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## PAIN REACTION TO COLD STIMULUS IN TEETH WITH EXPERIMENTAL FILLINGS

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Buccal cavities prepared in one tooth of each of 19 contralateral pairs were filled with gutta percha. After a few days a similar cavity was drilled in the other tooth of the pair and both were lined and filled with amalgam. A clinical test with ice a few minutes after the fillings had been placed and again after some days showed that the tooth that had contained a gutta percha filling was much more sensitive than the other. The former cavity was also more sensitive to an air blast and probing than the one recently drilled. Histological examination disclosed local mild inflammation beneath the cavity filled with gutta percha. With one exception the teeth without gutta percha displayed no such reaction.

In a further 7 pairs both cavities were filled with gutta percha for a few days, after which additional superficial dentine in one cavity was removed and both were filled with amalgam and submitted to the thermal sensitivity test with ice. There was no significant intra-pair difference in sensitivity. In both pulps of all these pairs there was evidence of an inflammatory reaction.

The results suggest that the increase in sensitivity to cold stimulus when an amalgam filling is placed in the cavity may be due in some measure to inflammation of the pulp.

The clinical experience that a tooth can be sensitive to cold for a few days after an amalgam filling has been placed is undoubtedly one source of the view that the pulp can be impaired by thermal shock and should therefore be protected by placing a thick layer of insulating cement beneath the amalgam. On the other hand the dentine is as effective an insulator as dental cement (*Phillips et al.*, 1956) and there is no histologic evidence that the pulp suffers damage from the brief temperature variations that normally occur in the mouth. Points to be borne in mind in this context are that pain can be elicited by a cold stimulus before any change in temperature has reached the pulp (*Hensel & Mann*, 1956; *Naylor*, 1963; *Brännström &*

Johnson, 1970), that the sensitivity to thermal stimuli can increase also in teeth with extremely shallow fillings, and that it can disappear within a couple of weeks. While the protection afforded by irregular dentine will not have developed during this time, the onset of sclerosis-like changes in the dentine cannot be excluded (Kato & Fusayama, 1971).

It has been postulated that a liquid-filled space between the amalgam and the cavity wall would increase the sensitivity of the tooth to thermal stimuli (Brännström, 1963). Evidence for this is found in the fact that the sensitivity may be reduced by applying a film of varnish about 5  $\mu$  thick (Dachi & Stigers, 1967), which possibly blocks the link between the space containing the liquid and the contents of the dentinal tubules.

That the amalgam filling can increase the sensitivity and discomfort is a current problem, not least in connection with the question of insulation. This paper reports the first study of a series in which an examination will be made of the cause of the increase in sensitivity to cold after an amalgam filling has been placed.

#### MATERIAL AND METHOD

The study was performed on 26 permanent contralateral pairs of teeth that were to be extracted on ortodontic indications. In 5 of them there was a small occlusal amalgam filling, while the other were clinically intact. One tooth of each of 19 pairs was chosen at random and a cavity was drilled in the cervical third of the buccal surface, the preparation being completed with a Meisinger no. 8 bur to give a cavity 2 mm in diameter and about 1½–2 mm deep. The preparation was carried out at a bur speed of less than 10,000 rev./min and with water cooling, a technique that has been found in earlier studies not to give rise to notable changes in the pulp (Brännström, 1960). The cavity was flushed with a water spray, scrubbed with cotton pellets and dried by applying a gentle air stream, after which it was filled with gutta percha which had been heated to plastic consistency. This material was chosen because it is known to give rise to pulp lesions and local inflammation through leakage (James *et al*, 1954); moreover, it is easily removed from the cavity without risk of mechanical damage to the dentine.

After 3–12 days a similar cavity was drilled in the other tooth of the pair. The gutta percha filling was removed from the first cavity, and both cavities were cleaned, dried with cotton wool and a 5-second air blast, and covered with a liner (Tubulitec®\*) which was blown out into a film over the cavity

\*) Tubulitec, Forssbergs Dental AB, Stockholm Sweden.

walls; amalgam fillings were then placed. The object of insulating with the liner was to reduce the effect of any leakage. After 10–15 minutes the sensitivity of the teeth to cold stimulus was tested by applying a piece of ice to the filling for 5 seconds without touching the gingiva. The patient, who was not aware of the object of the test, was asked to state whether he could detect any difference between the reactions in the two teeth. The test was repeated three times, the ice being applied alternately to each filling. The same sensitivity test was repeated after 3–8 days.

Earlier studies have suggested that some kind of change may occur in a dentine surface that has been exposed and left unprotected for a time (*Brännström* 1962, 1965). Moreover, it was noticed in one experiment that a greater hydrostatic pressure on the dentine was required in order to elicit pain in cavities that had been filled with gutta percha. After the dentine surface in the same cavity had been freshened, pain was felt at a lower pressure (*Brännström et al.*, 1969). As it was considered possible that not only pulp inflammation but also changes in the surface of the dentine might have a bearing on the sensitivity to thermal stimuli a supplementary test was performed on 7 pairs of teeth.

