An SEM Surface Analysis of the Efficacy of Four Composite Polishing Systems

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Abstract

Objectives: To evaluate the effect of four polishing methods on the surface of a composite. Methods: A total of thirty disks of composite Filtek Supreme Ultra B1(3M) were made and light cured for 40s using Elipar S10(3M). The disks were sanded to a uniform surface finish using 320 grit SiC paper. Specimens were assigned randomly to 5 groups(n=6) where four groups received a polishing finish. Control group (no treatment, just baseline sanding with 320 carbide paper), group 1. Rockstar system (BIOCLEAR), group 2. Soflex mylar discs (3M) followed by A.S.A.P. Wheels (Clinician's Choice), group 3. NS-C Points grey plus white (Neoshine/Microcopy) and group 4. Greenie/Brownie (SHOFU) followed by MINIBRUSH(Dental-Ventures-of-America) impregnated with Top Dotz medium (Dental-Ventures-of-America) followed by MINIBUFF(Dental-Ventures-of-America) without any material impregnating them. Groups 1 through 4 have been polished for a total working time of 3 minutes. Samples were mounted and sputter coated with a 10 nm Au/Pd coat using an SC7620 Mini Sputter Coater by Quorum Technologies. Images were captured using a Zeiss EVO 50 Scanning Electron Microscope at 500x. Surface analysis was done using Image J (1.53k NIH, USA) software. The ratio of the resin versus the filler on a distinguished red/grey ratio scale was determined based on the SEM images. ANOVA-ONE-WAY and Bonferroni-corrected t-test was used for statistical analysis.

Results: The most polished surface area was seen in Group 1 Rockstar (2.1±0.32), followed by Group 2 A.S.A.P. (1.8±0.21), Group 4 Greenie/Brownie (1.6±0.23), and by Group 3 NS-C Points (1.5±0.24).

Conclusions: All methods exhibited a high surface gloss when examined with the naked eye. This SEM study revealed a difference between several commercially available polishing methods. All polished samples had significantly more resin areas than filler particles compared to the control group that received no treatment. The control group had almost a 1:1 ratio between resin and filler particles and seemed dull to the naked eye.

Introduction

It's been more than 50 years since composite resins have made a mark in dentistry. Composite resins have been increasingly used to restore anterior and posterior teeth because of their optimal esthetics, improved physical and mechanical properties, availability of efficient bonding systems and concerns over amalgam use. The disadvantages of this material are accelerated wear and high pigmentation over time due to micro-porosity among others. However, these are universally accepted dental restorations due to overall good esthetics, adhesion capacity, longevity and thermal insulation. The surface roughness affects not only the esthetic appearance but also their effects in the patients mouth [1]. Rough surfaces may lead to plaque accumulation, staining, gingival irritation, recurrent caries, and tactile perception by the patient [2]. Therefore, finishing and polishing is a crucial part of restoring the composite resins. The focus is on longevity of the restoration and patient comfort [3].

Several studies have evaluated the effect of different finishing and polishing procedures on the surface roughness. Luca Giacomelli et al., conducted a research study using atomic force microscopy and used three different polishing systems (PoGo polishers, Enhance, Venus Supra) [4]. Enhanced polishing resulted in significant difference versus the control but there was no statistically significant difference among the different polishing systems.

In a systematic review the multistep polishing was compared to single step polishing systems. The study included seven Polishing Systems (PS) who had only one step application, seven PS with two steps, eight PS with three steps, three PS with four steps, and four PS with five steps [5]. Polishing Protocols (PP) varied, with application times ranging from 10 s to 60 s with speeds between 10,000 and

30,000 RPM. It was concluded that multistep polishing systems were most effective than single step polishing systems. Another in vitro study by Wheeler et al. [6] evaluated the effects of five different polishing systems on a hybrid composite resin. Diatech Shapeguard and Komet Spiral polishing systems produced the lowest surface roughness values. All the polishing systems yielded acceptable surface roughness values with regards to oral health and patient comfort. It might be difficult for the clinicians to differentiate which polishing system is better than others. Therefore, researchers have used different techniques to evaluate the polish ability of the composite surface. Many different composites have been used and no standard composite has been selected. To compare the polished surfaces of composites, the following methods have been used in previous studies: profilometer, Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM) and gloss meter. Each method might have advantages and disadvantages [7-14]. Ideally, only one system should be used for comparison. The analysis in this study was done using SEM in combination with a National Institute of Health approved software.

