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REACTION OF THE HUMAN DENTAL PULP TO  
SILVER AMALGAM RESTORATIONS  
EFFECT OF INSERTION OF AMALGAM OF HIGH  
PLASTICITY IN SHALLOW CAVITIES

by

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INTRODUCTION

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 (*Brännström, 1963; Granath & Möller, 1969*). *Granath & Möller (1969)* found a tendency to milder reactions of the pulp in human bicuspid 1 month after insertion than after 1 week. This was interpreted as a sign of improved sealing. But it was not possible to guarantee that the seal after 1 month was so good as to prevent capillary inspiration of saliva completely. On the basis of the literature on the cytotoxic effect of freshly prepared amalgam, among others by *Kawahara et al. (1959)*, it was felt that the initial and persisting pulpal changes were not due to leakage alone. Re-irritation by metallic mercury released by the corrosion process, which can improve the seal, was considered a possible contributory factor.

In the investigation accounted for above (*Granath & Möller, 1969*), use was made of an amalgam, whose sealing properties were not known. However, in order to evaluate the particular effect of the amalgam the degree of adaptation obtained as a result of a given preparation and packing should be defined. Biological testing of material according to such principles has, as

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far as we know, not been reported. This is probably due mainly to unavailability of a suitable method for comparative quantitation of *in vitro* leakage. Such a method has now been devised (Granath & Svensson, 1970).

The purpose of the present investigation was to assess the biological effect on human dental pulp of experimental restorations of silver amalgams of known relative sealing properties and with high plasticity at the time of insertion into shallow cavities.

#### MATERIAL AND METHODS

*Teeth.* The material consisted of 28 bicuspid, which were to be extracted for orthodontic reasons. The teeth were intact except for a few with superficial enamel decalcifications.

*Amalgams.* Two brands of amalgam, A and B, corresponding to amalgam IV and VIII in previous physical investigations (Granath, 1971) were used. As far as sealing properties are concerned, they represented extreme values in a series of 9 brands of amalgam. Twenty-four hours after preparation the test bodies with amalgam A had been tight, while those with amalgam B had shown leakage in the air pressure test. After the test bodies had been exposed to change in temperature, 6–48°C, also amalgam A showed leakage. For amalgam B leakage was then fairly severe.

*Experiments.* After application of a rubber dam a cavity was prepared through the buccal prominence of the tooth. The preparation was carried out in 3 stages under continuous irrigation with physiological saline of room temperature. After making a superficial mark on the tooth with a small spherical diamond to denote the centre of the cavity to be made, the circumference of the cavity was standardised with a spherical diamond about 3 mm in diameter. This step was done intermittently with the use of a machine with a maximum speed of 6,000 revolutions per minute to a depth corresponding to the radius of the diamond. Finally, the cavity was deepened with a spirally cut, cylindrical hard-metal bur with a rounded head, friction grip-adaptor, and about 1 mm in diameter. The third step, like the first, was carried out with a high-speed machine with a maximum speed of 100,000 revolutions per minute. The cavity was shallow, which means that its floor lay in the outer half of the dentin.

The effect of the operative procedure on the pulp was checked in a series of teeth in which deep cavities were prepared. No significant changes were noted, the results to be reported in a subsequent work.

The cavities were dried with gauze and filled with amalgam according to the wet technique (Jorgensen, 1967). Preparation and packing of the amalgam

was performed in exactly the same way as in the physical studies (*Granath*, 1971).

Fourteen cavities were filled with amalgam A and 14 with amalgam B. Seven of the teeth in each group were extracted after 1 week and 7 after 1 month.

The teeth were extracted with forceps under local anaesthesia with 1 ml 3 % Carbocain® Dental. The teeth were immediately immersed in water and the apical third was cut off with a diamond, after which the teeth were placed in 10 % neutral formalin.

*Histological treatment.* The teeth were decalcified in Versene® at pH 7.4 at 60°C. After the specimens had been embedded in paraffin, serial sections, 7–8  $\mu$ m thick, were cut and stained with haematoxylin and eosin.

#### RESULTS

The results are given in Table I. Nine of the teeth with amalgam A and 13 of those with amalgam B showed mild pulpal inflammation. The inflammatory changes consisted of dilated capillaries in the odontoblast layer and the cell-free zone associated with the dentinal tubules involved in the cavity preparation. In some cases the reactions were small. Fig. 1 shows the changes in a tooth examined 1 month after insertion of the amalgam. Disorganisation of the area pre-dentin — cell-rich zone was not noted in any case, but 2 teeth with amalgam A examined after 1 week and 1 month, respectively, showed scattered inflammatory cells.

