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## MERCURY LEAKAGE OF AMALGAM CAPSULES

*by*

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### INTRODUCTION

During studies of dental amalgams conducted in recent years at the technological department of the Royal Dental College in Copenhagen a fairly high level of mercury spillage has been noted in a number of cases when the amalgam is mechanically triturated in capsules.

The purpose of the present study is to indicate the possibility of such spillage also occurring in clinical practice, and moreover to describe a simple method of detecting leaking capsules. It is not our purpose to make an assessment of the quality of the many different makes of capsules as regards the leakage of mercury — although the study indicates that in this respect there can be considerable differences between the various makes.

### MATERIALS AND METHODS

Only one brand of alloy was employed in the study, viz. True Dentalloy (S. S. White Dental Mfg. Co., G. B. Batch No. 896837), and one type of mercury which met the requirements of F.D.I. specification no. 2. The amalgam was triturated by means of a Silamat automatic mixer from the firm of Ivoclar (Schaan, Liechtenstein); the capsules examined during the study

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Table I  
*Amalgam capsules studied for leakage of mercury during mechanical trituration*

No.	Brand name	Manufacturer
A	Plastic Capsule	Crescent Dental Mfg. Co., U.S.A.
B	Steel Capsule	Do.
C	Green Capsule 461-91Y	S.S. White Dental Mfg. Co., U.K.
D	Nylon Capsule 461-46Y	Do.
E	Amalgam Capsule	Flossy Dental Corporation, U.S.A.
F	Amalgam Kapsel	W. & H. Dentalwerk, Austria.
G	Amalcap	Ivoclar, Liechtenstein.
H	Silicap, cleaned	Do.

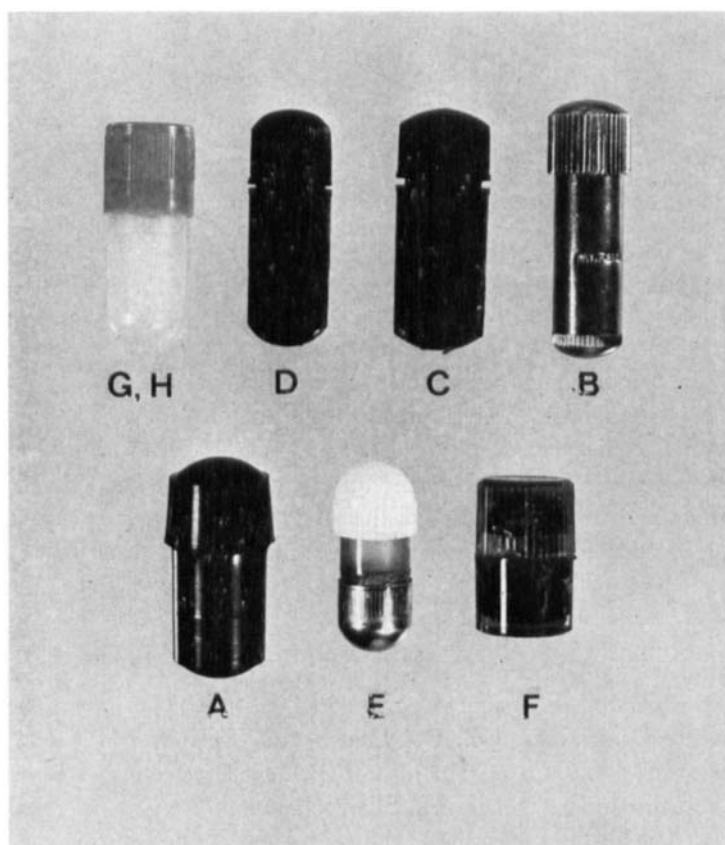


Fig. 1. The types of amalgam capsules used in the study. The letters A to H refer to the brand names in Table I. Approximately actual size.

