Cavity design and dimensions of tunnel preparations versus composite resin class-II preparations

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Fourteen pairs of extracted contralateral premolars with small, artificial, standardized, approximal 'caries lesions' were placed in 14 plaster jaws. Fourteen dentists made a mesial tunnel preparation and a distal composite resin preparation on one tooth and vice versa on the contralateral tooth. Less tooth substance was removed in the tunnel preparations than in the class-II preparations, but this difference was not statistically significant when the resin class-II preparations were made without occlusal retention. Twenty-five per cent of the tunnel preparations had residual 'caries', as opposed to 7% in the class-II composite preparations. Tunnel preparations with larger occlusal openings had less residual 'caries'. The morphology of the class-II resin preparations varied considerably, indicating a lack of precise descriptions in the dental literature. □ *Cavity preparation; operative dentistry*

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In the restorative treatment of caries, the use of composite and glass polyalkenoate cement is increasing (1). The reason is probably a growing attention to the possible detrimental effects of amalgam (2, 3) and the fact that restorations with tooth-colored materials are both esthetic and conserve more tooth substance than amalgam restorations. Interest has been focused on two alternatives to class-II amalgams: the tunnel preparation method and the class-II composite resin restoration.

The tunnel preparation proceeds diagonally from the occlusal surface to the approximal carious lesion, leaving the marginal ridge intact (4–6). Carious tissue is removed through the occlusal access, whereafter the cavities are restored with glass polyalkenoate cement (7, 8). Theoretically, the tunnel preparation can be described as either total or partial, depending on whether approximal demineralized enamel is removed or maintained to enable a possible remineralization (9, 10). The technique is suggested to be less destructive of tooth substance than conventional class-II cavity preparations (11), but few long-term studies exist (12, 13).

A traditional class-II preparation is most often recommended for approximal composite restorations (14–16), occasionally with retentive slots on the facial, lingual, and gingival wall of the proximal surfaces (17). Hosoda & Fusayama (18) claim, however, that dovetail retention is not required, as retention is dependent on the bonding of resin to enamel and dentin. One such preparation is the 'saucer preparation', which is characterized by curved internal dimensions (19, 20). The cavosurface angle should be large (21, 22), as it is claimed that enamel prisms cut transversely will improve both retention and sealing properties (8, 23). Beveling is generally not recommended (24, 25), although some recommend this on the gingival margin (23). Current research provides little information concerning the influence of cavity design on the long-term clinical performance of the approximal posterior composite restorations, and it is therefore not possible to give any valid clinical recommendations concerning the ideal cavity preparation.

The aim of the present study was to assess the morphology of tunnel preparations and class-II preparations for composite resin and to compare the amount of tooth substance removed on preparation, the distance from the cavity to the pulp, and the quality of the excavation.

Materials and methods

Thirty-nine dentists working in a Norwegian county were asked to participate in a simulated 'clinical' study. The requirement for participation was that they had previously carried out a minimum of 20 tunnel preparations and 20 approximal composite restorations. Of the 24 who gave a positive response, 14 were selected at random.

Fourteen pairs of newly extracted contralateral premolars (14, 24/15, 25/35, 45) were collected from orthodontic patients. Six pairs were from the upper jaw and eight pairs from the lower jaw. An acrylic resin replica of each tooth was made to facilitate the reproduction of original contours.

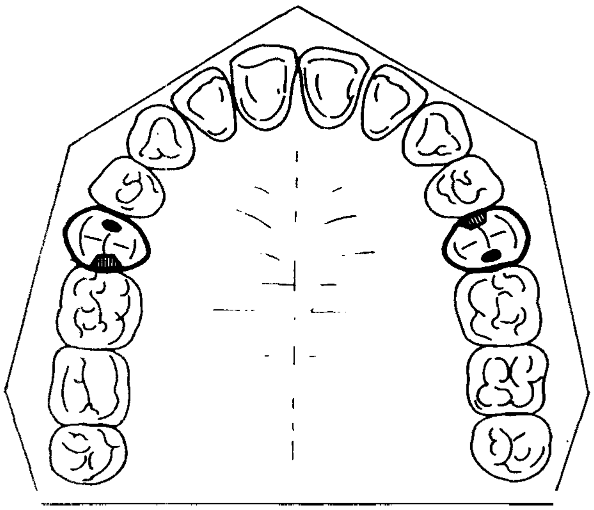
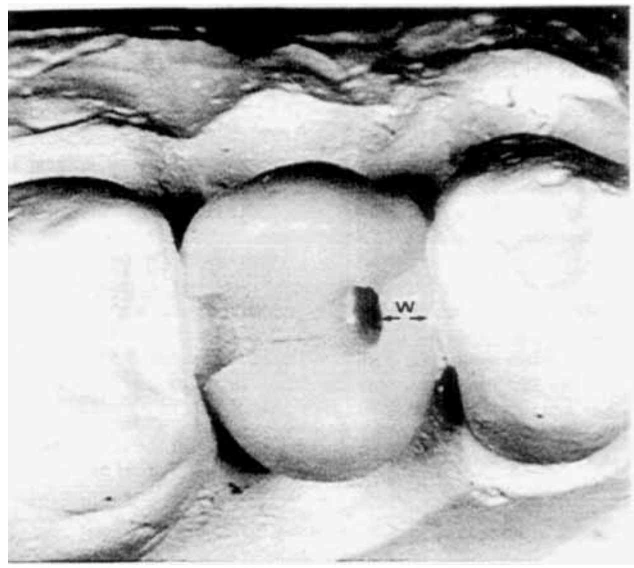


Fig. 1. Diagram of plaster model showing preparations in natural teeth.



