Proximo-occlusal composite restorations in primary molars: Marginal adaptation, bacterial penetration, and pulpal reactions

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Varpio M, Warfvinge J, Norén JG. Proximo-occlusal composite restorations in primary molars: Marginal adaptation, bacterial penetration, and pulpal reactions. Acta Odontol Scand 1990;48:161–167. Oslo. ISSN 0001–6357.

Marginal adaptation and bacterial penetration were studied in 32 primary molars filled with composite resin in shallow class II cavities. The restorations had served in the mouth for 3 years (mean, 3 years and 4 months; range, 8 months to 6 years and 4 months). Ground sections of the retrieved teeth were evaluated with polarized light microscopy and demineralized sections with light microscopy. Clinically excellent restorations, free from bacteria, were found in 25%. Gaps were recorded in 42%, under- or over-contouring and porosities in 95%, caries in the cervical area in 58%. Bacteria were observed subjacent to the fillings in 75% and in the dentin tubules in 61%. Pupal necrosis was found in 7 of 16 teeth. Marginal discoloration, visible crevice, or color mismatch was associated with marginal defects, bacterial leakage, and pulpal reactions. □ *Histology; microbiology; polarization microscopy; restorative materials*

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The inherent polymerization shrinkage of composite resins has an adverse effect on the marginal adaptation of the restoration. The formation of a gap between the cavity wall and the composite resin restoration has been demonstrated in class II restorations in vitro (1, 2). Microleakage and bacterial penetration around class V composite resin restorations have also been shown in vivo (3–9). Further, a positive correlation between the occurrence of gaps and bacteria adjacent to composite resin in class V cavities in vivo has been observed (7).

There are two major adverse effects of the inadequate seal. First, the risk of secondary caries is high owing to the retention of caries-inducing bacteria in the gap between the filling and the tooth. Secondly, bacterial leakage results in colonization subjacent to the restoration and in contact with the dentin. The number of bacteria colonizing the gap between the restorative material and dentin has been demonstrated to correlate with the inflammatory status of the pulp, leading to irreversible injuries (10–13).

Studies on composite resin in primary molars have shown that the main clinical drawback of the material is in occlusal wear (14). Attempts to restore proximal caries lesions by modified cavity design seem to fail more often than restorations in conventional class II cavities (14). As a part of the class II cavity extends to the same area as in the class V cavity, difficulties in obtaining adequate seal in the cervical boundary may be the same. However, there is no information on the gap formation and bacterial penetration of class II composite resin restorations that have been functioning in the oral cavity. It was therefore decided to study the adaptation of composite resin, recurrent caries, the penetration of bacteria, and pulpal reactions in modified class II cavities in primary molars exposed to occlusal forces in the oral environment.

Materials and methods

The test material originates from a clinical study of class II composite resin restorations in primary molars that were followed up for 6 years and collected after shedding (15).

For convenience, a brief description of

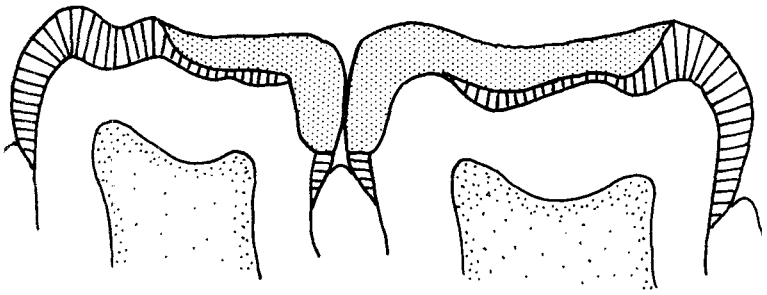

Fig. 1. The outline of class II restoration for composite resin.

the material will be given. Proximal caries lesions penetrating the dentinoenamel junction, degree 02, and lesions extending into the dentin but no more than halfway through it, degree 03 (16), in 91 primary molars were selected (17).

The modified class II cavity consisted of a proximal part, which was prepared into the dentin and extended buccolingually to self-cleaning surfaces. The occlusal lock was formed by opening the fissures that were bevelled but not extended into the dentin. The enamel of the proximal box was slightly bevelled buccolingually by disking. No effort was made to bevel the enamel of the cervical seat (17) (Fig. 1).

