©Operative Dentistry, 2009, **34-6,** 674-680

Laboratory Research

Effect of a Glaze/Composite Sealant on the 3-D Surface Roughness of Esthetic Restorative Materials

CR Perez • R Hirata Jr • AHMFT Silva
EM Sampaio • MS Miranda

Clinical Relevance

The use of a liquid polisher provided polished surfaces and reduced the surface roughness of tooth-colored restorative materials even when finishing procedures were performed solely with diamond burs.

*Cesar dos Reis Perez, DDS, MS, ScD, associate professor, Department of Restorative Dentistry, School of Dentistry of State University of Rio de Janeiro, Rio de Janeiro, RJ, Brazil

Raphael Hirata, Junior, DDS, MS, ScD, associate professor, Department of Microbiology, Immunology and Parasitology, Faculty of Medical Sciences, State University of Rio de Janeiro, Rio de Janeiro, RJ, Brazil

Antonio Henrique Monteiro da Fonseca Thomé da Silva, mechanical engineer, MSc, Adhesion and Adherence Lab, Polytechnical Institute, Materials Department, IPRJ/UERJ, Nova Friburgo, RJ, Brazil

Eduardo Martins Sampaio, mechanical engineer, MS, ScD, associate professor, Materials Department, IPRJ/UERJ, Nova Friburgo, RJ, Brazil

Mauro Sayão de Miranda, DDS, MS, ScD, associate professor, Department of Restorative Dentistry, School of Dentistry of State University of Rio de Janeiro, Rio de Janeiro, RJ, Brazil

*Reprint request: R Albano de Carvalho 300/302-CEP 22795-380, Rio de Janeiro, RJ, Brazil; e-mail: cesarperez@superig.com.br

DOI: 10.2341/08-014-L

SUMMARY

The main goal of the current study was to evaluate the surface roughness of tooth-colored restorative materials after different finishing/polishing protocols, including a liquid polisher (BisCover, BISCO, Schaumburg, IL, USA). The restorative materials tested included two nanofilled resin composites (Filtek Supreme, 3M Dental Products, St Paul, MN, USA and Grandio, Voco, Cuxhaven, Germany), one resin-modified glass ionomer cement (Vitremer, 3M Dental Products) and one conventional glass ionomer cement (Meron Molar ART, Voco). The finishing/polishing methods were divided into five groups: G1 (compression with Mylar matrix), G2 (finishing with diamond burs), G3 (Sof-Lex, 3M Dental Products), G4 (BisCover, BISCO, after diamond burs) and G5 (BisCover after Sof-Lex). Five cylindrical specimens of

each material were prepared for each group according to the manufacturer's instructions. The finishing/polishing methods were performed by a single operator in one direction to avoid variations at low speed (15,000 RPM). The surface roughness was evaluated using a 3-D scanning instrument with two parameters considered (Ra and Rz). The data was analyzed using one-way ANOVA followed by a multiple comparison Tukey's test. The results showed that BisCover (BISCO) was capable of reducing surface roughness and provided polished surfaces for all materials, enhancing smoothness over already polished surfaces (Sof-Lex, 3M Dental Products) and achieving polishing after finishing with diamond burs.

INTRODUCTION

Proper finishing and polishing procedures are critical for achieving the esthetics and longevity of tooth-colored restorations. Rough, poorly polished surfaces contribute to staining, plaque accumulation, gingival irritation and secondary caries.[1-2] A variety of instruments are commonly used to finish and polish esthetic restorative materials, including carbide burs, 25-50 µm diamond burs, abrasive impregnated rubber cups and points, abrasive strips, abrasive discs and polishing pastes.[3]

