

# Reaction of the human dental pulp to silver amalgam restorations

## The modifying effect of treatment with calcium hydroxide

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Cavities were prepared in 43 bicuspid teeth using two general categories of cavity depth. In the »deep» cavities the bottom was placed in the inner third of the dentin. In the »intermediate depth» cavities the bottom was positioned in the middle third of the dentin. The bottom of the cavities was either rubbed with calcium hydroxide, covered with calcium hydroxide, or left unlined before filling according to the wet amalgam technique. The teeth were extracted after 1 week and examined histologically. All cases, except 2 with deep and 1 with intermediate depth rubbed cavities, showed local vascular dilatation in the pulp underneath the cavity. In addition, all teeth with deep unlined cavities showed inflammatory cells as did 1 with an intermediate depth unlined cavity. There were fewer displaced odontoblast nuclei in the dentin in the calcium hydroxide-treated groups. The milder reactions in the rubbed or covered groups are probably due to the restrictive effect by calcium hydroxide on penetration of amalgam components. In the teeth with deep cavities there were only minor differences between the ones which had been rubbed and those which had been covered with calcium hydroxide.

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The literature on the reactions of the pulp to experimental silver amalgam restorations performed by the so-called conventional amalgam technique suggests that both leakage and the initial toxic effect of the amalgam can damage the pulp (for review see *Granath & Möller, 1969*). The effect on the pulp of filling shallow (*Granath & Möller, 1971*) or deep (*Möller & Granath, 1973*) cavities with amalgams with known sealing properties according to the wet technique (*Jørgensen, 1967*) was the subject of two previous papers. The total frequency of

inflammation was high but the severity differed with the depth. It was concluded from these experiments with amalgams of different sealing capacity that clinical leakage had been of little importance. The initially high mercury content had apparently irritated the pulp. Mild inflammatory changes consisting of dilated capillaries in the odontoblast layer — cell-rich zone boundary associated with the dentinal tubules involved in the cavity preparation were noted beneath shallow cavities. When the amalgams were inserted in deep cavities inflammatory cells were

invariably noted as well. No difference in frequency of inflammation was found between the cases examined after 1 week and those examined after 1 month. The short distance between the pulp and the floor of the cavity had probably been the decisive factor in the more pronounced reactions. However, the packing pressure may have affected the pulp. This assumption is based on results from experiments on the effect of packing pressure performed on teeth with lined deep and intermediate depth cavities where the teeth were extracted immediately after packing with amalgam (Möller & Granath, 1973).

It has been shown that normal dentin may become more mineralized subsequent to covering the bottom of experimentally prepared cavities with calcium hydroxide (Mjör, 1967). Intratubular deposition of minerals accounts for the effect (Mjör & Furseth, 1968).

A calcium hydroxide lining may prevent the cytotoxic effect of amalgam. It might also, depending on its thickness, reduce the effect of the packing pressure. The present investigation was undertaken to elucidate, in short term experiments, the modifying effect of a calcium hydroxide lining on pulp changes beneath experimental restorations of silver amalgam with known sealing properties and with high plasticity at the time of insertion into cavities of different depths.

#### MATERIAL AND METHODS

The material consisted of 43 bicuspid which were to be extracted for orthodontic reasons. The teeth were intact except for a few with subsurface caries lesions. According to the method described in earlier investigations (Granath & Möller, 1971; Möller & Granath, 1973) a deep buccal

cavity was prepared in 30 teeth, *i.e.* the bottom of the cavity was placed in the inner third of the dentin. In 13 teeth an intermediate depth cavity was made, *i.e.* the bottom was placed in the middle third of the dentin. The method of preparation used has been shown to give insignificant changes.

The bottom of 9 of the deep cavities was covered with a layer of a calcium hydroxide/water mixture about 1 mm thick from which the excess of water was removed with a cotton pellet (Fig. 1 A).

In 11 deep and 7 intermediate depth cavities the bottom was rubbed with a calcium hydroxide/water mixture in order to block the openings of the cut dentinal tubules (Fig. 1 B). The excess calcium hydroxide was removed before the cavities were filled with amalgam. In the remaining teeth, 10 with deep and 6 with intermediate depth cavities, no lining was applied before filling with amalgam (Fig. 1 C). Some of these teeth have been dealt with in the investigation by Möller & Granath (1973). The amalgam used (STA 68, Guldsmeds Aktiebolaget, Stockholm, Sweden) has been shown to give a good seal in a previous laboratory investigation (Granath, 1971).

