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Surface Finish Produced on 5 Aesthetic Restorative Materials by New Polishing Systems

SUMMARY

***Objective*:** *The purpose of this study was to investigate the surface finish of 5 different aesthetic restorative materials after polishing with 3 different polishing systems.*

***Materials and Method**: The materials included 2 nano-filled composites (Tetric Evo Ceram and Grandio), a compomer (Compoglass F), a resin-modified glass ionomer cement (Fuji II LC), and a highly viscous glass-ionomer cement (Fuji IX GP Fast). 32 specimens (6mm diameter x 3mm thickness) of each material were fabricated and divided into 4 groups. Specimens in the group 1 were left without finishing and polishing (matrix strip finish), while in the remaining groups specimens were finished with 30-fluted finishing tungsten carbide bur. The groups were then finished/polished with the following polishing systems: Group 2: Sof-Lex, Group 3: Optapol, Group 4: Diacomp. The surfaces were tested for surface roughness with a profilometer and examined with SEM. Data were subjected to ANOVA and Tukey's HSD test at significance level p<0.05.*

***Results*:** *The matrix strip group had the lowest Ra values and was significantly different from all of the finishing/polishing procedures. Tetric Evo Ceram, Grandio and Compoglass F had lower mean Ra values against matrix strip than Fuji II LC and Fuji IX GP Fast. For Fuji II LC and Fuji IX GP Fast there was no difference among the different polishing systems. For all materials a significantly smoother surface was obtained after polishing with Sof-Lex than with Optapol and Diacomp.*

***Conclusions:** There was a significant effect of the finishing methods and restorative materials on surface roughness (p<0.05).*

Keywords: Surface Finish; Surface Roughness; Polishing Systems; Restorative Materials

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Introduction

The use of aesthetic restorations has increased substantially over the past few years due to the increased aesthetic demand by patients, improvement in formulation and simplification of bonding procedures. On the extreme ends of the continuum of direct aesthetic restorative materials are conventional glass-ionomer cements (GICs) and resin composites.

To combine the major advantages of GICs (fluoride release, chemical bonding to dental tissues and biocompatibility) with the easy handling and aesthetic properties of composites, various hybrid materials have been developed. These include resin-modified GICs and compomers (polyacid-modified resin composites). Resin-modified and highly viscous GICs were developed to overcome early moisture sensitivity and low mechanical properties associated with conventional GICs. Compomers are basically composites that contain essential components of glass- ionomer cements, but at a level insufficient to promote an acid-base reaction in the dark.

The advent of visible light-curing resins and the use of finer fillers permit tooth-coloured restoratives to be polished to a higher degree[1,2].

One of the most important advances in the last few years is application of nanotechnology to resin

composites. Nanotechnology is based on the production of functional materials and structures ranging from 1 to 100nm using various physical and chemical methods. One of these materials, Grandio, contains glass ceramic particles (1μm) and silica (SiO_2) particles (20-50nm)[3]. Another material, Tetric Evo Ceram, also comprises features of nanotechnology. It contains a small quantity of inorganic nano-particles, nano-additives, known as rheological modifiers that have been incorporated in a targeted fashion[4].

The longevity and aesthetic appearance of tooth-coloured dental restorative material greatly depend on the quality of finishing and polishing techniques employed[5-9]. Finishing and polishing in restorative dentistry refers to the steps of: (1) gross contouring of the restoration to obtain the desired anatomy; (2) the reduction and smoothing of the surface roughness and scratches created by finishing instruments in the process of gross reduction and initial polishing; and (3) the process of producing a highly smooth, light-reflective, enamel-like surface through final polishing[10].

A wide variety of finishing and polishing systems are available in the market to the clinician. For years, a set of highly flexible finishing and polishing discs coated with aluminium oxide (AlO) were widely used for polishing tooth-coloured restorations. More recently, silicone synthetic rubbers have been introduced for finishing and polishing aesthetic restorative materials to reduce the clinical time spent to finish the restoration. According to manufacturers, they can be used to complete finishing and polishing procedures using a single instrument (one step).