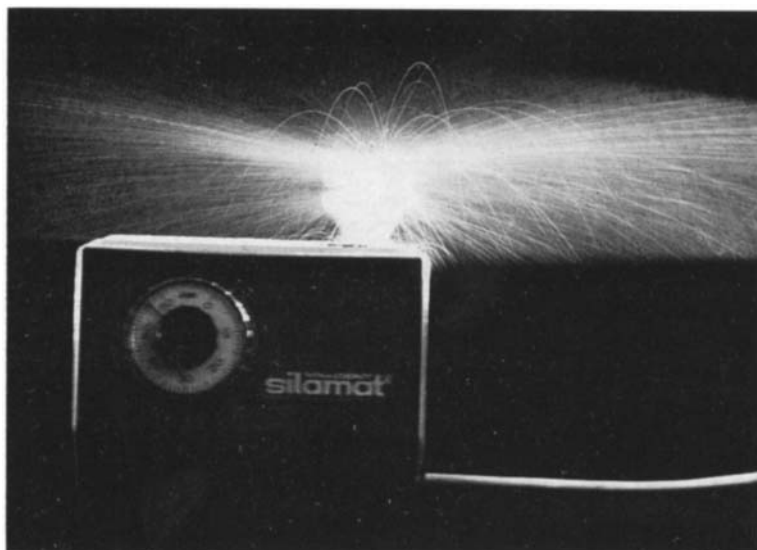


Fig. 2. Aerosol of mercury droplets in the case of an extreme loss of mercury from capsule B. The aerosol was illuminated by the light from a slide projector on the right of the amalgamator for five seconds for the photograph, immediately after the amalgamator was started. The ray of light from the projector can be seen in the aerosol. To make the aerosol visible for the purpose of the photograph, only mercury (1400 mg) was placed in the capsule; all the mercury escaped from the capsule while the photograph was being taken.

were without exception used without a pestle, and are named in Table I and illustrated in Fig. 1. New capsules were used for all tests; the Silicap capsules were first emptied, cleaned and wiped. Capsules E and F were held in the mixer by a special holder designed specifically for this purpose.

Normally a 5:7 weight ratio between alloy and mercury was employed for the mixes, viz. 1000 mg alloy and 1400 mg mercury; in one series however the mix ratio was fixed at 1000 mg alloy to 1000 mg mercury. Trituration time for every series was the same: 20 seconds.

Capsules A and C were used for the particular purpose of investigating the importance of a residue of set amalgam in the capsule from a previous mix. Two small spots of amalgam with a thickness of 0.1–0.2 mm were located on the tapered lower part of capsule A; a similar thickness of amalgam was located in the form of a broken ring inside the lid of capsule C on the shelf corresponding to the free lip of the lower part. The amalgam thus located on both capsules was permitted to set before the capsules were used for trituration of amalgam.

The mercury loss was determined by weighing the capsule, alloy and mercury both before and after trituration; post-trituration weighing was done

without opening the capsules. Weighing accuracy was better than 0.1 mg. The variation in each group suffering from mercury loss was very considerable; a detailed analysis was therefore abandoned, and the results in the tables are shown as mean, maximum and minimum values.

During experiments it was ascertained that mercury lost in the course of mechanical trituration was liberated from the capsules in the form of tiny droplets (Fig. 2). In a series conducted with capsule H these droplets were collected by winding adhesive plaster round the capsules, the liberated mercury droplets being caught on the sticky surface. After the plaster had been removed and the capsules containing triturated amalgam had been weighed, it was thus possible to obtain a visual impression of the quantity of mercury lost.

## RESULTS

The main results of the study are seen in Table II.

Table II  
*Mercury loss from capsules during mechanical amalgamation*  
*Mix ratio alloy/mercury = 1000/1400 mg.*

Capsule	No. of capsules	No. of triturations per capsule	Mercury loss in mg		
			Mean	Max.	Min.
A	10	1	0.3	0.9	0.0
B	10	1	40.2	140.6	0.3
C	10	1	0.2	1.5	0.0
D	2	5	5.7	36.4	0.0
E	10	1	151.4	673.1	0.3
F	10	1	0.1	0.4	0.0
G	50	1	0.07	0.3	0.0
H	10	1	15.0	35.3	0.5

To study the significance, if any, of the mix ratio for mercury loss, measurements were made with capsule H and a mix ratio of alloy/mercury of 1000/1000 mg and 1000/1400 mg respectively. The results are seen in Table III.