Table I.

*Occurrence of pulpal changes in 28 bicuspid teeth with experimental restorations of silver amalgam with high plasticity on insertion into shallow cavities*

	Dilated capillaries in odontoblast layer and cell-free zone	Odontoblast nuclei in the dentin	
		few	numerous
No. with amalgam A			
examined after 1 week (7)	4	3	1
» » 1 month (7)	5		
and with amalgam B			
examined after 1 week (7)	6	3	1
» » 1 month (7)	7	3	

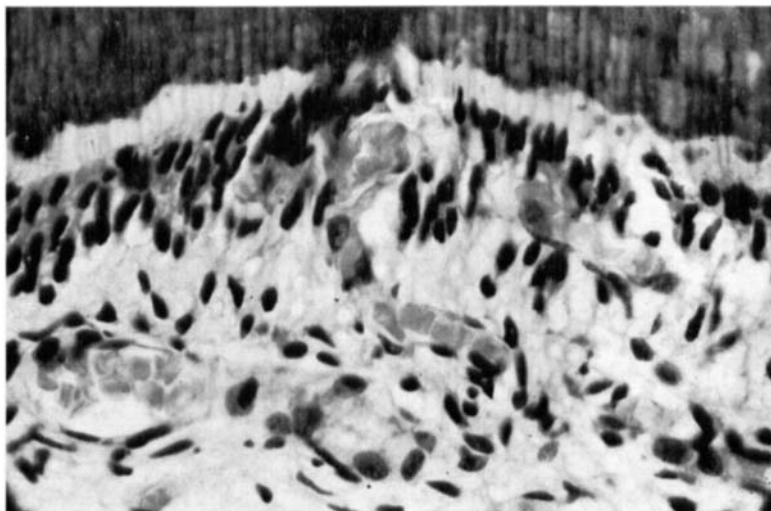


Fig. 1. One month case in group A with dilated capillaries adjacent to the predentin and a number of histiocytes around the vessels; otherwise no noteworthy changes;  $\times 475$

The occurrence of inflammation was roughly the same in the teeth examined after 1 week and in those examined after 1 month in group A and group B, respectively. On the other hand, the total frequency of inflammation in group B was somewhat higher than in group A. This difference was statistically not significant, according to analysis of hypergeometric distribution of the variable.

A few disintegrated odontoblast nuclei were found in dentinal tubules in communication with cavities, *viz* with amalgam A in 3 cases examined after 1 week, and with amalgam B in 3 cases examined after 1 week and in 3 examined after 1 month. Numerous nuclei were found with amalgam A in 1 case and with amalgam B in 1 case, both examined after 1 week. The findings were made in cases with inflammation.

#### DISCUSSION

The results of the physical investigations (Granath, 1971), which showed that the use of amalgam B resulted in comparatively poorer sealing than the use of amalgam A, warrant the following conclusions. Since an effect of change in temperature in the mouth cannot be excluded, one cannot, *a priori*, assume that amalgam A remained tight throughout the experimental period.

The presence of odontoblast nuclei in the dentinal tubules in the cases with inflammation and examined after 1 week lend support to this assumption (*James & Schour, 1955*). On the other hand, the insignificant difference in inflammatory reaction between group A and group B speak for that insufficient seal of the size that was registered for amalgam B in the physical studies does not result in clinical leakage of noticeable importance, when amalgam with high plasticity is inserted into shallow cavities.

The total frequency of inflammation was high. The initially high metallic mercury content of the amalgam had apparently irritated the pulp. It should, however, be born in mind that the inflammatory reactions were mild. The persisting changes might be a consequence of a fixation process which may perhaps be explained by the occurrence of mercury chloride in the pre-amalgamated alloys. Pre-amalgamation of alloy particles is done by washing them with mercury chloride. This compound fixes by coagulation biological tissue by reacting with the sulphhydryl(-SH) group in the cysteine component of the proteins (*Baker, 1958*).

It is still too early to give any clinical recommendations on the basis of this investigation. Further knowledge of the biological effect of insertion of amalgam of high plasticity is desirable.

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#### SUMMARY

The purpose of the investigation was to assess the *biological effect on human dental pulp* of experimental restorations of silver amalgams of known relative sealing properties and with high plasticity at the time of insertion into shallow cavities.

The material consisted of 28 bicuspid teeth to be extracted for orthodontic reasons. Fourteen cavities were filled according to the wet technique (*Jørgensen, 1967*) with amalgam A, which had been shown to give a good seal, and 14 with another amalgam, B, which gave a comparatively less good seal (*Granath, 1971*). Seven of the teeth in each group were extracted after 1 week and 7 after 1 month. The teeth were examined histologically.