With the ultimate goal of achieving a smooth surface of composites, compomer, conventional and resin-modified GICs in fewer steps, it is common to see new polishing systems being introduced and therefore, updated evaluations are necessary. The **aim** of the current study was to examine the surface roughness of 2 nano-filled composites, a compomer, a resin-modified glass-ionomer cement, and a highly viscous glass-ionomer cement after polishing with 3 different polishing systems. The aim was also to evaluate the effectiveness of these polishing systems and its possible surface damage by scanning electron microscope (SEM) analysis.

Materials and Methods

2 novel resin composites containing nano-particles, a compomer, a resin modified and a highly viscous glass-ionomer cement were used in this study. The evaluated are presented in table 1. The polishing systems tested (Tab. 2) were Sof-Lex (3M ESPE), Optapol (Ivoclar Vivadent) and Diacomp (EVE).

Table 1. Characteristics of the restorative materials used in the study

Material	TYPE	Manufacturer	BATCH No	Shade
Tetric Evo Ceram	Composite resin (nanohybrid)	Ivoclar Vivadent Schaan, Liechtenstein	L01344	A3
Grandio	Composite resin (nanohybrid)	Voco, Cuxhaven Germany	492726	A3
Compoglass F	Compomer	Ivoclar Vivadent Schaan, Liechtenstein	K31913	A3
Fuji II LC	Resin-modified GIC	GC Corporation Tokyo, Japan	0106208	A3
Fuji IX GP Fast	Highly viscous GIC	GC Corporation Tokyo, Japan	0812031	A3

Table 2. Composition and manufacturers of the polishing systems used in this study

Polishing System	Composition	Manufacturer
Sof-Lex (multi-step)	Aluminium oxide-coated disk coarse (100μm), medium (40μm), fine (24μm), extra fine (8μm)	3M ESPE St Paul MN, USA
Optapol (one-step)	Caoutchouk, silicone carbide, aluminium oxide	Ivoclar Vivadent Schaan, Liechtenstein
Diacomp (two-step)	20μm aluminium oxide 7μm aluminium oxide	EVE, Ernst Vetter GmbH, Germany

Cylindrical moulds, measuring 6mm in diameter and 3mm in deep, were fabricated from Teflon. 32 specimens of each restorative material were made for this study. The moulds were slightly over-filled with material, covered on each side with matrix strips (Have-Neos Dental, Bioggio, Switzerland) and placed between 2 microscope glass slides (1mm thick); pressure applied to extrude the excess material. The samples were then light cured for 40 seconds (except Fuji II LC: 20 seconds) on both sides of the specimens with a light source (Elipar 2500, 3M ESPE, St Paul, MN, USA) through the matrix strip and glass slide, while the glass-ionomer cement Fuji IX GP Fast was allowed to set for 10 min. The intensity of light source was 810mW/cm^2 and was checked after every 5 samples using a photometric tester (Hilux, Curing Light Meter, Benlioglu Dental Inc. Turkey). Following light curing, the specimens were placed into 37ºC de-ionized water for 24h.

32 specimens of each material were made and divided into 4 groups of 8 specimens. Specimens in Group 1 (MS) were left without any finishing or polishing procedure (matrix strip finish), while the remaining groups, in an attempt to simulate the clinical conditions, were finished with 30-fluted finishing tungsten carbide bur (Diatech Dental AC, Switzerland). Specimens were then finished/polished with the following systems: Group 2 (SL): Sof-Lex, Group 3 (OP): Optapol and Group 4 (DC): Diacomp. Table 2 reflects the manufacturers and details of the finishing/polishing sequences that were based upon manufacturers' instructions.

Sof-Lex is a multi-step graded abrasive disk system, Optapol is a 1-step finishing/polishing system and Diacomp is a 2-step finishing/polishing system. The 1-step (OP) and 2-step (DC) polishing systems tested were manufactured in different shapes; however, disc shaped polishers were in this study used in order to obtain direct contact with the surfaces of the specimens. The Group 2 (SL) was polished with graded abrasive disks, applying feather light pressure on the discs with continuous water irrigation for 30 seconds. For Groups 3 and 4 (OP and DC), discs were used with moderate pressure in conjunction with copious water spray for 30 seconds.

