Marginal adaptation of resin veneers to gold castings

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Berge M, Gjerdet NR, Silness J. Marginal adaptation of resin veneers to gold castings. Acta Odontol Scand 1985;43:103–107. Oslo. ISSN 0001–6357.

The magnitude of the fissures between resin facing materials and gold castings was measured by light microscopy. Two different products and two different processing procedures were used. The effect of water sorption on the fissure size was also studied. Mean fissure sizes varied between 3 and 25 μm. The best adaptation between the resin material and the gold alloy was obtained by the conventional closed flasking technique compared with free processing in a pressure vessel. When processed by closed flasking the product that did not contain microfiller showed fissure widths approximately one fourth of those resulting from the open processing technique. The other product, containing microfiller, was less sensitive with regard to processing. The effect of water sorption on the fissure width was most evident in the test groups containing specimens processed in flask. □ *Marginal leakage; processing procedures; prosthetics; resin facings; resin-veneered crowns*

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Resin-veneered crowns are used frequently in crown and bridge prosthodontics. They appear to have some superior qualities compared with the crowns with ceramic veneers. They are well tolerated by the periodontal tissues (1), and it is possible to practice acceptable direct repair methods on them (2). In addition, they constitute in most cases the cheapest prosthetic alternative for the patient (3).

However, there are some disadvantages with regard to the use of acrylic resin-veneered crowns. The abrasion resistance of the resins is low (2), and they have a tendency to change color after some time in the mouth (1, 3, 4). Furthermore, marginal leakage between the resin and the gold alloy also represents a significant disadvantage (2, 3, 5). Seepage of oral fluids between the casting and the resin may contribute to the discoloration of the facing and chronic inflammation in the marginal gingiva (6).

There are several reports on the nature of the interface between the acrylic resin and the gold alloy (4–13). The minute space is considered to be the result of the polymerization shrinkage of the resin and of effects of differences in the coefficients of thermal expansion between the resin and the gold alloy (3, 7).

The leakage through the fissures has been shown to depend on the nature of the retentive means on the cast (3, 6, 10), the content of microfiller (8), polymerization temperature (8), and temperature cycling after processing (7).

In recent years a new processing and polymerization technique, termed free polymerization or free processing, has been introduced. The modeling of the resin is performed directly on the cast. The curing is conducted in water under raised pressure and temperature during a few minutes. The procedure is therefore less time-consuming for the dental technician.

The purpose of this investigation was to compare the free polymerization technique with the conventional flasking technique with regard to possible effects on the width of the marginal space between the gold alloy and acrylic resin facing material. In addition, two different products, one conventional and one containing a microfiller, were to be compared with regard to marginal adaptation

between the facing material and the casting. Furthermore, the effect of water sorption on the width of the marginal fissure during 4 weeks of immersion was to be studied.

Materials and methods

The products and their constituents examined are listed in Table 1. The processing of the specimens was performed in accordance with the manufacturers' instructions (Table 2). For SR-Isosit-PE® no flasking procedure was described, and the processing was carried out as described for Biodent K + B Plus® (Table 2). Only the dentin variant of the products was chosen as the test material because the dentin constitutes the bulk of the resin in a veneered crown.

Moulds as explained in Fig. 1 were processed in cast gold type IV alloy (Delta 2®) produced on the same die. The bottom and the inner walls of the moulds except the marginal 1 mm were covered by retention spheres with a diameter of 0.6 mm (Fig. 1), and the same area was painted with opaquer. Six moulds were filled with resin and processed in a flask, and six were packed with the veneer material in accordance with the free processing technique. The conventional flasking procedure used involved mounting of the moulds in the flask by use of plaster,

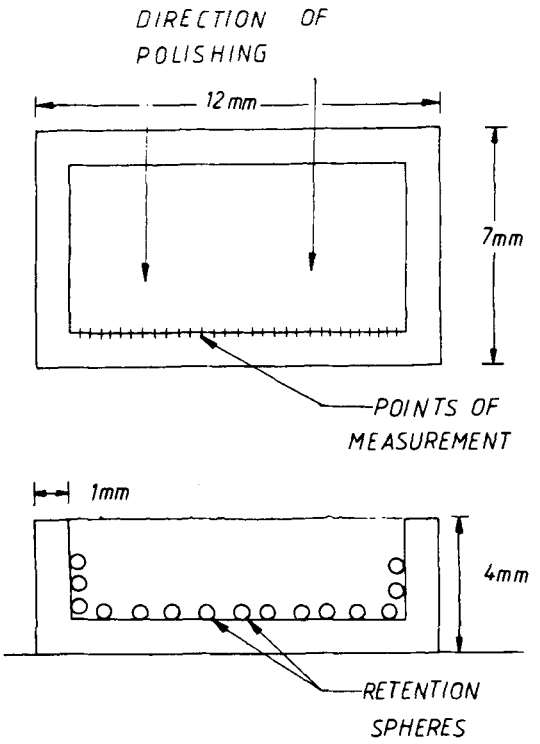

Fig. 1. The outline of the resin-filled gold casting seen from above and in cross-section. The diameter of the retention spheres was 0.6 mm.

