Oxygen-inhibited surface layers on Microfill Pontic

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Radical polymerization of composite resins is inhibited by oxygen. For Microfill Pontic, a self- and photo-curing resin cement, irradiation is proposed as a means to reduce the thickness of the oxygen-inhibited surface layer. The thickness of the layer was measured by a dial gauge technique on irradiated and non-irradiated specimens, to determine a possible effect of irradiation. The results indicate that the depth of inhibition is reduced by irradiation and that an irradiation time of 20 sec is sufficient to give the maximum reduction. □ *Adhesive dentistry; dental materials; polymerization; resin-bonded bridges*

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Oxygen is known to inhibit the polymerization of the surface layer of composite resins (1). This is because of the greater ability of oxygen, compared with that of a monomer molecule, to react with growing radicals. The thickness of the inhibited layer has been found to depend on the viscosity, the composition, and the initiating system of the composite resin (1). Thus, photocuring resins result in thinner inhibited layers than chemically curing resins of similar viscosity.

Microfill Pontic (Kulzer & Co., Wehrheim, FRG) is a two-component self- and photocuring resin for fixing adhesive bridges. Two base resins and two catalyst resins are available. The two base resins differ in color: BO is opaque and thus recommended for anterior bridges, and BU is transparent and recommended for posterior bridges. The catalyst pastes differ in handling and curing times. The manufacturer recommends that photocuring take place after the initial setting of the cement, and it is claimed that this leads to a more complete polymerization of surface layers and reduces the thickness of the oxygen-inhibited layer.

The process of inhibition takes place during the setting period of the composite resin (2). Since the setting period of Catalyst II (K II)—that is, the time elapsed between the end of handling and initial curing—is longer than that of Catalyst I (K I), one would expect K II to give rise to a thicker inhibited layer than K I.

As it is recommended not to irradiate until after initial curing, when the inhibited layer has already formed, it is open to questioning whether the irradiation has an effect in reducing this layer. It was the purpose of the present investigation to search for any such effect.

Materials and methods

The base and catalyst resins investigated are listed in Table 1. The components were mixed in accordance with the manufacturers' instructions and placed in a brass mold (height = 3.0 mm; outer diameter = 20.0 mm; inner diameter = 6.0 mm). The surface of the resin cement was made plane and flush with the top surface of the mold by means of a glass slab, which was removed immediately to admit oxygen.

At the end of the initial curing (4 min and 7.5 min, respectively) the specimens in experiments A and C (Table 2) were placed at 37°C in a thermostat room, whereas the specimens in experiments B and D were irradiated for 20 sec and those in experiment E for 60 sec before being moved to the thermostat room. After 24 h the top surface of the specimens was brushed for 45 sec with

Table 1. Materials used in the investigation

	Batch no.	Handling time	Initial curing time
Base resin (BU)	31.12.89 027		
Catalyst I (KI)	31.12.88 025	Approx. 1.5 min	Approx. 4.0 min
Catalyst II (KII)	30.06.88 023	Approx. 3.0 min	Approx. 7.5 min

ethanol on a Tandex 40 toothbrush. Using a dial gauge, we measured the height of the resin cement and of the brass mold at four corresponding sites of each specimen. Since the resin cement was originally flush with the brass mold, the difference in height after washing in ethanol was taken as a measure of the thickness of the inhibited layer. Each of the five experiments consisted of five specimens.

Results

The thickness of the inhibited layers is given in Table 2. Analysis of variance (3) of the five values with a pooled standard deviation of 0.035 mm showed the differences between the inhibition depths to be statistically significant ($P < 0.025$). Using Student's t tests, we found no statistically significant differences between A and B, between A and C, or between D and E ($P > 0.05$), whereas the difference between C and D or E was statistically significant ($P < 0.005$). When we pooled non-irradiated groups A and C and irradiated groups B, D, and E and compared the two groups, we found a significant difference between the inhibition depth of non-irradiated and irradiated specimens ($P < 0.001$).

Discussion

The results have shown that irradiation reduced the thickness of the inhibited layer. An explanation of this finding may be sought in the fact that a resinous material does not reach its final strength until several hours after initial setting (4). This implies that the setting reactions were still going on at the time when the specimens were irradiated. The irradiation gave rise to new radicals, since the materials were both light and chemically curing. A new supply of radicals increases the rate of the setting reactions, so that the deeper parts of the material will harden before diffusing oxygen can interfere with the rest of the polymerization process (1).

Had irradiation taken place during, and not after, initial curing, a more pronounced reduction of the depth of inhibition is likely to have occurred. Nevertheless, irradiation at this early point seems impracticable, as the bridge has to be kept stable until initial curing of the cement has occurred.

Provided that excess cement is not removed until 15 min after the start of mixing, as recommended by the manufacturer, the presence of an inhibited layer with a thickness of 0.2 mm or less is of minimum importance, since the layer is situated away

Table 2. Mean thickness and standard deviation of inhibited layers with different combinations and treatments of the resin cement

Code	Treatment of base and catalyst resins	Inhibition depth, mm
A	BU + KI: −irradiation	0.15 ± 0.025
B	BU + KI: irradiation 20 sec	0.12 ± 0.046
C	BU + KII: −irradiation	0.18 ± 0.037
D	BU + KII: irradiation 20 sec	0.11 ± 0.034
E	BU + KII: irradiation 60 sec	0.11 ± 0.029

from the marginal areas of the bridge. However, as removal of excess cement after initial cure can be difficult and time-consuming, the excess is commonly removed before initial curing. In these situations the existence of an inhibited layer has a more decisive influence, and its depth should be reduced to a minimum.

Contrary to what had been anticipated, the inhibited layer of experiment C did not differ significantly from that of experiment A. The tendency, however, is in the expected direction, and the lack of significance is best accounted for by the inherent variation of the method.

It may be concluded that the depth of inhibition of a resin-based cement that is both chemically and light cured is reduced as a consequence of the irradiation proposed by the manufacturer.

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