To minimize the effect of operator variability, all finishing/polishing procedures were carried out by the same researcher. The polished specimens rinsed, cleansed in an ultrasonic cleaner for 3 min, allowed to dry and kept in 100% humidity for 24h, before measuring the surface roughness. The average surface roughness (Ra) of each specimen was measured using a surface profilometer (Mitutoyo SJ 201, Kanagawa, Japan). Readings were taken at the centre of each specimen and 5 sampling lengths of 0.8mm were used, giving a total evaluation length 4mm with a standard cut-off of 0.8mm, a transverse length of 0.8mm and a stylus speed of 0.25mm/sec. The Ra of a specimen was defined as the arithmetic average height of roughness component irregularities from the mean line measured within the sampling length. 5 profilometer tracings were made at the centre of each specimen and the numerical average was determined for each group.

2-way ANOVA ($p<0.05$) was used to determine significant interactions between materials and the finishing/polishing methods. 1-way ANOVA and Tukey's HSD test ($p<0.05$) were used to compare the mean surface roughness between materials for each treatment group.

One representative specimen of each group was prepared for the scanning electron microscope, SEM (JEOL, JSM-840, Tokyo, Japan). The specimens were sputter coated with carbon to a thickness of approximately 200Å in a vacuum evaporator. Photographs of the representative areas of the polished surfaces were taken at 500x magnification.

Results

The Ra values produced by the matrix strip, Sof-Lex, Optapol and Diacomp on the 5 restorative materials are presented in table 3. Results of statistical analysis are shown in tables 4 and 5. 2-way ANOVA revealed significant interaction among the materials and finishing/polishing techniques. The effect of finishing/polishing on surface finish was therefore material dependent.

Table 3. Average roughness values (Ra, μm) and standard deviations for 5 restorative materials and 3 polishing systems tested

Restorative material Polishing system	Tetric Evo Ceram (TEC)	Grandio (GR)	Compoglass F (CG)	Fuji II LC (FII)	Fuji IX GP Fast (FIX)
Matrix Strip (MS)	0.08 (0.02)	0.09 (0.01)	0.10 (0.01)	0.14 (0.02)	0.16 (0.02)
Sof-Lex (SL)	0.20 (0.04)	0.18 (0.03)	0.28 (0.04)	0.32 (0.03)	0.38 (0.06)
Optapol (OP)	0.31 (0.06)	0.30 (0.06)	0.46 (0.07)	0.66 (0.11)	0.71 (0.09)
Diacomp (DC)	0.30 (0.04)	0.31 (0.04)	0.42 (0.06)	0.70 (0.12)	0.74 (0.11)

Table 4. Comparison of mean surface roughness among restorative materials

Polishing Systems	Differences
Matrix Strip	TEC , GR , CG < FII , FIX
Sof-Lex	TEC , GR < CG, FII < FIX
Optapol	TEC , GR < CG < FII , FIX
Diacomp	TEC , GR < CG < FII , FIX

The symbol < denotes statistically significant difference

Table 5. Comparison of mean surface roughness among polishing systems

Restorative Materials	Differences
Tetric Evo Ceram	MS < SL < OP, DC
Grandio	MS < SL < OP, DC
Compoglass F	MS < SL < OP, DC
Fuji II LC	MS < SL < OP, DC
Fuji IX GP Fast	MS < SL < OP, DC

The symbol < denotes statistically significant difference.

The MS group had the lowest Ra value and was significantly different from all of the finishing/polishing procedures ($p<0.05$), when the 1-way ANOVA and Tukey's HSD tests were applied. Tetric Evo Ceram, Grandio and Compoglass F had lower mean Ra values against matrix strip than Fuji II LC and Fuji IX GP Fast ($p<0.05$).

For all the restorative materials, a significantly smoother surface was obtained from polishing with Sof-Lex, and a rougher surface resulted after polishing with Optapol and Diacomp. Qualitative assessment of the SEM photomicrographs accorded well with the quantitative results.