wax modeling, removal of the wax, packing of the resin into the gold castings, pressing,

Table 1. The products and their constituents included in the investigation

Product	Manufacturer	Color variant	Batch no.
Biodent K + B plus Dentin	De Trey GmbH, Postf. 2009 6200 Wiesbaden, FRG	D-21	20
Biodent K + B plus Liquid N	De Trey GmbH	—	41
Biodent K + B plus Liquid S	De Trey GmbH	—	112
Biodent K + B plus Opaker	De Trey GmbH	OD 24	7
SR-Isosit-PE Dentin	Ivoclar AG, FL 9494 Schaan, Liechtenstein	6C	469S
SR-Isosit-PE Cross-linking paste	Ivoclar AG	—	—
SR-Isosit-PE Catalyst	Ivoclar AG	—	436S
SR-Isosit-PE Opaker	Ivoclar AG	CO 26	—

Table 2. Polymerization and processing conditions used: the dentin variant of the products

		Powder / liquid ratio (weight)	Curing temp. (°C)	Curing pressure (kPa)	Time under pressure (min)	Liquid (type)
Free processing	Biodent K + B	2:1	95	600	15	S
	SR-Isosit-PE	†	120‡	600	9	—
Flasked processing	Biodent K + B	2:1	100	None	*	N
	SR-Isosit-PE	†	100	None	*	—

* For flasked polymerization, the instructions for Biodent were also applied to SR-Isosit-PE; the clamped flask was immersed in water at approximately 20°C; the water was heated to 100°C for 30 min and boiled for 30 min. The clamped flask was bench-cooled before deflasking.

† The dosage used for SR-Isosit-PE was 1 large measuring spoon of powder, 2 scale divisions of cross-linking paste, and 1 measuring spoon of SR-Isosit-PE Catalyst.

‡ The polymerization cycle for SR-Isosit-PE and dentin when using free polymerization was 100°C and 600 kPa for 3 min and then 120°C and 600 kPa for 6 min.

clamping of the flask, curing, bench-cooling, and removal from the flask. The moulds were filled with 1 mm excess of resin.

Three hours after completion of the polymerization, the specimens were ground by waterproof silicone carbide papers (220–1000 grit) under water irrigation until plane surfaces were obtained. Polishing was done on a polishing disc (Lamplan 415®) rotating at 200 rpm. Diamond spray with a grain size of 14 and 6 μm was applied to the disc (Hyprez fine/star/diamond Compound 14/6 μm-FS-40®), and an ethanol/ethylene glycol mixture was used as a lubricant. One and the same direction was used during the grinding and polishing procedures to prevent moving or drawing the gold alloy surface so as to close or reduce the fissure between the metal and the resin (Fig. 1). The test specimens were rinsed in 100% ethanol for 3 min in an ultrasonic bath between each step in the polishing procedure. Before the examination of the fissures, the specimens were also rinsed in distilled water and dried in hot air.

Measurement of fissures was carried out along the long side of the specimens, where the polishing had taken place in an outward direction (Fig. 1). Thirty registrations were taken on each specimen. The width of the fissures was measured through a light microscope (Reichert 3042367®), using a total magnification of ×400 with a graded scale in one of the oculars. The ocular scale was calibrated against a metric standard so that the size of the fissures could be expressed in micrometers. The first set of measurements was performed approximately 4 h after completion of processing. Corresponding measurements were done after 1, 2, 3, and 4 weeks of immersion in distilled water at 37°C.

Statistical evaluation of the differences about the means of the fissure sizes between the four groups of specimens after 4 weeks of immersion was performed with Student's *t* test. The chosen level of significance was 5%.

Results

The mean width of the fissures varied between approximately 3 and 25 μm (Figs. 2 and 3). For each product, the fissures of the specimens polymerized in a flask were generally narrower than those processed by free polymerization. The differences between the two test procedures after the full test period were statistically discernible for both products at the 5% level of sig-

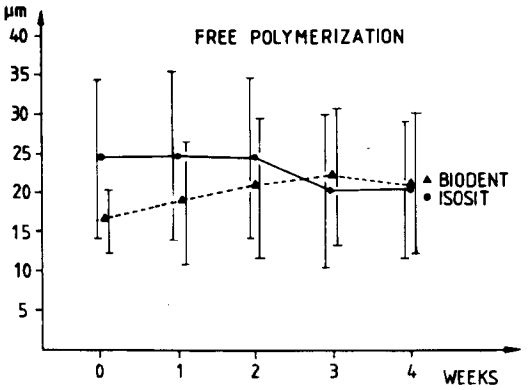

Fig. 2. The development of the fissures in the free-processed specimens during 4 weeks of immersion in distilled water at 37°C. The vertical lines indicate the standard deviations at the different test intervals.

nificance. Biodent K + B Plus, processed in a flask, showed the lowest mean overall value. This value was recorded after 3 weeks of immersion in distilled water at 37°C.

