©Operative Dentistry, 2006, **31-1,** 11-17

Effect of Polishing Techniques and Time on Surface Roughness, Hardness and Microleakage of Resin Composite Restorations

D Venturini • MS Cenci • FF Demarco
GB Camacho • JM Powers

Clinical Relevance

The effects of polishing techniques on surface roughness, microhardness and microleakage of resin composites are material dependent. In general, since immediate polishing has not had a negative influence on the tested properties of the two composites compared to delayed polishing, this procedure could be preferred, reducing the number of clinic sessions and bringing more comfort and satisfaction to the patient.

SUMMARY

This study evaluated the effects of immediate and delayed polishing on the surface roughness, microhardness and microleakage of a microfilled (Filtek A110) and a hybrid (Filtek Z250) resin composite. Standardized preparations were made on the buccal surfaces of 256 bovine teeth; half were restored with each composite (128 teeth per composite). Immediately after curing, gross finishing was carried out with #280 sandpaper. The specimens restored with each composite were divided into two subgroups. The first group (IM) was polished immediately after gross finishing, using three different systems (n=16): Sequence A, Sof-Lex; Sequence B, Flexicups and Sequence C, Flexicups + Jiffy Polishing Brush + Flexibuffs. The specimens were then stored for three weeks in saline 37°C. The second group (DE) was stored for two weeks, then polished with the same systems and stored for one additional week. The controls (n=16) were analyzed without polishing. Five readings per specimen were taken for surface roughness and hardness. After immersion in basic fuchsin, microleakage was evaluated (40x) using standardized scores. The data were analyzed at a significance level of 0.05, with analysis of variance and an SNK test (surface roughness and microhardness) or with Kruskal-Wallis (microleakage). In both composites, only for the sequential technique was there an influence of delay in polishing on roughness (Ra). Flexicups exhibited the highest Ra of the

Daniela Venturini, MSc student, School of Dentistry, Federal University of Pelotas, RS, Brazil

Maximiliano Sérgio Cenci, DDS, MSc, PhD student, Faculty of Dentistry of Piracicaba, State University of Campinas, SP, Brazil

*Flávio Fernando Demarco, DDS, PhD, associate professor, Department of Operative Dentistry, School of Dentistry, Federal University of Pelotas, RS, Brazil

Guilherme Brião Camacho, DDS, PhD, associate professor, Department of Operative Dentistry, School of Dentistry, Federal University of Pelotas, RS, Brazil

John M Powers, PhD, Director, Houston Biomaterials Research Center, University of Texas Dental Branch at Houston, Houston, TX, USA

*Reprint request: Gonçalves Chaves, 457, 5° andar, 96015 560 Pelotas, RS, Brazil; fdemarco@ufpel.tche.br; or ffdemarco@hotmail.com

DOI: 10.2341/04-155

three systems. The IM and Filtek Z-250 groups showed higher hardness than the DE and Filtek A-110 groups, respectively. Dentin margins showed more leakage than enamel margins; the sequential technique produced more leakage than the other techniques in dentin (*p*<0.05) and delay of polishing was not significant in the majority of situations. In conclusion, several conditions—composite, time and polishing technique—had a significant influence on surface roughness, hardness and microleakage. Generally, immediate polishing produced no detrimental effect compared to delayed polishing.

INTRODUCTION

No other restorative material has been so modified and improved as resin composite, which was introduced by Bowen (1962). Despite all initial inherent problems, the current status of composite restorations used in conjunction with the total acid-etch technique has made many dentists choose these materials, even for restoring areas of high occlusion stress, such as posterior teeth (Leinfelder, 1993; Ferreira, Lopes & Baratieri, 2004).