All teeth were extracted after 1 week with forceps under local anesthesia with 1 ml 3% Carbocain® Dental. The teeth were immediately immersed in water, the apical third cut off with a diamond wheel, and the teeth were placed in 10% neutral formalin. The teeth were decalcified in Versene®, pH 7.4, at 37°C. After paraffin embedding, serial sections, 7–8 µm thick, were cut and stained with haematoxylin and eosin. The actual changes to be recorded were the presence and signs of inflammation, reduction in the number of odontoblasts, presence of odontoblast nuclei in the dentinal tubules, and ruptured

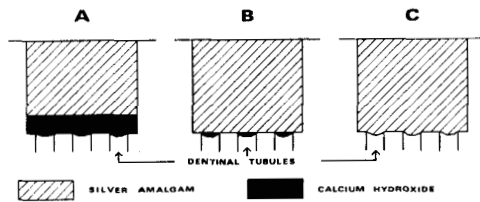


Fig. 1. Schematic drawings of the three methods of cavity treatment.

vessels indicated by fresh haemorrhage. The shortest distance between the floor of the cavity and the pulp was measured. The statistical analysis was carried out as a one-sided test based on the hypergeometric probability distribution applied to tests of the equality of two proportions (Lieberman & Owen, 1961). Differences significant at the 5% level were said to be statistically significant.

## RESULTS

The results are given in Table I and examples shown in Fig. 2. In the 30 teeth with deep cavities the mean of the shortest distance from the floor of the cavity to the pulp was 0.39 mm with a standard deviation of 0.16 mm. The corresponding figures for the teeth with intermediate depth cavities were 0.95 mm and 0.13 mm, respectively. The difference in depth between the two groups was statistically significant ( $p < 0.001$ ) according to Student's *t*-test.

Inflammation in the form of dilated capillaries in the odontoblast layer — cell-rich zone boundary associated with the dentinal tubules involved in the cavity preparation was demonstrable in all teeth, except in 2 with a deep and 1 with an

Table I. *Pulpal changes in odontoblast layer — cell-rich zone boundary in 43 bicuspid with experimental restorations of silver amalgam of high plasticity at time of insertion into deep and intermediate depth cavities, respectively, which were either unlined or lined with Ca(OH)<sub>2</sub>*

	Num-ber	Mean distance pulp—cavity mm $\bar{x}$	S.D.	Dilated capil-laries	Inflammatory cells few or slight or dense infiltration	Reduction in number of odontoblasts slight great	Odontoblast nuclei in dentin few numerous	Ruptured vessels			
A. Deep cavities	10	0.44	0.19	10	6	4	2	5	2	8	8
B. A + Ca(OH) <sub>2</sub> -covering	9	0.38	0.16	9			2	1	7	2	9
C. A + Ca(OH) <sub>2</sub> -rubbing	11	0.35	0.14	9	1		3	1	9	2	10
D. Intermediate depth cavities	6	0.96	0.17	6		1			4	2	5
E. D + Ca(OH) <sub>2</sub> -rubbing	7	0.95	0.10	6			1		6		7

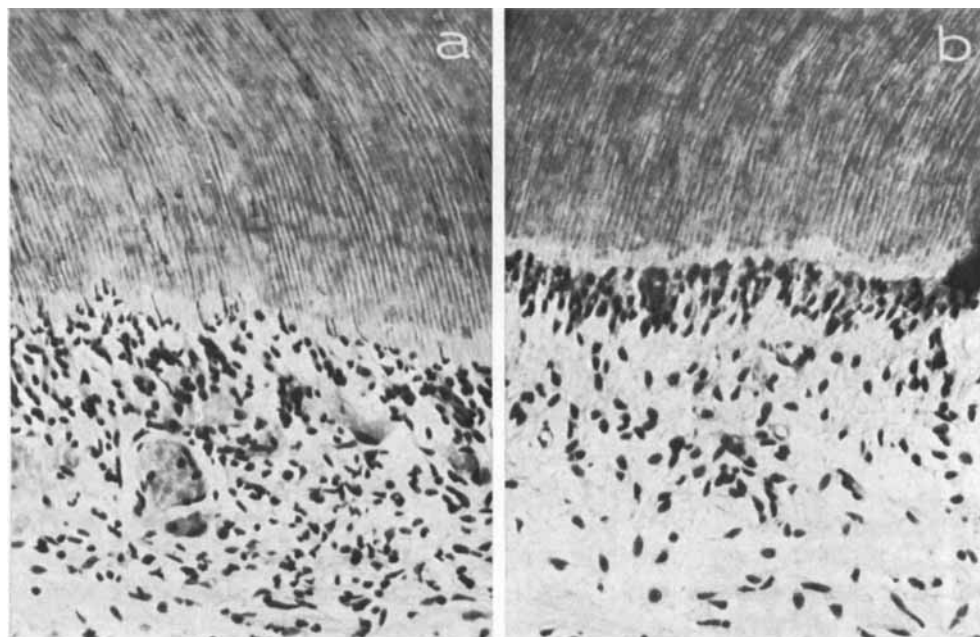


Fig. 2a. Dilated and ruptured vessels, inflammatory cells and great reduction in the number of odontoblasts together with numerous odontoblast nuclei in the dentin beneath a deep unlined cavity filled with silver amalgam. Pulp — cavity distance 0.59 mm; x 300