After 4 weeks the highest values were shown on the free-processed specimens of both products (Biodent K + B Plus, 20.88 ± 10.26 µm; SR-Isosit-PE, 20.46 ± 8.74 µm). These values were not statistically different at the 5% level of significance. When processed in a flask, Biodent K + B Plus showed the narrowest fissures, whereas the size of the fissures of flasked SR-Isosit-PE were in between after the full test period.

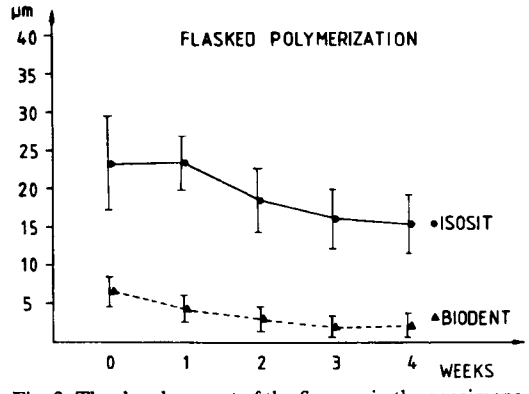

Fig. 3. The development of the fissures in the specimens processed in a flask during 4 weeks of immersion in distilled water at 37°C. The vertical lines indicate the standard deviations at the different test intervals.

The specimens of both products processed by flasking showed a more pronounced decrease in fissure width during the immersion period than the resins polymerized in the pressure vessel (Figs. 2 and 3). The difference between the fissure widths were statistically significant for the specimens processed in a flask between the week 0 and the week 4 measurements ($p < 0.05$). Similar differences were not evident for the free-processed specimens ($p > 0.05$).

By evaluation of the curves in Figs. 2 and 3 it is evident that the free processed specimens had greater standard deviations than the flasked ones at all test intervals.

Discussion

Several investigations have proved the existence of a fissure between gold castings and acrylic veneer resins (3, 9, 10, 12). The methods used to determine a fissure have been indirect and based on detection of leakage of substances, either dye or radioisotopes. In the present study the size of the fissure was measured in a microscope to enable presentation of the fissure widths in metric units.

The results of the study have shown that measurable fissures developed in all types of specimens examined. Specimens polymerized in flask, heated to 100°C during 30 min, and boiled for 30 min on the average showed narrower fissures than specimens cured by free polymerization.

The reason for the differences in fissure widths between the products processed in flask is not known. However, for SR-Isosit-PE the manufacturer has not recommended the use of a conventional flasking technique. Biodent K + B Plus is supplied with a special monomer liquid that is used for processing in flask (Tables 1 and 2). The marked differences between the two methods of processing for this product may therefore reflect differences in the chemical composition of the resulting resin.

The present results do not agree with the conclusions made by Hohmann (8), who stated that products containing microfiller may tend to develop narrow fissures. Devel-

opment of fissures may, however, also be influenced by the physical properties of the resin (3, 6, 7).

The decrease in width of the fissures during the immersion period taking place in the specimens processed by flasking is thought to be due to sorption of water (3). The resins have probably completed their sorption of water after 4 weeks of immersion, and thus no further decrease in fissure sizes is likely to take place after the test period (10). The pattern of the fissure sizes for the specimens cured in flask was not the same as for the specimens processed by free polymerization. This could be explained by several factors. The specimens processed in pressure vessel may have been affected by delayed polymerization contraction related to the differences in the temperature and duration of the curing procedures used. For Biodent K + B Plus a curing temperature of 95 °C for 15 min is recommended. In comparison, the same product, when cured in flask, is heated to boiling during a period of 30 min and boiled for another 30 min. In addition, the cooling procedures above and below the glass transition temperature may have been of importance (3). Friction between the plaster and the soft resin may reduce thermal contraction during the cooling procedure while the resin is still soft, and, in addition, the flask might reduce stress relaxation of the resin owing to a slower cooling procedure (3).

The explanation for the high standard deviations for the specimens processed in the pressure vessel (Fig. 2) compared with the specimens processed by flask (Fig. 3) may be that standardization of the direct modeling technique is less easily obtained than standardization of the pressing procedure used for flasks. The use of modeling instruments during the direct application of the resin may involve an uneven initial adaptation between the resin and the metal. The conventional pressing procedure used for flasks is likely to lead to a more even adaptation. This may be of importance with regard to development of fissures (14).

From a hygienic and cosmetic point of view, there are good arguments for recommending flasked polymerization for both products studied. This is likely to lead to narrower fissures between resin and gold casting.

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Received for publication 15 August 1984