The proper finishing and polishing of dental restoratives are critical clinical procedures and very important for the esthetics and longevity of restorations. Residual surface roughness of restorations can influence dental biofilm retention, resulting in superficial staining, gingival inflammation and secondary caries, thus affecting the clinical performance of restorations (Yap, Lye & Sau, 1997; Hoelscher & others, 1998; Setcos, Tarim & Suzuki, 1999; Reis & others, 2002). However, a highly polished surface of composites is difficult to achieve, because of factors such as different amounts of filler particles, the size of particles and the differences in hardness between the filler particles and matrix of the resin composite. Traditionally, it is believed that the polishing ability of composites vary depending on particle size (Strassler, 1990) and microfilled resin composites are more easily polished than hybrid types.

Finishing is defined as the gross contouring or reduction of a restoration to obtain ideal anatomy. Polishing refers to the reduction of roughness and scratches created by finishing instruments (Yap & others, 1997). Different methods can be used for the finishing and polishing of resin composite restorations (Setcos & others, 1999). However, there is no consensus on which material and technique provides the smoothest surfaces for resin composites, and little research has been conducted on the influence of delay in polishing on the surface roughness, hardness and marginal sealing of composite restorations.

This study evaluated the effects of different techniques and times (immediate and delayed) of polishing on the surface texture, surface microhardness and sealing ability of two composites in an *in vitro* tooth-restoration model. The null hypothesis tested was that there were no differences caused by polishing techniques, types of composite and polishing time on the surface texture, surface microhardness and sealing ability of resin composite restorations.

METHODS AND MATERIALS

Two hundred and fifty-six freshly extracted bovine incisors were selected. The teeth were cleaned and stored in saline at 4°C until use. The teeth were sectioned 5 mm above and 5 mm below the cemento-enamel junction using a low-speed diamond-impregnated disk under water cooling; they were then embedded in cylindrical molds with acrylic resin. The buccal surface of each tooth was ground with 180-grit silicon carbide paper under running water. Standardized Class V preparations were made on the exposed surface. The cavities were 3-mm mesio-distally and occluso-gingivally and 2-mm deep. The occlusal-cavosurface margin was located in enamel, while the gingival-cavosurface margin was located in dentin. The specimens were kept hydrated in distilled water throughout all the steps.

The cavity on each tooth was restored with Single Bond adhesive system (3M ESPE, St Paul, MN, USA) and a microfilled resin composite (Filtek A-110, 3M ESPE,) or with a microhybrid resin composite (Filtek Z-250, 3M ESPE) according to the manufacturer's instructions (Table 1). Shade B2 was used for both composites to standardize the depth of curing, and the composite was placed in three increments, with the cervical increment placed first. Transparent matrixes were placed over the filled cavities, and pressure was applied to extrude excessive material that was removed. Each increment was cured for 20 seconds, and the final restoration was cured for another 40 seconds using a light-curing unit operating at 650mW/cm^2 (XL 3000, 3M ESPE).

The positive control groups (n=16) were evaluated without any finishing/polishing procedure and remained stored in saline solution at 37°C for three

Table 1: *Characteristics of Resin Composites Tested*

Composite/ Manufacturer	Shade	Classification	Filler Content (type/mean size/amount	Batch #
Filtek Z250/3M ESPE	B2	Microhybrid	Zirconia and Silica/0.19-3.3 μm/60%	2ML
Filtek A110/3M ESPE	B2	Microfilled	Silica/0.04 μm/40%	2BC

Table 2: *Technical Profile of Polishing Systems and Details of Polishing Procedures*

System/Manufacturer	Speed (rpm)	Condition
Sof-Lex finishing system/3M ESPE		
Medium (medium orange—29 µm)	30,000	Dry
Fine (light orange—14 µm)	30,000	Dry
Extra fine (yellow—5 µm)	30,000	Dry
Flexicups/Cosmedent		
Medium (blue)	20,000	Dry (polishing paste)
Extra fine (pink)	20,000	Dry (polishing paste)
Sequential technique		
Flexicups medium	20,000	Dry (polishing paste)
Flexicups extra fine	20,000	Dry (polishing paste)
Jiffy Polishing Brush/Ultradent	30,000	Dry (polishing paste)
Flexibuffs/Cosmedent	30,000	Dry (polishing paste)

