The effect of different polishing systems on the surface roughness of two restorative dental materials

A. LIBONATI[1], G. GALLUSI[2], V. ANGOTTI[2], V. DI TARANTO[2], A. MEA[2], S. CASELLA[2], V. CAMPANELLA[2]

[1] Department of Surgical Sciences, Dental School, Catholic University of Our Lady of Good Counsel of Tirane, Tirane, Albania
[2] Department of Clinical Sciencesand Translational Medicine, University of Rome "Tor Vergata", Dental School, Rome, Italy

SUMMARY

Aim. The aim of this study was to determine a single valid polishing procedure for composite and amalgam.
Material and methods. Two restorative materials, a light-cured resin composite – Enamel Plus – and an amalgam – IQC Palladium Dispersalloy – were used. Forty disc-shaped specimens for each material were made and randomly assigned to eight groups. For the composite samples, the polishing procedures were realized with brownie rubber points, greenie rubber points, and Enhance® polishing system (group B), with brownie rubber points and greenie rubber points (Group C), and with Enhance® polishing system (Group D). The amalgam samples were polished with a multi-blade bur, brownie rubber points, and greenie rubber points (Group F), with brownie rubber points and greenie rubber points (Group G) and brownie rubber points (Group H). The control groups were not polished, and the control surface was in contact with the Mylar strip (group A for composite and group E for amalgam samples). The surface roughness of each sample was recorded by using a laser profilometer.
Results. The smoothest surfaces were obtained under the Mylar strip for the composite samples. Statistically significant difference with the control group was observed when the Enhance® polishing system was used alone. For the amalgam samples, the roughest surfaces were obtained under the Mylar strip. All the finishing procedures reduced the surface roughness significantly. Composite finishing and polishing procedure determine an increase in surface roughness compared to the surface at contact with the Mylar strip.
Conclusions. Brownie and greenie rubber points showed a valid polishing system for both restorative materials compared to surface roughness.

Key words: surface roughness, finishing, dental restorative materials, polishing, laser profilometer.

Introduction

Finishing and polishing of dental restorations is an important conditioning factor for esthetics and longevity of the restored teeth. Materials with rough surfaces enhance bacterial adhesion and decrease stain resistance (1-4) thus determining plaque accumulation (1, 5), gingival inflammation (6), surface staining (2), marginal leakage, and secondary caries (7-11).

Finished and polished restorations are essential to guarantee patient comfort; patients will detect differences in roughness values of at least 0.5 µm (12).

Metal restorations are easily polished to a high degree of luster. A well-finished and polished surface is difficult to obtain from composite restorations as the resin matrix and the organic filler differ in hardness preventing homogeneous abrasion (13).

The literature reports, with respect to finishing and polishing esthetic restorative material, that the smoothest possible surface is achieved by using a polyester matrix (7, 14-20). However, with the use of a matrix it is difficult to obtain a restoration with a perfect shape and outline and without excesses (7, 17). Furthermore, composites polymerized with a clear matrix on the surface will leave a

resin-rich surface layer that is easily abraded in the oral environment exposing unpolished, rough, and inorganic filler material (21).
Clinicians have their choice among a wide range of finishing and polishing instruments. The most popular include diamond or carbide burs, stones, rubber wheel-cups and points, discs, strips, and pastes.
The aim of this study was to determine a single polishing procedure for both materials, in order to find a universal polishing method.

