The effect of three polishing systems on the surface roughness of four hybrid composites: A profilometric and scanning electron microscopy study

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A highly polished composite restoration is necessary to help promote a plaque-free environment. In this study the polishability of four hybrid composites (Pertac, APH, Herculite, and Z100) was compared after finishing and polishing with the Caulk Enhance polishing kit, Kerr composite finishing kit, and the ESPE MFS/MPS polishing kit. Profilometric evaluation revealed that the MFS/MPS polishing system gave a superior polish for Z100, Herculite, and Pertac; the Enhance polishing system demonstrated the poorest polish with all four composites tested. There were no significant differences among the four composites when polished with each of the three polishing systems. (J Prosthet Dent 1996;76:34-8.)

A highly polished composite restoration is necessary to help promote a plaque-free environment. Surface roughness seems to affect the initial adhesion of cells but seems independent of bacterial accumulation once initial adhesion has taken place.[1] Weitman and Eames[2] reported plaque accumulation on composite samples with a surface roughness of 0.7 to 1.44 μm.

Curing composite against a Mylar (Du Pont Co., Wilmington, Del.) polyester strip will produce the smoothest surface.[3,4] Unfortunately, in the clinical environment most restorations need to be finished and polished. The quality of the polish depends on the ability of the abrasive to polish yet not damage the surface of the composite or the adjacent enamel-dentin.

Quiroz and Lentz[5] found that even the finest grade of Brasseler's ET diamond finishing bur caused extensive damage to surface areas of enamel. They concluded that composites finished with diamond burs appeared rough and uneven, which was particularly evident with the hybrids because of the mixture of large and small particles. Grundy[6] used scanning electron microscopy and observed that diamond burs had a tendency to tear filler particles and leave irregularities on the composite surface. Goldstein and Waknine[7] found that although diamond burs gave rougher surfaces overall the gouges were not as deep as with carbide burs and could therefore more easily be polished to a smooth surface. They also found that hybrid composites could achieve a smoother surface with a fine diamond and two grades of rubber cups.

Lutz et al.[8] found that the hardness of microfill complexes and their weak bond to the organic matrix do not permit the flutes of a carbide bur to cut cleanly. Boghosian et al.[9] found that carbide burs used at high speed on hybrid composites created a smooth surface.

Van Noort and Davis[10] stated that the large particles embedded in Sof-lex disks (3m Dental Products, St. Paul, Minn.) have a tendency to rip through the surface of the composite. Van Dijken and Ruyter.[11] demonstrated that Sof-lex disks used with certain hybrid composites had a tendency to cut or abrade filler particles and resin matrix equally, which results in smoother surfaces. Sof-lex disks also seemed to cause cracks, caused by frictional heat on the polymer matrix.

With the development of new, small hybrid composites, updated evaluations of polishing procedures are necessary. This study compared the effect of three polishing systems on the surface roughness of four hybrid composites.

MATERIAL AND METHODS

Four hybrid composites (Table I) and their polishability were compared with the Caulk Enhance polishing kit (L.D. Caulk, Milford, Pa.), the Kerr composite finishing kit (Kerr Mfg. Co., Romulus, Mich.), and the ESPE MFS/MPS polishing kit (ESPE/Premier, Norristown, Pa.) (Table II). A total of 48 test samples (four composite samples per polishing system) were prepared by compressing the composite in a 20 mm × 1 mm ring with two glass slabs. The samples were cured on each side for 30 seconds with a visible light–curing unit (Optilux 50, Demetron, Danbury, Conn.), assigned a number, and stored for 45 minutes in a 37° C water bath. The samples were then randomly assigned to one of the four test groups, finished, and polished by a single investigator.

This research was supported in part by a grant from the ESPE/Premier Co.