Objective

To evaluate the effect of four polishing methods on the surface

Figure 1a: Rockstar Polishing System (BIOCLEAR).

Figure 1c: NS-C Points composite polishing burs /white (Neoshine/Microcopy).

B. Group 2. Soflex mylar discs (3M) followed by A.S.A.P. Wheels (Clinician's-choice). Four different grades of Soflex discs were used from rough to fine for 20 sec each disc Figure 1b. This was followed by A.S.A.P. pre-polishers for 40 sec. It has diamond particles with 44 microns embedded. Finally, the A.S.A.P. final high shine polisher (embedded with diamond particle of 3-6 microns) was used for 60 seconds. All instruments were run at 20,000 rpm.

C. Group 3. NS-C Points Satin [grey-first] and Hi-Gloss [white-second] (Neoshine/Microcopy). The NS-C Point 1 (Satin) was used for 90 seconds with water spray followed by the NS-C

gloss of a composite.

Material and Methods

A total of thirty specimens in disk format of composite Filtek Supreme Ultra shade B1 (3M) were fabricated, and light cured for 40s using Elipar S10(3M)4. The dimensions of the discs were 10 mm in diameter and 4 mm in height. The disks were sanded on the flat top surface to a uniform surface finish using 320 grit Silicate Carbide (SiC) paper6. Specimens were assigned randomly to 5 groups with six specimens in each group (n=6). Four groups received a polishing finish and one group served as a control group. The following polishing methods were assigned:

Control group (no treatment was done, just baseline finish with 320 SiC paper).

A. Group 1. Rockstar system (BIOCLEAR). This is a two-step polishing system. First, a pre-polish is accomplished with the Magic-Mix-Paste using the Magic-Mix-Cup (30 sec). After a thorough rinse the polishing continues dry with RS polisher (120 sec). The final step is a wet run of the RS polisher (30 sec). All instruments were run at 20,000 rpm (Figure 1a).

Figure 1b: A.S.A.P. wheels (Clinician's choice).

Figure 1d: Brownie/Greenie: Mini brush and Top Dotz polishing paste (Dental-Ventures of America).

Point 2 Hi-Gloss with water spray. All instruments were run at 20,000 rpm (Figure 1c).

D. Group 4. Greenie/Brownie (SHOFU) followed by Mini Bristle Brushes (Dental-Ventures-of-America) impregnated with Top Dotz medium (Dental-Ventures-of-America) followed by Mini Cotton Buffs (Dental-Ventures-of-America) without any material impregnating them. The brownies and greenies were used for 30 sec each, the Mini Bristle Brushes with Top Dotz were used for 60 sec and finally, the Mini Cotton Buffs were used for 60 seconds as well, at 20,000 rpm (Figure 1d).ll

Groups 1 to 4 have been polished for a total working time of 3 min for each specimen with different applications. Samples were mounted and sputter coated with a 10 nm Au/Pd coat using an SC7620 Mini Sputter Coater by Quorum Technologies. Images were captured using a Zeiss EVO 50 Scanning Electron Microscope (SEM) at 500x. One image per sample was acquired (Figure 2). Surface analysis was done using Image J (1.53k NIH, USA) software. Image J is an open-source software readily available at the National Institute of Health website. Even though it is not known very much in dentistry because it is focused more on biological-image analysis, Image J can calculate area and pixel value statistics from intensity-thresholded objects. In this study a randomly selected area from each sample was chosen to take an image at 500x with the SEM. The images were further analyzed with the Image J software after a gray scale calibration to assure the same study conditions for each sample. The ratio of the lower-level red surface versus the higher level grey surface on a distinguished red/grey scale was determined based on the SEM images. Less polished surfaces are areas at the same level as the flattened filler particles. A lower level was determined as the higher polished area. The ratio of the red versus the grey area was determined on each image individually with the Image J software; hence, the unit of the results is the ratio. ANOVA-ONE-WAY and Bonferroni-corrected t-test was used for statistical analysis. One operator prepared all the samples while a second operator handled the imaging, and a third operator used the Image J software and made the calculations.
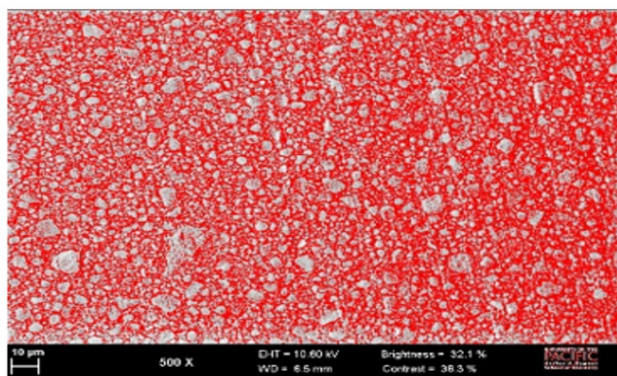

