

# Appearance of finished and unfinished composite surfaces after toothbrushing

## A scanning electron microscopy study

Jan W. V. van Dijken, Jaana Stadigh and Jukka H. Meurman

Department of Cariology, Faculty of Dentistry, University of Umeå, Umeå, Sweden,  
and Institute of Dentistry and Department of Electron Microscopy,  
University of Helsinki, Helsinki, Finland

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The effect of toothbrushing, using tap water, pumice, or dentifrice, on five resins—two microfiller resins, one composite resin with both large and microfiller particles, one composite resin introduced as a filling material for posterior teeth, and one conventional composite resin—was studied by scanning electron microscopy. Brushing with water had almost no effect on the unfinished specimens. When the unfinished and finished specimens of the large filler-containing materials were brushed with toothpaste or pumice, rough surface characteristics were obtained. After the finishing and toothbrushing procedures only one of the microfiller materials showed very smooth surface characteristics. The microfiller materials may be finished with successively finer devices to smooth surfaces that will stay smooth after toothbrushing, whereas finishing the large filler-containing resin materials does not lead to a lasting smooth surface. □ *Composite resin; dental materials; dentifrice*

Jan van Dijken, Department of Cariology, Faculty of Odontology, University of Umeå, S-901 87 Umeå, Sweden

The surface of a restoration should be as smooth as possible. Several authors have reported that rough surfaces favor the accumulation and retention of debris and bacterial plaque (12, 18, 22, 28). This promotes gingivitis, recurrent caries, and staining of the fillings (9, 16, 17, 23, 24). Skjørland et al. (21) have later reported that surface roughness alone cannot explain differences in plaque formation.

One of the main disadvantages of the conventional composite resin restorations is that their surfaces cannot be properly finished. The surface is smoothest when the resin is allowed to set under a plastic strip. This smooth surface, however, cannot be maintained when the restorations are finished to correct contour.

Different techniques have been used to minimize the roughness of finished restorations (5). A polishing system was recently developed in which successively finer grit discs are used without water-cooling (6). The heat evolved will soften the resin matrix, and a smeared layer is formed that covers the

filler particles, resulting in a smooth surface layer (19). However, the use of a polishing paste or dentifrice during a home care program will soon expose the filler particles lying just beneath the finished surface (1, 5, 15, 19).

Because no polishing procedure could give a lasting surface smoothness of the conventional composites, other materials were developed. First, microfiller resins were introduced, and lately composites containing a combination of large and microfiller particles or only conventional filler particles ground to an intermediate size have been introduced. In the present study we have compared the effect on surface smoothness of some polishing procedures applied to the different types of composites: one conventional composite resin (Adaptic), two microfiller resins (Isopast and Silar), one composite resin with both conventional and microfiller particles (Miradapt), and one composite resin with intermediate-size filler particles (Profile). The latter material was developed for use in posterior teeth. A

Table 1. Characteristics of the two paste resin materials, as described by the manufacturers

Dimension of filler particle	Material of filler particle	Commercial product
Large, 1–40 µm	Quartz	Adaptic; Johnson and Johnson Ltd., New Brunswick, N.J., USA
Large + micro, 12 + 0.06 µm	Barium glass + SiO <sub>2</sub>	Miradapt; Johnson and Johnson Ltd., New Brunswick, N.J., USA
Intermediate, 8 µm	Strontium glass	Profile; SS White Dental Products International, Philadelphia, Pa., USA
Micro, 0.04 µm	SiO <sub>2</sub> (pyrogenic)	Silar; 3 M Dental Products, St. Paul, Minn., USA
Micro 0.04 µm	SiO <sub>2</sub> (pyrogenic)	Isopast, Vivadent, Schaan, Liechtenstein

three-body-wear system was used, brushing the specimens with water, dentifrice, or pumice (3).

## Materials and methods

The characteristics of the filling materials tested are given in Table 1.

### Preparation of test specimens

Forty class-V cavities were prepared in extracted teeth. The cavities were filled with the test materials in accordance with the manufacturers' instructions. An acid-etch technique was used throughout. Eight fill-

ings were made of each filling material. Each filling was allowed to set under a tightly held plastic strip. After setting, the specimens were stored in water at room temperature until treated further. Four specimens of each material were finished as shown in Table 2. One of these finished specimens and one of the four unfinished specimens were used as controls. Three specimens of each filling material were then exposed to toothbrushing with various abrasives.