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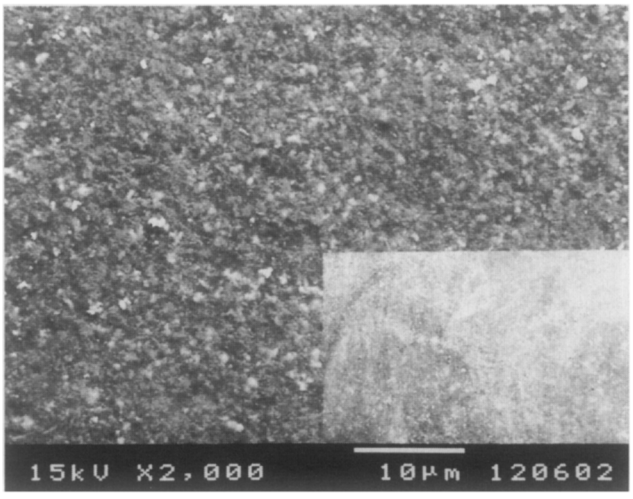

Fig. 1. Pertac composite cured against glass slab shows resin-rich layer. (Original magnification ×15 and ×2000.)

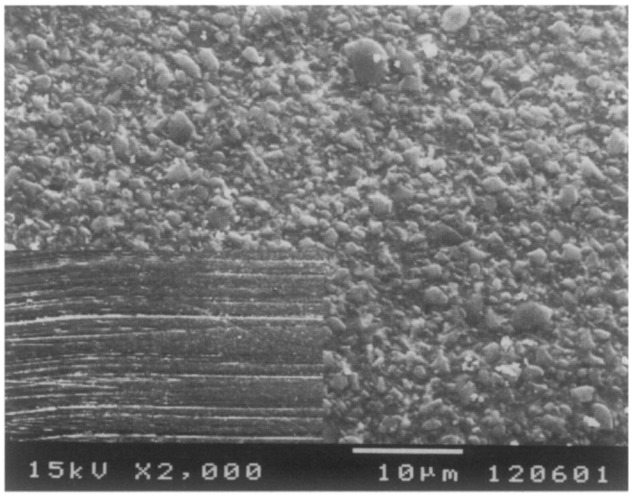

Fig. 2. Pertac sample polished with Enhance polishing kit. (Original magnification ×15 and ×2000.)

Table I. Composites

Composite	Manufacturer	Organic filler	Inorganic filler	Filler content (%vol)*	Particle size*
Pertac	ESPE/Premier, Norristown, Pa.	Modified bis-GMA	Quartz and yttrium trifluoride	61	2.0 μm
APH	L.D. Caulk, Milford, Pa.	UDMA/TEGDMA	Barium glass and fumed silica	57	1.0 μm
Herculite	Kerr Manufacturing Co., Romulus, Mich.	Bis-GMA	Barium-aluminum-borosilicate	79	0.6 μm
Z100	3M Dental Products Division, St. Paul, Minn.	Bis-GMA	Zirconium silicate	66	0.2 μm

GMA, Glycerol methacrylate.
*Supplied by manufacturer.

Table II. Polishing kits

Polishing kit	Compound
Enhance	1. Aluminous oxide disks
	2. Foam polishing rubber cups with 1 and 0.3 μm aluminum oxide pastes
Kerr	1. Carbides (12, 30 flutes)
	2. Prophylaxis cup with 1 and 0.3 μm aluminum oxide pastes
MFS/MPS	1. 45, 20, and 15 μm diamonds
	2. Brushes, tips with 4 to 6 and 0.1 μm diamond pastes

One half the disk was polished and the other half was left untouched. When they were being polished, the samples were always tracked in the same direction. The samples were then scanned on the polished half at six random sites per disk and on the unpolished side at three random sites per disk. Scanning was performed with a Surtest 4 profilometer (Mitutoyo Manufacturing Ltd., Tokyo, Japan) by a second evaluator who was blind to the composite and the polishing system. The transversing length was 4.8 mm and the results were reported for average roughness value (Ra) measured in micrometers. Scanning electron images were recorded with a scanning electron microscope (JSM-5400, Jeol, Tokyo, Japan) at magnifications of ×15 and ×2000.