Figure 2: Scanning electron microscope picture at 500x from A.S.A.P. group (after modification with Image J software in red/grey ratio).

Results

All polishing methods showed statistically significant better polished surfaces compared to the control samples (p≤0.05). Among the polishing groups (groups 1 to 4) no significant differences were found except for Group 1 Rockstar versus Group 3 NS C Points group (p=0.006). The highest ratios were seen in Group 1: Rockstar (2.1, ± 0.32), followed by Group 2: A.S.A.P. (1.8, ± 0.21), Group 4 Brownie/Greenie (1.6, ± 0.23), and by Group 3 NS-C Points (1.5, ±0.24) (Figure 3) [15,16].
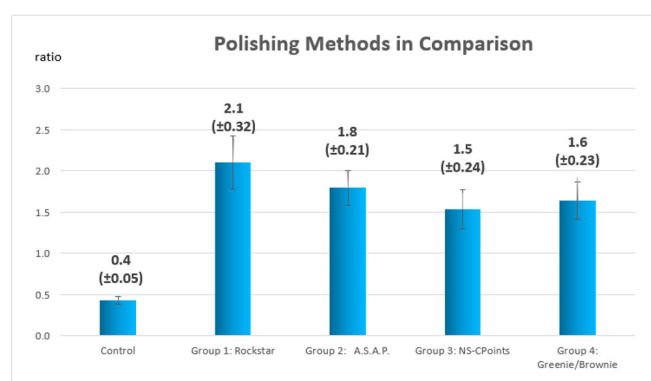

Figure 3: Graph with results of tested groups.

All samples showed more red than grey areas in the red/grey images. The grey areas are the filler particles that were ground flat. That grey area is at a higher level compared to the red remaining area that symbolizes the embedding resin. In summary, the ratios resulted in positive numbers because we found more red areas than grey areas even with the control samples. The control group was sanded with 320 grit carbide paper and resulted in a ratio of 0.4. That is closer to a 1:1 ratio than any other groups in this study meaning similar amounts of grey and red. With the naked eye one can see the dull surface of the control group while all other groups look shiny and glossy. Our eye cannot distinguish which of the polished samples has a better polish. Statistically all groups had significantly more red than grey areas.

Discussion

Every dentist wishes to produce a gloss on their finished composites that will stand the test of time. There is no greater dissatisfaction than creating beautiful shiny anterior composite restoration and observing it lose its beauty due to extrinsic staining through the years [17]. Typically, Filtek Supreme Ultra (3M) the subject material in this study should generate 60 to 80 out of 100 Gloss Units (GU) with popular polishing methods. Composites with 40-50 GU are clinically acceptable [18,19]. The most popular dental manufacturer's gloss measuring device is the Novo-Curve Glossmeter. This device measures gloss at a 60-degree specular angle of reflectance and is very consistent. ln conjunction with a Profilometer researchers can get very accurate assessments of different polishing techniques [12,20]. In place of these expensive devices/systems the authors decided to ascertain polish values using a readily available SEM at our facility in combination with the Image J software. SEM was used in similar studies as named above and recently presented by Richard Price et al at a IADR meeting [21]. The human eye frequently can't differentiate between several high-quality polishing systems; however, the SEM will vet out the subtle differences that could spell staining problems in the future [17]. The substrate/composite was held constant in this study, as the Filtek Supreme Ultra, is generally accepted as a superior polishable material.

Reflecting on the results in this study, a statistically significant difference was found between the control group and all polished samples. The control group represents the surface finish with a carbide finishing bur. That usually leaves a dull surface to the human naked eye and feels rough with the tongue in the patient's mouth. The ratios from red to grey went up in the polished samples and all polished samples had a high shine. The naked eye could not identify the Rockstar group as the best group of all polished samples. The relatively small standard deviation indicates that each polishing method gives consisted results. It is assumed that during the polishing process some fillers get removed from the surface and more resin is left. As a result, more resin areas correlate to a more glossy and higher polished surface.

