

Porosity of resin filling materials

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Four paste-paste types of resin filling materials and three capsulated products were tested with respect to porosity content and size distribution of the pores. The data were obtained by using an automatic image analyzer. The paste-paste products were inserted into the test cavities by a bulk-packing technique and an injection technique. The results showed that the use of a syringe reduced the porosity content, mainly by the elimination of big pores. The capsulated products were not less porous than the paste-paste materials.

Key-words: Restorative materials; pores

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The surfaces of dental restorations should be as smooth as possible since retention of plaque is enhanced as the roughness is increased (14, 16). Many investigators have demonstrated that resin filling materials containing hard filler particles are difficult to finish to a desirable smoothness (4, 9). The main reason for this is attributed to the difference in hardness between the filler particles and the resin matrix (11). The porosity may affect the clinical performance of the materials since the pores will cause a roughness which is impossible to reduce with usual finishing procedures. The mechanical properties of the materials are also affected by the amounts of porosity: Using ultrasonic testing, it has been estimated that the elastic constants of the products may be improved by reduction of the amount of porosity (12). Furthermore, fracture of the

materials is most likely to occur through the pores (6). The voids have been observed by several authors (5, 7, 8, 10, 15) but few quantitative measurements have been made (1, 2).

Regarding the influence of manipulation on the porosity content, it has been demonstrated for one product that insertion of the filling material using a bulk-packing technique is more likely to enclose bubbles as compared to insertion by an injection technique (2). One study revealed that a mechanically mixed product has less voids in the surface than a hand-mixed one (6). Furthermore, subjecting the freshly mixed pastes to pressure inside a syringe before insertion, lowers the porosity content (1). Making the pastes more fluid by dilution with pure resin also has the same effect (3).

The purpose of this study was to measure

the amount and size distribution of microscopically visible pores of resin filling materials with respect to different brands and insertion techniques.

MATERIALS AND METHODS

The brands and insertion techniques are listed in Table 1. Cylinders with a diameter of 4 mm and a length of approximately 5 mm were made in a Teflon[®] mold, a matrix strip was placed on the surface and loaded with a weight of 1 kg. The strip was removed after 5 minutes and at 15 minutes the specimen was extruded from the mold and stored dry for at least 1 week at 37 °C. Five specimens in each group were tested.

The test was performed by mounting the specimen in a stainless steel block with its end protruding 0.5 mm above the surface. It was ground by hand on No. 220 through No. 600 grinding paper in water, then on No. 000 emery paper until flush with the steel surface. The specimen was cleaned in an ultrasonic cleanser and dried.

To accentuate the pores water-based paint was applied to the ground surfaces and subjected to vacuum to remove air bubbles. The surface was wiped off with lens tissue and photographed on 9 x 12 cm high-contrast film using a microscope (MeF[®], Reichert, Vienna, Austria). The magnification on the film was 23.75 x.

After developing, the films were analyzed with an automatic image analyzer (Quantimet 720[®], Cambridge Instrument, Melbourne, Royston, England) giving the area of the orifices of the pores in the plane of sectioning as percentages of the total analyzed area. The number of pores in each of ten logarithmically divided groups of pore diameters was also given. Since the pores were not always spherical the diameters were presented as diameters of circles having the

same area as the pores as calculated from the following formula:

$$D = 2 \sqrt{\frac{A}{\pi}}$$

where D is the equivalent circle diameter and A the area of the pore.

To estimate the precision of the technique, several surfaces were repainted and analyzed. This indicated that variations up to 0.5 % porosity could occur due to variations in painting of the specimens and exposure and developing of the films.

Repeated analyses of identical films revealed that the image-analyzing procedure was precise as compared to other sources of error.

No estimation of the accuracy of the method was performed.

RESULTS

The difference in porosity content between specimens produced by bulk-packing technique and injection technique was most often directly observable under microscope (Fig. 1). The results obtained by the image analyses revealed that the average amount of porosity ranged from 0.8 % to 3.3 % for the different products (Fig. 2). The pastes inserted with a syringe always gave less porous specimens as compared to those that had been made by bulk-packing. Generally, the capsulated products did not exhibit lower amounts of porosity than the pastes used for the injection technique.

The distribution of the pores are presented in Fig. 3. The most numerous pores have diameters in the range 10–50 μm. The use of a syringe reduced the number of big pores, but tended to increase the number of small ones in some products (Fig. 3, a, b).

Table 1

Product	Batch no.	Manufacturer	Mixing	Insertion technique
<i>Paste-paste types</i>				
Adaptic®	3455 D 102	Johnson & Johnson, East Windsor, N.J. U.S.A.	By hand, 20 seconds	Bulk-packing, using a plastic in- strument
Concise®	5310 C 26	3-M Company, St. Paul, Minnesota U.S.A.		
Cosmic®	Base: SK 11 SL Cat.: SK 8 SL	Amalgamated Dental, London, England		
Isopast®	—	Vivadent, Schaan. Liechtenstein		
<i>Capsulated types</i>				
Compocap-S®	151076 327	Vivadent, Schaan. Liechtenstein	Mechanically** 10 seconds	Injection, by means of the cap- sules and supplied tools
Concise® Cap-C-Rynge	6138-1	3-M Company, St. Paul, Minnesota U.S.A.		
Isocap®	—	Vivadent, Schaan. Liechtenstein		

* Centrix C-R Syringe®, Clev. Dent, Cleveland, U.S.A.