RESULTS

The average Ra of the untreated composites was 0.01 μm, and no difference was evident between the composites cured against the glass slab. The postpolishing results revealed that the Enhance finishing kit had greater mean Ras than did any of the other kits (Table III). A two-way analysis of variance (ANOVA) (Table IV) demonstrated a highly significant effect for the polishing kits, no effect for composites, and no interaction between composites and polishing kits. Post hoc ANOVA and Scheffe ($p < 0.01$) tests were performed on the composites and polishing kits; a difference was demonstrated among all three polishing kits.

The best polishing was evident in the MFS/MPS with the Z100 (Table V), Herculite (Table VI), and Pertac (Table VII) composites, achieving results similar to that achieved when a composite is cured against a glass slab. The Kerr composite finishing kit polished the APH composite (Table VIII) with the best results. There were no statistically significant differences between the four composites when they were tested with each of the three polishing systems.

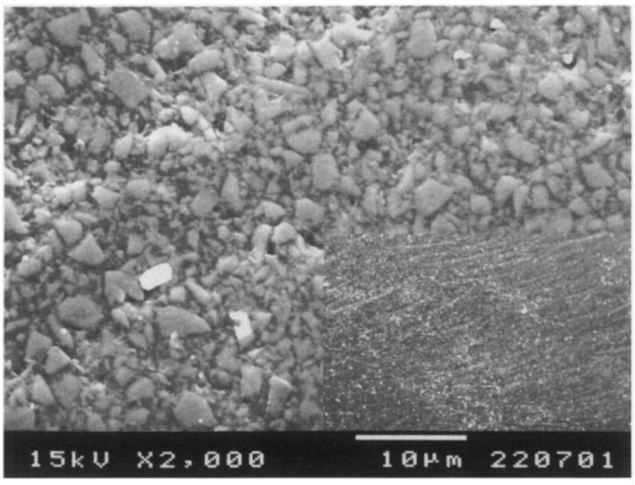

Fig. 3. APH sample polished with Enhance polishing kit. (Original magnification ×15 and ×2000.)

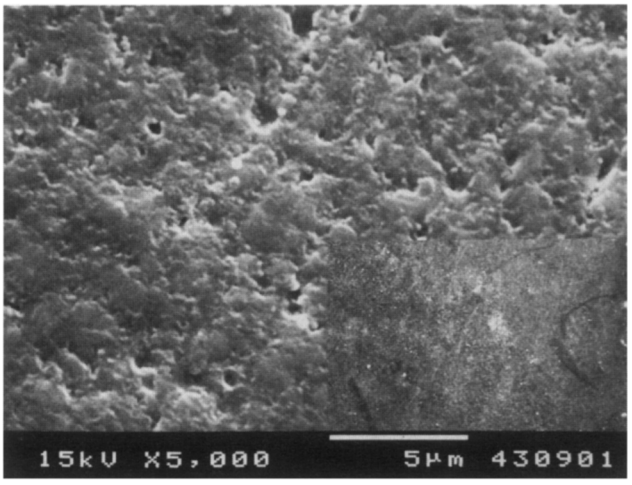

Fig. 4. Z100 polished with Kerr polishing kit. (Original magnification ×15 and ×5000.)

Table III. Results

	Polishing kits			
	Enhance (SD)	Kerr (SD)	MFS/MPS (SD)	Overall mean
Composites				
Pertac	31.0 (19.4)	5.0 (0.8)	2.5 (1.3)	12.8 (16.9)
APH	12.3 (2.2)	8.5 (0.6)	10.3 (6.7)	10.3 (4.0)
Herculite	23.3 (31.3)	4.8 (1.5)	1.5 (0.6)	9.8 (19.2)
Z100	15.3 (5.7)	7.3 (1.3)	2.3 (1.3)	8.3 (6.4)
Mean	20.4 (18.3)	6.4 (1.9)	4.1 (4.8)	

Values are for Ra in micrometers.