weeks. The solution was changed twice a week. For the testing groups, transparent matrices were removed immediately after light-polymerization, and gross finishing was carried out by grinding the specimens on 280-grit silicon carbide paper in one direction under running water. This procedure was done to simulate a fine diamond bur texture and was provided with a Gallone precision machine where a fine diamond bur was fixed in one axis in order to avoid formation of a wave-like surface. The surface roughness of 20 specimens of each composite was then obtained and compared to the surface roughness obtained from specimens using 180, 220, 280, 320 and 360 grit sandpaper. In as much, the most appropriated roughness pattern was obtained. Only two negative control groups (n=16) were obtained with this gross finishing.

The restored and finished specimens were then randomly divided into 12 groups of 16 teeth and polished with: (A) aluminum-oxide discs–Sof-Lex Pop On XT (3M ESPE), (B) rubber-polishing cups–Flexicups (Cosmedent, Chicago, Il, USA) and (C) the sequential use of rubber-polishing cups, polishing brush–Jiffy Polishing Brush (Ultradent, South Jordan, UT, USA) and felt-polishing discs–Flexibuffs (Cosmedent). The materials were used according to manufacturers' directions. The systems were used in the same way (10 strokes and 20 seconds each step) to permit comparison among them. A polishing paste (Enamelize, Cosmedent) was used in polishing sequences B and C. Table 2 provides additional information on the polishing systems.

Half the group was polished immediately after curing (IM), while the remaining half was polished after two weeks (DE). All groups were stored in saline for three weeks at 37°C before analyses. All the specimens were evaluated with the profilometer, but only half was submitted to hardness and microleakage evaluations (n=8). Eight samples from each group were stored in saline at 37°C (solution changed twice a week) to promote aging and will be further evaluated.

Surface roughness (Ra) was measured with a profilometer (Surfcorder SE 1200, Kosaka Laboratory Co, Chiyoba-Ku, Tokyo, Japan). The Ra value is the arithmetic mean line calculated by the analyzer. Five traces were recorded for each specimen on five different locations. The roughness value was recorded as the average of these five readings. A calibration block was used periodically to check the performance of the profilometer. The equipment consistently provided an accurate recording of the calibration block (3.10 ± 0.10 µm).

Knoop hardness was determined using the Miniload Hardness Tester (Ernest Leitz, GmbH, Wetzlar, Germany). Indentations were made with a 50-g load applied for 30 seconds. Five indentations were recorded for each specimen, and the microhardness value was obtained as the average of these five readings.

The specimens were subsequently sealed with two coats of nail varnish applied 1.5-mm short of the restorations' margins exposed to dye. The specimens were then immersed in 1% aqueous basic fuchsin dye for 24 hours at 37°C. After removal from the dye solution, the teeth were cleaned and sectioned longitudinally through the restorations in a bucco-palatal plane using a diamond saw under water irrigation. The margin sealing ability, as indicated by depth of dye penetration around the enamel (incisal) and dentin (gingival) margins, was evaluated under magnification (40x). A 0-3 scoring system was used to describe the severity of infiltration: 0 = no evidence of dye penetration, 1 = dye penetration to less than half the cavity depth, 2 = dye penetration to the full cavity depth, 3 = dye penetration to the axial wall and beyond.

For surface roughness and microhardness, statistical differences were tested by three-way analysis of variance (ANOVA) and Student-Newman-Kels (SNK) test at the 0.05 level of significance. To detect differences in sealing ability, Mann-Whitney and Kruskal-Wallis were used ($p<0.05$).