Standardized lesions imitating caries were made on the mesial and distal surfaces with a 009 high-speed round bur. A 2-mm-deep approximal penetration was made in a direction perpendicular to the long axis of the tooth at a distance of 2 mm from the top of the marginal ridge. The bur was angled at approximately 45° in the buccal, lingual/palatinal, and gingival direction to create a cavity in the dentin. The teeth were radiographed and filled with a substance consisting of 50/50 glass polyalkenoate cement (Base Line, De Trey) and zinc oxide-eugenol cement with a dash of brown dry pigment added. When this mixture hardens, it adheres to tooth substance yet is still soft enough to be excavated.

Each pair of teeth was placed in the correct position in an acrylic jaw. Alginate impressions were taken of the jaw and plaster models made with the two premolars in place.

A plaster model and radiographs of the premolars were sent to each dentist, requesting them to carry out operative treatment on the premolars in the same manner as if treating their own patients. In each premolar one tunnel and one approximal composite preparation were to be prepared opposite each other (Fig. 1). It was emphasized that all 'dentinal carious tissue' had to be removed. The preparations were to remain unfilled but should be carried out with the intention of filling the tunnel and the class-II composite preparation with glass polyalkenoate cement and posterior composite resin, respectively. The plaster jaws were then returned.

The extension of the composite preparation relative to the neighboring tooth was assessed as '+' if both the lingual and the buccal cavosurface margin was accessible to probing and '−' if this was not the case. Plaster surrounding the premolars was removed. The width of the remaining approximal wall (w) and the area of the occlusal opening in the tunnel preparations (Fig. 2) were measured with a digital Image Analyzer (Cue-2, version 4.0 1992, Galai Production Ltd., Migdal Haemek, Israel). Cavity characteristics such as dovetail, beveling, and retention grooves were registered for the approximal composite preparations.

The cavities were filled with an impression material (Extrude Polyvinylsiloxane Impression Material, Type I Wash, Kerr AG, Basel, Switzerland), which was shaped to the original contour of the teeth by means of the acrylic resin replica. After 7 min of hardening the impression material was removed in toto. Five impressions were taken of each preparation, and the average weight calculated.

After mesiodistal sectioning, residual 'caries' was assessed, and any dentin remaining within the marginal ridge above the tunnel path was noted. The smallest distance between the cavity and the pulp was measured with the digital morphometric analyzer.

For statistical testing of the effect of the preparation technique, unbalanced analysis of variance for repeated measurements was used (26). Interactions were tested when possible but are reported only if $p < 0.01$. Computations were performed with the BMDP computer package (27).

Results

Residual 'caries' was observed in seven (25%) of the tunnel-prepared teeth. Two dentists left caries in both tunnel preparations, whereas three dentists failed in the excavation of one and succeeded in the other. The

Table 1. Analysis of variance of morphologic characteristics of tunnel preparations without and with residual 'caries', using an additive model with upper/lower tooth as grouping variable, mesial/distal surface as trial factor, and whether residual 'caries' was present as covariate

	Tunnel preparations without residual 'caries' ($n = 21$)				Tunnel preparations with residual 'caries' ($n = 7$)				
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	p value
Marginal width (mm)	1.1	0.3	0.5	1.5	1.2	0.3	0.9	1.7	0.040
Opening area (mm^2)	2.5	1.0	1.4	4.7	1.7	0.4	1.2	2.3	0.001
Substance weight (mg)	12.3	3.4	7.1	19.4	11.7	2.9	9.0	17.1	0.639

Table 2. Analysis of variance of substituted weight: a) all preparations, b) preparations without residual caries, c) composite preparations without caries and dovetail, d) composite preparations with dovetail but without caries; and distance between cavity and pulp. P values for additive models with upper/lower tooth as groupings and mesial/distal surface and preparation technique as trial factors