Before the filling procedure, the teeth were isolated with a rubber dam, and the cavity was cleansed with a surface-active and microbicidal solution containing 0.1% chlorhexidine (Tubulicid, Dental Therapeutics, Nacka, Sweden). The dentin was lined with a polystyrene liner (Fluoritec, Dental Therapeutics), and the enamel etched with 37% phosphoric acid for 2 min, rinsed with water, and dried with a gentle air stream. The chemically cured composite resin (Concise Cap-C-Rynge, 3M, St. Paul, Minn., USA) was inserted in a tube adapter without intermediate enamel bonding resin. After 5 min the filling was contoured to occlusion, but the final finishing was left until a later appointment.

The clinical performance of the restorations was evaluated annually for 6 years in accordance with the guidelines of the California Dental Association (18). A restoration without any defects was rated as excellent, a restoration with minor defects, such as slight over- or under-contouring, marginal discoloration, reduced occlusal height, or visible crevice, was rated as satisfactory, whereas color mismatch, marginal caries, or fracture of the filling was rated as clinically unacceptable.

Most children participating in the clinical trial were 6 years old at the start (mean age, 7.4 years). Of the original material of 91 primary molars, 83 could be followed up for at least 1 year, and 30 of these 83 teeth could be collected after shedding for this study. Another two primary molars outside the clinical trial but treated in the same manner and followed up for 2 years showing excellent restorations were included in this study. Of these 32 teeth, 3 were excluded for future scanning electron microscopic study. The mean time of function in the mouth of the exfoliated and retrieved teeth was 3 years and 4 months (range, 8 months to 6 years 4 months). A test tube with 10% buffered formaldehyde solution was available at the children's home at the time of exfoliation. The teeth were stored in fresh solution until histologic preparation could be carried out. Before the histologic processing, each tooth was split in half in the mesiodistal direction through the center of the cavity. One half was used for the preparation of ground sections after embedding in epoxy resin. Two to three sections 80–100 μm thick were obtained of each half (19). The other half of the tooth was demineralized in 5.2% nitric acid, and the end-point of demineralization determined radiographically. After demineralization the tooth specimens were embedded in paraffin and serially sectioned. Every fifth section was stained with a modified Gram staining technique (20), and the section next to this was stained with

Table 1. Clinical status of the restorations evaluated in situ and ex situ

Clinical status before shedding	Status after shedding			Total
	Excellent	Satisfactory	Unacceptable	
Excellent	11	6	0	17
Satisfactory	0	7	0	7
Unacceptable	0	0	8	8
Total	11	13	8	32

hematoxylin–eosin. In all, 7–14 sections from each tooth were stained and examined.

The ground sections were examined and evaluated dry in air under a polarized light microscope. The occurrence of gaps, secondary caries, and fractures was recorded. The paraffin sections were analyzed under a light microscope, and the occurrence of stainable bacteria was classified as no stainable bacteria on the cavity walls (0), stainable bacteria on the cavity walls (I), or stainable bacteria on the cavity walls and in the dentin tubules (II). In teeth in which enough pulp tissue was left for evaluation of the condition of the pulp, the degree of inflammation was classified as none, mild, moderate, or severe, and necrosis in accordance with an established scale (10, 21).

The clinical status of the 32 restorations assessed in vivo was excellent in 17 teeth, satisfactory in 7, and unacceptable in 8 teeth. When examined after exfoliation, six excellent restorations showed defects in the cervical area (Table 1).

For bacterial penetration, 28 teeth could be examined. For the investigation of the marginal adaptation, 25 teeth were available, as 3 specimens were lost during the preparation of the ground sections. Of the 25 teeth remaining for the polarized light microscopic study, another 6 teeth could not be evaluated owing to severe resorption or loss of the filling. The histologic findings in relation to the clinical status of the restorations are presented in Table 2.

