Effect of Finishing Systems on the Surface Roughness of an Experimental Low-shrinking Composite Resin

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ABSTRACT

Purpose: This study evaluated the surface quality of a new low-shrinking experimental resin restorative material after polishing with seven different techniques.

Methods: The composite resin used in this study was the experimental material, Hermes (3M/ESPE). Seventy standardised specimens were prepared using a perspex mould. All samples were stored in distilled water for 10 days. Samples were randomly divided into 7 groups (n=10). Thereafter, the average roughness of one side of each specimen (formed against the matrix) was recorded using a surface roughness meter (Surftest SJ 301)(control). The other side of each specimen was roughened with 320grit silicone-carbide paper in a polishing machine for 45 seconds. The finishing/polishing of specimens was performed following the five different protocols according to the manufacturer's instructions: (1) Enhance polishing cones (E), (2) Enhance followed by POGO (EPG), (3)Jiffy Polishing Cups (J), (4) consecutive use of four flexible Sof-Lex discs (S), (5) consecutive use of four flexible Sof-Lex discs followed by Sof-Lex brush(SB), (6) consecutive use of three flexible OptiDiscs (O), and (7) consecutive use of three flexible OptiDiscs followed by Optishine brushes (OB). The mean roughness of each polished surfaces was determined using the surface profilometer, collecting 5 measurements from each specimen. Data was analyzed statistically (ANOVA).

Results: The mean average roughness (Ra) values obtained for specimens in Groups 2-8 that were treated with one of the polishing systems ranged from 0.63 – 1.21 µm. ANOVA analysis demonstrated a statistically significant difference between Enhance (roughest) compared to all the other groups ($P < 0.001$). There were no statistical significant differences ($p < 0.001$) between Groups 3(Enhance and POGO2), 4(Jiffy Polishing Cups), 5(Sof-Lex), 6(Sof-Lex and Sof-Lex Brushes), 7(OptiDiscs) and 8 (OptiDiscs and OptiShine Brushes).

Clinical Significance: All the polishing techniques evaluated in this study, with the possible exception of Enhance Points, can be utilised to produce a smooth surface on Hermes composite resin material. The material Hermes can be polished to a high gloss and excellent smoothness, and will be acceptable for usage in the mouth.

INTRODUCTION

Proper finishing and polishing are important steps which contributes to both aesthetics and the longevity of tooth-coloured restoratives[1,2,3]. The presence of surface irregularities may influence appearance, staining, plaque retention, secondary caries risk and gingival irritation[4,5]. According to Strassler and Bauman, smoother restorations are more easily maintained, and show less plaque accumulation[4].

Concurrently with the development of hybrid and nanofilled composites resin materials, advances have also been made in developing low-shrinking resin materials. Such a resin based composite has recently become available to the authors for evaluation purposes.

Many research projects have been done on initial contouring, finishing and polishing to provide clinicians with clinical concepts and protocols[6,7]. Most investigators agree that the aluminium oxide discs are the finishing and polishing agents which produce the lowest average surface roughness on resin based composites[8,9]. However, their use is restricted to anterior teeth and therefore a variety of other finishing and polishing devices are used by clinicians[2,3].

Although the surface finish of many microfill, hybrid and nanofilled composites, compomers, conventional and resin-modified glass-ionomers has been investigated both *in vitro*[1,10] and *in vivo*[11,12], the quality of surface finish of a newly developed low- shrinking composite resin has not yet been reported.

The aim of this study was to evaluate the surface quality of a new low-shrinking resin material after polishing with seven different finishing and polishing techniques.