RESULTS

Table 3 shows the average surface roughness (Ra) for combinations of resin composites, polishing instruments and polishing times (immediate vs delayed). The smoothest surfaces for both composites were observed in the positive control groups. Compared to the negative control, all polishing treatments produced a decrease in surface roughness ($p<0.05$). The highest values of Ra were obtained with rubber-polishing cups

Table 3: *Means and Standard Deviations (n=8) of Surface Roughness (Ra-μm) of the Different Combinations of Materials, Polishing Techniques and Polishing Times*

Restorative Material–Polishing Method	Delayed Polishing	Immediate Polishing
Filtek A 110–Sof-Lex	0.14 ± 0.04^{c}	0.14 ± 0.02^{c}
Filtek A 110–Flexicups	0.18 ± 0.04^{d}	0.19 ± 0.05^{d}
Filtek A 110–Sequential Technique	0.13 ± 0.03^{c}	0.09 ± 0.02^{b}
Filtek Z 250–Sof-Lex	0.12 ± 0.03^{bc}	0.15 ± 0.03^{c}
Filtek Z 250–Flexicups	0.27 ± 0.06^{e}	0.21 ± 0.03^{d}
Filtek Z 250–Sequential Technique	0.11 ± 0.02^{b}	0.13 ± 0.03^{c}
Filtek A 110–Positive Control	0.03 ± 0.01^{a}	
FilteK A 110–Negative Control	1.13 ± 0.05^{f}	
Filtek Z 250–Positive Control	0.04 ± 0.02^{a}	
FilteK Z 250–Negative Control	1.24 ± 0.06^{g}	

Groups identified by different superscript lower case letters are significantly different (p<0.05).

Table 4: *Mean and Standard Deviations (n=8) of Surface Hardness (KHN) of the Different Combinations of Materials, Polishing Techniques and Polishing Times*

Restorative Material–Polishing Method	Delayed Polishing	Immediate Polishing
Filtek A 110–Sof-Lex	62.5 ± 9.4^{fg}	58.6 ± 5.5^{g}
Filtek A 110–Flexicups	57.3 ± 11.3^{g}	70.2 ± 9.9^{e}
Filtek A 110–Sequential Technique	49.8 ± 16.3^{h}	75.7 ± 3.7^{e}
Filtek Z 250–Sof-Lex	96.2 ± 5.0^{b}	94.8 ± 7.0^{bc}
Filtek Z 250–Flexicups	83.6 ± 11.3^{d}	106.5 ± 2.8^{a}
Filtek Z 250–Sequential Technique	104.5 ± 11.1^{a}	101.1 ± 10.3^{a}
Filtek A 110–Positive Control	68.4 ± 6.3^{ef}	
FilteK A 110–Negative Control	64.6 ± 5.8^{f}	
Filtek Z 250–Positive Control	89.5 ± 4.8^{cd}	
FilteK Z 250–Negative Control	93.5 ± 7.3^{bc}	

Groups identified by different superscript lower case letters are significantly different (p<0.05).

Table 5: *Mean, Median and Standard Deviations (n=8) of Dye Penetration to the Different Combinations of Materials, Polishing Techniques and Polishing Times for Enamel Margins*

Restorative Material–Polishing Method	Delayed Polishing	Immediate Polishing
Filtek A 110–Sof-Lex	0.50 (0.0) ± 0.76^{ab}	0.62 (0.5) ± 0.74^{bc}
Filtek A 110–Flexicups	1.25 (1.0) ± 0.71^{cd}	1.00 (1.0) ± 0.0^{c}
Filtek A 110–Sequential Technique	0.62 (0.5) ± 0.74^{bc}	0.75 (1.0) ± 0.71^{c}
Filtek Z 250–Sof-Lex	0.37 (0.0) ± 0.52^{ab}	0.87 (1.0) ± 0.83^{c}
Filtek Z 250–Flexicups	0.25 (0.0) ± 0.46^{ab}	0.75 (1.0) ± 0.70^{c}
Filtek Z 250–Sequential Technique	1.12 (1.5) ± 0.64^{d}	0.87 (1.0) ± 0.64^{c}
Filtek A 110–Positive Control	0.76 (1.0) ± 0.73^{bc}	
FilteK A 110–Negative Control	0.69 (0.5) ± 0.58^{b}	
Filtek Z 250–Positive Control	0.37 (0.0) ± 0.41^{ab}	
FilteK Z 250–Negative Control	0.89 (1.0) ± 0.74^{bc}	