Nine of the teeth with amalgam A and 13 of those with amalgam B showed mild inflammatory changes consisting of dilated capillaries in the odontoblast layer and the cell-free zone. No difference in frequency was found between the cases examined after 1 week and those examined after 1 month. The

total frequency of inflammation in group B was somewhat higher than in group A, but the difference was statistically not significant.

It was concluded that any clinical leakage had been of little importance. The initially high metallic mercury content had apparently irritated the pulp.

#### RÉSUMÉ

#### RÉACTION DE LA PULPE DENTAIRE HUMAINE AUX RESTAURATIONS D'AMALGAME D'ARGENT. ACTION DE L'INSERTION D'AMALGAME À HAUTE PLASTICITÉ DANS DES CAVITÉS PEU PROFONDES

Le but de ce travail a été d'étudier l'effet biologique produit dans la pulpe par des restaurations expérimentales d'amalgame d'argent dont les propriétés relatives d'étanchéité étaient connues et ayant une haute plasticité au moment de l'insertion dans des cavités peu profondes.

Le matériel se composait de 28 prémolaires devant être extraites dans un but orthodontique. Les obturations ont été faites dans 14 cavités suivant la technique «mouillée» (*Jorgensen, 1967*) avec l'amalgame A, dont la qualité de l'étanchéité avait été démontrée, et dans 14 autres cavités avec l'amalgame B dont l'étanchéité était relativement moins bonne (*Granath, 1971*). Dans chaque groupe, 7 dents ont été extraites au bout d'une semaine et 7 dents au bout d'un mois. Les dents extraites ont été soumises à un examen histologique.

Neuf des dents obturées avec l'amalgame A et 13 de celles obturées avec l'amalgame B présentaient de légères altérations inflammatoires consistant en capillaires dilatés dans la couche des odontoblastes et dans la zone acellulaire. Il n'a pas été trouvé de différence entre les fréquences parmi les cas examinés au bout d'une semaine et parmi les cas examinés au bout d'un mois. La fréquence totale des cas d'inflammation dans le groupe B était légèrement plus élevée que dans le groupe A, mais cette différence n'était pas significative du point de vue statistique.

En conclusion, un manque d'étanchéité clinique n'avait guère eu d'importance notable. La teneur initiale élevée en mercure métallique semblait être la cause de l'irritation pulpaire.

## ZUSAMMENFASSUNG

DIE REAKTION DER MENSCHLICHEN ZAHNPULPA AUF SILBERAMALGAMFÜLLUNGEN.  
DER EFFEKT BEI APPLIKATION VON AMALGAM MIT HOHER PLASTIZITÄT IN  
KAVITÄTEN VON GERINGER TIEFE

Ziel der Untersuchung war, den biologischen Effekt von experimentellen Füllungen mit Silberamalgam mit verschliessenden Eigenschaften, deren Relation zu einander bekannt war, und mit hoher Plastizität während der Applikation in Kavitäten von geringer Tiefe auf die menschliche Pulpa zu veranschaulichen.

Das Material bestand aus 28 Bikuspiden, die auf Grund orthodontischer Behandlung extrahiert werden sollten. Vierzehn Kavitäten wurden nach der nassen Methode (*Jørgensen*, 1967) mit Amalgam A, das sich als gutes Verschlussmaterial erwiesen hatte, und 14 andere Kavitäten mit Amalgam B gefüllt, das einen verhältnismässig weniger guten Verschluss gab (*Granath*, 1971). Sieben Zähne aus jeder Gruppe wurden nach einer Woche, weitere 7 Zähne nach einem Monat extrahiert. Die Zähne wurden histologisch untersucht.

Neun Zähne mit Amalgam A und 13, die mit Amalgam B gefüllt waren, zeigten milde inflammatorische Veränderungen, und zwar erweiterte Kapillaren in der Odontoblastenzone und der zellfreien Zone. Zwischen den Zähnen, die nach einer Woche und jenen, die nach einem Monat untersucht wurden, war kein Frequenzunterschied festzustellen. Die Gesamtfrequenz inflammatorischer Veränderungen lag in der B-Gruppe etwas höher als in der A-Gruppe, aber der Unterschied war statistisch nicht signifikant.

Man stellte fest, dass jegliche Leckage von geringerer Bedeutung gewesen war. Der anfänglich hohe Gehalt an metallischem Quecksilber hatte offensichtlich die Pulpa gereizt.

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