Another statistically significant difference was found between the highest performing group Rockstar and the lowest performing group NS-CPoints. The authors could not identify why this difference occurred. From this ratio analysis it is assumed that fewer particles on the surface result in a smoother overall resin surface. The resin is responsible for the shine and gloss while the filler particles create a rougher surface and more dull appearance.

In addition, the authors noticed that no porosities were detected on the surface. This would have added a third dimension in this study. It speaks to the homogeneous surface and good quality of the Filtek Supreme Ultra composite material.

A limitation to the study is the variability of the handling of the polishing materials. The outcome is for example influenced by the pressure of the polishing cup on the surface of the composite, or in

which angle it was used. Surely, the amount of polishing paste during polishing makes a difference too. This was not standardized and varied from sample to sample. As a self-critique the authors could have included a group of samples that have not been sanded nor polished. This group would have been light cured only. The challenge with that group would have been to generate a flat surface.

Four popular polish systems were chosen that could employ following strict protocol and comparing the result of each to a non-polished polymerized sample with basic sanding. All four systems generated a very high surface shine to the human eye; however, it was apparent on the SEMs that the group 1 Rockstar System was superior to the other three techniques. How superior? Rockstar was statistically significant superior to Group 3 NS-C Points. The Rockstar system is very simple and more importantly very economical. The first step of the Rockstar system is applying Magic Mix Paste to the composite surface. It consists of large to small particles of Aluminum Oxide with a binder that prevents the material from splattering while polishing. A rigid prophy cup is used so that the operator can take advantage of the concave shape of the cup thereby allowing subgingival polishing. Bullet points do not allow travel beneath the free gingival margin. The A.S.A.P. brushes can enter the sulcus however not as well as the prophy cup filled with Magic Mix Paste. It is possible to "sharpen" the Brownie and Greenie points to allow the tip to pass under the gingiva but again not as intimately as the flexible cup. In general, the Brownie/Greenie combination is used more for metal and amalgam but can be used in some cases for composite polishing. The second step of the Rockstar system is the final polish with the diamond impregnated latch type cups; the cups are a very high durometer silicone to facilitate exerting more pressure on the surface. Used first dry at 20,000 rpms followed by copious water spray at 2000 rpms these diamond cups yield a very high gloss to the naked eye. The Rockstar system also has bullet shaped points that are latch connected consisting of the same diamond impregnated silicone material for deeper occlusal anatomy on Class 2 restorations. The technique involving the friction grip Brownies and Greenies with accompanying water spray followed by the diamond compound impregnated into a latch type bristle brush is also very economical. In addition, the "cake" nature of the Top Dotz compound does not create splatter when applied with a 20,000-rpm handpiece. This is analogous to polishing gold with rouge as well as dentures with whiting compound. There is no waste with the Top Dotz diamond compounds, unlike the runny diamond pastes available in syringes. The bristle brushes and the cotton buffs are autoclavable. Class 2 occlusal anatomy is best adjusted using Brownies and Greenies sharpened at the tip resembling a Christmas tree. The beauty of the brownies and greenies is that they will adjust and polish composite but will not remove enamel. Although this was not tested in the study, perhaps a hybrid technique of incorporating the Rockstar base gloss/polish to the brownie/greenie and Top Dotz will cover the Class 2 with deeper anatomy. The Rockstar alone covers the Class 3 and 4 relatively flat to ovoid surfaces. This study shows that, except for the NS-C Points, the other techniques allow flexibility and hybridization.

The NS-C Points do not allow a water spray nor do the Rockstar cups and bullets due to their latch connection to the slow speed handpiece, which generally does not have a water spray. This applies to most dental chair unit setups in the United States. Many dental chair units in Europe or other places in the world may have water spray on latch connected slow speed handpieces. Brownies and Greenies are friction grip thereby allowing easy access to air/water spray and providing 50,000 rpm speed for electric handpieces. Water during polishing with points and cups is a critical last step. Subjecting the polished samples to common teeth staining foods, such as tea and coffee, over time should corroborate the SEM values. Although we did not perform that task, a good follow up study would be to determine if Rockstar is superior to the other techniques/materials. We know how to cycle substrates through the staining process, including

thermal cycling to facilitate impregnation of stain particles [22].