Surface roughness affects the adhesion of bacteria to the restoration and tooth structures. In order to prevent this bacterial adhesion, various studies have found that the restoration needs to present Ra (average surface roughness) values between 0.7-1.44 µm,[4] 0.2 µm[5-6] and 0.25-0.50 µm.[7] Unfortunately, polishing is complicated by the heterogeneous nature of esthetic materials, with the hard filler particles embedded in a relatively soft matrix.[1] It is very difficult to determine the best method/instruments for finishing these materials when considering every material (various resin composites and ionomers) and access to the restoration. Some authors claim that finishing and polishing procedures might be avoided and are performed only when strictly necessary due to the risk of damage to the dental structure, restoration and adhesion. Concurrently, there is difficulty in obtaining well-polished restorations, even when using new-technology nanofilled composites.[8] To achieve better results, the finishing and polishing processes might be performed in four distinct steps: gross finishing and excess removal, contouring, soft finishing and polishing. A system that follows these steps, such as with sequential polishing discs, potentially presents better results.[9] Discs also present planar rotary movement, which is most likely less aggressive to the restoration surface because of the regular effect produced.[10] The major problem related to the use of discs is the access to the restoration and the anatomy of the dental surfaces. Recently, a new glaze composite sealant was introduced, claiming several advantages: reduced clinical time; easy access and application; high polymeric conversion rate; enhanced resistance to wear, staining and plaque formation and the potential to achieve a polished restoration with fewer clinical steps.[11] This product is multifunctional, acrylate-based, light-cured and a highly reactive material that generates many free radicals and contains high concentrations of photo initiators. It is also a clear, hard, tough and water- and wear-resistant material after 10 to 15 seconds of light curing with a halogen curing unit that has a minimum output of 500mW/cm^2 (7.5J/cm^2) at a distance of 0-2 mm. This material also exhibits a conversion rate of 80% with no oxygen-inhibition layer.

Studies on finishing/polishing techniques may employ several surface scanning methods (2-D and 3-D surface profile analysis, scanning electronic microscopy and atomic force microscopy).[12-15] In the current work, analysis of the surfaces was performed by 3-D scanning, so that quantitative parameters such as Ra (Arithmetical Mean Roughness) and Rz (Ten-point Mean Roughness) could be obtained. These two parameters are regarded as sufficient to describe the main aspects related to surface roughness, as Ra measures general roughness aspects and Rz indicates the particular distribution of peaks and valleys, both of which are closely related to the main aspects of retentiveness. Although Ra is the most common roughness parameter used to describe surface texture, the Rz parameter was included in the current analysis in order to minimize the chance of misinterpretation of the Ra parameter. The Ra parameter presents several advantages, among which are that it is the most used parameter and is available with nearly all instruments. However, some disadvantages are also listed: this parameter does not make a distinction between peaks and valleys, it does not qualitatively evaluate the form of the peaks and valleys, and generally, it does not consider unusual peaks or valleys. Therefore, it is necessary to include another parameter in the analysis to overcome some setbacks related to the use of Ra alone. The Rz parameter was then used, as it represents an arithmetic mean from 10 values of partial roughness, acting as a complementary parameter to Ra analysis, as it is more sensitive to distribution of the peaks and valleys in the surface. In the current work, the results obtained were proportional when considering both parameters.[2,16-17]

The evaluation of surface roughness using 3-D scanning is based on ISO 4288:1995, with cutoff values for roughness dimensioning that were properly chosen, considering the nature of the different materials under analysis. Considering all these aspects, it was important to analyze the performance of the superficial glaze sealant applied over different esthetic restorative materials after contouring or polishing using a 3-D surface scanning instrument.

METHODS AND MATERIALS

Table 1 lists the manufacturers of the restorative and finishing/polishing materials used in the current study.

Samples were made by placing each restorative material into a cylindrical cavity (9 mm diameter x 2 mm depth) created in a custom-made acrylic matrix 13 cm in length, 6 cm high and 4 mm thick, that was specifically developed to receive five groups of five cavities. This matrix was developed to facilitate the positioning of the active point of the scanning instrument, since the materials were directly inserted, cured and finished/polished in the cavities, allowing for an easier positioning of the gauge analyzer.