MATERIALS AND METHODS

The composite resin used in this study was the experimental resin composite material, Hermes[a]. Seventy specimens, sized 9x5x3mm, were prepared using perspex moulds. The upper and lower surfaces of the material were covered with mylar strips, which in turn was covered with glass slabs. The specimens were polymerized for 40 seconds with an Optilux 501 light-curing unit[b] on each side. The glass slabs and mylar strips were removed and the samples then cured for an additional 40 seconds from each side, using the same light-curing unit.

a. 3M/ESPE, St Paul, MN, USA.
b. Kerr Corporation, Orange, CA, USA.
c. Mitutoyo, Tokyo, Japan.
d. Dentsply, Milford, DE, USA.
e. Ultradent Products, INC., South Jordan, UT, USA.
f. JEOL CO, Tokyo, Japan.

Table 1: Finishing / Polishing Systems and Sequences					
Product	**Usage**	**Handpiece Speed**	**Particle Size**	**Abrasive**	**Manufacturer**
Enhance	Dry,15 Strokes	12 000 rpm	40µm	Aluminum oxide, silanized pyrolytic silica	Dentsply, Konstanz, Germany
Enhance and PoGo	As Above	As Above	40µm	Aluminum oxide, silanized pyrolytic silica	As Above
	Dry, 24 light intermittent strokes	12 000 rpm	*	Diamond powder impregnated in UDMA resin	
Jiffy Polishing cups Green Yellow White	 Dry, 15 strokes Dry, 15 strokes Dry, 15 strokes	 12000 rpm 12000 rpm 12000 rpm	 2µm 1.5µm 1 µm	Aluminum Oxide	Ultradent Products, South Jordan, Utah, USA
Sof-Lex Coarse Medium Fine Extra-Fine	 Dry, 15 strokes Dry, 15 strokes Dry, 15 strokes Dry, 15 strokes	 10 000 rpm 10 000 rpm 20 000 rpm 20 000 rpm	 100µm 29µm 14µm 5µm	Aluminum Oxide	3M ESPE Dental Products,St Paul, MN, USA
Sof-Lex and Sof-Lex Brushes	As Above Dry, 24 strokes	As Above 12 000 rpm	As Above *	As Above Aluminum Oxide	As Above
OptiDiscs Coarse/Medium Fine Extra-Fine	 Dry, 15 strokes Dry, 15 strokes Dry, 15 strokes	 10 000 rpm 10 000 rpm 10 000 rpm	 44.5 µm 21.8µm 8.4 µm	Aluminum Oxide	KerrHawe , Bioggio, Switzerland
OptiDiscs and OptiShine Brushes	As Above	As Above	As Above	As Above	As Above
		5000 rpm	*	Silcon Carbide	
*Abrasive particle size not stated by the manufacturer					

Table 2: Average Mean Surface Roughness and Standard Deviation (SD) for Hermes Composite Resin		
Polishing Technique	**Mean Surface Roughness in µm and SD**	
	Before Polishing (Mylar)	Before Polishing (Mylar)
Enhance	0.10 (0.03)	1.21 (0.45)
Enhance and POGO	0.10 (0.02)	0.64 (0.12)
Jiffy Polishing Cups	0.11 (0.03)	0.66 (0.21)
Sof-Lex Discs	0.10 (0.01)	0.65 (0.23)
Sof-Lex Discs followed by Sof-Lex Brush	0.11 (0.03)	0.63 (0.24)
OptiDiscs	0.11 (0.02)	0.68 (0.27)
OptiDiscs followed by Optishine Brush	0.10 (0.03)	0.64 (0.25)

All samples were stored in distilled water at 37°C for 10 days. Thereafter, the average roughness of one side of each specimen (formed against the matrix) was recorded using a Surftest SJ 301(Mitutoyo)[c] (Figure 1). Five measurements were made for each specimen at different locations and then averaged. The other side of each specimen was roughened with 320grit silicone-carbide paper in a polishing machine for 30 seconds and the specimens randomly divided into seven groups (n=10).