** Silamat®, Vivadent, Schaan, Liechtenstein

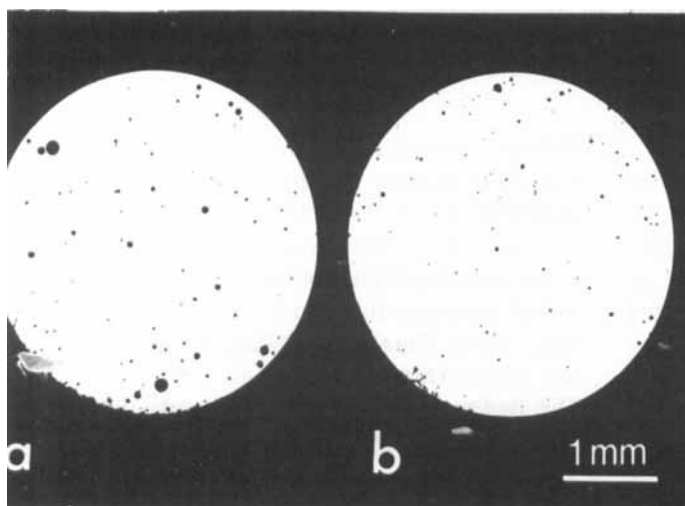


Fig. 1. High-contrast photomicrographs of surfi of a resin material (Isopast) inserted by the t packing technique (a), and the injection techn (b). The porosity of (a) was 1.2 % and of 0.7 %.

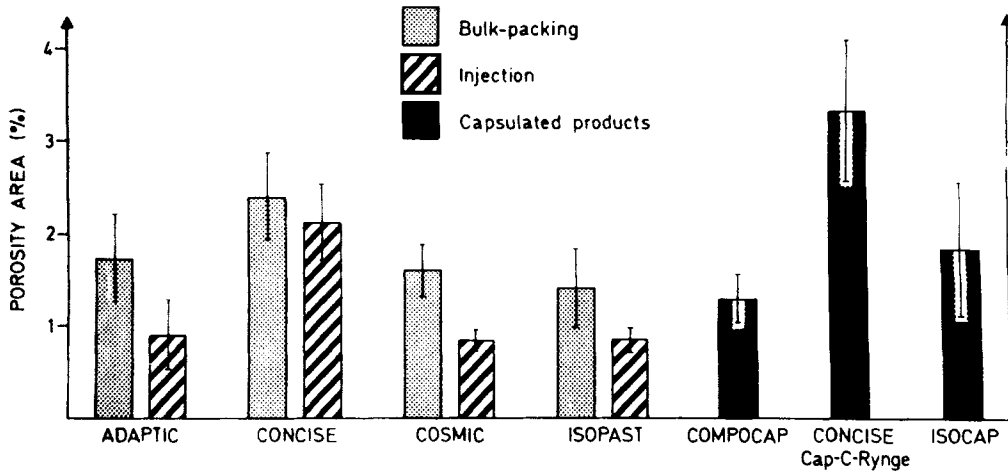


Fig. 2. Porosity content for different products and different insertion techniques. The vertical lines on the bars represent standard deviations.

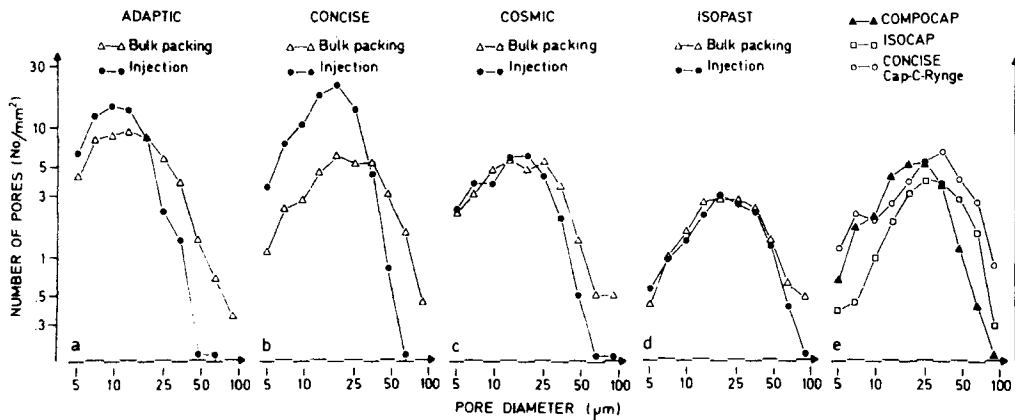


Fig. 3. Distributions of pores for different products and insertion techniques. The individual lines along the horizontal axis represent the classes of pore diameters. The first class starts at $4.5 \mu\text{m}$ and the last class contains pores with diameters of $80 \mu\text{m}$ and greater. Both axes are in a logarithmic scale.

DISCUSSION

The presented results show that pores of variable amounts and sizes are part of the resin filling structure. However, it is judged that insertion of fillings using a syringe reduces the porosity content as demonstrated by Fischel & Tay (2). The present study indicates that the reduction of porosity when a syringe is used is mainly due to the elimination of big pores.

The relatively high porosity of the capsulated products is in contrast to the

findings of Hannah & Smith (7) but this may be explained by the properties and manipulation of the polymethylmethacrylate resin (TD71®) they studied.

In an *in vivo* study Roulet (13) compared several materials and found that after one year Concise Cap-C-Ryng fillings discolored to a greater extent than did Adaptic fillings. This finding may partly be explained by the difference in porosity between the two products.

Since no estimation of the accuracy of

the presented method was performed, and the amount of porosity most likely is influenced by several factors, the numbers given should only be used for comparative purposes in this paper.

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