Table III  
*Significance of mix ratio for mercury loss (capsule H)*

Mix ratio Alloy/Hg mg	No. of capsules	No. of triturations per capsule	Mercury loss in mg		
			Mean	Max.	Min.
1000/1000	10	1	1.1	6.4	0.0
1000/1400	10	1	15.0	35.3	0.5

The constancy of individual capsules with regard to leakage was tested by repeating trituration 10 times for each of the two H capsules in Table II which during the first experiment had recorded the maximum and minimum mercury loss respectively. The results are seen in Table IV.

Table IV  
*Constancy of individual capsules with regard to mercury loss (capsule H)*  
*Mix ratio alloy/mercury = 1000/1400 mg*

Mercury loss in first test (mg)	Mercury loss during subsequent 10 tests (mg)		
	Mean	Max.	Min.
0.5	33.3	65.7	4.6
35.3	76.3	208.3	16.8

The mercury loss from capsules which could not be completely closed because of contamination by set amalgam is indicated in table V.

Table V  
*Mercury loss from capsules contaminated by set amalgam*  
*Mix ratio alloy/mercury = 1000/1400 mg*

Capsule	No. of capsules	No. of triturations per capsule	Mercury loss in mg		
			Mean	Max.	Min.
A	10	1	56.4	201.1	0.0
C	10	1	0.6	1.6	0.0

Fig 3. shows two pieces of adhesive plaster which were used on capsule H to detect a mercury loss of 9 mg and 20 mg respectively. The smallest weight loss detected during tests with adhesive plaster was 0.9 mg; even in this case the small number of mercury droplets were clearly visible.

DISCUSSION

Measurements carried out in connection with the tests (Table II) show that, during mechanical trituration of the amalgam, capsules can be subject to considerable leakage of mercury. Of the brands of capsules studied, some were relatively tight (A, C, F and G) while others leaked considerable quantities of mercury (B, E and H). With regard to H capsules it should be noted that



Fig. 3. Droplets of mercury on adhesive plaster which was wound around leaking capsules during mechanical trituration. The top plaster represents a mercury loss of 9 mg, the lower plaster a loss of 20 mg. Approx. twice actual size.

these are not actually intended for trituration of amalgam; the reason for including them in our study however was that we were informed that they are nevertheless used for this purpose to a great extent in clinical practice. The studies moreover demonstrated (Table V) that capsules which are normally relatively tight can be subject to considerable leakage if there are traces of amalgam residue on the surfaces of the two matching halves of the capsule. A low mix ratio of alloy to mercury, i.e. a relatively high proportion of mercury, would seem to a great extent to increase the spillage of mercury from leaking capsules (Table III).

It is not known to what extent the capsules studied are representative of the various makes; there is therefore a risk that capsules of a given type which, although relatively leakproof during the present study, are not tight in every case and in all circumstances. As manufacturers give no guarantee of the tightness of amalgam capsules, the user himself must check this quality. The check can be made in the following manner: A liberal quantity of alloy and mercury (mix ratio approx. 5:7) is placed in the capsule, which is then wound in adhesive plaster. After mechanical amalgamation, the adhesive plaster is removed and inspected carefully for drops of mercury; in order that the capsule may be described as relatively tight, there should be no or

only one or two tiny droplets of mercury on the sticky surface of the plaster. It would be advisable to conduct this check both when a new capsule is brought into use and later at suitable intervals. Drops of mercury with a diameter of as little as approx. 0.1 mm can be seen with the naked eye in good lighting; such drops weigh approx. 0.01 mg. The check described above is therefore very sensitive.

Nothing can at present be said with certainty about the toxicological effect of the spilled mercury. It is a fact however that the spilled mercury is released as numerous, tiny droplets and thus has a relatively considerable evaporation area. It is not therefore inconceivable that the mercury aerosol created repeatedly around a leaking capsule can over a certain period represent a fairly great danger of poisoning — particularly for the personnel who carry out the mechanical trituration.

Mechanical trituration of dental mercury presents a possible source of mercury spillage from leaking amalgam capsules. The mercury can be liberated in considerable quantities with each trituration, and takes the form of an aerosol of numerous, tiny droplets of mercury with a very large total area of evaporation. Mercury spillage means a potential and not inconsiderable danger of poisoning, particularly for personnel who are required over a certain period to carry out repeatedly mechanical amalgamation with leaking capsules.