There are many more polishing techniques the authors could have added, but we felt it important to use the techniques our faculty used in the school and their private practices. The longevity of a composite is heavily relying not only on the composite properties themselves but also on the final polishing procedure. Published research studies in the last two decades show that this topic is consistently evaluated and will do so in the future [23-30]. Operator variability may influence the study's outcome, so the authors chose only one operator in the various parts of the study [31]. The method used in this study for analysis is one way to visualize the height difference of the composite surface. Assuming the Filtec Supreme has a homogeneous distributed filler to resin matrix, the polishing methods make the difference in the outcome since it is the only variable in this study. All samples showed significantly higher polished surface than the control group samples which is similar to many other studies. In addition, this evaluation exhibited the statistically significant difference between the Rockstar and the NS-C Points group with a superior performance of Rockstar. This system was marketed in 2018. As mentioned above all polished samples show an evenly glossy surface to the naked eye. Other factors such as occlusal forces and eating habits may additionally influence the outcome and longevity of each restoration. The finishing and polish procedure definitely plays a big role in that process and should receive an appropriate amount of time in the restoration procedure

Conclusion

In this study all polishing methods have been used on the same composite Filtek Supreme for a duration of 3 minutes for better comparisons. The outcome might be different for various composites on the market. All polishing methods exhibited a high surface gloss when examined with the naked eye. This SEM study revealed a statistically significant difference between two commercially available polishing methods which are the Rockstar vs the NS-C Points group. Rockstar had the highest polished surface gloss from all materials tested in this study.

References

1. Chour RG, Moda A, Arora A, Arafath MY, Shetty VK, et al. (2016) Comparative evaluation of effect of different polishing systems on surface roughness of composite resin: An in vitro study. J Int Soc Prev Community Dent 6(Suppl 2): S166-S170.

2. Silva JP, Coelho A, Paula A, Inês Amaro, José Saraiva, et al. (2021) The Influence of Irrigation during the Finishing and Polishing of Composite Resin Restorations-A Systematic Review of In Vitro Studies. Materials (Basel) 14(7): 1675.

3. Avsar A, Yuzbasioglu E, Sarac D (2015) The Effect of Finishing and Polishing Techniques on the Surface Roughness and the Color of Nanocomposite Resin Restorative Materials. Adv Clin Exp Med 24(5): 881-890.

4. Giacomelli L, Derchi G, Frustaci A, Bruno Orlando, Ugo Covani, et al. (2012) Surface roughness of commercial composites after different polishing protocols: an analysis with atomic force microscopy. Open Dent J 4: 191-194.

5. Jaramillo Cartagena R, López Galeano EJ, Latorre Correa F, Agudelo Suárez AA (2021) Effect of Polishing Systems on the Surface Roughness of Nano-Hybrid and Nano-Filling Composite Resins: A Systematic Review. Dent J (Basel) 9(8): 95.

6. Wheeler J, Deb S, Millar BJ (2020) Evaluation of the effects of polishing systems on surface roughness and morphology of dental composite resin. Br Dent J 228(7): 527-532.

7. Dennis T, Zoltie T, Wood D, Altaie A (2021) Reduced-step composite polishing systems - a new gold standard?. J Dent 112: 103769.

8. Costa GFAD, Fernandes ACBCJ, Carvalho LAO, de Andrade AC, de Assunção IV, et al. (2018) Effect of additional polishing methods on

the physical surface properties of different nanocomposites: SEM and AFM study. Microsc Res Tech 81(12): 1467-1473.

9. Elbishari H, Silikas N, Satterthwaite JD (2020) Is Deterioration of Surface Properties of Resin Composites Affected by Filler Size? Int J Dent 2020: 2875262.

10. Kakaboura A, Fragouli M, Rahiotis C, Silikas N (2007) Evaluation of surface characteristics of dental composites using profilometry, scanning electron, atomic force microscopy and gloss-meter. J Mater Sci Mater Med 18(1): 155-163.

11. Nithya K, Sridevi K, Keerthi V, Ravishankar P (2020) Evaluation of Surface Roughness, Hardness, and Gloss of Composites After Three Different Finishing and Polishing Techniques: An In Vitro Study. Cureus 12(2): e7037.