Materials and methods

Two restorative materials, a light-cured resin composite (Enamel Plus, Mycerium) and an amalgam (IQC Palladium Dispersalloy, Dentalica), were used for this study. Forty disc-shaped specimens for each restorative material were realized by using a plexiglass mold with a central hole (6 mm in diameter and 4.5 mm deep). The composite specimens were realized by compaction of the resin composite against a Mylar strip with 1.5 mm increments and subjected to light curing for 60 s with a halogen lamp (Coltolux, Coltene). The amalgam specimens were realized by packing the amalgam into the plexiglass mold after mixing the capsules in a Roto-Mix (3M ESPE) for 7 s. The samples were removed from the mold and were stored in distilled water at 37 °C for 24 h.
The polishing procedures were realized with brownie rubber points (Shofu), greenie rubber points (Shofu), Enhance® polishing kit (Dentsply), and multi-blade bur.
The specimens were divided in eight groups and randomly allocated according to one of the finishing and/or polishing protocols.
For the composite samples, the polishing procedures were realized with brownie rubber points (Shofu), greenie rubber points (Shofu), and Enhance® polishing kit (Dentsply) by using a low-speed handpiece under water-cooling (group B), with brownie rubber points and greenie rubber points by using a low-speed handpiece under water-cooling (group C), and with the Enhance® polishing system by using a low-speed handpiece under water-cooling (group D). The amalgam samples were polished with a multiblade bur by using a high-speed handpiece under water-cooling, brownie rubber points (Shofu) and greenie rubber points (Shofu) by using a low-speed handpiece under water-cooling (group F), brownie and greenie rubber points (Shofu) by using a low-speed handpiece under water-cooling (group G) and brownie rubber points (Shofu) by using a low-speed handpiece under water-cooling (group H). The control groups (group A for the composite and group E for amalgam, respectively) were not polished and the control surface was the one in contact with the Mylar strip.
To reduce variability, the same operator carried out specimen preparation, finishing, and polishing procedures. Multiblade burs were applied by using light pressure in a single direction that was previously traced onto the specimen surface. After application on five surfaces, a new bur was used. The polishing rubber points were discarded after each use.
The surface roughness (Ra, µm) was measured on each specimen by means of a surface profilometer (Alpha – Step IQ, Tencor Instruments) with a 1.5-mm tracing length and a 50 µ/s scanning speed.
Data for surface roughness were analyzed by the Kruskal-Wallis Test ($p < 0.05$) (22).
One specimen of each group was prepared for the scanning electron microscopy (Leika LEO 440). Specimens were sputter coated with gold (Agar Auto Sputter Coater) and viewed at different magnifications (150 X, 500 X, and 2500 X).

Results

Ra values (µm) and standard deviations are presented in Tables 1 and 2 for composite and amalgam, respectively.
For the composite samples, the smoothest surfaces were obtained under the Mylar strip (control). Statistically significant difference with the

Table 1 - Mean Ra, standard deviation and statistical significance for composite.	
Group A	0,063 ± 0,032a
Group B	0,123 ± 0,097ab
Group C	0,064 ± 0,07a
Group D	0,261 ± 0,177b

Ra is expressed in micron. Different letters indicates statistical significant differences ($p<0,05$)

Table 2 - Mean Ra, standard deviation and statistical significance for amalgam.	
Group E	0,547 ± 0,258 a
Group F	0,074 ± 0,013 bc
Group G	0,104 ± 0,036 b
Group H	0,100 ± 0,008 bc

Ra is expressed in micron. Different letters indicates statistical significant differences ($p<0,05$)

control group was observed when the Enhance® polishing system was used alone. For the amalgam samples, the roughest surfaces were obtained under the Mylar strip (control). All the finishing procedures significantly reduced the surface roughness.
SEM analysis of composite specimens that were polished with rubber points revealed the same surface appearance as that of the Mylar strip while the surface polished with Enhance® had some scratches (Figure 1).
For the amalgam samples, an improvement in surface smoothness was observed after polishing (Figure 2).

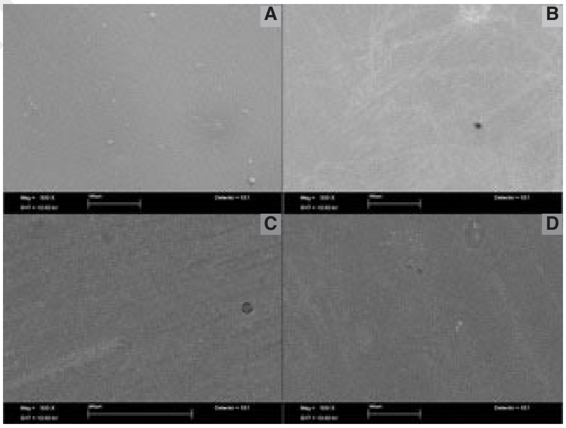

Figure 1
Sem photographs of Enamel at 500X finished with A) mylar strip; B) brownie rubber cup, greenie rubber cup, enhance polishing kit; C) brownie rubber cup, greenie rubber cup; D) enhance polishing kit.