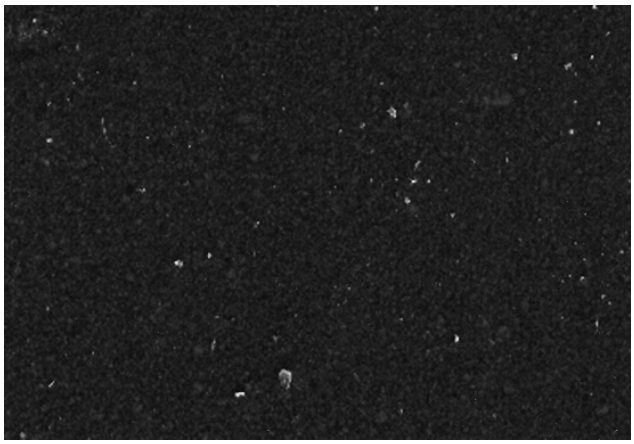

Figure 1. SEM photomicrograph of the Tetric Evo Ceram after removal of the matrix strip

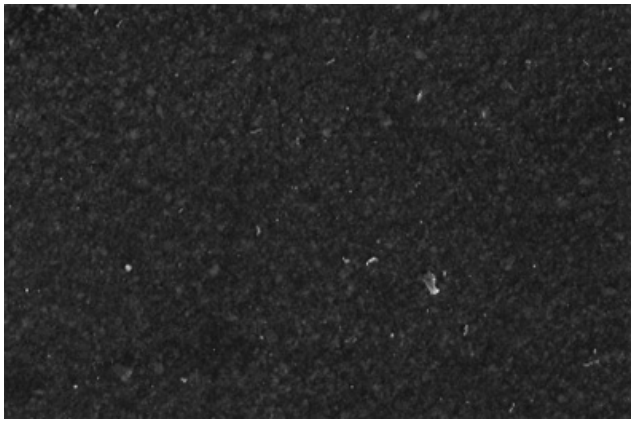

Figure 2. SEM photomicrograph of the Tetric Evo Ceram after polishing by Sof-Lex

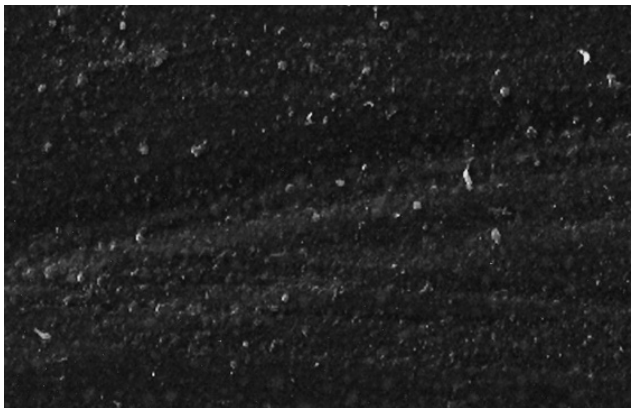

Figure 3. SEM photomicrograph of the Grandio after polishing by Optapol

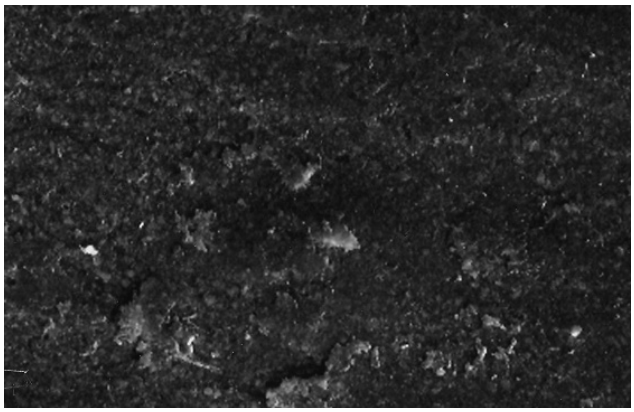

Figure 4. SEM photomicrograph of the Compoglass F after polishing by Diacomp

SEM analysis of the Tetric Evo Ceram and Grandio samples polished with Sof-Lex revealed the same surface appearance as the matrix strip, although the roughness values were not the same, while the surfaces polished with Optapol and Diacomp had some scratches (Figs. 1-3).