In both teeth of each pair buccal cavities were drilled and filled with gutta percha at the first appointment. After 3–12 days both fillings were removed and in one of the cavities chosen at random the dentine surface was freshened by means of a Meissinger bur with water cooling and without deepening the cavity appreciably. Both cavities were cleaned, dried, insulated, filled with amalgam and tested for sensibility as described above.

After the last test, that is, 3–8 days after the amalgam fillings had been placed, the teeth were extracted. In 9 subjects where 2 pairs of teeth were available the second pair was not extracted until a further week had elapsed. All teeth were fixed in formaldehyde, decalcified and cut into serial sections through the middle of the cavity and the corresponding pulp. The sections of the pulp were examined without knowledge of which form of treatment had been applied. In a further 3 teeth cavities were drilled. One of the teeth was extracted immediately afterwards. The cavities in the other 2 were filled with gutta percha and 3 days later the dentine was freshened in one of them, and then both teeth were extracted for an examination of the appearance of the dentine surface. The bottom of the cavities were covered by a film of gold about 200 Å thick deposited by vaporization *in vacuo* at  $10^{-4}$  torr. The surfaces were photographed in a Gambridge Scanning electron microscope at an acceleration potential of 30 kV.

## RESULTS

*Clinical observations.* For the 19 pairs of teeth where one cavity had first been filled with gutta percha some days before the amalgam fillings were placed in both cavities, an intra-pair comparison was made with respect to the cold stimulus, the results are presented in Table I.

A statistical analysis of the results by means of the sign test showed that the intrapair difference is significant at the 1 per cent level.

The difference in sensibility was appreciable in most cases and the patient showed a definite reaction. This is particularly true for the tests conducted after 10–15 minutes. Before the cavities were filled with amalgam it was noticed that the dentine in the cavity previously filled with gutta percha was much more sensitive to probing and an air stream than the newly prepared cavity.

In the 7 pairs where gutta percha fillings were left in both cavities in the pair for some days, after which one of the cavities chosen at random was freshened with a bur, a definitely more marked pain was elicited by the sensibility test in two of the unfreshened contralateral cavities. In the other cases the patient detected no clear difference in the intensity of pain in the teeth of the pair. Before the amalgam fillings were placed the cavities were all highly sensitive, especially to probing and an air blast.

*Histological observations.* For the 19 pairs of teeth in which one cavity had first been filled with gutta percha, the distance to the pulp measured along the dentinal tubules ranged from 0.4 to 2.5 mm (mean 1.3 mm). For the 7 pairs provided first with gutta percha fillings the values were 0.9 and 2.4 mm (mean 1.7 mm). The intra-pair difference was small.

In the first group of 19 pairs the pulp displayed local changes under 15 cavities that had first been filled with gutta percha but no reaction under the respective contralateral cavities. In 2 pairs there was an insignificant reaction under both cavities and in two other pairs no reaction at all.

Table I.  
*Results of intra-pair comparison with respect to cold stimulus*

Interval between placing amalgam filling and the test	No. of tooth pairs with stronger reaction in		No intra-pair difference
	Tooth first filled with gutta percha	Tooth filled directly with amalgam	
10–15 minutes	16	1	2
3–8 days	14	4	1

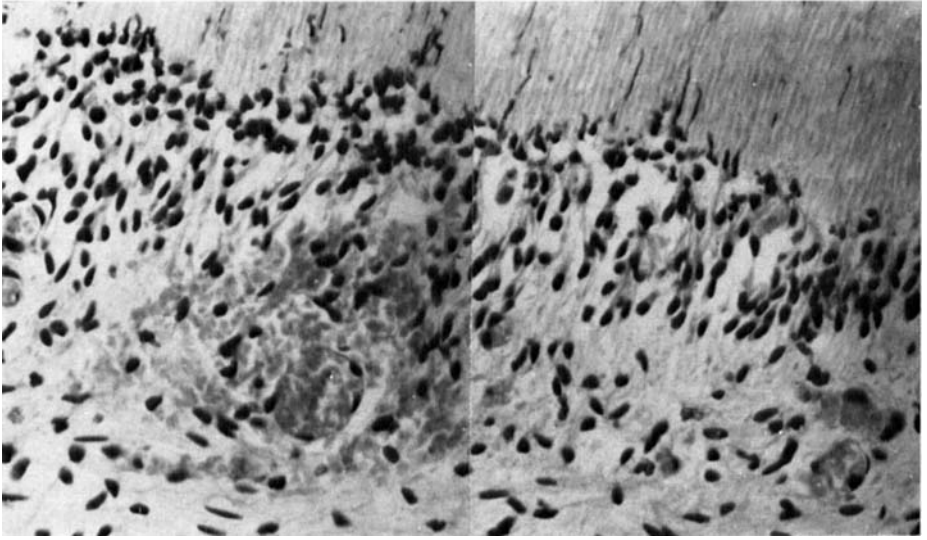


Fig. 1. Dentine and pulp beneath a cavity that had been filled with gutta percha for 3 days and then insulated and filled with amalgam. The tooth was extracted after a further 4 days. There are nuclei in the tubules, and leukocytes along the dentine wall.



