Original Article

# Investigation of Polishing Abilities of Undergraduates and Postgraduates by Using Various Systems on Composite Materials

**A. Dina Erdilek, Meriç Berkman, M. Alp Boyana, Musab Qamheya, Begüm G. Efes**

*From, Department of Restorative Dentistry, Faculty of Dentistry, Istanbul University, Istanbul, Turkey*

**Correspondence to:** Dr. Ayşe Dina Erdilek, Department of Restorative Dentistry, Faculty of Dentistry, Istanbul University, Topkapı Mahallesi, Turgut Özal Millet Cd, Fatih/Istanbul 34093, Turkey. Email: derdilek@yahoo.com

*Received – 18 June 2019* *Initial Review – 19 June 2019* *Accepted – 24 July 2019*

## ABSTRACT

**Background:** The purpose of dental education is to enable students to gain the knowledge and skills to provide the best service to their patients upon graduation. In order to achieve this, students need to work with a sufficient number of cases and use current materials throughout their education. **Aim:** The aim of this *in vitro* study, conducted in 2017, was to examine the surface roughness of two types of composites prepared with different polishing systems, constructed by either undergraduate or doctoral students. **Methods:** Bulk-fill (Filtek Bulk Fill Posterior) and nano-hybrid (Ceram.x One Universal) composites were polished using single-step (OneGloss Set) and multi-step (Sof-Lex System) systems. The finishing and polishing procedures were performed by ten dental undergraduate students and ten doctoral students. Average surface roughness values ($R_a$, µm) were measured using a profilometer. Data were analyzed using the Wilcoxon signed-rank test ($\alpha = 0.05$). **Results:** No statistically significant differences in $R_a$ values were noted between operators with different levels of experience. Surface roughness was higher in the samples prepared using the single-step system than in those prepared using the multi-step system for both sample types tested in this study. **Conclusion:** Practitioner ability does not affect the performance of polishing systems. Regardless of the composite type, the single-step polishing system produces rougher surfaces than the multi-step system.

***Key words:*** *Dental composites, Education stages, Operator variability, Polishing systems, Surface roughness,*

Dental education requires a minimum of five or six years to complete and includes preclinical training in the first few years and clinical training in the last two or three years. The training of a dental student should include working with a sufficient number of patients and the most up-to-date materials to gain equivalent technical precision and capability to that of a graduated dentist. The aim of dental education is to prepare students to fulfill the most appropriate conditions for graduating as a dentist, and to provide technical sensitivity required for dental practice.

The success of a dental restoration depends on a variety of factors, including the experience of the operator, the material's nanostructure, the usage method, and the patient's oral hygiene habits [1]. Importantly, the smoothness of the surface of a dental restoration is a key factor for its longevity in the oral cavity. Previous studies have revealed that intraoral hard surfaces with a roughness greater than 0.2 µm have a significant role in initial bacterial colonization and the maturation of plaque, which increases the risk for periodontal infections, secondary caries, and discoloration [2, 3]. Mei et al. [4] stated that the adhesive force of streptococci is higher on rougher surfaces than on smoother surfaces because of the high surface energy; thus, streptococci are more difficult to remove from such surfaces. The surface irregularities of dental restorations can be removed with effective finishing and polishing. Proper finishing and polishing results in suitable light reflection and optimal esthetics, and provides acceptable oral soft tissue health, decreases wear, and maintains the marginal integrity of the restorative interface. Various materials are used for polishing, such as carbide and diamond finishing mills with abrasive particles and stones, abrasive-coated disks, polishing tires, abrasive-containing polishing pastes, and abrasive-impregnated brushes [5].

The polishability of a resin composite depends on the inorganic filler particle content, size, shape, and loading, the resin matrix composition, the use of a silane coupler, the degree of conversion of the polymer matrix, and the difference in hardness between the matrix and filler particles [6]. Larger particles increase irregularity, and increased irregularity leads to an increase in roughness [1, 7]. Filler size is approximately 0.04µm in micro-filled composites, between 0.01 and 2.0µm in micro-hybrid composites, and between five and 100nm in nano-filled composites [8]. The new generation of nano-hybrid composites contains high filler loading, which increases surface hardness. With tight coupling between the small pieces instead of less-integrated, large particles, smaller particles detach from the surface during erosion [9]. In this study, we used Filtek Bulk Fill and Ceram.x One, which have average filler particle sizes of 0.004–0.1µm and 1.1–1.5µm respectively.