The finishing/polishing of the specimens was performed by a single operator, following seven different protocols according to the manufacturer's instructions: (1) Enhance polishing cones(E)[d], (2) Enhance followed by POGO (EPG)[d], (3) Jiffy Polishing cups (J)[e], (4) consecutive use of four flexible Sof-Lex discs (S)[a], (5) consecutive use of four flexible Sof-Lex discs followed by Sof-Lex Brush(SB)[a], (6) consecutive use of three flexible OptiDiscs (O)[b], and (7) consecutive use of three flexible OptiDiscs followed by OptiShine brushes (OB)[b].

Table 1 reflects the manufacturer and details of the finishing/polishing sequences.

After all specimens were polished they were thoroughly rinsed with water and allowed to dry for 24 hours before measurement of the average surface roughness. The mean roughness (R_a) of each polished surface was determined by surface profilometry. A Surftest SJ 301 surface roughness tester was used to collect 5 measurements from each specimen, providing a total of 50 recordings for each polishing technique. Data was collected and analyzed statistically (ANOVA).

After profilometric examination, four samples of each group were prepared for the scanning electron microscope (JEOL JSM-840 SEM)[f]. Samples were sputter-coated with gold in a vacuum evaporator. The samples were observed and photographs of the most representative regions were taken.

RESULTS

Table 2 shows the mean surface roughness observed for Hermes after finishing/polishing with the different systems.

The mean Ra values for the control group (mylar strip) was between 0.10 and 0.11µm. ANOVA demonstrated a statistically significant difference between the control (smoothest) group compared to all the other groups ($p<0.001$).

The mean Ra values obtained for specimens in Groups 2-8 ranged from 0.63 – 1.21 µm. ANOVA analysis demonstrated a statistically significant difference between Enhance (roughest) compared to all the other groups ($P <0.001$). There were no statistical significant differences ($p<0.001$) between Groups 3 (Enhance and POGO2), 4 (Jiffy Polishing Cups), 5 (Sof-Lex), 6 (Sof-Lex and Sof-Lex Brushes), 7 (OptiDiscs) and 8 (OptiDiscs and OptiShine Brushes).

Results of the SEM examinations are depicted in Figures 2-9.

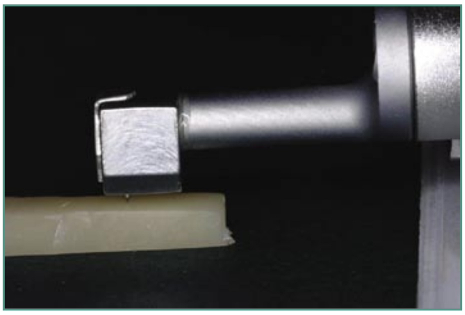

Figure 1. A Surftest SJ 301 surface roughness tester was used to measure roughness of all samples.

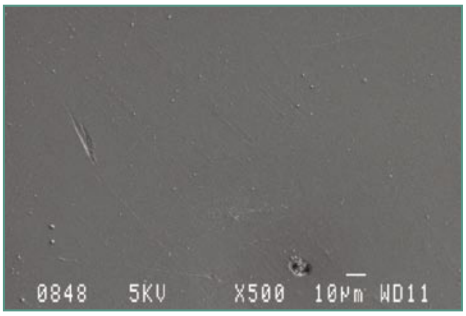

Figure 2. SEM micrograph of Hermes composite surface formed against the Mylar plastic strip. A homogenous, smooth surface is evident

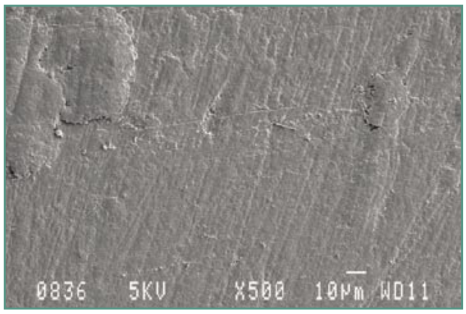

Figure 3. SEM micrograph of Hermes composite surface polished with Enhance. Several deep scratches and surface irregularities are still visible.