Discussion

Proper finishing of restorations is desirable to obtain a restoration that has good contour, occlusion, healthy embrasure forms, and a smooth surface (18). Proper polishing of restorations minimizes the possible gingival irritation, surface staining, plaque accumulation, and secondary caries (5, 20).
Many studies (7, 16-20) have demonstrated that the smoothest surface on composite resin restorations is achieved by the Mylar strip in contact with the composite resin during polymerization.

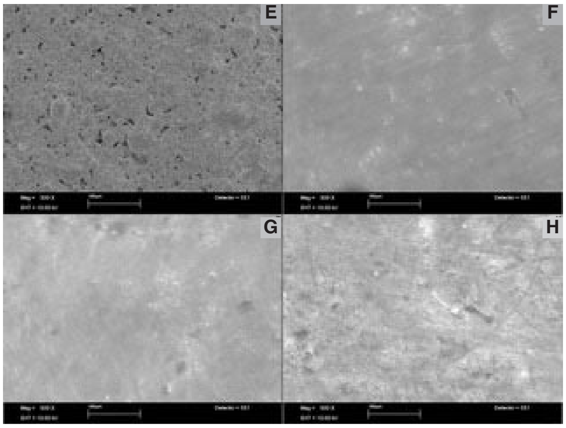

Figure 2
Sem photographs of amalgam at 500X finished with E) mylar strip; F) multiblades bur, brownie rubber cup, greenie rubber cup; G) brownie rubber cup, greenie rubber cup; H) brownie rubber cup.

However, these surfaces result in a reduction in hardness or surface discoloration owing to insufficient polymerization or a rich content of organic resin binder (23-26). Leached components from the composite-material induced embryotoxicity *in vitro*. However, no toxicity was observed when they are subcutaneously implanted *in vivo* (27). The removal of the outermost composite by finishing/polishing procedures is necessary to produce a wear-resistant, harder, and color-stabilized restoration (19). Clinically, some functional adjustment is necessary in almost all restorations. Diamond or carbide burs are often necessary to contour anatomically structured and concave surfaces, such as the lingual of the anterior teeth or the occlusal of the posterior tooth surfaces (17).

The finishing and polishing procedures may increase surface roughness by four times compared to the initial values (28, 29). Roughness can be measured in a number of ways but the most commonly used both in dentistry and in engineering is the Ra value. Stout (1981) describes Ra as the arithmetic mean of the departure of the profile from a mean line derived from the top and bottom of the undulations on the trace (30). He also states that the problem with Ra value is that it is two-dimensional, and it only gives information on the roughness height; and it gives no information at all on the profile of the surface. To provide this information, a means of creating an image of the surface is necessary. Scanning electron microscopy can provide this. However, it does not provide a qualitative value in three dimensions. The combination of quantitative measurements and qualitative data by microscopy provides a definite characterization of the surface.

The finishing procedure was realized under water cooling to avoid rise in temperature of the materials owing to frictional forces generated during the process. Surfaces finished in a dry condition are smoother for amalgam than composites (12). The smoother surfaces obtained for amalgam under dry conditions might be because higher temperature is more likely to produce surface smearing and thus, a smoother surface. For the composites, the possible explanation might be that higher temperature at the surface may cause localized softening and melting of the resin component. Clinically, finishing in dry conditions might determine pulp damage for excess heat production (31).

In the present study, the smoothest composite surface was for the Mylar strip and polishing procedures caused an increase in surface roughness. The increase of surface roughness in the composite samples was still clinically acceptable when using the rubber points since the values obtained were below the threshold Ra value of 0.2 μm for bacterial adhesion (1, 4, 32). Poorest results were obtained by using the Enhance® polishing system (33, 34) that provided mean surface roughness values above the threshold Ra value (1, 4).