The composites were inserted into the molds in two increments, with each increment polymerized with a light-curing unit (Optilux 401, Demetron/Kerr, Danbury, CT, USA) for 20 seconds. The conventional glass-ionomer cement was inserted in only one increment with a waiting period of five minutes for initial chemical curing. The resin-modified glass ionomer was inserted in two increments, following the resin composite insertion method. All materials were placed with excess to allow for overflow after compression with a Mylar matrix strip (SS White Co, Philadelphia, PA, USA) and a glass slide (Knittel, Germany) using a 2 Kg weight. Photo-activation was performed through both the glass slide and Mylar strip. To ensure complete light curing, an additional 10 seconds of photo-activation was performed after weight removal. The output from the curing light was 520mW/cm^2.

The specimens were stored in stainless steel boxes for 72 hours after polymerization at 37°C in 100% relative humidity. Thereafter, the samples were subjected to the finishing and polishing routines. All processes were performed for 15 seconds by a single operator at low speed (15000 RPM) in a single direction. Following each step, the specimens were flushed thoroughly with air-water spray to remove finishing and polishing debris. The application of the liquid polisher was performed following the manufacturer's instructions: acid etchant was applied for 10 seconds, thoroughly rinsed and air-dried. A thin coat of BisCover was applied and photo-cured for 15 seconds as close as possible to the material's surface. After finishing/polishing, all the specimens were immediately stored at 100% relative humidity.

To evaluate the effects of the liquid polisher, five groups were created: GROUP 1—compression with Mylar matrix (negative control group), GROUP 2—finishing with diamond burs (positive control group), GROUP 3—Sof-Lex, GROUP 4—BisCover after positive control group, GROUP 5—BisCover after Sof-Lex.

3-D Surface Roughness Measurements

Sample roughness was analyzed using a TalyScan 150 3-D surface scanning system (Taylor Hobson, Leicester, England) equipped with a contact probe that had an inductive gauge presenting a 2.5 mm extended range. The 3D scanning parameters measured were Ra (arithmetic mean roughness) and Rz (10-point partial roughness), regarded as the two more important parameters when considering the general aspects of surface roughness.

The scanning methodology was based on ISO 4288:1995. Initially, the "form removal" method was used to level samples prior to roughness analysis in order to compensate for any undesired concavity on the surface. Another method, "erase defects," was used, when necessary, to eliminate surface defects not created by the finishing or polishing methods. This method was particularly important for the conventional glass ionomer material that presented several defects derived from fluid evaporation, even in a 100% relative humidity environment.

Table 1: *Esthetic Restorative Dental Materials and Finishing/Polishing Products with Characteristics and Manufacturers*

Sof-Lex System	Coarse disk aluminum oxide (55 µm), slow speed Medium disk aluminum oxide (40 µm), slow speed Fine disk aluminum oxide (24 µm), slow speed Superfine disk aluminum oxide (8 µm), slow speed	3M Dental Products, St Paul, MN, USA
BisCover	Liquid Polisher	BISCO, Schaumburg, IL, USA
KG Sorensen diamond burs	3118 F (25 µm) 3118 FF (15 µm)	KG Sorensen, São Paulo, Brazil
Vitremer	Resin modified glass ionomer cement	3M Dental Products, St Paul, MN, USA
Filtek Supreme	Nano-filled resin composite	3M Dental Products, St Paul, MN, USA
Grandio	Nano-hybrid resin composite	Voco, Cuxaven, Germany
Meron Molar ART	Glass ionomer cement	Voco, Cuxaven, Germany

RESULTS

Ra and Rz mean values were obtained through the analysis of several profiles for all materials and finishing/polishing techniques employed and are shown in Tables 2 and 3. Statistical evaluation of

Table 2: *Mean Ra (mm) and Standard Deviation for the Various Materials and Finishing/Polishing Procedures Evaluated*

Ra	G1	G2	G3	G4	G5
Vitremer	0.237 ± 0.086	1.675 ± 0.131	0.749 ± 0.156	0.798 ± 0.204	0.742 ± 0.052
Filtek	0.155 ± 0.042	3.21 ± 0.084	0.453 ± 0.172	0.607 ± 0.065	0.390 ± 0.016
Grandio	0.036 ± 0.011	4.538 ± 0.232	0.271 ± 0.063	0.166 ± 0.030	0.225 ± 0.060
Meron Molar	0.78 ± 0.232	4.393 ± 0.612	0.298 ± 0.066	0.356 ± 0.082	0.877 ± 0.210