Notwithstanding that it is possible for the user to make his own check of the tightness of amalgam capsules, it would certainly be advisable to draw up an international standard specification for amalgam capsules, stipulating among other things certain norms for tightness. It would then be possible for manufacturers to refer the quality of their capsules to this standard.

#### SUMMARY

Studies have been conducted of mercury spillage occurring during mechanical trituration of dental amalgams; several types of amalgam capsules showed a very significant leakage, and none was completely tight (Table II). Mixes with a relatively high proportion of mercury to alloy seem to produce more mercury spillage than relatively dry mixes (Table III); the mercury leakage can also increase significantly if otherwise relatively tight capsules cannot be closed properly because of a residue of set amalgam from an earlier mix (Table V).

The liberated mercury creates an aerosol of numerous, tiny mercury droplets around the leaking capsule, producing a potential risk of mercury poisoning of personnel using the mechanical amalgamator.

The user can make his own check of the leakage of amalgam capsules by winding adhesive plaster around each one before starting trituration. A careful inspection of the sticky surface of the plaster after the mix is completed can reveal mercury droplets down to a weight of about 0.01 mg.

It would seem appropriate to draw up an international standard specification for amalgam capsules, to include specific requirements concerning the tightness of capsules against mercury spillage.

#### RÉSUMÉ

#### CAPSULES NON HERMÉTIQUES LORS DE LA TRITURATION MÉCANIQUE DE L'AMALGAME

Cet article rend compte d'études effectuées sur les projections de mercure qui se produisent lors de la trituration mécanique de l'amalgame; plusieurs types de capsules présentaient un défaut très marqué d'herméticité et aucune n'était entièrement hermétique (tableau II). Les mélanges riches en mercure semblaient donner lieu à des projections de mercure plus importantes que les mélanges pauvres en mercure (tableau III); des projections de mercure importantes peuvent également se produire lorsque la présence de restes de vieil amalgame empêche la fermeture complète de capsules relativement hermétiques (tableau V).

Le mercure ainsi libéré constitue à l'entourage de la capsule défectueuse un aérosol composé de nombreuses gouttelettes minuscules de mercure, ce qui représente un risque potentiel d'intoxication au mercure, essentiellement pour le personnel qui effectue la trituration.

Il est possible pour l'utilisateur de contrôler lui-même l'herméticité des capsules en enroulant un bandage adhésif autour des capsules avant la trituration mécanique; après trituration, l'inspection des surfaces adhésives du bandage permet de mettre en évidence des quantités de mercure aussi minimes que 0,01 mg.

Il serait souhaitable que soit élaborée une spécification internationale des normes concernant les capsules pour trituration mécanique de l'amalgame, avec entre autre les exigences concernant l'herméticité des capsules à l'égard du mercure.

#### ZUSAMMENFASSUNG

#### UNDICHTE AMALGAMKAPSELN

Es wurden Untersuchungen vorgenommen über den Quecksilberverlust bei der mechanischen Mischung von Amalgam; mehrere Kapseltypen zeigten

eine beträchtliche Undichtigkeit, und keine Kapsel war vollkommen dicht (Tabelle II). Quecksilberreiche Mischungen scheinen einen höheren Quecksilberverlust zu ergeben als quecksilberarme Mischungen (Tabelle III); der Quecksilberverlust kann ebenfalls bedeutend werden, wenn sich im übrigen relativ dichte Kapseln wegen zurückgebliebener Reste abgebundenen Amalgams nicht ganz schliessen lassen (Tabelle V).

Das freigegebene Quecksilber erzeugt um die undichte Kapsel ein Aerosol zahlreicher feinsten Quecksilbertröpfchen, wodurch die potentielle Gefahr eine Quecksilbervergiftung vor allem des Personals, das die Mischung vornimmt, entsteht.

Es ist dem Verbraucher möglich, die Dichtigkeit der Kapseln selbst zu prüfen, indem er sie mit Heftpflaster umwickelt, bevor die Mischung vorgenommen wird; eine anschliessende Inspektion der Haftflächen des Pflasters ermöglicht den Nachweis von Quecksilbermengen bis auf ca. 0,01 mg herab.

Es wäre zweckmässigerweise die Ausarbeitung einer internationalen Standardspezifikation für Amalgamkapseln mit Anforderungen u.a. an die Dichtigkeit der Kapseln gegenüber Quecksilber vorzunehmen.

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