### The brushing of the test specimens

The specimens were brushed with a Butler G.U.M. 411 toothbrush under a pressure of

Table 2. Finishing procedures, recommended by the manufacturers, used before the brushing of test materials

Material	Finishing agent	Manufacturer
Adaptic	Sof-lex polishing system	Johnson and Johnson Ltd., New Brunswick, N.J., USA
Miradapt	Polishing stone	Johnson and Johnson Ltd., New Brunswick, N.J., USA
Profile	Profile polishing discs	SS White Dental Products International, Philadelphia, Pa., USA
Silar	Sof-lex polishing system	3 M Dental Products, St. Paul, Minn., USA
Isopast	Polishing stone + disc	Vivadent, Schaan, Liechtenstein

Table 3. Finishing agent used with the mechanical tooth-brushing machine

Abrasive agent	Particle size	Amount of abrasive used	Manufacturer
Tap water	–	6 ml	
Pepsodent tooth-paste (CaHPO <sub>4</sub> ·2H <sub>2</sub> O)	17 µm	4 g toothpaste	Turun Saippua Oy, Finland
Pumice	20–50 µm	2 g in 6 ml of tap water	Pumese, Italy

Table 4. Grading of surface roughness

0	Very smooth surface without scratches or air bubbles.
1	Smooth surface with small scratches and/or air bubbles.
2	Fairly smooth surface with large scratches and/or many air bubbles. Filler particles are not visible.
3	Fairly rough surface with filler particles visible but not clearly protruding.
4	Rough surface with filler particles partly visible.
5	Very rough surface with protruding filler particles.

400 g for 17 min, corresponding 1100 double strokes (2, 25) in the presence of either 6 ml of tap water, 4 g of Pepsodent toothpaste, or a suspension of 2 g of pumice powder in 6 ml of tap water (Table 3). A new toothbrush was used for each specimen, and five specimens were brushed simultaneously.

#### *Scanning electron microscopy of the specimens and grading of the surfaces*

All the specimens were prepared for SEM by being mounted on metal stubs and coated with a 350-Å layer of gold in a JEOL Fine Coat JFC-1100 ion-sputtering device. The specimens were studied in a JEOL-35 C scanning electron microscope at standardized tilting angles with an accelerating voltage of 13 kV. Photomicrographs were taken at magnifications of  $\times 300$  and  $\times 1000$ . The final evaluation was made double-blindly on the photomicrographs. The surface roughness of specimens was graded with a score from 0

to 5 (Table 4), using photomicrograph standards.

## Results

Table 5 gives the gradings of the surface roughness of the test materials as evaluated from the photomicrographs.

#### *Unfinished specimens*

The surfaces obtained under the plastic strips were smooth for all materials (Fig. 1). Occasionally, this surface was covered by loose surface material, but basically there was no difference in characteristics among the surfaces of unfinished intact test materials. Brushing the unfinished specimens with tap water did not change their surface characteristics much. Small scratches, however, were frequently seen (Fig. 2). The use of toothpaste or pumice

Table 5. Classification of surface roughness\*

Characteristics of a test material	Unfinished specimens				Finished specimens			
	Before brushing	Brushing with			Before brushing	Brushing with		
		Tap water	Tooth-paste	Pumice		Tap water	Tooth-paste	Pumice
Large filler (Adaptic)	0	1	4	5	2	4	5	5
Large- + microfiller (Miradapt)	0	1	4	5	2	4	5	5
Intermediate filler (Profile)	0	1	5	5	4	4	5	5
Microfiller (Silar)	0	1	1	1	1	1	1	2
Microfiller (Isopast)	0	1	2	2	2	2	2	2

\* For criteria, see Table 4.