Table IV. ANOVA

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	2630.937	5	526.187	4.370	0.003
COMP	130.063	3	43.354	0.360	0.782
POLKIT	2500.875	2	1250.438	10.386	0.000
2-Way interactions	965.125	6	160.854	1.336	0.267
COMP, POLKIT	965.125	6	160.854	1.336	0.267
Explained	3596.062	11	326.915	2.715	0.012
Residual	4334.250	36	120.396		
Total	7930.312	47	168.730		

Table V. Z100

	Mean Ra (μm)	SD	Statistically significant subsets
Enhance	15.3	5.7	C
Kerr	7.3	1.3	B
MFS/MPS	2.3	1.3	A

Table VI. Herculite

	Mean Ra (μm)	SD	Statistically significant subsets
Enhance	23.3	31.3	C
Kerr	4.8	1.5	B
MFS/MPS	1.5	0.6	A

Figure 1 is a scanning electron image of Pertac composite cured against a glass slab (unpolished control sample). All control composites had a similar appearance. The resin rich layer is visible at a magnification of ×15. Figures 2 and 3 represent images of Pertac and APH samples polished by the Enhance polishing kit. The images show exposed filler particles that have been polished flat. Figures 4 and 5 demonstrate Z100 and APH samples polished with the

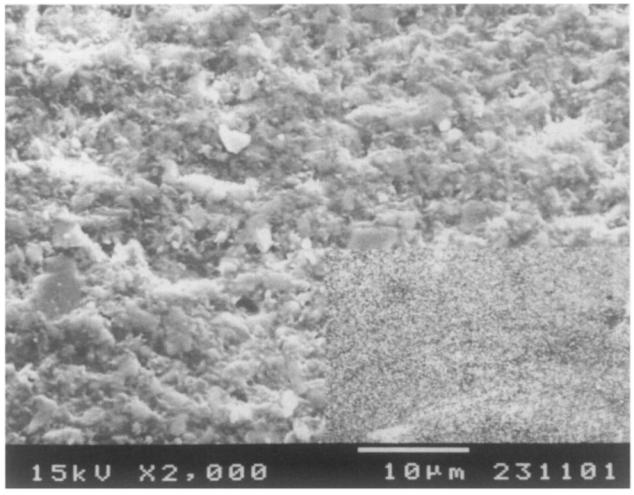

Fig. 5. APH polished with Kerr polishing kit. (Original magnification ×15 and ×2000.)

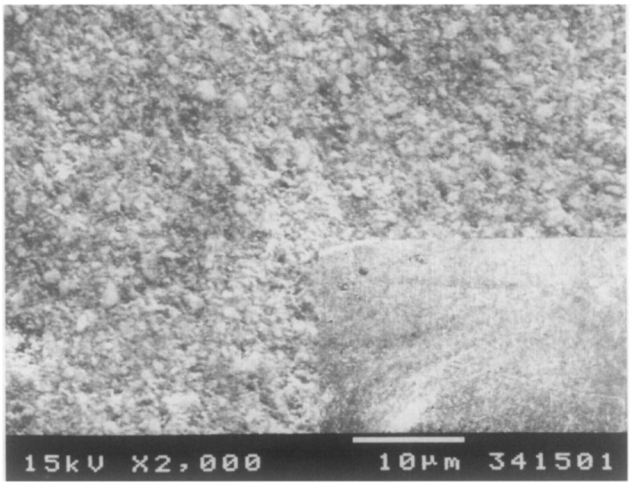

Fig. 6. Herculite polished with MFS/MPS system. (Original magnification ×15 and ×2000.)