Fig. 2b. No pulpal changes are seen beneath a deep cavity rubbed with calcium hydroxide before filling with silver amalgam. Fragments of odontoblast nuclei can be traced in the dentin. Pulp — cavity distance 0.58 mm; x 300

intermediate depth cavity where the bottom was rubbed with calcium hydroxide. Inflammatory cells were seen under all deep cavities with no lining, *i.e.* 4 showed moderate infiltration of inflammatory cells and 6 a few inflammatory cells. Under 1 cavity with rubbed floor a few inflammatory cells were noted. The difference between the teeth with no lining and those covered or rubbed with calcium hydroxide was statistically significant ( $P < 0.001$ ). In the teeth with intermediate depth cavities and no lining, a moderate infiltration of inflammatory cells was seen in 1 tooth. Teeth where the bottom of the cavity was rubbed with calcium hydroxide showed no inflammatory cells.

In the group with unlined deep cavities great reduction in the number of odontoblasts was noted in 5 cases and slight

reduction in 2. The corresponding figures for the group with rubbed bottoms were 1 and 3, and for the group with a calcium hydroxide covering 1 and 2, respectively. Under 1 intermediate depth cavity with a rubbed bottom there was a slight reduction. There were no statistically significant differences between the subgroups within the two main depth groups, but there were significantly more teeth with reduction in the group with deep cavities ( $P < 0.05$ ). In all teeth with deep cavities odontoblast nuclei were found in the dentin. There were numerous nuclei in 8 unlined cases and in 2 cases in each of the groups of covered or rubbed cavities. There were significantly fewer nuclei in the dentinal tubules in the calcium hydroxide-treated groups ( $P < 0.05$ ).

Among the teeth with intermediate depth, rubbed cavities 6 showed a few odontoblast nuclei in the dentin. Out of those with unlined cavities 4 showed a few and 2 numerous nuclei. This difference was only numerical but not statistically significant. In the teeth with unlined, intermediate depth cavities ruptured vessels, indicated by an extravasation of erythrocytes, were noted in all cases except one. Two teeth with deep unlined cavities, and 1 with rubbed cavity bottom, showed no rupture.

#### DISCUSSION

In an earlier study on pulp reactions to restorations of amalgam with high plasticity inserted in deep cavities (Möller & Granath, 1973) it was suggested that the initially high mercury content of the amalgam, together with the packing pressure, were the main reasons for the inflammatory changes in the pulp. In the present study, presence of inflammatory cells was less common in cases where the bottom of the experimentally prepared deep cavities had been either rubbed or covered with calcium hydroxide than in cases with untreated dentin.

Concerning unlined cavities, inflammatory cells seem to be present almost exclusively when the bottom of the cavity is situated in the inner third of the dentin. Therefore, it seems, important to define and state the depth of the cavity when dealing with pulp reactions beneath restorative materials.

In teeth with deep cavities only minor differences were noted between those with rubbed and those with covered bottoms. As there is no reason to believe that the mere rubbing of the cavity bottom with calcium hydroxide will decrease the effect of the packing pressure, the main reason

for the milder reactions in these cases must be the limiting effect of calcium hydroxide, even in small amounts, on penetration of amalgam components into the pulp. This effect was not so obvious beneath intermediate depth cavities since the changes beneath unlined cavities in that category were mild.

There was a greater number of odontoblast nuclei in the dentin beneath unlined cavities, *i.e.* in cases where the inflammatory changes in the pulp were more pronounced, than beneath calcium hydroxide-treated ones. The displacement of odontoblast nuclei may thus be explained by a localized intrapulpal pressure due to inflammation (Stenvik, Iversen & Mjör, 1972; Stanley & Swerdlov, 1958). The presence of odontoblast nuclei in the dentin also suggests that the seal was incomplete. It must be emphasized, however, that an incomplete seal does not necessarily result in a clinical leakage.

The mild inflammatory reaction, *e.g.* dilated vessels, in teeth treated with calcium hydroxide may be caused by the lining material. The alkalinity cannot be ignored as a causative factor as has been suggested by Mjör (1963). Almost all cases showed fresh haemorrhage in the pulp beneath the cavity. These haemorrhages were probably caused by extraction trauma on vessels already weakened by a localized inflammation. As mentioned in the introduction, it has been shown that the packing pressure may mechanically damage pulp vessels, thus contributing to intrapulpal bleeding in connection with the extraction. However, this contribution seems to be of minor importance in the present investigation since there were no differences between teeth with deep and intermediate depth cavities, respectively.

The investigation showed that, in routine clinical work with amalgam of

high plasticity. the pulp beneath deep cavities could be properly protected from amalgam irritation by rubbing the bottom of the cavity with a calcium hydroxide/water mixture. This procedure does not seem to interfere with the adaptation of the filling material to the cavity walls.

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