Groups identified by different superscript lower case letters are significantly different (non-parametric Kruskal Wallis test—p<0.05). Values are mean (median) ± standard deviation.

for both composites ($p<0.05$). A comparison of surface roughness between materials and polishing times revealed that significant differences were only observed in the sequential technique for the two composites ($p>0.05$). There is a statistically significant interaction in surface roughness among composites, polishing techniques and polishing times (Table 3—$p<0.001$).

In relation to microhardness, there is a statistically significant interaction among composites, polishing techniques and polishing times. This indicates that the effect of one factor is not consistent at all combinations with the other factors. However, some significant interactions can be observed. There is a significant difference ($p<0.001$) between composites, with the microhybrid composite exhibiting higher surface microhardness values than the microfilled composite in both the control and experimental groups (Table 4). Polishing techniques are a significant factor if considered within the interactions between composites and time of polishing; and in immediate polishing time for both composites, aluminum-oxide discs exhibited the lowest hardness values ($p<0.05$). In delayed polishing time with the microfilled composite, the sequential polishing technique showed the lowest hardness values (Table 4—$p<0.05$) of the three techniques. For delayed specimens of the microhybrid composite, the sequential polishing technique exhibited higher hardness than the other techniques, and the aluminum-oxide discs exhibited higher hardness than rubber cups (Table 4—$p<0.05$). There is a significant difference in microhardness between polishing times ($p>0.05$), and the delayed polished specimens showed lower hardness than the immediate polished specimens (Table 4).

Tables 5 and 6 show the dye penetration means, medians and standard deviations (enamel and dentin), respectively. In enamel margins, the microhybrid composite for delayed finishing time had more leakage ($p<0.05$) with the sequential technique compared to the rubber cups and aluminum oxide discs polishing techniques. No significant differences were observed between groups in immediate polishing. In dentin margins, the sequential polishing technique exhibited more leakage in most of the interactions among composites and polishing time. A comparison of leakage between composites and polishing times revealed no significant differences in enamel or dentin margins ($p>0.05$). Dentin margins exhibited more dye penetration than enamel margins ($p<0.05$).

Table 6: *Mean, Median and Standard Deviations (n=8) of Dye Penetration to the Different Combinations of Materials, Polishing Techniques and Polishing Times for Dentin Margins*

Restorative Material–Polishing Method	Delayed Polishing	Immediate Polishing
Filtek A 110–Sof-Lex	1.50 (1.0) ± 1.07[ab]	1.87 (2.0) ± 0.83[c]
Filtek A 110–Flexicups	1.87 (2.5) ± 1.36[cd]	2.12 (2.5) ± 1.13[cd]
Filtek A 110–Sequential Technique	2.87 (3.0) ± 0.35[e]	2.25 (2.5) ± 0.89[d]
Filtek Z 250–Sof-Lex	1.75 (1.5) ± 0.89[b]	1.62 (1.0) ± 0.92[ab]
Filtek Z 250–Flexicups	2.25 (2.5) ± 0.89[cd]	2.25 (2.5) ± 0.89[d]
Filtek Z 250–Sequential Technique	2.50 (3.0) ± 0.92[e]	2.87 (3.0) ± 0.35[e]
Filtek A 110–Positive Control	1.76 (1.5) ± 0.73[bc]	
FilteK A 110–Negative Control	1.98 (1.5) ± 0.88[bc]	
Filtek Z 250–Positive Control	2.37 (2.5) ± 0.91[cd]	
FilteK Z 250–Negative Control	2.69 (2.5) ± 1.09[cd]	

Groups identified by different superscript lower case letters are significantly different (non-parametric Kruskal Wallis test—p<0.05). Values are mean (median) ± standard deviation

DISCUSSION

The clinician's objective in placing esthetic restorations is to achieve the smoothest surface, which will minimize dental biofilm accumulation and stain retention and can be easily maintained (Neme & others, 2002). To achieve a natural appearance, it is also important to reproduce all light reflection areas in teeth with esthetic involvement.