12. Yadav RD, Raisingani D, Jindal D, Mathur R (2016) A Comparative Analysis of Different Finishing and Polishing Devices on Nanofilled, Microfilled, and Hybrid Composite: A Scanning Electron Microscopy and Profilometric Study. Int J Clin Pediatr Dent 9(3): 201-208.

13. Ishii R, Takamizawa T, Tsujimoto A, S Suzuki, A Imai, et al. (2020) Effects of Finishing and Polishing Methods on the Surface Roughness and Surface Free Energy of Bulk-fill Resin Composites. Oper Dent 45(2): E91-E104.

14. Jung M, Eichelberger K, Klimek J (2007) Surface geometry of four nanofiller and one hybrid composite after one-step and multiple-step polishing. Oper Dent 32(4): 347-355.

15. Janus J, Fauxpoint G, Arntz Y, Pelletier H, Etienne O (2010) Surface roughness and morphology of three nanocomposites after two different polishing treatments by a multitechnique approach. Dent Mater 26(5): 416-425.

16. Türkün LS, Türkün M (2004) The effect of one-step polishing system on the surface roughness of three esthetic resin composite materials. Oper Dent 29(2): 203-211.

17. Paravina RD, Roeder L, Lu H, Vogel K, Powers JM (2004) Effect of finishing and polishing procedures on surface roughness, gloss and color of resin-based composites. Am J Dent 17(4): 262-266.

18. Lassila L, Säilynoja E, Prinssi R, Vallittu PK, Garoushi S (2020) The effect of polishing protocol on surface gloss of different restorative resin composites. Biomater Investig Dent 7(1): 1-8.

19. Lu H, Roeder LB, Powers JM (2003) Effect of polishing systems on the surface roughness of microhybrid composites. J Esthet Restor Dent 15(5): 297-304.

20. Roeder LB, Tate WH, Powers JM (2000) Effect of finishing and polishing procedures on the surface roughness of packable composites. Oper Dent 25(6): 534-543.

21. Price R, Juckes S, Sullivan B, Labrie D (2020) Effect of Polishing and the Effect of Toothbrushing on Four Composites. IADR/AADR/CADR General Session Conference, Washington, DC, USA.

22. Pala K, Tekçe N, Tuncer S, Serim ME, Demirci M (2016) Evaluation of the surface hardness, roughness, gloss and color of composites after different finishing/polishing treatments and thermocycling using a multitechnique approach. Dent Mater J 35(2): 278-289.

23. St Pierre L, Martel C, Crépeau H, Vargas MA (2019) Influence of Polishing Systems on Surface Roughness of Composite Resins: Polishability of Composite Resins. Oper Dent 44(3): E122-E132.

24. Bansal K, Gupta S, Nikhil V, Jaiswal S, Jain A, et al. (2019) Effect of Different Finishing and Polishing Systems on the Surface Roughness of Resin Composite and Enamel: An In vitro Profilometric and Scanning Electron Microscopy Study. Int J Appl Basic Med Res 9(3): 154-158.

25. Uçtaşli MB, Arisu HD, Omürlü H, Eligüzeloğlu E, Ozcan S, et al. (2007) The effect of different finishing and polishing systems on the surface roughness of different composite restorative materials. J Contemp Dent Pract 8(2): 89-96.

26. Barbosa SH, Zanata RL, Navarro MF, Nunes OB (2005) Effect of different finishing and polishing techniques on the surface roughness of microfilled, hybrid and packable composite resins. Braz Dent J 16(1): 39-44.

27. Ozgünaltay G, Yazici AR, Görücü J (2003) Effect of finishing and polishing procedures on the surface roughness of new tooth-coloured restoratives. J Oral Rehabil 30(2): 218-224.

28. Gönülol N, Yilmaz F (2012) The effects of finishing and polishing techniques on surface roughness and color stability of nanocomposites. J Dent 40(Suppl 2): e64-e70.

29. Antonson SA, Yazici AR, Kilinc E, Antonson DE, Hardigan PC (2011) Comparison of different finishing/polishing systems on surface roughness and gloss of resin composites. J Dent 39(Suppl 1): e9-e17.

30. Da Costa J, Ferracane J, Paravina RD, Mazur RF, Roeder L (2007) The effect of different polishing systems on surface roughness and gloss of various resin composites. J Esthet Restor Dent 19(4): 214-226.

31. Zimmerli B, Lussi A, Flury S (2011) Operator variability using different polishing methods and surface geometry of a nanohybrid composite. Oper Dent 36(1): 52-59.