Successful dental restoration, along with other dental procedures, requires training and careful attention to detail. This randomized, double-blind study aimed to measure and compare the average surface roughness ($R_a$) values of two different composite materials after dental treatment was performed by undergraduate and doctoral students who used single-step and multi-step polishing systems. The null hypothesis was as follows: in composite restoration applications, $R_a$ values will differ according to the operator's skill level, the composite type, and the polishing system used for restoration.

## MATERIAL AND METHODS

This study received ethical approval from the institutional Clinical Research Ethics Committee (Approval #367). The properties of the resin composites and polishing systems and their batch numbers are listed in Tables 1 and 2. Two types of resin composites were used: Filtek Bulk Fill Posterior Restorative (Bulk-fill; 3M ESPE, St. Paul, MN, USA) and Ceram.x One Universal (Nano-hybrid; Dentsply, Surrey, UK). Additionally, two types of polishing systems were used: OneGloss Set (Single Step; Shofu, Japan) and Sof-Lex System (Multi-Step; 3M ESPE). In total, eighty composite samples were used, which were prepared in accordance with the manufacturers' instructions by a single operator. The first group of samples (forty pieces of Filtek Bulk Fill Posterior Restorative; 3M ESPE) were prepared using Teflon™ molds with a 10mm diameter and a 4mm thickness, whereas the second group (Ceram.x One Universal; Dentsply) was made using Teflon™ molds with a 10-mm diameter and a 2mm thickness. To standardize the samples, their upper surfaces were covered with a transparent matrix and a glass plate. Light hand pressure was applied to remove the excess material. Samples were polymerized for 40s using a halogen light device (Optilux, Orange, CA) with a 1mm (turbo) light tip from a distance of 1mm. The samples were then removed from the Teflon™ molds and divided into two main groups according to their composite types (forty each). Each of the two main groups were divided into two subgroups according to the polishing system (twenty each).

After preparing each composite sample, finishing and polishing were performed by twenty different operators (10 male and 10 female) with different levels of experience. Each operator was randomly selected from the entire operator population via the random number method from the undergraduate and doctoral student lists. Of these, undergraduate students had one year of clinical experience, and the postgraduates were doctoral students who had been dentists for at least five years.

As shown in Table 3, the first and second groups of samples were polished by undergraduate and postgraduate students, respectively, using the one-step and multi-step polishing systems, in accordance with the manufacturers' instructions. Polishing was performed without water, the polishing motion was constant, from the center to the periphery, and each polishing material was used only once. The polishability of the nano-hybrid and nano-filled composites as well as the polishing performance of the single-step and multi-step finishing and polishing systems were evaluated.

**Table 1: Properties of the composite materials used**

| Material | Composition | Manufacturer | Batch No. |
|---|---|---|---|
| Filtek Bulk Fill Posterior (Nano-Hybrid) | Resin Matrix: AUDMA, UDMA, 1,12-dodecane-DMA<br>Filler Type: non-agglomerated/ non-aggregated silica[a], non-agglomerated/non-aggregated zirconia[b], aggregated zirconia/silica cluster,[c] ytterbium trifluoride.[d]<br>Filler Content: 76.5% (wt), 58.4% (vol) | 3M ESPE, St. Paul, MN, USA | 4864TK |
| Ceram.x One Universal (Nano-Ceramic) | Resin Matrix: methacrylate modified ceramic particles with polysiloxane backbone<br>Filler Type: barium alumino-borosilicate<br>Filler content: up to 77% (wt) / up to 55% (vol) | Dentsply, Surrey, UK | 60701532 |

[a] 20-nm particles; [b] 4- to 11-nm particles; [c] 20-nm silica, 4- to 11-nm zirconia particles; [d] agglomerate 100-nm particles.

**Table 2: Properties of the polishing materials**

| Material | Composition | Manufacturer |
|---|---|---|
| OneGloss Set (One-Step) | Synthetic rubber (polyvinyl siloxane), abrasive grain (aluminum oxide [$Al_2O_3$]), and silicon oxide ($SiO_2$) | Shofu, Japan |
| Sof-Lex System (Multi-Step) | XT Discs: polyester film, aluminum oxide grit and binder<br>Diamond PS: thermo plastic abrasive wheel, aluminum oxide or diamond abrasive | 3M ESPE, St. Paul, MN, USA |

The one-step system (OneGloss Set) uses an inverted cone shape in which aluminum oxide polishers were applied for 15 s to each composite sample; this procedure was performed in a single step. The multi-step system (Sof-Lex System) consisted of the following steps: first, for finishing, Sof-Lex™ XT Discs (dark, light, and medium orange) with different grit sizes were used for 15 s each; second, for polishing, the Sof-Lex™ Diamond Polishing System that includes a pre-polishing spiral followed by a diamond polishing spiral was used for 15s each. During each material exchange, samples were rinsed and dried.

