms, and a smooth surface. Bacterial adhesion to the surface of composite resins and other dental restorative materials is an important parameter in the etiology of secondary caries formation.[15,16] Hardness of material is defined as its resistance to permanent surface indentation or penetration, and this property is related to material strength, ductility, elastic stiffness, plasticity, strain, toughness, viscoelasticity, and viscosity.[17,18]

In addition, the effect of composition, degree of conversion, finishing, and polishing procedures can also affect the surface quality of composite resins. For this reason, the surface finish of composite resin is dependent on the microstructure and also on the finishing and polishing systems used to modify their surface.[19,20] Literature has well reported no appreciable difference in plaque accumulation between surfaces polished by different methods that resulted in standard surface Ra values in the range of 0.7–1.4 µm. Mostly, the Ra value was measured in each sample after the finishing and polishing procedures following the manufacture's instruction using a surface profilometer.[21,22]

The present study compared the surface roughness of different composite resin restorative materials; nanohybrid (Tetric Evo Ceram), nanoceraic (Ceram-x), Bulk-fill resin composite (Tetric Evo Ceram Bulk-Fill), and microhybrid resin composite (Z250) after finishing/polishing with Eve system. These restorative materials were selected because they have different filler load. Profilometers have been used for years to measure surface roughness in laboratory investigations.[23,24] More valid predictions of clinical performance can be made when the surface roughness measurements are combined with a SEM analysis that permits evaluation on the destructive potential of a finishing tool.[25] In this study, surface roughness measurements were used for relative comparisons, and the results of the profilometric measurements were largely confirmed by SEM analysis.

Regarding the surface roughness of the different restorative resin composites investigated in this study, Mylar strip produced the smoothest surface in all restorative resin composite groups tested (Ra =0.112 µm). The efficiency of abrasive systems is usually 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.[14] For a composite finishing system to be effective, the abrasive particles must be relatively harder than the filler materials. If not, the polishing agent will only remove the soft resin matrix and leave the filler particles protruding from the surface. Even though the effects of previous finishing instruments on the surface roughness of resin composites have been well studied, the results are controversial.[26] This difference is partly attributed to the size, hardness, and amount of filler of the resins used to restore the teeth. When surface roughness is evaluated, another contributing variable is the resin composite system.

Eve discs produced smoothest surfaces for Tetric Evo Ceram (Ra =0.204 µm) and Tetric Evo Ceram Bulk-Fill (Ra =0.181 µm). This can be attributed to the fact that two products are from the same manufacturer and may be more compatible with each other. An important factor is the intrinsic roughness of a composite material, which is determined by the size, shape, and quantity of the filler particles. During polishing, these particles can be worn away, rather than plucking out the large second particle from the resin itself. Eventually, the surfaces have smaller defects and better polish retention. On the other hand, Ceram-x surfaces (Ra = 0.451 µm) and Z250 (Ra = 0.292 µm) produced the roughest surface among resin composites tested. This may be attributed to both materials containing Barium glass filler. Z250 surfaces (Ra = 0.292 µm) produced less rough surfaces, and this may be attributed to Z250 contains the same filler (Zirconia/silica). Abdurazaq and Al-Khafaji in a similar study on nanohybrid, nanofilled, and microhybrid also concluded that all composites exhibited surface roughness, wherein nanohybrid exhibited consistent results in surface roughness values. This was in accordance to the results exhibited in our study.[27] Giacomelli *et al.* in a similar study on different polishing systems and composites concluded that all composites and polishing systems generally exhibit surface roughness.[28] Their compilation of results was found to be comparable and close to our study results. Hosoya *et al*. estimated surface roughness soon after polishing with different grit SiC paper. However, their results showed that surface roughness and color changes were greater with nanoceramics.[29] This is also in agreement with our study results; however, the differences in results other samples may be explained on the basis of method of surface roughness measurement in ours and their study. Furthermore, nanoceramics release more TEGDMA (monomer) than microhybrid composites. Nanoceramics may present higher degradation in the oral environment than hybrid ones. This happens as the result of water sorption which leads to monomer elution.[30]

According to the SEM images of Tetric Evo Ceram Bulk-Fill, no particle dislodging was observed, whereas the large glass fillers (0.04–1.2 μm) of Ceram-x were plucked away, leaving voids, or craters behind after being polished with Eve discs. Z250 also displayed a rougher surface after the application of Eve although it did not contain large glass fillers as did Ceram-x. This may be due to the fact that the effectiveness of the polishing systems was material dependent. In our study, we evaluated total sixty samples, wherein Bulk-Fill and nanohybrid resin composites showed smoothest surfaces compared with nanoceramic and microhybrid resin composites. Nevertheless, the results of this *in vitro* study sought to be compared with other studies of larger sample size. Results of the present study must also be interpreted with caution since in clinical practice; the intricate use of restorative materials and polishing systems could be limited to the real accessibility and uniformity of the surfaces to be finished. Further studies are also need to be conducted to determine the most appropriate finishing technique in clinical practice that can offer the best possible clinical results.