Specimen surfaces of Compoglass F, Fuji II LC and Fuji IX GP Fast after treatment with the 3 finishing/polishing systems were mainly characterized by the remaining minor grooves and surface irregularities (Figs. 4-6).

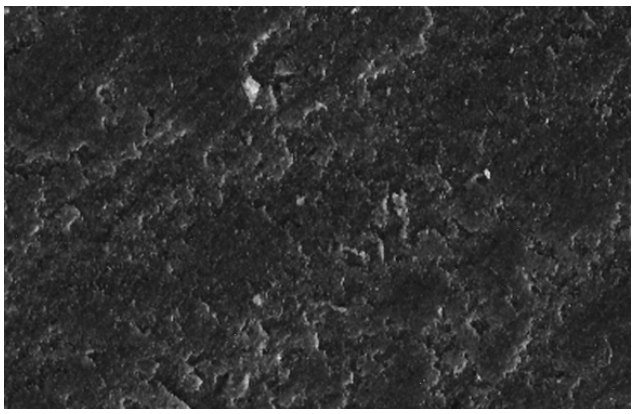

Figure 5. SEM photomicrograph of the Fuji II LC after polishing by Optapol

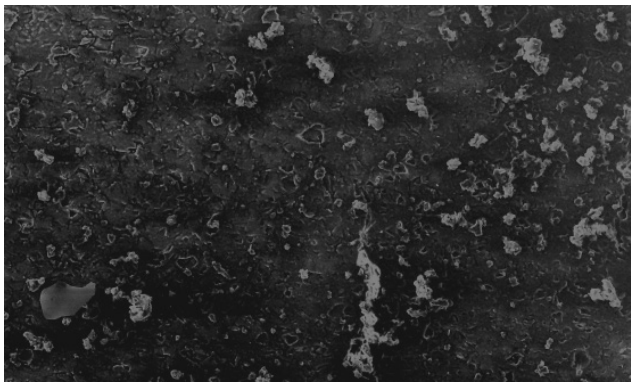

Figure 6. SEM photomicrograph of the Fuji IX GP Fast after polishing by Diacomp

Discussion

Effective finishing and polishing of dental restorations not only results in optimal aesthetics but also provide for acceptable health of soft tissues and marginal integrity of the restorative interface[7-9]. Some of the difficulties resulting from improperly finished and polished restorations are excessive plaque accumulation, gingival irritation, increased surface staining and poor or suboptimal aesthetics of the restored teeth[10,11]. In the polishing process, a series of abrasives of increasing fineness were used. To reduce cost and clinical time, multi-step (graded abrasive disks) systems were replaced with 2- and 1-step systems.

In this study, the smoothest surfaces were obtained from composite resins, compomer and glass-ionomer cements against a matrix strip. This finding agreed with previous studies on composite resins, compomers, conventional and resin modified glass-ionomer cements[12-17]. All finishing/polishing procedures decreased the smoothness obtained with matrix strips[18].

The surface finish of aesthetic restorative materials is dependent in part on their particle size range. The latter can be estimated by the mean particle size of the inorganic fillers of composite resins and the fluorosilicate glasses used in glass-ionomers and compomers. Glass-ionomers and compomers with larger particles are expected to be rougher than nanohybrid composite resins. Nanohybrid composite filling materials contain inorganic filler glass particles with size approximately 1μm and silica particles with size 5-60nm[3,4]. The mean particle size of Fuji II LC and Compoglass F is approximately 4.5μm, while that of Fuji IX GP Fast is approximately 7μm[10].

In view of the aforementioned, the significantly higher Ra values observed with Compoglass F, Fuji II LC and Fuji IX GP Fast after finishing/polishing is expected[19-23]. For all the materials a significantly smoother surface was obtained from polishing with Sof-Lex and a rougher surface resulted after polishing with Optapol and Diacomp[16,24].

Some authors have shown in their researches on packable, hybrid and micro-filled resin composites that Sof-Lex discs produced the best results in surface roughness[25-27]. With the exception of the composite resins when finished/polished with Sof-Lex, the finished/polished surfaces of all materials had Ra values greater than 0.2μm[28]. The differences in surface finish between materials were therefore clinically relevant.