After polishing, the samples were kept in separate, labeled tubes in distilled water for 24 h at 37°C. These were then removed from water and dried for 10s using an air-water syringe, and their average surface roughness values ($R_a$, µm) were measured by a single-blinded operator using a profilometer (Surtronic 25; Taylor-Hobson, Leicester, UK). The instrument was calibrated after placing it in a non-vibrating location. The cutoff and evaluation lengths of the device were set at 0.25 mm and 2 mm, respectively. Measurements were recorded at three different points on the surface of each sample, and the average value of these three measurements was regarded as the average surface roughness value. Statistical analyses were performed using SPSS 23.0 software (IBM Corp., Armonk, NY, USA). The results were analyzed by calculating the mean and standard deviation for each group. Data were analyzed using the Wilcoxon signed-rank test. $P < 0.05$ was considered statistically significant and the corresponding confidence level was 95%.

## RESULTS

The mean values of the surface roughness for the composite materials according to the operator and the polishing system are shown in Table 3. The Wilcoxon signed-rank test showed that the surface roughness values of the Ceram.x One composites were significantly different between the polishing systems used by the group of undergraduate students ($P < 0.05$). There was no significant difference in the surface roughness values of the Filtek bulk fill composites polished by doctoral versus undergraduate students or of the Ceram.x One composites polished by doctoral students regarding the polishing systems ($P > 0.05$).

The lowest $R_a$ values were obtained for the Ceram.x One composites polished with the multi-step polishing system used by undergraduate students ($R_a$ = 0.16µm) (Table 3). The highest surface roughness values were found for the Ceram.x One composites polished with the single-step system by undergraduate students ($R_a$ = 0.27µm) (Table 3).

**Table 3: Surface roughness in the two training groups**

| Tested Configurations | | | Average Surface Roughness ($R_a$, µm) Composite Types | |
|---|---|---|---|---|
| # | Training Groups | Polishing Systems | Filtek Bulk Fill Posterior | Ceram.x One |
| 1 | Undergraduate Students | Single Stage (OneGloss, Shofu, Japan) | 0.26 (0.09) | 0.27 (0.11) |
| | | Multi-Stage (Soflex, 3M ESPE, St. Paul, MN, USA) | 0.18 (0.07) | 0.16 (0.06) |
| 2 | Postgraduate Students | Single Stage (OneGloss) | 0.22 (0.08) | 0.25 (0.09) |
| | | Multi-Stage (Soflex, 3M ESPE) | 0.20 (0.05) | 0.18 (0.06) |
| $R_a$, average surface roughness values are presented as the mean (standard deviation). | | | | |

## DISCUSSION

The hypothesis in this study was partially accepted because the surface roughness values of the nano-hybrid composite significantly differed according to the polishing system used; however, contrary to our hypothesis, the operator's skill level and composite type did not significantly impact the surface roughness values. The smoothest polished surfaces were achieved by undergraduate students with the multi-step system, but the difference was not statistically significant.

The finishing and polishing processes, as well as the brightness and esthetic properties of the composite materials, are very important for the success of dental restoration [10]. Polishing increases hydrophobicity and reduces plaque accumulation [11]. Additionally, a poor polishing process creates roughness and increases surface energy [12]. The depth of the rough surface can also provide space and shelter for bacteria to survive; this promotes adhesion of surface bacteria, thereby increasing colonization and biofilm accumulation [13]. In resin composites, unreacted monomers (e.g., triethylene glycol dimethacrylate and thromboelastography) and other composite degradation products promote the development of various bacterial strains, such as *Streptococcus mutans*, *Lactobacillus acidophilus*, and *Streptococcus sobrinus* [14]. Bacteria are detrimental to the composites; in particular, *S. mutans* increases surface roughness by degrading the resin material through its esterase activities [15].

The polishing procedures in our study produced smooth surfaces similar to those observed in previous studies [16, 17]. However, in clinical conditions, restorations require final contouring, removal of excess material, and elimination of the oxygen inhibition layer. Some studies [7,18,19] have reported no significant differences in the surface roughness between one-step and multi-step polishing systems and between multi-stage polishing systems using different types of composite materials, whereas other studies [15, 16, 20] have reported that the surface roughness values after the finishing and polishing processes depend on the quantity of filler particles, polishing material used, and whether the polishing system was a one-step or multi-step system. The hardness of the aluminum oxide abrasives in the Sof-Lex System (multi-step system) is higher than that of the silicon oxide in the OneGloss Set (one-step system). Previous studies have shown that the Sof-Lex System, with aluminum oxide abrasive disks, provides a slightly smoother surface on a rigid matrix because the disks flatten the filler particles and abrade the resin matrix at an equal rate [21, 22]. Compared with one-step polishers, multi-step polishers have been found to provide a superior surface geometry for resin composites [23].