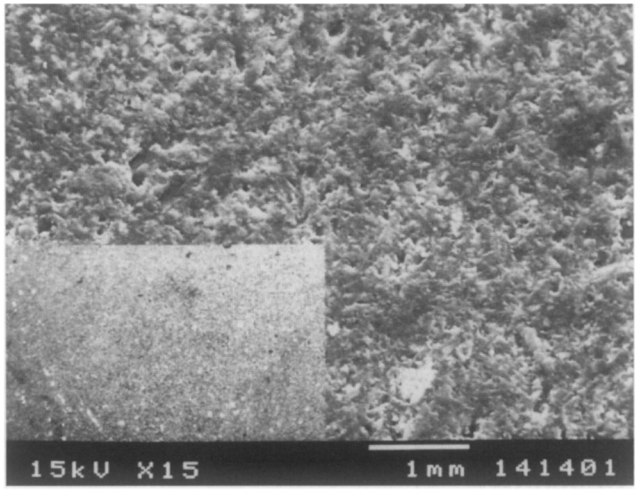

Fig. 7. Pertac polished with MFS/MPS system. (Original magnification ×15 and ×2000.)

Table VII. Pertac

	Mean Ra (μm)	SD	Statistically significant subsets
Enhance	31.0	19.4	C
Kerr	5.0	0.8	B
MFS/MPS	2.5	1.3	A

Table VIII. APH

	Mean Ra (μm)	SD	Statistically significant subsets
Enhance	12.3	2.2	C
Kerr	8.5	0.6	A
MFS/MPS	10.3	6.7	B

Kerr composite finishing kit. The samples are smoother in appearance than the Enhance samples; however, pitting is evident. Figures 6 and 7 are images of Herculite and Pertac samples polished with the MFS/MPS system. These samples appear to be the smoothest, with less overall pitting.

DISCUSSION

Figures 2 and 3 are images of Pertac and APH samples polished with the Enhance polishing system. The lower magnification view (×15) reflects the first stage of the polishing procedure, and the appearance closely relates to the profilometer readings (Table III) where the Pertac had a greater Ra than the APH did. At the higher magnification (×2000) the surfaces appear similar, with the exception that the particles in the APH appear larger than in the Pertac, despite the manufacturer's claims (Table I). The filler particles are exposed, which indicates resin removal during the polishing procedure. Figures 4 and 5 appear similar in morphologic characteristics, with the exception of some pitting in the Z100 composite (Fig. 4) which may be due to plucking of the filler particle during polishing. Figures 3 and 5 are both APH polished with the Enhance and Kerr polishing kits, respectively. In Figure 3 the particles are more evident, whereas in Figure 5 they are not as clearly delineated. This may be due to less resin being removed during polishing. Because the pastes of the two systems are similar, the differences may be a result of the differences between the foam cup of the Enhance system and the prophylaxis cup used with the Kerr system. Figures 6 and 7 (Herculite and Pertac polished with the MFS/MPS system) appear to be the smoothest and they conform to their Ras. Both appear similar to Figure 1, the as-cured specimen.

CLINICAL IMPLICATIONS

Both diamonds and carbides may be used for finishing composites. Although diamonds cause a greater degree of gouging, the gouges are not as deep as with carbides and therefore can be brought to a smoother polish. The MFS/MPS system, a diamond-based system, was slightly superior to the Kerr composite finishing kit, which is a carbide-based system. Both gave a clinically acceptable polish. The Enhance system presented clinically unacceptable results, especially with Pertac and Herculite composites. Ra values less than 10 μm are clinically undetectable, and hence any system that delivered a surface roughness less than 10 μm would be acceptable.

SUMMARY

The polishability of four hybrid composites was compared after finishing and polishing. Profilometric evaluation demonstrated that the MFS/MPS system gave a superior polish for three of the four composites tested. The Enhance polishing system gave the poorest polish with all four composites tested.

CONCLUSIONS

The following conclusions were drawn from this study:

1. There were statistically significant differences between the three polishing kits.
2. The MFS/MPS polishing system gave a superior polish for Z100, Herculite, and Pertac composites.
3. The Enhance polishing system gave the poorest polish with all three composites tested.
4. There were no statistically significant differences in the polishability of the four composites tested when tested with each of the three polishing kits.

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