The amalgam lacked smoothness when condensed against a Mylar. A significant improvement in surface smoothness was observed after the specimens were polished using the three techniques (35, 36).

Greenie and brownie rubber points showed a valid polishing system for both the restorative materials. In fact, composite surface roughness was lower when compared to other reported polishing systems (14, 18, 19, 22, 37).

Conclusion

Greenie and brownie rubber points represent a clinically valid polishing system for both amalgam and composite.

Competing interests

The Authors declare that they have no competing interests.

Acknowledgements

We acknowledge S.P.I. (Professional Editing Service) for the revision of language.

References

1. Bollen ML, 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. Dent Mater. 1997;13:258-269.
2. Reis A, Giannini M, Lovadino J, Ambrosano G. Effects of various finishing systems on the surface roughness and staining susceptibility of packable composite resins. Dent Mater. 2003;19:12-18.
3. Lu H, Roeder LB, Lei L, Powers JM. Effect of surface roughness on stain resistance of dental resin composites. J Esthet Restor Dent. 2005;17:102-108.
4. Quirynen M, Bollen CML. The influence of surface roughness and surface-free energy on supra- and subgingival plaque formation in man. A review of the lit erature. J Clin Periodontol. 1995;22:1-14.
5. 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;1:225-227.
6. Marchetti E, Monaco A, Procaccini L, Mummolo S, Gatto R, Tetè S, Baldini A, Tecco S, Marzo G. Periodontal disease: the influence of metabolic syndrome. Nutr Metab (Lond). 2012;9(1):88.
7. Yap AUJ, Sau CW, Lye KW. Effects of finishing/polishing time on surface characteristics of tooth coloured restorative. J Oral Rehabilitation. 1998;25:456-461.
8. Ballesio I, Angotti V, Gallusi G, Libonati A, Tecco S, Marzo G, Campanella V. Durability of adhesion between an adhesive and post-space dentin: Push-out evaluation at one and six months. Int J Adhes Adhes. 2012;38:75-78.
9. D'Amario M, De Angelis F, Vadini M, Marchili N, Mummolo S, D'Arcangelo C. Influence of a repeated preheating procedure on mechanical properties of three resin composites. Oper Dent. 2015;40(2):181-189.
10. Tecco S, Mummolo S, Marchetti E, Tetè S, Campanella V, Gatto R, Gallusi G, Tagliabue A, Marzo G. sEMG activity of masticatory, neck, and trunk muscles during the treatment of scoliosis with functional braces. A longitudinal controlled study. J Electromyogr Kinesiol. 2011;21(6):885-892.
11. Tundo GR, Sbardella D, Ciaccio C, De Pascali S, Campanella V, Cozza P, Tarantino U, Coletta M, Fanizzi FP, Marini S. Effect of cisplatin on protesome activity. J Inorg Biochem. 2015;153:253-258.
12. Jones CS, Billington RW, Pearson. The effects of lubrication on the temperature rise and surface finish of amalgam and composite resin. J Dent. 2007;35:36-42.
13. Pratten DH, Johnson GH. An evaluation of finishing instruments for an anterior and posterior composite. J Prosthet Dent. 1988;60:154-158.
14. Barbosa SH, Zanata RL, Navarro MFL, 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.
15. St-Georges AJ, Bolla M, Fortin D, Muller-Bolla M, Thompson Jy, Stamatiades PJ. Surface finish produced on three resin composites by new polishing systems. Oper Dent. 2005;30:593-597.
16. Roeder LB, Tate WH, Powers JM. Effects of finishing and polishing procedures on the surface roughness of packable composites. Oper Dent. 2000;25:534-543.
17. Özgünaltai G, Yazici AR, Görücü J. Effect of finishing and polishing procedure on the surface roughness of new tooth-coloured restoratives. J Oral Rehabilitation. 2003;30:218-224.
18. Türkün LS, Türkün M. The effect of one-step polishing system on the surface roughness of three esthetic resin composite materials. Oper Dent. 2004;29:203-211.
19. Kameyama A, Nakazawa T, Haruyama A, Haruyama C, Hosaka M, Hirai Y. Influence of Finishing/Polishing Procedures on the Surface Texture of Two Resin Composites. Open Dent J. 2008;2:56-60.
20. Çelik C, Özgünaltay G. Effect of finishing and polishing procedures on surface roughness of tooth-colored materials. Quintessence Int. 2009;40:783-789.
21. Krejci I, Lutz F, Boretti R. Resin composite polishing-Filling the gap. Quintessence Int. 1999;30:490-495.
22. Yazici AR, Tuncer D, Antonson S, Onen A, Kilinc E. Effects of Delayed Finishing/Polishing on Surface Roughness, Hardness and Gloss of Tooth-Coloured Restorative Materials. Eur J Dent. 2010;4:50-56.
23. Weitman RT, Eames WB. Plaque accumulation on