Conclusion

Within the limitations of the study, it was concluded that the general effect of a finishing and polishing system on surface roughness is largely dependent on both the polishing system and the restorative material. Among the tested materials, Bulk-Fill and nanohybrid resin composites exhibited smoothest surfaces compared with nanoceramic and microhybrid resin composites after polishing.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Yap AU, Lye KW, Sau CW. Surface characteristics of tooth-colored restoratives polished utilizing different polishing systems. Oper Dent 1997;22:260-5.
2. Solomon RV, Byragoni C, Jain A, Juvvadi Y, Babu R. An *in* vitro evaluation of microhardness of different direct resin-based restorative materials on using 10% carbamide peroxide gel as a bleaching agent. J Oral Res Rev 2016;8:59-65.
3. Al-Mansour KA, Al-Qussier AM. The effect of 10% carbamide peroxide bleaching gel on the microhardness of IPS empress direct: An *in-vitro* study. Pak Oral Dent J 2015;35:504-8.
4. Kamangar SS, Kiakojoori K, Mirzaii M, Pourhashemi SJ. The effect of bleaching on micro hardness of silorane-based composite resins. Caspian J Dent Res 2014;3:46-53.
5. Bouvier D, Duprez JP, Lissac M. Comparative evaluation of polishing systems on the surface of three aesthetic materials. J Oral Rehabil 1997;24:888-94.
6. Morgan M. Finishing and polishing of direct posterior resin restorations. Pract Proced Aesthet Dent 2004;16:211-7.
7. Jones CS, Billington RW, Pearson GJ. The *in vivo* perception of roughness of restorations. Br Dent J 2004;196:42-5.
8. Yap AU, Yap SH, Teo CK, Ng JJ. Finishing/polishing of composite and compomer restoratives: Effectiveness of one-step systems. Oper Dent 2004;29:275-9.
9. Turssi CP, Ferracane JL, Serra MC. Abrasive wear of resin composites as related to finishing and polishing procedures. Dent Mater 2005;21:641-8.
10. Heintze SD, Forjanic M, Rousson V. Surface roughness and gloss of dental materials as a function of force and polishing time *in vitro*. Dent Mater 2006;22:146-65.
11. Yap AU, Ng JJ, Yap SH, Teo CK. Surface finish of resin-modified and highly viscous glass ionomer cements produced by new one-step systems. Oper Dent 2004;29:87-91.
12. Mitra SB, Wu D, Holmes BN. An application of nanotechnology in advanced dental materials. J Am Dent Assoc 2003;134:1382-90.
13. Lu H, Roeder LB, Powers JM. Effect of polishing systems on the surface roughness of microhybrid composites. J Esthet Restor Dent 2003;15:297-303.
14. Senawongse P, Pongprueksa P. Surface roughness of nanofill and nanohybrid resin composites after polishing and brushing. J Esthet Restor Dent 2007;19:265-73.
15. Tabatabaee MH, Sakineh A, Asieh R, Maryam G. Monomer release from nanofilled and microhybrid dental composites after bleaching. J Dent Tehran Univ Med Sci 2014;11:56-66.
16. Kumari CM, Bhat KM, Bansal R. Evaluation of surface roughness of different restorative composites after polishing using atomic force microscopy. J Conserv Dent 2016;19:56-62.
17. Mopper KW. Finishing and polishing. Using the best tool to achieve natural-looking results. Inside Dent 2013;9:90-2.
18. Can Say E, Yurdagüven H, Yaman BC, Özer F. Surface roughness and morphology of resin composites polished with two-step polishing systems. Dent Mater J 2014;33:332-42.
19. Shayan M, Jung Y, Huang PS, Moradi M, Plakseychuk AY, Lee JK, *et al.* Improved osteoblast response to UV-irradiated PMMA/TiO2 nanocomposites with controllable wettability.

J Mater Sci Mater Med 2014;25:2721-30.
20. Ferraris F, Conti A. Superficial roughness on composite surface, composite enamel and composite dentin junctions after different finishing and polishing procedures. Part I: Roughness after treatments with tungsten carbide vs. Diamond burs. Int J Esthet Dent 2014;9:70-89.
21. Avsar A, Yuzbasioglu E, Sarac D. The Effect of finishing and polishing techniques on the surface roughness and the color of nanocomposite resin restorative materials. Adv Clin Exp Med 2015;24:881-90.
22. Quiroz L, Lentz DL. The effect of polishing procedures on the surface smoothness of several light-cured posterior composites. Compend Contin Educ Dent 1986;7:676-8.
23. Weitman RT, Eames WB. Plaque accumulation on composite surfaces after various finishing procedures. J Am Dent Assoc 1975;91:101-6.
24. Shintani H, Satou J, Satou N, Hayashihara H, Inoue T. Effects of various finishing methods on staining and accumulation of *Streptococcus mutans* HS-6 on composite resins. Dent Mater 1985;1:225-7.
25. Jung M, Sehr K, Klimek J. Surface texture of four nanofilled and one hybrid composite after finishing. Oper Dent 2007;32:45-52.
26. Koh R, Neiva G, Dennison J, Yaman P. Finishing systems on the final surface roughness of composites. J Contemp Dent Pract 2008;9:138-45.
27. Abdurazaq MR, Al-Khafaji AH. The effect of different finishing and polishing systems on surface roughness of new low polymerized composite materials – An *in vitro* study. J Baghdad Coll Dent 2013;25:24-30.
28. Giacomelli L, Derchi G, Frustaci A, Orlando B, Covani U, Barone A, *et al.* Surface roughness of commercial composites after different polishing protocols: An analysis with atomic force microscopy. Open Dent J 2010;4:191-4.
29. Hosoya Y, Shiraishi T, Odatsu T, Nagafuji J, Kotaku M, Miyazaki M, *et al*. Effects of polishing on surface roughness, gloss, and color of resin composites. J Oral Sci 2011;53:283-91.
30. Villalta P, Lu H, Okte Z, Garcia-Godoy F, Powers JM. Effects of staining and bleaching on color change of dental composite resins. J Prosthet Dent 2006;95:137-42.