Table 3: *Mean Rz (mm) and Standard Deviation for the Various Materials and Finishing/Polishing Procedures Evaluated*

Rz	G1	G2	G3	G4	G5
Vitremer	2.598 ± 0.902	9.270 ± 0.954	6.282 ± 0.776	5.250 ± 1.381	5.918 ± 1.585
Filtek	1.945 ± 0.319	13.375 ± 7.784	3.788 ± 1.364	4.748 ± 0.250	3.408 ± 0.049
Grandio	0.800 ± 0.436	24.150 ± 0.742	2.228 ± 0.511	1.340 ± 0.367	2.013 ± 0.013
Meron Molar	6.908 ± 2.269	23.125 ± 2.699	2.588 ± 0.615	3.440 ± 1.093	6.175 ± 1.272

the data was performed with one-way ANOVA, followed by the Tukey's test to perform pairwise comparisons between the groups, with both evaluations occurring at a 95% level of confidence. Normality analysis of the results was performed by the Skewness and Kurtosis analysis.

Within the factor "material," Filtek Supreme presented no significant statistical difference between G3/G4 and G3/G5 when considering Ra values. This result indicates that using the BisCover coating did not improve the roughness profile of Filtek Supreme surfaces submitted to Sof-Lex finishing. Moreover, after BisCover coating, both diamond bur and Sof-Lex finished Filtek Supreme surfaces presented statistically similar roughness profiles. When considering Rz values, there was no statistical difference between G3/G4, G4/G5 and G3/G5. Only Grandio showed a significant statistical difference between G2 and the other groups when considering Ra values, indicating that the use of Sof-Lex seems to be sufficient to guarantee roughness profiles similar to the ones obtained for the negative control or BisCover-coated surfaces finished with either diamond bur or Sof-Lex for Grandio. However, Rz values were also analyzed and they verified a significant statistical difference between G1/G4, G3/G4, G4/G5 and G3/G5. These results indicate that the finishing method used (Diamond bur or Sof-Lex) influenced the final Grandio surface roughness levels after the BisCover coating. Moreover, BisCover seemed to improve the roughness profile of the Sof-Lex finished surfaces, even though the diamond bur finished BisCover coated surfaces presented a lower value for Rz. Vitremer presented no significant statistical differences between G3/G4, G4/G5 and G3/G5 when considering Ra and Rz values, leading to the same conclusion mentioned above with Filtek Supreme. Meron Molar ART demonstrated no significant statistical differences between G1/G4, G1/G5, G3/G4, G4/G5, and G3/G5 when considering Ra values. When Rz values were considered, there were no significant statistical differences between G1/G3, G1/G4, G1/G5, G3/G4, G4/G5 and G3/G5, presenting a general behavior similar to the groups previously discussed.

Representative 3-D images of samples submitted to the different finishing/polishing procedures are shown in Figures 1-3.

DISCUSSION

The effectiveness of finishing and polishing procedures on esthetic restorative materials is an important step in restorative treatment. In accordance with the scientific literature, smoother surfaces are obtained by curing the materials against Mylar strips. Unfortunately, this procedure is usually clinically insufficient, since post-curing finishing procedures have to be performed to remove excess material, obtain the correct anatomic form and polish these surfaces.[8]

Two different groups of esthetic materials were evaluated in the current work: resin composites and glass ionomer cements. In the latter group, two types of

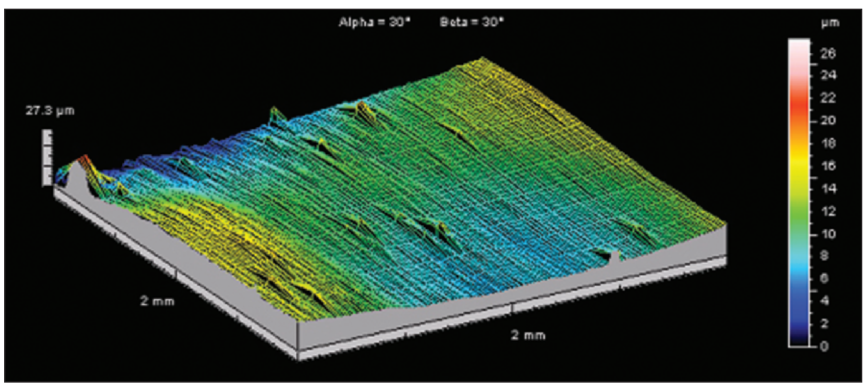

Figure 1. *3-D image of the Vitremer (3M Dental Products) surface–G1 (Mylar strip compression).*