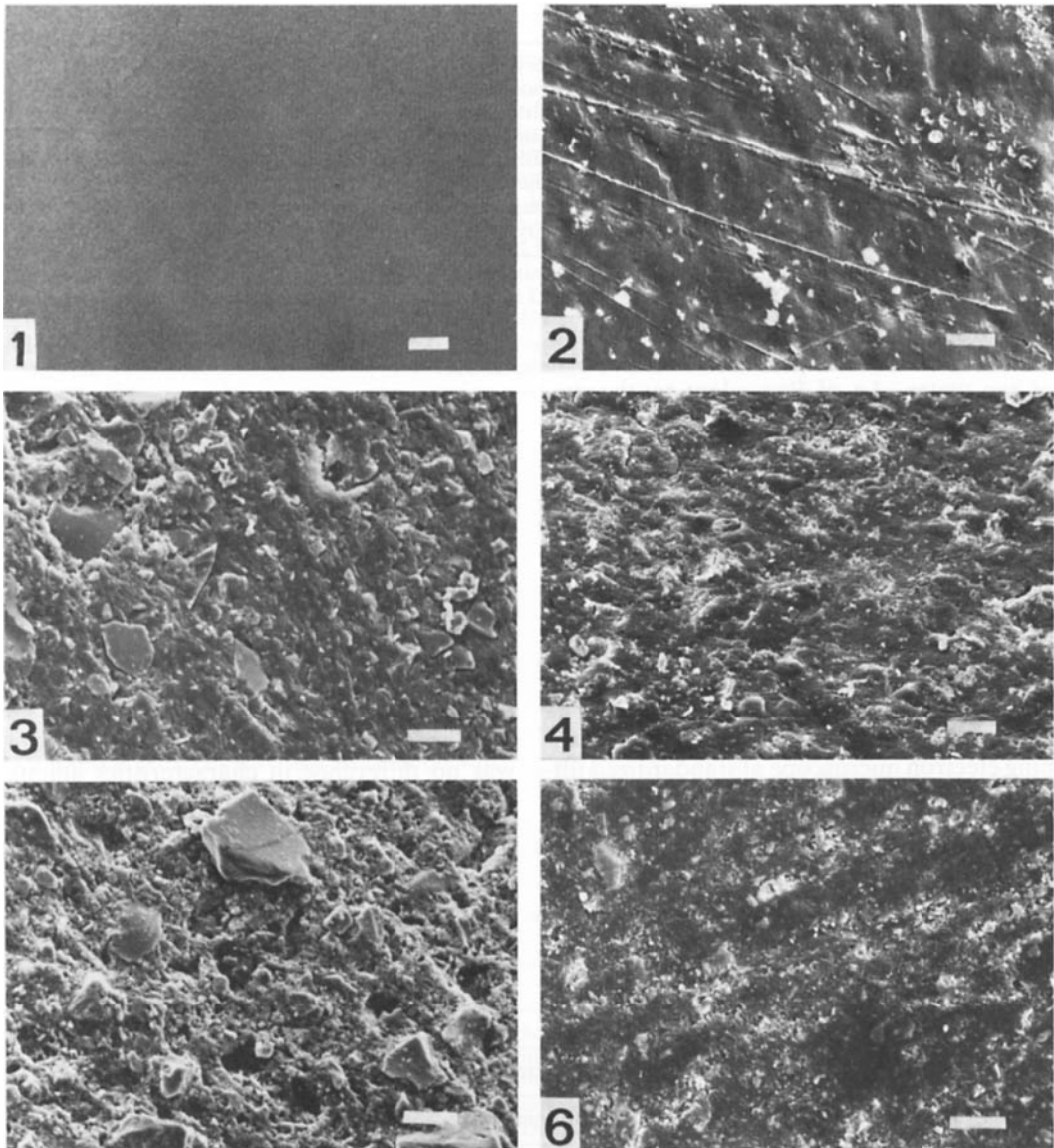


Fig. 1. Unfinished Silar specimen allowed to set under a plastic strip. A grade 0 surface roughness. Original magnification in this and all the following photomicrographs is  $\times 1000$ . Bar,  $10\ \mu\text{m}$ .

Fig. 2. Unfinished Isopast specimen brushed with tap water. The surface is smooth but with scratches (grade 1). Bar,  $10\ \mu\text{m}$ .

Fig. 3. Unfinished Adaptic specimen brushed with toothpaste. Filler particles are revealed within composite matrix, and the surface is rough (grade 4). Bar,  $10\ \mu\text{m}$ .

Fig. 4. Unfinished Isopast specimen brushed with toothpaste. A grade 2 surface roughness. Bar,  $10\ \mu\text{m}$ .