composite surfaces after various finishing procedures. J Am Dent Assoc. 1975;91:101-106.
24. Park SH, Krejci I, Lutz F. Hardness of celluloid strip-finished or polished composite surfaces with time. J Prosthet Dent. 2000;83:660-663.
25. Park SH, Noh BD, Ahn HJ, Kim HK. Celluloid strip-finished versus polished composite surface: difference in surface discoloration in microhybrid composites. J Oral Rehabil. 2004;31:62-66.
26. Baseren M. Surface roughness of nanofill and nanohybrid composite resin and ormocer-based tooth-colored restorative materials after several finishing and polishing procedures. J Biomater Appl. 2004;19:121-134.
27. Libonati A, Marzo G, Klinger FG, Farini D, Gallusi G, Tecco S, Mummolo S, De Felici M, Campanella V. Embryotoxicity assays for leached components from dental restorative materials. Reprod Biol Endocrinol. 2011;9:136.
28. Roulet JF, Roulet-Mehrens TK. The surface roughness of restorative materials and dental tissues after polishing with prophylaxis and polishing pastes. J Periodontol. 1982;53:257-266.
29. Gargari M, Ceruso FM, Pujia A, Prete V. Restoration of anterior teeth using an indirect composite technique. Case report. Oral Implantol (Rome). 2014;6(4):99-102.
30. Stout KJ. Surface Roughness - measurement, interpretation and significance of data. Mat Eng. 1981;2:260-265.
31. Christensen G, Dilts WE. Thermal changes during dental polishing. Journal of Dental Research. 1968; 47(5):690-693.
32. Quirynen M, Bollen CM, Papaioannou W, Van Eldere J, van Steenberghe D. The influence of titanium abutment surface roughness on claque accumulation and gingivitis: short term observations. Int J Oral Maxillofac Implants. 1996;11:169-178.
33. Kwok-hung Chung. Effects of finishing and polishing procedures on the surface texture of resin composites. Dent Mat. 1994;10:325-330.
34. Kaplan BA, Goldstein GR, Vijayaraghavan TV, Nelson IK. The effect of three polishing systems on the surface roughness of four hybrid composites: a profilometric and scanning electron microscopy study. J Prosthet Dent. 1996;76:34-38.
35. Creaven PJ, Dennison JB, Charbeneau GT. Surface roughness of two dental amalgams after various polishing techniques. J Prosthet Dent. 1980;43:289-297.
36. Kakaboura A, Vougiouklakis G, Argiri G. A study of different polishing techniques for amalgams and glass-cermet cement by scanning electron microscope (SEM). Hell Stomatol Chron. 1989;33(4):217-225.
37. Gallusi G, Galeano P, Libonati A, Giuca MR, Campanella V. Evaluation of bond strenght of different adhesive system: Shear and Microtensile Bond Strenght Test. Oral Implantol (Rome). 2009 Oct;2(4):19-25.

Correspondence to:
Prof. Vincenzo Campanella
Department of Clinical Sciences and Translational Medicine
University of Rome "Tor Vergata", Dental School
Rome, Italy
E-mail: vincenzo.campanella@uniroma2.it