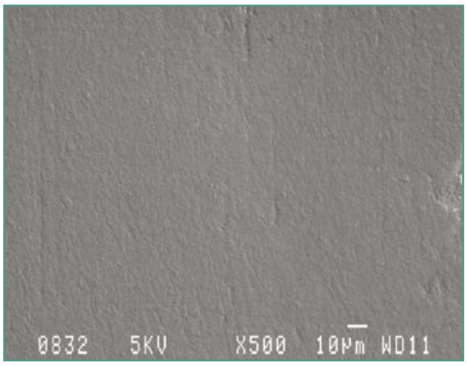

Figure 4. SEM micrograph of Hermes composite surface polished with Enhance and POGO. The POGO improved the surface quality – most of the deep scratches are removed, producing a smooth surface.

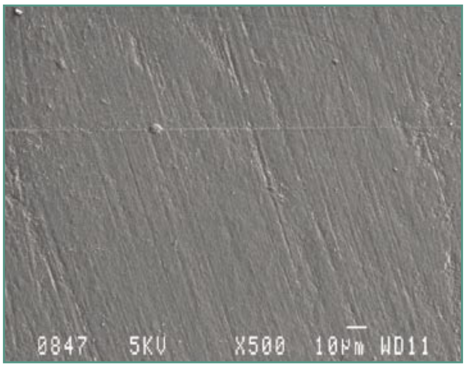

Figure 5. SEM micrograph of Hermes composite surface polished with Jiffy Polishing cups. The surface remained rough, with reasonable deep scratches visible.

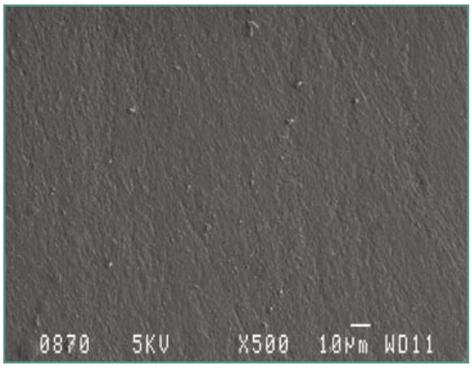

Figure 6. SEM micrograph of Hermes composite surface polished with Sof-Lex discs. Most of the deep scratches are removed.

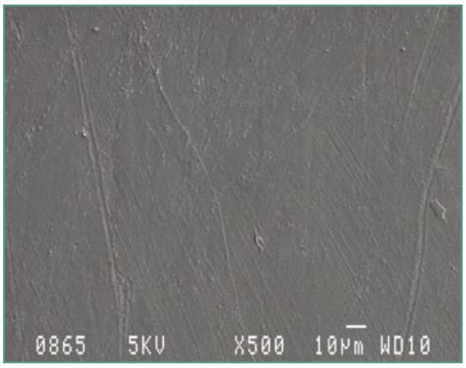

Figure 7. SEM micrograph of Hermes composite surface polished with Sof-Lex discs and Sof-Lex Brushes. A more homogenous surface texture was obtained compared to using only Sof-Lex Discs.

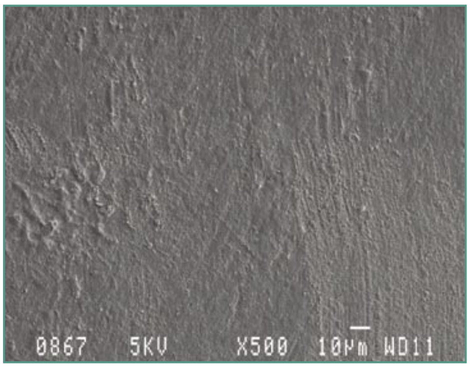

Figure 8. SEM micrograph of Hermes composite surface polished with OptiDiscs. The surface texture appeared granular, with smooth areas in between.