Fig. 5. Very rough surface (grade 5) of an unfinished Profile specimen after brushing with toothpaste. Bar,  $10\ \mu\text{m}$ .

Fig. 6. Adaptic specimen finished with Sof-lex system shows a grade 2 surface roughness. Bar,  $10\ \mu\text{m}$ .

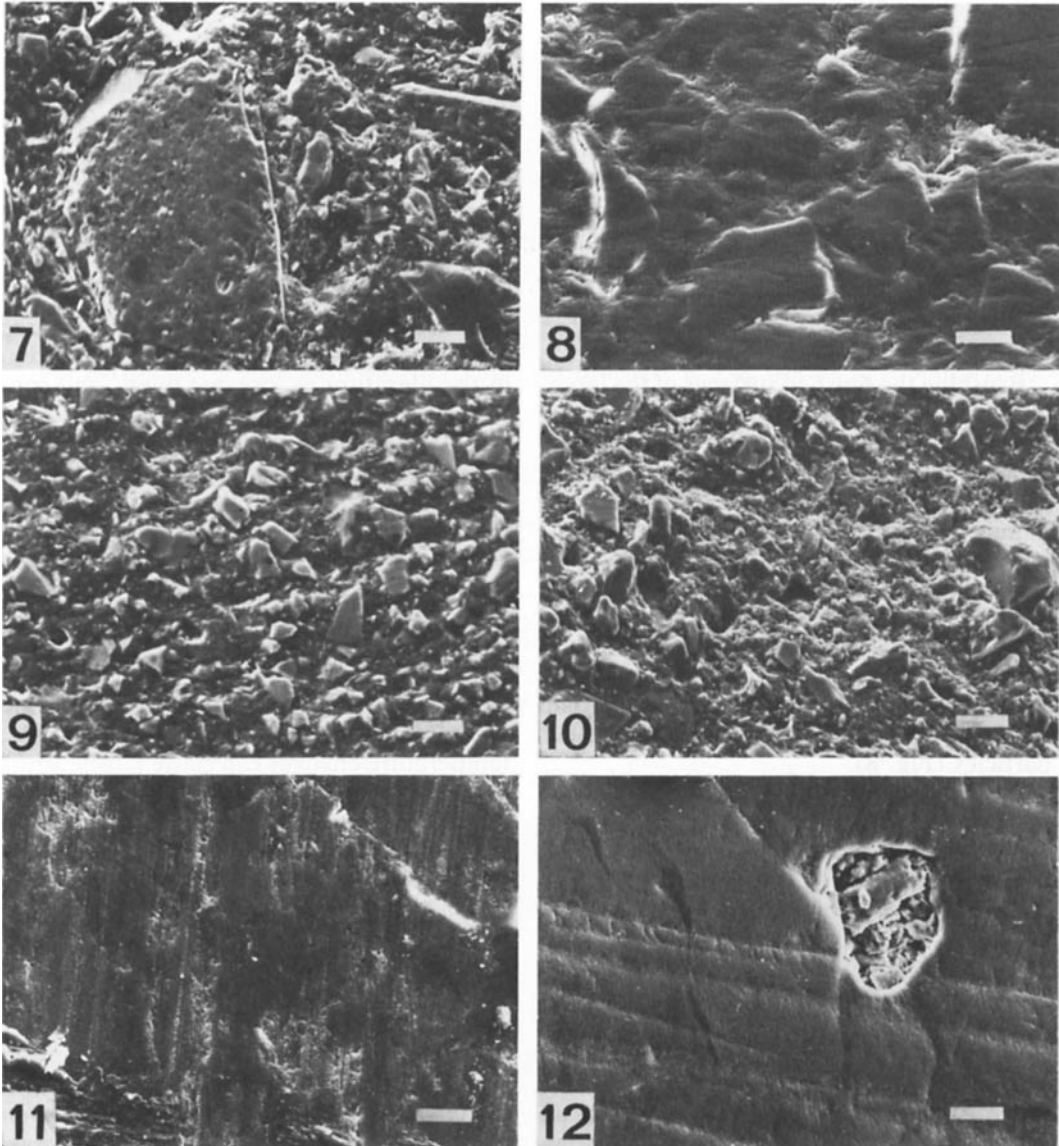


Fig. 7. *Adaptic* finished with Sof-lex discs and brushed with toothpaste, showing a very rough surface (grade 5) with protruding filler particles. Bar, 10  $\mu$ m.