The release of unreacted monomers impacts the material's mechanical features [24]. It has been shown that elution from Filtek Bulk-Fill is higher than that from the other bulk-fill composites, and that it may contribute to the increase of surface roughness [25]. Bulk-fill composites have more acceptable threshold values of surface properties and color stability than do incrementally filled materials after toothbrush abrasion.

In a previous study [26], the abilities of undergraduate students have been evaluated or compared with those of postgraduates, but more research is needed regarding skills in the finishing and polishing of restorative composite materials. Zimmerli et al. [27] found no correlation between the clinical experiences of the operators and their finishing-polishing performance. Jones et al. [28] stated that clinical instructions, with respect to the use of the finishing and polishing systems for operators, must include how to use the instruments with the optimal load, speed, and time, in order to prevent any damage to the restoration in the finishing stage.

In our study, the smoothest surfaces were achieved for nano-hybrid (Ceram.x One Universal) composites, but the difference in smoothness between nano-hybrid and bulk-fill (Filtek Bulk Fill Posterior) composites was not statistically significant. Composite resins prepared based on nanotechnology have smoother surfaces after finishing and polishing than do conventional composite resins[29]. Composite materials with large particle sizes could increase surface roughness due to detachment from the matrix that leads to the formation of grooves on the composite surface [30]. In this study, we used nanocomposites and found acceptable surface roughness values. Within the limitations of this *in vitro* study, surface roughness values were not affected by the operator's experience. Therefore, performance of dental clinic materials may be appropriately evaluated by undergraduate students, in future clinical follow-up studies.

In our study, the distribution of female and male operators was random. Gender was not considered as a separate parameter because the aim of the study was to evaluate polishing performance specifically with regard to the level of experience. A limited number of studies have been performed regarding the effects of gender on dental education; thus, further studies on this subject should be performed, because dental tendencies of male or female students may be different. For example, because female students' interest in esthetics is higher than that of males' their interest in esthetic dentistry and their success in finishing and polishing procedures may be higher than that of male students [31].

## CONCLUSION

In our study, dentistry students were not under any directive, and the materials were applied in accordance with the manufacturer's instructions. Using a multi-step polishing system, undergraduate students achieved results that were equal to those of doctoral students. However, roughness values of the dental composite material were affected by the type of polishing system. These findings reveal the importance of using the right material to ensure the quality of dental education provided to the student. This study showed that students could successfully implement complex systems, even when they were only supplied the user instructions; moreover, it is necessary to encourage undergraduates to work with more complicated systems, rather than with simple systems, in order to gain technical sensitivity.

## REFERENCES


1. Rodrigues-Junior SA, Chemin P, Piaia P P, et al. Surface roughness and gloss of actual composites as polished with different polishing systems. Operative Dentistry. 2015;40:418-29.
2. Quirynen M, Bollen C M. The influence of surface roughness and surface-free energy on supra- and subgingival plaque formation in man. A review of the literature. Journal of Clinical Periodontology. 1995; 22:1-14.
3. Kumari RV, Nagaraj H, Siddaraju K, et al. Evaluation of the effect of surface polishing, oral beverages and food colorants on color stability and surface roughness of nanocomposite resins. Journal of International Oral Health 2015;7: 63-70.
4. Mei L, Busscher HJ, van der Mei HC, et al. Influence of surface roughness on streptococcal adhesion forces to composite resins. Dental Materials. 2011;27:770-8.