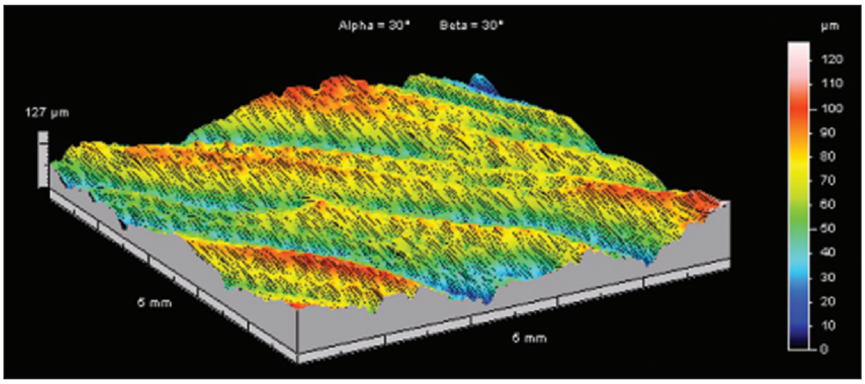

Figure 2. *3-D image of the Grandio (Voco) surface–G2 (diamond bur).*

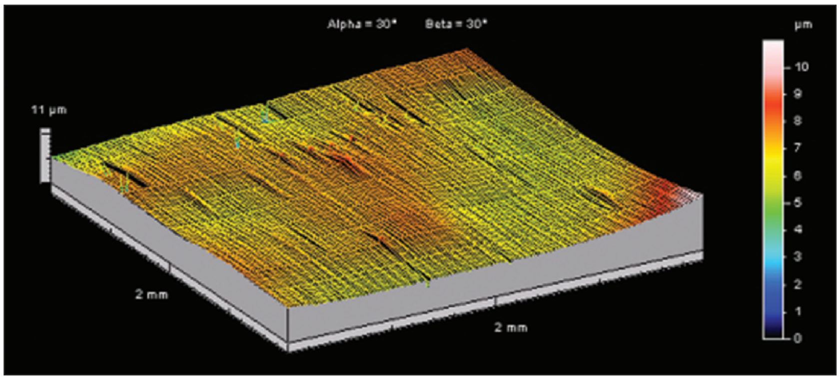

Figure 3. *3-D image of the Filtek Supreme (3M Dental Products) surface–G4 (BisCover [BISCO] after diamond bur).*

material were studied: a conventional (Meron Molar ART/Voco) and a resin modified glass ionomer cement (Vitremer, 3M ESPE). The major difficulty encountered in obtaining a smooth surface for glass ionomer restorations using conventional finishing and polishing techniques is due to the intrinsic non-uniform nature of the material, namely the presence of glass particles and the immature characteristics of the colloid matrix.[12] The resin-modified glass ionomer presents several advantages when compared to the conventional acid-base reaction. One of these advantages seems to be better results in the surface roughness analysis.[13] In the resin composite group, two nanofilled materials were analyzed: a typical nanofilled material (Filtek Supreme, 3M ESPE) and a nano-hybrid material (Grandio, Voco). Although the resin composites also presented complicated polishing due to the heterogeneous nature of the composite (hard filler particles embedded in a relatively soft matrix), this specific group presented advantages related to the size and distribution of their filler particles within the material.[14-15]

Every effort was made to standardize the methodology in the current study. All steps in the experiment were conducted by a single operator to keep variations to a minimum. The instrument used to analyze the surface topography was the TalyScan 150, a contact-scanning instrument designed to obtain 3-D measurements. The contact probe used was the Form Talysurf Series inductive gauge with an extended range of 2.5 mm. The equipment was associated with TalyMap analysis software, which provides a full measurement control and a status window that shows the surface being scanned in real time. The equipment presented as a powerful tool for surface topographic analysis.