Results

Marginal adaptation

The main findings were as follows: secondary caries in the cervical area was seen in 11 cases (58%) (Fig. 2), and in three more cases recurrent caries was detected occlusally. In eight cases (42%) a gap was recorded (Fig. 3), and fractures of the cervical part of the filling in four cases (21%). In 10 teeth (53%) 2 or more defects could be found. Operator errors such as under- or over-contouring and porosities owing to insufficient condensation were found in 18 teeth (95%).

Table 2. Number and percentage of restorations showing gaps, recurrent caries, and bacterial penetration related to the clinical status of the restorations

Clinical status before shedding	*n*	Marginal defects in polarized light			Bacteria	
		Gap		Caries,		
		n	*n*+ (%)	*n*+ (%)	*n*	*n*+ (%)
Excellent	17	10	7 (70%)	7 (70%)	16	10 (63%)
Satisfactory	7	3	0 (0%)	3 (100%)	6	5 (83%)
Unacceptable	8	6	1 (17%)	4 (67%)	6	6 (100%)
Total	32	19	8 (42%)	14 (74%)	28	21 (75%)

n+ = number of positive findings.

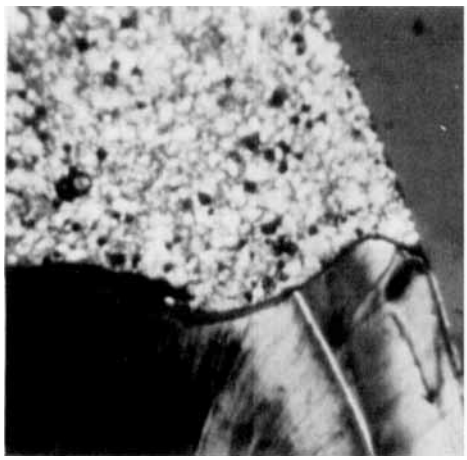

Fig. 2. Recurrent caries at the cervical boundary of the restoration.

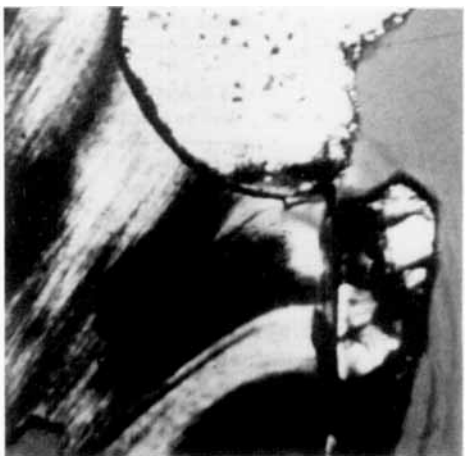

Fig. 3. Gap between the filling and the cervical enamel.

Bacterial penetration

Bacteria subjacent to the fillings were found in 21 teeth (75%) (Fig. 4). In 17 teeth (61%) bacteria had penetrated deep into the dentinal tubules. In most cases bacteria consisted of both gram-negative and gram-positive organisms.

Sufficient pulp tissue had remained in 16 teeth (57%) for the evaluation of the pulpal condition. In the rest of the cases no pulp tissue was left or the soft tissue was altered owing to resorption. No pulp inflammation was detected in 5 of the 16 teeth (31%). Moderate or severe pulp inflammation was registered in four cases (25%), and necrotic pulp tissue was found in seven teeth (44%) (Table 3).

When bacterial penetration was correlated to the occurrence of marginal defects, 12 teeth showed both kinds of findings, 3 teeth showed only bacterial leakage, whereas in 4 teeth with microscopic marginal defects or recurrent caries no bacterial penetration was seen.

When the bacterial penetration was correlated to the clinical status, six of the seven teeth without stainable bacteria were rated as excellent and the seventh as satisfactory owing to overcontouring.

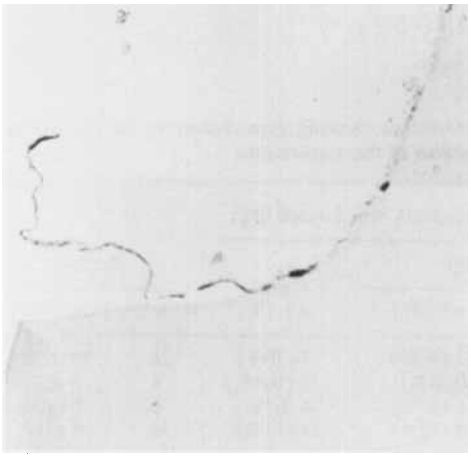

Fig. 4. Bacteria subjacent to the restoration.