Different methods can be used to finish and polish dental restorations. The best surface is the one achieved with a matrix band (Hondrum & Fernádez, 1997; Yap & others, 1997; Yap & Mok, 2002; Yap & others, 2004). In this study, the smoothest surface was also found with polyester strips. However, use of these strips is limited by the complexity of tooth anatomy and other restorative procedures. Therefore, diamond or carbide burs are often necessary to contour anatomically structured and concave surfaces such as the lingual of anterior teeth or the occlusal of posterior tooth surfaces (Özgünaltay, Yazici & Görücü, 2003).

Clinically, some functional adjustment is necessary in almost all restorations. In this study, initial finishing was carried out with standardized 280-grit silicon carbide paper under running water to simulate a fine diamond bur texture and produce specimens finished without undulations.

Most investigators agree that flexible aluminum-oxide discs are the best instruments for providing low roughness on composite surfaces (Berastegui & others, 1992; Toledano, De La Torre & Osório, 1994; Lu, Roeder & Powers, 2003). Van Dijken and Ruyter (1987) showed that the capability of aluminum oxide discs to produce a smooth surface was related to their ability to cut the filler particle and matrix equally. Their efficacy, however, depends on the anatomical form and accessibility of the restoration. Therefore, specialized shapes of abrasives are usually necessary in clinical practice to achieve the best results. This study showed similar or lower performance regarding surface roughness between aluminum oxide discs and the sequential use of rubber cups, polishing brushes and felt discs. This sequential technique could improve polishing in areas of difficult access to aluminum oxide discs. The roughest surfaces were achieved with rubber cups that were used individually.

Hardness may be defined as the resistance of solid structures to permanent indentation or penetration. Changes in hardness may reflect the state of the setting reaction of a material and the presence of an ongoing reaction or maturity of the restorative material (Bourke, Walls & McCabe, 1992; Yap, Wong & Lim, 2000). In this experiment, hardness tests were conducted after storage for three weeks in saline at 37°C for all specimens. In this way, the maturity of the composites was common at the time of evaluation, and any differences in hardness could be attributed to the effects of the polishing procedures at the two time intervals. Some authors suggest that, if the polishing procedure is completed before complete resin composite maturation, the restoration could be more susceptible to thermal insults that could result in lower surface hardness (Pearson & Messing, 1979; Craig & Powers, 2002). In this study, however, delayed polished specimens presented lower microhardness than immediate polished specimens; in most interactions, this could be explained by compromising the composite surface post curing properties with delayed polishing procedures. Also, a significant interaction was observed among composites, polishing procedures and polishing time. The microfilled composite exhibited lower hardness than the microhybrid composite in the control and experimental groups. These findings can be explained by compositional differences between the two composites. Microfilled composites usually have lower filler contents, which result in some reduction in mechanical properties of these materials (Pereira & others, 2003).

Finishing and polishing techniques can affect microleakage, probably because of the thermal insults produced with rotary instruments during these procedures (Taylor & Lynch, 1993; Yap, Ang & Chong, 1998b). Yu and others (1990) showed increased leakage when the finishing procedures were done in dry conditions, suggesting a deficiency in marginal fit. However, Yap and others (2000) found no differences in microleakage among finishing and polishing procedures performed in dry conditions. In this study, distilled water was used during finishing procedures, and an extra fine polishing paste was used with rubber polishing cups, brush polishing systems and felt polishing discs. Only aluminum-oxide discs were used without polishing paste. Polishing pastes had no influence on the surface roughness achieved with polishing systems (Marigo & others, 2001; Turssi & others, 2000), and their use only improved surface brightness (Strassler & Bauman, 1993). This study showed some differences related to polishing techniques in different composites and polishing times, mainly concerning dentin margins. The sequential technique (C) seemed to produce higher marginal damage, probably because of the number of steps and repetitions with the polishing instruments and, as a consequence, the increased damage caused by thermal insults.