The first goal of the current study was to evaluate the effects of a glaze sealant (BisCover, BISCO) on the polishing of esthetic restorative materials after two different procedures: finishing with diamond burs (3118 F and 3118 FF/KG Sorensen, Barueri, SP, Brazil) and finishing/polishing with aluminum oxide discs (Sof-Lex System, 3M ESPE). Three other finishing/polishing procedures were performed to compare results: Mylar compression (G1–negative control), finishing with diamond burs alone (G2–positive control) and finishing/polishing with the Sof-Lex System alone. The objectives of these additional groups were to verify the effects of the liquid polisher over a surface solely obtained by finishing procedures or over a surface obtained by finishing/polishing procedures and the ability of the material to diminish surface roughness in both cases. In the current study, as well as in others,[10,15,18-21] the Mylar strip formed the smoothest surface for all the restorative materials evaluated. G2 (finishing with diamond burs) presented significantly rougher surfaces. G3 (Sof-Lex) resulted in good finishing/polishing levels, considering the expected standards.[4-7] Groups G4 (BisCover after positive control group) and G5 (BisCover after Sof-Lex) showed that the liquid polisher was effective when applied over rougher surfaces but also improved polishing. BisCover enhanced the surface smoothness in both situations that were analyzed: after an adequate finishing/polishing system (G5) or finishing with diamond burs (G4), the roughness values were sufficient to ensure superficial smoothness. Even after a good polishing methodology, this material can provide equal or better results than just polishing (as in G5), and, additionally as an action against wear and marginal gaps, which is expected clinically. An exception might occur for conventional glass ionomer cements, where the results showed some changes due to the nature of this material. Groups 3, 4 and 5 presented similar roughness results, because all of them had the capacity to obtain clinically ideal polishing levels.

Regarding the performance of the restorative materials, when improved polishing results were expected in the resin composite group, although the dissimilarity in surface roughness of the materials may be attributable to differences in their size and the content of the filler particles, these restoratives differ in many other ways. The polishing performance of the glass ionomer material was harmed by its intrinsic characteristics. Conventional glass ionomer cement was evaluated, even though there was a concern that the liquid polisher might be used over a dry surface.[22] This would result in the liquid polisher possibly concentrating in the center of the sample due to the wet surface of the colloids. The readings of these samples presented important distortions, justifying the bad results from the roughness analysis after application of the liquid polisher over this material.

The conventional glass ionomer presented another problem during the scanning process: water evaporation during the methodology resulted in some cracks in the material. The TalyScan 150 (Taylor Robson) 3-D scanning system presented a method to digitally compensate for this problem: the "erase defects" mode. When using the system, the irregularities caused by evaporation of the colloid were eliminated, so they would not contribute to the results.

In laboratory-based experiments, the inherent complexity of the oral environment is disregarded to highlight the main factor under analysis. Other aspects that were not included in the current study were simulated abrasive wear, thermal stress and occlusal loading.[1,23] However, considering the development of new restorative and polishing materials, laboratory studies are still very important.

CONCLUSIONS

Under the current conditions, it may be concluded that:

1. The liquid polisher demonstrated being a valuable tool in obtaining polished surfaces and reducing surface roughness.
2. It was possible to obtain polished surfaces using only the liquid polisher after finishing with a diamond bur.
3. Longitudinal studies are necessary to confirm the clinical validity of the liquid polisher.