Discussion

Composite resin restorations in modified class II cavities in primary molars showed bacterial penetration and defects in the quality of the restoration when investigated microscopically.

The technique of dividing the teeth sagittally into halves made it possible to evaluate both demineralized and undemineralized tooth specimens. With this technique, some information might have been lost, as micro-

Table 3. Correlation between the degree of bacterial penetration and the status of the pulp tissue

Degree of pulpal inflammation	Degree of bacterial penetration			
	0	I	II	Total
None	2	2	1	5
Slight	0	0	0	0
Moderate	0	1	2	3
Severe	0	0	1	1
Necrosis	2	1	4	7
Total	4	4	8	16

scopic defects could be located either buccally or lingually in the proximal area.

Shortcomings at the cervical boundary of the enamel in cavities filled with composite resin have been observed by several investigators. Thus, microleakage at the cervical border of class V cavities in vitro (22–26) and in vivo (6) and of class II cavities in vitro (22, 27, 28) has been reported. In this study recurrent caries was mostly found cervically but also under the occlusal lock prepared in the enamel. This may be due to the effect of masticatory forces, since microleakage seems to occur more frequently in cavities of those teeth that have an occluding antagonist (29). Further, the omission of the enamel bonding resin may also have resulted in increased leakage, since dilution of the composite resin with bonding agent has been shown to reduce leakage (30). Opened enamel fissures in permanent teeth sealed only with preventive resin showed no signs of leakage (31).

The common occurrence of defects owing to insufficient condensation is mainly due to clinical difficulties in the manipulation of the restorative material. Cervically located gaps between the cavity wall and the filling may be caused by dislocation or by the polymerization shrinkage of the material. Incremental application of condensable light-cured composite resin causes less shrinkage than bulk application (32). The clinical success of composite resin restorations may be improved when current material and methods are applied.

The frequent occurrence of bacteria, even under clinically excellent restorations, is related to the defective marginal seal rather than to the biologic resorption and exfoliation of the primary teeth, since no bacteria have been found in intact primary teeth during shedding (33). If the composite resin could form a tight seal, no viable bacteria should be detected (34). The use of a dentin liner seemed not to have inhibited the bacterial leakage, as previously suggested (4, 35). Bacteria in contact with the dentin are a potential hazard in inducing pulp tissue inflammation, as even large bacterial components can penetrate the dentin and reach the pulp tissue (11). Although in two of the seven necrotic teeth no bacteria were found in the one half, they might have been present in the other half used for polarized light microscopy.

As demonstrated by this study, marginal discoloration and visible crevices of restorations rated clinically as satisfactory are an indication of bacterial leakage and should be considered serious defects that may result in pulpal complications. The trial teeth that showed no bacterial leakage after long clinical service were all rated excellent in situ except for one, which was rated satisfactory owing to overcontouring.

Primary molars offer a suitable test model for microscopic investigations of the restorations after several years in the oral environment, although the condition of the pulp tissue in most cases cannot be studied, owing to the high degree of resorption at shedding. To make the period of clinical performance uniform, the children should be of approximately the same age at the start of the trial. If a restorative material performs well in primary teeth with their more exacting demands with regard to the quality of the

enamel and the tiny proportions, then the clinical success should be still greater in permanent teeth.

In conclusion, 25% of the composite resin restorations in class II cavities formed a tight seal up to 6 years without a bacterial invasion. However, in 75% a tight seal was not achieved, and bacteria were found in the cavity and surrounding dentin, causing pulpal reactions.

Acknowledgements.—This study has been supported by grants from the Swedish Dental Society, Stockholm, Sweden, and by Göteborgs Tandläkare-Sällskap, Gothenburg, Sweden.

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Received for publication 17 February 1989