Fig. 2. The floor of the newly prepared cavity. The apertures of the dentinal tubules are blocked with debris. Because of dehydration *in vacuo* fissures have appeared in the material on the tubule apertures  $\times 2200$ .



Fig. 3. The floor of the cavity containing gutta percha for 3 days. There is a weak pattern of the apertures of the tubules, some of which are patent (*arrow*).  $\times 2200$

In the group of 7 pairs where both cavities had first been filled with gutta percha, changes in the pulp were observed under all but one of the cavities; in this case there had been an error in sectioning and no evaluation was possible.

The changes observed were restricted to a reduction in the number of odontoblasts, nuclei or fragments of nuclei in the dentinal tubules, an increased number of visible vessels in the odontoblastema and the neighbouring area, and, under 20 cavities, leukocytes spread along the dentine wall bounding the pulp (Fig. 1). Under 19 cavities which were only lined and filled with amalgam there were in one case a few leukocytes.

The scanning photographs showed that the apertures of the dentinal tubules were blocked by debris in the new recently drilled cavity (Fig. 2). In the cavity filled with gutta percha for 3 days there was a weak pattern of the tubule apertures, some of which were patent (Fig. 3). In the cavity that had been freshened after the gutta percha filling had been in place for 3 days the dentine surface had the same appearance as that in the new cavity.

## DISCUSSION

It should be noted that the cavities were not particularly deep, and in most cases there was a fairly thick insulating layer of dentine between the amalgam and the pulp. The liner used was blown out into a film which, to judge from measurements performed in another connection (*Johnson*, unpubl.), was less than  $5 \mu$  thick. Compared with the dentine this provides little thermal insulation. The pain reaction to ice placed on the amalgam is not necessarily due to a cold stimulus reaching the pulp (*Hensel & Mann*, 1956, *Naylor*, 1963). A layer of dentine one millimetre thick provides better thermal insulation than the same thickness of enamel and insulating cement (*Phillips*, 1956; *Craig & Peyton*, 1961). Under many cavities in the present material the thickness of the dentine was about 2 mm. It might be expected that the cold stimulus would be rapidly transmitted by the amalgam to the tubule liquid, which would then contract, producing a centrifugal flow which would displace or deform the nerve fibres in the corresponding area of the pulp (*Brännström & Johnson*, 1970). As shown in earlier experiments, the pulp can act as a mechanoreceptor for such stimuli, which mobilize the capillary force in the tubules (*Brännström & Åström*, 1964). The same effect occurs in the case of an air blast, and probably also when a probe scrapes the surface of the dentine where there is a liquid film over the apertures of the tubules. The cavities filled with gutta percha were also appreciably more sensitive to these types of stimuli than were corresponding freshly prepared ones. One possible reason for this is that in the cavities which had been filled with gutta percha some of the apertures of the tubules were patent whereas in the newly drilled cavity these were blocked with debris (Figs. 2, 3). That the removal of the superficial dentine in a cavity did not alter the sensitivity to cold stimulus would suggest that this reached the tubule contents and produced a distal flow irrespective of the conditions at the apertures. On the other hand, the conditions at the apertures are probably of greater significance as regards the transmission of other types of pain stimuli such as an air blast, probing and dehydrating chemical agents, and the application of hydrostatic pressure to the tubules (*Brännström* 1960, 1965; *Brännström et al.*, 1969).

From the results of the histological examination it would appear that one of the intentions of this study was realized, namely, to create an inflammatory reaction under one cavity of a pair but not under the other. Such a reaction may obviously change the sensitivity not only to cold after an amalgam filling has been placed but also to other types of stimuli producing the same effect in the dentine, namely a centrifugal flow. It was noticed by *Anderson et al.* (1958) that cavities with gutta percha fillings were for a period more

sensitive to hyperosmotic solutions. It has also been demonstrated that the essential effect of such solutions applied to the dentine is to produce a centrifugal flow in the tubules (*Lindén & Brännström, 1967*).

Because of its poor adaption gutta percha gives rise to conditions in a shallow cavity similar to those produced by exposure of dentine through, for instance, grinding, wear or decalcification of the tooth necks. A resulting increase in sensitivity to the above stimuli may be due in some measure to mild local inflammation in the corresponding area of the pulp.

As the extractions were performed some days after placing amalgam fillings in the cavities that had contained gutta percha, it cannot be ruled out that during this time the inflammation had diminished, and in 2 cases had even disappeared. This may also explain why intra-pair difference was not always as great on the second occasion of the test.

The clinical experience of an increase in sensitivity just after an amalgam filling has been placed may to some extent have its explanation in an inflammatory reaction in the pulp to caries. Irritation from a space formed between the filling and the cavity wall on the contraction of the amalgam, and filled with saliva through the action of capillary forces, may also lead to inflammation and an increase in sensitivity.

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