When specimens were finished with matrix strips, Ra values between materials were significantly different. The differences may not be clinically relevant as values were all below the critical threshold value of 0.2μm[28]. The significant differences in Ra values may be attributed to inherent material properties, such as filler or glass particle sizes and their ability to form a polymer-rich layer when the material is cured.

Although the surface obtained by the use of the matrix strip is very smooth, it is rich in resin matrix; therefore, removal of the outermost resin by finishing/polishing procedures would tend to produce a harder, more wear resistant, and hence a more aesthetically stable surface[29]. Despite the careful placement of the matrices, removal of excess material or re-contouring of restorations by diamond and carbide burs is often clinically necessary. It was suggested that the determining step in finishing and polishing restorations might be the use of finishing carbide burs prior to using polishers[30,31].

Regardless of treatment groups, the surface finish of Tetric Evo Ceram and Grandio was significantly better than Compoglass F, Fuji II LC and Fuji IX GP Fast in this study. Harder filler particles were left protruding from the surface during finishing/polishing of composite resins, as

the softer resin matrix was preferentially removed. The set glass-ionomers are heterogeneous and biphasic in nature and consist of non-reacted glass particles embedded in a poly-salt resin matrix. During finishing and polishing, the softer matrix phases are preferentially removed, leaving the harder, non-reacted glass particles to protrude from the surface.

Profilometers used for *in vitro* investigations, provide limited 2-dimensional information, but an arithmetic average roughness can be calculated[32]. Therefore, the complex structure of a surface cannot be fully characterized by use of only surface roughness measurements. However, in combination with SEM analysis, more valid predictions of clinical performance can be made[32,33]. In this study, the texture of the surfaces was examined with SEM, additionally to the surface roughness measurements. The results of the profilometric measurements were largely confirmed by SEM analysis.

Conclusions

Under limitations of this *in vitro* study:

1. There was a significant effect of the finishing methods and restorative materials on surface roughness ($p<0.05$);
2. The use of matrix strip resulted in the best surface finish for nano-hybrid composite resins, compomer and resin-modified and highly viscous glass-ionomer cements;
3. All the used finishing/polishing systems decreased the smoothness obtained with matrix strip;
4. Among the aesthetic material evaluated, the surface finish of Compoglass F, Fuji II LC and Fuji IX GP Fast was significantly poorer than that of Tetric Evo Ceram and Grandio;
5. For all the materials, the smoothest surfaces were obtained with Sof-Lex discs.