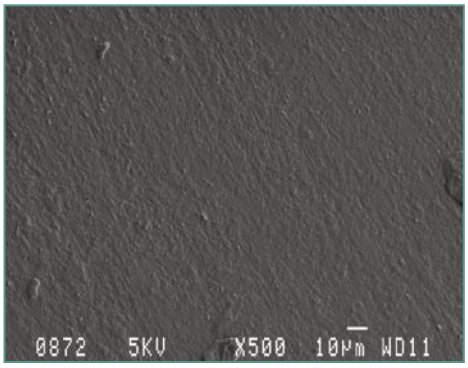

Figure 9. SEM micrograph of Hermes composite surface polished with OptiDiscs and Optishine Brush. A less granular surface texture was obtained compared to using only Sof-Lex Discs.

DISCUSSION

Finishing and polishing of anterior and posterior composite restorations directly influence the longevity of the restoration and its environment[13,14]. This study evaluated the surface quality of a new low-shrinking resin material after polishing with seven different finishing and polishing techniques.

Surface roughness of composite resin materials is usually dictated by the size, hardness and amount of filler, which influence the mechanical properties of the resin-based material, and by the flexibility of the backing material, the hardness of the abrasive, and the grit size[15.16]. The average size of a microfill composite filler is 0,04µm, and a microhybrid contains particles that range between 0,01 and 2.0µm. Microfill and microhybrid composites can be finished to an average roughness (Ra) varying from 0.12 to 0.25µm, due to their small filler particle size and arrangement8. The low shrinking composite resin that was evaluated in this study, contain 0,6µm filler particles, according to the manufacturer. However, the smoothest surface that could be obtained with this material had an average roughness of 0.63µm and this could be attributed to the filler particle size of the material.

The surface roughness of all specimens prior to polishing was measured, as described by Roeder and colleagues[17]. The mean average value after light-curing against the mylar matrix was 0,10µm. The ideal situation would be to leave composite resin restorations untouched after placement. However, in most clinical situations finishing of the restoration is necessary to remove excess material and to re-contour, thereby reducing the surface smoothness and necessitating polishing of the restoration.

It was observed that the average roughness of the low shrinking resin material was significantly lower after polishing with the different finishing and polishing systems tested. Comparing the Ra values after polishing systems, it can be observed that most polishing systems presented similar behaviour, with the exception of one system. The smoothest surface was obtained by polishing with Sof-Lex Discs and Sof-Lex Brushes in combination, followed by OptiDiscs and Optishine Brushes, Enhance and POGO, Sof-Lex Discs, OptiDiscs and Jiffy Polishing Cups. However, there were no statistically significant differences noted between these polishing systems. The roughest surface was obtained by polishing the low shrinking resin material with Enhance points. There was a statistically significant difference between Enhance compared to all the other groups. Examination of the polished samples in the Scanning Electron Microscope confirmed these findings.

Generally, it was observed that the results correlated with particle sizes of the polishing system. Enhance polishers that created the roughest surfaces, contain Aluminum oxide particles of 40 µm compared to the 5µm Aluminum oxide particles in Sof-Lex discs and µm particles in the Sof-Lex brushes that were used in combination to produce the smoothest surface. For a composite polishing system to be effective, the abrasive particles must be relatively harder than the filler particles of the resin materia[13]. Otherwise, the polishing agent will only remove the soft resin matrix and leave the filler particles protruding from the surface[8]. Scanning electron microscope investigations revealed that most polishing systems polished the resin filler particles on the surface.

CONCLUSIONS

1. The smoothest surface was obtained by curing Hermes composite resin against the Mylar strip.
2. The greatest Ra value (roughest polished surface) was found when the material was polished with Enhance Points.
3. The lowest Ra value (smoothest polished surface) was found when the material was polished with Sof-Lex discs followed by a Sof-Lex Brush.
4. All the polishing techniques evaluated in this study, with the possible exception of Enhance Points, can be utilised to produce a smooth surface on Hermes composite resin material.
5. The material Hermes can be polished to a high gloss and excellent smoothness, and will be acceptable for usage in the mouth.

<u>Declaration</u>: No conflict of interest was declared

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