(Received 24 September 2008)

References

1. Yap AU, Sau CW & Lye KW (1998) Effects of finishing/polishing time on surface characteristics of tooth-coloured restoratives *Journal of Oral Rehabilitation* **25(6)** 456-461.
2. Özgünaltay G, Yazici AR & Görücü J (2003) Effect of finishing and polishing procedures on the surface roughness of new tooth-coloured restoratives *Journal of Oral Rehabilitation* **30(2)** 218-224.
3. Jones CS, Billington RW & Pearson GJ (2004) The *in vivo* perception of roughness of restorations *British Dental Journal* **196(1)** 42-45, discussion 31.
4. Kaplan BA, Goldstein GR, Vijayaraghavan TV & Nelson IK (1996) The effect of three polishing systems on the surface roughness of four hybrid composites: A profilometric and scanning electron microscopy study *Journal of Prosthetic Dentistry* **76(1)** 34-38.
5. Bollen CM, Lambrechts P & Quirynen M (1997) Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention: A review of the literature *Dental Materials* **13(4)** 258-269.
6. Heintze SD, Forjanic M & Rousson V (2005) Surface roughness and gloss of dental materials as a function of force and polishing time *in vitro Dental Materials* **22(2)** 146-165.
7. Jones CS, Billington RW & Pearson GJ (2005) Laboratory study of the loads, speeds and times to finish and polish direct restorative materials *Journal of Oral Rehabilitation* **32(9)** 686–692.
8. Ferreira RS, Lopes GC & Baratieri LN (2004) Direct posterior resin composite restorations: Considerations on finishing/polishing. Clinical procedures *Quintessence International* **35(5)** 359-366.
9. Türkün LS & Türkün M (2004) The effect of one-step polishing system on the surface roughness of three esthetic resin composite materials *Operative Dentistry* **29(2)** 203-211.
10. Chung K (1994) Effects of finishing and polishing procedures on the surface texture of resin composites *Dental Materials* **10(9)** 325-330.
11. Barghi N & Alexander C (2003) A new surface sealant for polishing composite resin restorations *Compendium of Continuing Education in Dentistry* **24(8)** 30-33.
12. Geiger S, Ravchanukayev M & Leberman R (1999) Surface roughness evaluation of resin modified glass-ionomer polished utilizing poly(acrylic acid) gel *Journal of Oral Rehabilitation* **26(9)** 704-709.
13. Pedrini D, Candido MSM & Rodrigues AL (2003) Analysis of surface roughness of glass-ionomer cements and compomer *Journal of Oral Rehabilitation* **30(7)** 714-719.
14. Bagheri R, Burrow MF & Tyas MJ (2007) Surface characteristics of aesthetic restorative materials—a SEM study *Journal of Oral Rehabilitation* **34(1)** 68-76.
15. Baseren M (2004) Surface roughness of nanofill and nanohybrid composite resin and ormocer-based tooth-colored restorative materials after several finishing and polishing procedures *Journal of Biomaterials Applications* **19(2)** 121-134.
16. Marigo L, Rizzi M, La Torre G & Rumi G (2001) 3-D surface profile analysis: Different finishing methods for resin composites *Operative Dentistry* **26(6)** 562-568.
17. Lu H, Roeder LB & Powers JM (2003) Effect of polishing systems on the surface roughness of microhybrid composites *Journal of Esthetic Restorative Dentistry* **15(5)** 297-304.

18. Fruits TJ, Miranda FJ & Coury TL (1996) Effects of equivalent abrasive grit sizes utilizing differing polishing motions on selected restorative materials *Quintessence International* **27(4)** 279-285.

19. Bouvier D, Duprez JP & Lissac M (1997) Comparative evaluation of polishing systems on the surface of three aesthetic materials *Journal of Oral Rehabilitation* **24(12)** 888-894.

20. Borges AB, Marsilio AL, Pagani C & Rodrigues JR (2004) Surface roughness of packable resins polished with various systems *Journal of Esthetic Restorative Dentistry* **16(1)** 42-48.

21. Barbosa SH, Zanata RL, Navarro MFL & Nunes OB (2005) Effect of different finishing and polishing techniques on the surface roughness of microfilled, hybrid and packable composite resins *Brazilian Dental Journal* **16(1)** 39-44.

22. Suh BI (2003) A new resin technology: A glaze/composite sealant *Compendium of Continuing Education in Dentistry* **24(Supplement 8)** 27-29.

23. Turssi CP, Ferracane JL & Serra MC (2005) Abrasive wear of resin composites as related to finishing and polishing procedures *Dental Materials* **21(7)** 641-648.