The main controversy regarding composite polishing probably is when to initiate polishing. While some manufacturers claim that finishing and polishing should be done after removal of the matrix or five minutes later, several authors have suggested that if these procedures were delayed 24 hours, better marginal sealing could be obtained (Asmussen & Jorgensen, 1972). Also, immediate finishing and polishing could cause flow of the composites due to the thermal insults of polishing (Lopes, Franke & Maia, 2002). Because the composite polymerization reaction would not be complete prior to 24 hours and, because water sorption would still be occurring, the hygroscopic expansion of composites (Craig & Powers, 2002; Lopes & others, 2002) could result in a reduction in microleakage (Prati & others, 1994). However, delayed polishing could compromise the marginal sealing obtained with the hygroscopic expansion of the composite and adhesive system, resulting in an increase in microleakage because of the stresses generated by the procedure (Yap & others, 1998b). Immediate finishing and polishing could also compromise the initial marginal sealing; however, hygroscopic expansion could improve marginal sealing (Yap & others, 1998b).

In this study, polishing time showed a significant effect in some conditions on the surface roughness, surface hardness and marginal sealing ability of composite restorations. Other studies presented similar results, even showing better results with immediate polishing (Yap & others, 1998a,b). However, Lopes, Franke and Maia (2002), studying hybrid and microfilled composites, showed that microfilled composites could be adversely affected by immediate polishing. These authors attributed their findings to differences in residual polymerization between the two resin composites.

The results of this study confirm the hypothesis that polishing can be done immediately after restoration placement without any negative influence on the surface roughness, surface hardness or sealing ability of composite restorations. In fact, in most situations, immediately polished specimens performed similarly or better than delayed polished specimens. Therefore, immediate polishing is recommended, since this procedure reduces the number of clinic sessions and brings more comfort and satisfaction to the patient. However, the null hypothesis tested was partially rejected since surface roughness, surface hardness and marginal sealing ability of restorations showed significant differences in several experimental conditions (polishing techniques and resin composite).

CONCLUSIONS

Within the limitations of this study, it was concluded that:

1. Immediate polishing procedures did not negatively affect the surface hardness, roughness and sealing ability of a microfilled and microhybrid composite.
2. A sequential polishing technique had similar or superior performance compared to aluminum oxide disks, except for sealing ability in dentin margins.
3. The microfilled composite showed lower surface hardness than the microhybrid composite.

(Received 19 August 2004)

References

Asmussen E & Jorgensen KD (1972) A microscopic investigation of the adaptation of some plastic filling materials to dental cavity walls *Acta Odontologica Scandinavica* **30(1)** 3-21.

Berastegui E, Canalda C, Brau E & Miquel C (1992) Surface roughness of finished composite resins *Journal of Prosthetic Dentistry* **68(5)** 742-749.

Bourke AM, Walls AW & McCabe JF (1992) Light-activated glass polyalkenoate (ionomer) cements: The setting reaction *Journal of Dentistry* **20(2)** 115-120.

Bowen RL (1962) Dental filling material compressing vinyl-silane-treated fused silica and a binder consisting of the reaction product of bisphenol and glycidyl methacrylate *US Patent* **3(6)** 112.

Craig RG & Powers JM (2002) *Restorative Dental Materials* 11th ed Mosby St Louis.

Ferreira Rde S, Lopes GC & Baratieri LN (2004) Direct posterior resin composite restorations: Considerations on finishing/polishing. Clinical procedures *Quintessence International* **35(5)** 359-366.

Hoelscher DC, Neme AM, Pink FE & Hughes PJ (1998) The effect of three finishing systems on four esthetic restorative materials *Operative Dentistry* **23(1)** 36-42.