	Tunnel preparation			Approximal composite preparation			
	Mean	SD	n	Mean	SD	n	p value
Weight (mg)	a) 12.1	3.2	28	a) 14.9	4.8	28	0.001
	b) 12.3	3.4	21	b) 15.0	4.9	26	0.013
				c) 14.1	4.8	20	0.110
				d) 18.0	4.6	6	0.001
Distance (mm)	1.2	0.6	21	1.3	0.5	26	0.339

tunnel preparations without caries ($n = 21$) had a mean occlusal opening area of 2.5 mm^2 situated at an average of 1.1 mm from the outer approximal surface (Table 1). The corresponding figures for preparations with residual caries ($n = 7$) were 1.7 mm^2 and 1.2 mm, respectively. The differences were statistically significant. In tunnels without residual caries the correlation between the width of the remaining approximal wall and the area of the occlusal opening was positive ($r = 0.483$, $p = 0.027$). With regard to the mean width of the remaining approximal wall, there was no significant difference between the mesial and the distal surfaces, but the difference between upper (1.2 mm) and lower (1.0 mm) teeth was significant ($p = 0.0002$). However, the difference in the opening area of upper and lower teeth was not significant. The amount of tooth substance removed in preparations without residual caries was not significantly greater than that in preparations with residual caries (Table 1). Five tunnels were totally surrounded by dentin, whereas in the remaining 23 teeth the tunnel wall most proximally consisted only of enamel.

In the posterior composite resin preparations the marginal ridges were removed. A small dovetail was registered in 8 of the 28 preparations; that is, only 4 dentists used occlusal retention. Residual caries was registered in two (7%) teeth. The morphology of the cavities was in general more box-like than saucer-shaped. None of the preparations had bevels or margins below the cementoenamel junction. A flat gingival wall with a dentinal retention groove was present in all preparations. Seventeen teeth showed vertical retention grooves either lingually or buccally or in both walls, in which case the proximal preparations had a cylinder-like appearance. In eight of the preparations the lingual and buccal margins were extended beyond the contact area, to give clearance between the cavity and the neighboring tooth.

The amount of tissue removed and the distance from the cavity to the pulp for the different preparations are shown in Table 2. In preparations without residual caries the amount of tissue removed during preparation was 22% higher in the class-II composite resin preparations than in the tunnel preparations. However, this difference was no longer significant when the class-II preparations with occlusal extension were excluded.

The mean distance from the cavity to the pulp in the class-II composite preparations without occlusal retention was 1.3 mm, whereas in those with occlusal retention and in the tunnel preparations it was 1.1 mm and 1.2 mm, respectively.

The maximum deviation between any five weight measurements never exceeded 8%. The precision of the measurement was checked by repeating some of the recordings 10 times. The coefficient of variation was 3%.

Discussion

The tunnel preparation is claimed to be a technique that conserves tooth substance (5, 11, 28). This study shows that the amount of tooth substance removed in a tunnel preparation does not differ significantly from that removed in an approximal class-II resin preparation, provided this preparation is carried out without occlusal retention. The difference is rather of a qualitative nature, since the tunnel preparation mainly removes dentin, whereas the composite preparation primarily removes tooth enamel.

The fact that 25% of the tunnels and 7% of the composite preparations contained residual caries suggests that it is more difficult to obtain adequate excavation when using the tunnel preparation method. However, it must be emphasized that the caries lesions were artificial and this may possibly have influenced tactility. On the other hand, this was an in vitro study with better opportunities to manipulate the subjects than in a clinical situation.

The proximity of the cavity to the pulp for the preparations did not differ significantly. In a different study, however, the distance to the pulp was found to be much smaller in tunnel preparations than in class-II preparations (29). In that study the tunnels were prepared closer to the center of the occlusal surface, ending far below the contact area on the approximal surface.

Less residual caries was found in tunnel preparations with large occlusal openings or narrow approximal walls, which is in accordance with the results from a previous study (10). This indicates that improved accessibility with higher quality of caries excavation is achieved by placing a large opening close to the marginal ridge. A large opening might be expected to result in a thinner approximal wall, but the correlation analysis showed that this was not the case. Moreover, it appears that the total substance removed by preparation is of less importance for caries removal than the size of the opening. In the present study the width of the marginal ridge was only about 1 mm, which is in accordance with a previous clinical study (13). It is, however, generally suggested that the marginal ridge of a tunnel-prepared tooth should have a width of at least 2 mm to withstand the occlusal forces (8, 30). The dentists' positioning of the access opening caused the most proximal part of the tunnel approximal wall to consist solely of enamel, thus confirming the results of Papa et al. (31). Why the remaining approximal wall was thicker in upper than in lower teeth is not clear, but it may be due to morphologic factors.

The frequency of discrepancies in the composite class-II cavities was rather high, indicating that precise descriptions of adequate cavity morphology is lacking in the dental literature. Just 4 of the 14 dentists used occlusal retention. In only eight preparations was the outline form such that a clearance was created buccally and lingually, enabling proper instrumentation and visualization. Proximal locking in the buccal, lingual, and gingival wall frequently resulted in unsupported enamel. The polymerization shrinkage of composite resins may cause breakage of the thin enamel edges (22). Perhaps more effort should be concentrated on broad enamel margins than on retention grooves.

The fact that at least 60% of the dentists in this district fulfilled the criterion of 'broad experience' with these new preparation techniques indicates that these are commonly used restorations. However, little is known about their longevity and whether they in fact are viable alternatives to amalgam therapy. Longitudinal clinical studies on the performance of such restorations must be carried out to ascertain acceptable and unacceptable preparation features.

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