References

6. *Bauer JG, Caputo AA*. The surface of composite resin finished with instruments and matrices. *J Prosthet Dent*, 1983; 50:351-357.
7. *Health JR, Wilson HJ*. Surface Roughness of Restorations. *Br Dent J*, 1976; 140:131-137.
8. Voco, Grandio, Light-curing Nano-hybrid filling material. Corresponds to EN 24049/ISO 4049 Instructions for Use, Cuxhaven, Germany, 2003.
9. Ivoclar Vivadent. Tetric Evo Ceram. Scientific Documentation Schaan, Liechtenstein, 2005.
10. *Marigo L, Rizzi M, Torre G, La, Rumi G*. 3D surface profile analysis: different finishing methods for resin composites. *Oper Dent*, 2001; 26:562-568.
11. *Shintani H, Satou J, Satou N, Hayashiliara H, Inoue T*. Effects of various finishing methods on staining and accumulation of Streptococcus mutans HS-6 on composite resins. *Dent Mater*, 2001; 1:225-227.
12. *Dunkin RT, Chambers DW*. Gingival response to Class V composite resin restorations. *J Am Dent Assoc*, 1983; 106:482-484.
13. *Chan KC, Fuller JL, Hormati AA*. The ability of foods to stain two composite resins. *J Prosth Dent*, 1980; 43:542-545.
14. *Weitman RT, Eames WB*. Plaque accumulation on composite surface after various finishing procedures. *J Am Dent Assoc*, 1975; 91:101-106.
15. *Jefferies SR*. Abrasive finishing and polishing in restorative dentistry: A state of the Art Review. *Dent Clin North Am*, 2007; 51:379-397.
16. *Van Dijken JW, Sjöstrom S, Wing K*. The effect of different types of composite resin fillings on marginal gingival. *J Clin Periodontology*, 1987; 14:185-189.
17. *Ergücü Z, Turkun LS*. Surface roughness of novel resin composites polished with one-step systems. *Oper Dent*, 2007; 32:185-192.
18. *Yap AUJ, Yap SH, Teo CK, Ng JJ*. Finishing/polishing of composite and compomer restoratives: Effectiveness of one-step systems. *Oper Dent*, 2004; 29:275-279.
19. *Yap AUJ, Ng JJ, Yap SH, Teo CK*. Surface finish of resin-modified and highly viscous glass ionomer cements produced by new one-step systems. *Oper Dent*, 2004; 29:87-91.
20. *Paulillo LA, Coradazzi JL, Lovadino JR, Serra MC*. Surface finishing of glass ionomer. *Am J Dent*, 1997; 10:137-140.
21. *Hondrum SO, Fernandez R*. Contouring, finishing/polishing Class V restorative materials. *Oper Dent*, 1997; 22:30-36.
22. *Yap AU, Lye KW, Sau CW*. Surface characteristics tooth-colored restoratives polished utilizing different polishing systems. *Oper Dent*, 1997; 22:260-265.
23. *Gedik R, Hürmüzlu F, Coskun A, Bektas O, Ozdemir AK*. Surface roughness of new microhybrid resin based composites. *J Am Dent Assoc*, 2005; 136:1106-1112.
24. *Yap AU, Pek YS, Cheang P*. Physico-mechanical properties of a fast-set highly viscous GIC restorative. *J Oral Rehabil*, 2003; 30:1-8.
25. *Türkün LS, Turkun M*. The effect of one-step polishing system on the surface roughness of three esthetic resin composite materials. *Oper Dent*, 2004; 29:203-211.
26. *Yap AU, Tan WS, Yeo JC, Yap WY, Ong SB*. Surface texture of resin-modified glass ionomer cements: Effects of finishing/polishing systems. *Oper Dent*, 2002; 27:381-386.
27. *Schmidlin PR, Göhring TN*. Finishing tooth-colored restorations in vitro: An index of surface alteration and finish-line destruction. *Oper Dent*, 2004; 29:80-86.
28. *Yap AU, Yap SH, Teo CK, Ng JJ*. Comparison of surface finish of new aesthetic restorative materials. *Oper Dent*, 2004; 29:100-104.
29. *Hoelscher DC, Neme AML, Pink FE, Hughes PJ*. The effect of three finishing systems on four esthetic restorative materials. *Oper Dent*, 1998; 23:36-42.
30. *Roeder LB, Tate WH, Powers JM*. Effect of finishing and polishing procedures on the surface roughness of packable composites. *Oper Dent*, 2000; 25:534-243.

31. *Setcos JC, Tarim B, Suzuki S*. Surface finish produced on resin composites by new polishing systems. *Quintessence Int*, 1999; 30:169-173.
32. *Bouvier D, Duprez JP, Lissac M*. Comparative evaluation of polishing systems on the surface of three aesthetic materials. *J Oral Rehabil*, 1997; 24:888-894.
33. *Bollen CM, Lambrechts P, Quirynen M*. Comparison of x 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.
34. *Studdard JW, Johnson GH*. An evaluation of polishing agents for composite resins. *J Prosthet Dent*, 1991; 65:491-495.
35. *Turssi CP, Ferracane JL, Serra MC*. Abrasive wear of resin composites as related to finishing and polishing procedures. *Dent Mater*, 2005; 21:641-648.
36. *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.
37. *McLundie AC, Murray FD*. Comparison of methods used in finishing composite resin: A scanning electron microscope study. *J Prosth Dent*, 1974; 31:163-171.
38. *Lambrechts P, Vanherle G*. Observation and comparison of polished composite surfaces with the aid of SEM and profilometer. *J Oral Rehabil*, 1982; 9:169-182.

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