Hondrum SO & Fernández R Jr (1997) Contouring, finishing, and polishing Class V restorative materials *Operative Dentistry* **22(1)** 30-36.

Leinfelder KF (1993) Posterior composites. State-of-the-art clinical applications *Dental Clinics of North America* **37(3)** 411-418.

Lopes GC, Franke M & Maia HP (2002) Effect of finishing time and techniques on marginal sealing ability of two composite restorative materials *Journal of Prosthetic Dentistry* **88(1)** 32-36.

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)** 297-303.

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.

Neme AL, Frazier KB, Roeder LB & Debner TL (2002) Effect of prophylactic polishing protocols on the surface roughness of esthetic restorative materials *Operative Dentistry* **27(1)** 50-58.

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.

Pearson GJ & Messing JJ (1979) The abrasivity of finishing agents used on composite filling material *Journal of Dentistry* **7(2)** 105-110.

Pereira CL, Demarco FF, Cenci MS, Osinaga PW & Piovesan EM (2003) Flexural strength of composites: Influences of polyethylene fiber reinforcement and type of composite *Clinical Oral Investigations* **7(2)** 116-119.

Prati C, Tao L, Simpson M & Pashley DH (1994) Permeability and microleakage of Class II resin composite restorations *Journal of Dentistry* **22(1)** 49-56.

Reis AF, Giannini M, Lovadino JR & dos Santos Dias CT (2002) The effect of six polishing systems on the surface roughness of two packable resin-based composites *American Journal of Dentistry* **15(3)** 193-197.

Setcos JC, Tarim B & Suzuki S (1999) Surface finish produced on resin composites by new polishing systems *Quintessence International* **30(3)** 169-173.

Strassler H (1990) Polishing composite resins to perfection depends on the filler *Dent Off* **10(4)** 9-10.

Strassler H & Bauman G (1993) Current concepts in polishing composite resins *Practical Periodontics Aesthetic Dentistry* **5(3 Supplement 1)** 12-17.

Taylor MJ & Lynch E (1993) Marginal adaptation *Journal of Dentistry* **21(5)** 265-273.

Toledano M, De La Torre FJ & Osório R (1994) Evaluation of two polishing methods for resin composites *American Journal of Dentistry* **7(6)** 328-330.

Turssi CP, Saad JR, Duarte SL Jr & Rodrigues AL Jr (2000) Composite surfaces after finishing and polishing techniques *American Journal of Dentistry* **13(3)** 136-138.

van Dijken JW & Ruyter IE (1987) Surface characteristics of posterior composites after polishing and toothbrushing *Acta Odontologica Scandinavica* **45(5)** 337-346.

Yap AU, Ang HQ & Chong KC (1998b) Influence of finishing time on marginal sealing ability of new generation composite bonding systems *Journal of Oral Rehabilitation* **25(11)** 871-876.

Yap AU, Lye KW & Sau CW (1997) Surface characteristics of tooth-colored restoratives polished utilizing different polishing systems *Operative Dentistry* **22(6)** 260-265.

Yap AU & Mok BY (2002) Surface finish of a new hybrid aesthetic restorative material *Operative Dentistry* **27(2)** 161-166.

Yap AU, Yap SH, Teo CK & Ng JJ (2004) Finishing/polishing of composite and compomer restoratives: Effectiveness of one-step systems *Operative Dentistry* **29(3)** 275-279.

Yap AU, Sau CW & Lye KW (1998a) Effects of finishing/polishing time on surface characteristics of tooth-coloured restoratives *Journal of Oral Rehabilitation* **25(6)** 456-461.

Yap AU, Wong ML & Lim AC (2000) The effect of polishing systems on microleakage of tooth-coloured restoratives. Part 2: Composite and polyacid-modified composite resins *Journal of Oral Rehabilitation* **27(3)** 205-210.

Yu XY, Wieczkowski G, Davis EL & Joynt RB (1990) Influence of finishing technique on microleakage *Journal of Esthetic Dentistry* **2(5)** 142-144.