5. Ölmez A, Kisbet S. Advancements in finishing and polishing procedures for composite resin restorations. Acta Odontologica Turcica. 2013;30:115-22.
6. Blackham JT, Vandewalle KS, Lien W. Properties of hybrid resin composite systems containing prepolymerized filler particles. Operative Dentistry 2009;34:697-702.
7. Nagem Filho H, D'Azevedo MT, Nagem HD, et al. Surface roughness of composite resins after finishing and polishing. Brazilian Dental Journal. 2003;14:37-41.
8. Kumari CM, Bhat KM, Bansal R. Evaluation of surface roughness of different restorative composites after polishing using atomic force microscopy. Journal of Conservative Dentistry. 2016;19:56-62.
9. Marghalani HY. Effect of filler particles on surface roughness of experimental composite series. Journal of Applied Oral Science. 2010;18:59-67.
10. Moda MD, Godas AGL, Fernandes JC, et al. Comparison of different polishing methods on the surface roughness of microhybrid, microfill, and nanofill composite resins. Journal of Investigative and Clinical Dentistry. 2018; 9.
11. Costa GFAD, Fernandes ACBJ, Carvalho LAO, et al. Effect of additional polishing methods on the physical surface properties of different nanocomposites: SEM and AFM study. Microscopy Research & Technique. 2018; 81: 1467-73.
12. Bollen CM, 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. Dental Materials. 1997;13: 258-69.
13. Sainan Z, Li J, Lei Z, et al. Influence of surface roughness on oral streptococcal adhesion forces to dental filling materials. Hua Xi Kou Qiang Yi Xue Za Zhi, 2016: 34; 448-53.
14. Delaviz Y, Finer Y, Santerre JP. Biodegradation of resin composites and adhesives by oral bacteria and saliva: A rationale for new material designs that consider the clinical environment and treatment challenges. Dental Materials. 2014;30:16-32.
15. Beyth N, Bahir R, Matalon S, et al. Streptococcus mutans biofilm changes surface-topography of resin composites. Dental Materials. 2008;24:732-6.
16. Sahbaz C, Bahsi E, Ince B, et al. Effect of the different finishing and polishing procedures on the surface roughness of three different posterior composite resins. Scanning. 2016; 38: 448-54.
17. Kocaagaoglu H, Aslan T, Gürbulak A, et al. Efficacy of polishing kits on the surface roughness and color stability of different composite resins. Nigerian Journal of Clinical Practice. 2017;20:557-65.
18. Biçer CÖ, Öz FD, Attar N, et al. Effects of different polishing systems on the surface roughness of esthetic composite resins. Acta Odontologica Turcica. 2017; 34:77-80.
19. da Costa JB, Goncalves F, Ferracane J L. Comparison of two-step versus four-step composite finishing/polishing disc systems: evaluation of a new two-step composite polishing disc system. Operative Dentistry. 2011;36:205-12.
20. 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: E1-12.
21. Singh S, Mandlik J, Kanyal K, et al. An in-vitro evaluation of effect of three finishing and polishing systems on the surface of nanofilled composite resin. Indian Journal of Conservative and Endodontics. 2016; 1: 37-41.
22. Venturini D, Cenci MS, Demarco FF, et al. Effect of polishing techniques and time on surface roughness, hardness and microleakage of resin composite restorations. Operative Dentistry. 2006;31:11-17.
23. Jung M, Eichelberger K, Klimek J. Surface geometry of four nanofiller and one hybrid composite after one-step and multiple-step polishing. Operative Dentistry. 2007;32:347-55.
24. Lempel E, Czibulya Z, Kovács B, et al. Degree of conversion and bisGMA, TEGDMA, UDMA elution from flowable bulk fill composites. International Journal of Molecular Sciences. 2016;17:E732.
25. Rigo LC, Bordin D, Fardin VP, et al. Influence of polishing system on the surface roughness of flowable and regular-viscosity bulk fill composites. International Journal of Periodontics & Restorative Dentistry. 2018; 38: e79-e86.
26. Gomes GM, Gomes OM, Reis A, et al. Effect of operator experience on the outcome of fiber post cementation with different resin cements. Operative Dentistry. 2013;38:555-64.
27. Zimmerli B, Lussi A, Flury S. Operator variability using different polishing methods and surface geometry of a nanohybrid composite. Operative Dentistry.2011;36:52-9.
28. Jones CS, Billington RW, Pearson GJ. Interoperator variability during polishing. Quintessence International. 2006;37:183-90.
29. Aytac F, Karaarslan ES, Agaccioglu M, et al. Effects of novel finishing and polishing systems on surface roughness and morphology of nanocomposites.

Journal of Esthetic and Restorative Dentistry. 2016; 28: 247-61.
30. Ilie N, Bucuta S, Draenert M. Bulk-fill resin-based composites: an in vitro assessment of their mechanical performance. Operative Dentistry. 2013; 38: 618-25.
31. Jones GM, Howe A, Rua MJ. Gender differences in students' experiences, interests, and attitudes towards science and scientists. Science Education. 200; 84:180–92.

*Funding: None; Conflict of Interest: None Stated.*

**How to cite this article:** Erdilek AD, Berkman M, Boyana MA, Qamheya M, Efes BG. Investigation of Polishing Abilities of Undergraduates and Postgraduates by Using Various Systems on Composite Materials. Eastern J Med Sci. 2019;4(3):118.

DOI: 10.32677/EJMS.2019.v04.i03.002