Fig. 8. A finished *Isopast* specimen after brushing with toothpaste, showing a grade 2 surface roughness. Bar, 10  $\mu$ m.

Fig. 9. A finished *Miradapt* after brushing with toothpaste. Very rough surface with protruding filler particles (grade 5). Bar, 10  $\mu$ m.

Fig. 10. A finished *Profile* specimen after brushing with toothpaste. A grade 5 roughness. Bar, 10  $\mu$ m.

Fig. 11. *Silar* finished with Sof-lex system. A smooth grade 1 surface roughness. Bar, 10  $\mu$ m.

Fig. 12. A finished *Silar* specimen after brushing with toothpaste showing a smooth grade 1 surface roughness. Bar, 10  $\mu$ m.

caused increased roughness in all specimens except Silar, exposing the large filler particles especially of the Adaptic, Miradapt, and Profile specimens (Figs. 3–6).

#### *Finished specimens*

After finishing of the surface obtained under the plastic strips, one microfiller material (Silar) had a smooth (grade 1) surface, three had fairly smooth surfaces (grade 2), and one (Profile) had a rough surface (grade 4).

Brushing the finished surfaces of the large, intermediate, and mixed filler-containing materials with water increased the roughness (grade 4) by exposing part of their filler particles. Brushing the finished surfaces with pumice or toothpaste gave very rough surfaces (grade 5; Figs. 7, 9, and 10).

Brushing one of the microfiller materials (Isopast) with water, pumice, or toothpaste after the initial finishing procedure had no additional effect on the smoothness of the surface (grade 2), which still showed some cracks and protruding prepolymerized filler particles (Fig. 8).

In the other microfiller material (Silar) there was no difference in surface morphology after toothpaste treatment (grade 1; Figs. 11 and 12). The pumice treatment caused a fairly smooth surface (grade 2).

## Discussion

The surfaces of all tested resins set under plastic strips are smooth (5, 6, 19) and can stand up to toothbrushing with water. However, when materials with large fillers, mixed fillers—containing both microfiller and large filler particles—or intermediate-size filler particles are contoured and finished, which is often necessary in clinical practice, brushing even with tap water will soon increase the surface roughness.

The use of the Sof-lex polishing system or other fine polishing devices (6) on the conventional composite resins seems not to have any advantage in clinical practice. The produced smear layer covering the filler particles

soon disappeared after toothbrushing even without any abrasive agent.

Because finishing does not lead to a smooth surface of conventional composites, it is important to insert the material carefully, leaving no excess or only a small excess that can be removed by a light touch of the margin of the filling. A rough surface caused by finishing can only be temporarily restored with glazes (10, 11, 14, 29).

The microfiller particles of Silar and Isopast are arranged in prepolymerized large aggregates. These aggregates are referred to in the literature as 'organic fillers' and contain 50% resin matrix in the Silar material and 63% in the Isopast material (8). This difference, differences in the composition of the resin matrices, and the difference in size of the 'organic filler' particles may all account for the different resistance to wear of cured fillings of the two materials. The protruding 'organic filler' particles observed in our study were also shown by von Soltész et al. (27) after abrasive wear of the Isopast material.

In vivo more variables than toothbrushing can cause wear of composites. For example, temperature changes can cause tensile stress in the filling, because of differences in the thermal expansion coefficients between matrix and filler (13). Occlusal wear may also cause a loss of material during mastication. Aging of the filling and thermo-mechanical fatigue combined with toothbrushing and dentifrice wear can further alter surface characteristics of the microfiller resins.

In conclusion, the present study showed that the microfiller resins retain the surface obtained in the finishing procedure even after brushing of the materials with abrasives. The conventional composites and other large filler composites, however, lose their finish after brushing.

#### *Comment*

Recently, some results were published on the effect of organic solvents on the surface structure of composite fillings (J. Dent. Res. 1982, 61, 1180–1183). In a recent paper by Aker (JADA 1982, 105, 633–635) data are presented which confirm our results.

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