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THE EFFECT OF ULTRASONIC CONDENSATION ON DENTAL SILVER AMALGAM

A PRELIMINARY REPORT

by

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The use of ultrasonics in dentistry has been discussed in the literature over the past ten years. Biological considerations in particular have been taken into account. Little attention, however, has been paid to the condensation of dental amalgams.

Already in 1950, however, *Karlström* reported certain successful pilot studies on amalgam condensation with a magnetostrictive supersonic transmitter designed for echo-sounding. The frequency was about 23,000 c/sec. and the effect about 300 watt. In an experiment with equipment devised for oral procedures in the form of a thick pencil with a nickel rod as vibrating element, the results obtained, however, were too insignificant to be of practical value. *Karlström* does not seem to have continued these experiments.

In 1958 *Skinner & Mizera* reported a detailed investigation on the effect of ultrasonics on the physical properties of amalgam. They made recommendations of the use of a technique evolved for the Cavitron equipment (model C 200). With regard to physical properties they found in general that dimensional changes obtained with ultrasonic condensation corresponded with those obtained with manual condensation, that flow values could be lower with ultrasonic condensation, and that the one hour compressive strength was definitely improved with ultrasonic con-

densation, whereas the seven-day improvement was questionable. The effect of the output energy or amplitude was not particularly significant. Output settings of 70—80, however, seemed to be most favourable. Condenser points with a surface area of less than about two square millimetres produced inferior properties. With greater surface areas no significant differences were recorded between linear and contra-angled vibration. The condensation pressure recommended was very low as compared with that of hand packing. When the most favourable condenser point and output setting were combined, however, even the values of dimensional changes were decreased.

Tascher (1958) presented the technique and instrumentation necessary for carrying out ultrasonic amalgam condensation with a set of magnetostrictive transducer stacks in combination with a portable, 30 watt ultrasonic generator of a frequency of 25,000 c/sec. He suggested that the possible application of this technique in the repairing and correcting of amalgam filling defects deserves further investigation.

Modern considerations of the physical properties of dental amalgams deal with their clinical significance. A great number of articles have been published in this field. Factors influencing micro-leakage and marginal failures are thoroughly discussed. The unquestionable value of decreased mercury content as well as the role of dimensional changes have received special attention. The aim of this paper, therefore, is to report some preliminary results both on the effect on dimensional changes of dental silver amalgams with ultrasonic condensation and on the clinical significance of the findings. Furthermore, the possibility of using an amalgam with a mercury content lower than that required for hand packing is studied.

MATERIALS AND METHOD

Ultrasonic equipment

The apparatus used, though still in an experimental stage, was kindly placed at our disposal by the firm of Dentron, Lyngby, Denmark. It worked with a maximal frequency of 30,000 c/sec. and with an amplitude which gave a mechanical effect of 4—6

watt. The flat pressure point, with a surface area of about 10 mm^2, had a slightly bent shaft which was in a rigid connection with the handpiece.

Amalgam procedures and experimental planning

1. *Dimensional changes*

Two different silver alloys were used, one of them a pre-amalgamated, fine grain alloy (I) with an alloy/mercury ratio of 5: 5, the other a coarse-filed alloy (II) with a ratio of 5: 7. All specimens were prepared according to a standardised technique (*Granath*, 1964, see page 186 in this issue). For ultrasonic experiments, specimens mechanically condensed according to this technique were cut in four equal slices, each slice being divided into four parts. The amalgam pieces were then once again condensed by ultrasonic vibration into the cylindrical steel moulds, time and suitable pressure being subjected to the operator's personal variation.

The measuring of dimensional changes was performed at $37^\circ C \pm 1^\circ$ with a Microcator Type 531-1, C. E. Johansson, Eskilstuna, Sweden. The registration of measurements of both specimens condensed mechanically and those condensed by ultrasonic vibration started five and ten minutes respectively after trituration had begun.

2. *Experiments on micro-leakage*

Experiments designed to reproduce clinical conditions, these including the effect of corrosion and temperature variations, were performed by means of the radioactive isotope Na^{22} in sodium chloride solution. The technique employed is a slight modification of the method of *Söremark & Bergman* (1961). This involves the quantitative determination of micro-leakage in order to compare the different models under testing. The moulds consisted of epoxy-resin. The detailed description of these is not given at present, since this test is merely introductory as compared with the previous one. Alloy I and II were utilised. Two specimens of each were packed by hand with a final conden-

sation with a mechanical vibrator (type Bergendahl, Dentatus, Sweden) while two of each were packed by ultrasonic vibration. Concerning the techniques employed, se below.

3. Condensation of amalgam with decreased mercury content

These experiments were performed in order to estimate the residual mercury content after employment of differing clinical methods. The following test series were drawn up:

Series C I[1] and C II, corresponding to alloys I and II and accepted clinical treatment. A well-trained nurse triturated alloy and mercury according to the directions of the manufacturer, until complete macroscopic amalgamation had occurred. After slight mulling in rubber dam to give the mass uniform consistency, mercury was immediately squeezed out by means of a linen cloth to such an extent that the remaining quantity was just sufficient to allow the operator to perform satisfactory packing of the amalgam with moderate pressure. The specimens were finally condensed with a Bergendahl vibrator, the surplus amalgam immediately being removed, thus giving the specimen a dull appearance.

Series C I u[1] and C II u are corresponding to alloys I and II. The technique was the same except that the maximal amount of mercury was squeezed out by means of the linen cloth and a pair of tongs. The specimens were then packed by ultrasonic condensation with the surplus amalgam being removed as above.

Series N I[1], M I, N II, and M II, corresponding to normal and maximal squeezing with alloys I and II, were drawn up to check the accuracy of the assistant nurse up to the stage when the operators handed the amalgam.

The mercury analyses were performed according to a method of *Bladh & Månsson*[2] which employs complexometric titration.

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[1] C = clinical u = ultrasonic N = normal M = maximal.

[2] This method has been worked out at the Department of Analytical Chemistry (Head: Dr. *K. J. Karrman*), University of Lund, and will be published in the near future in a journal of analytical chemistry.

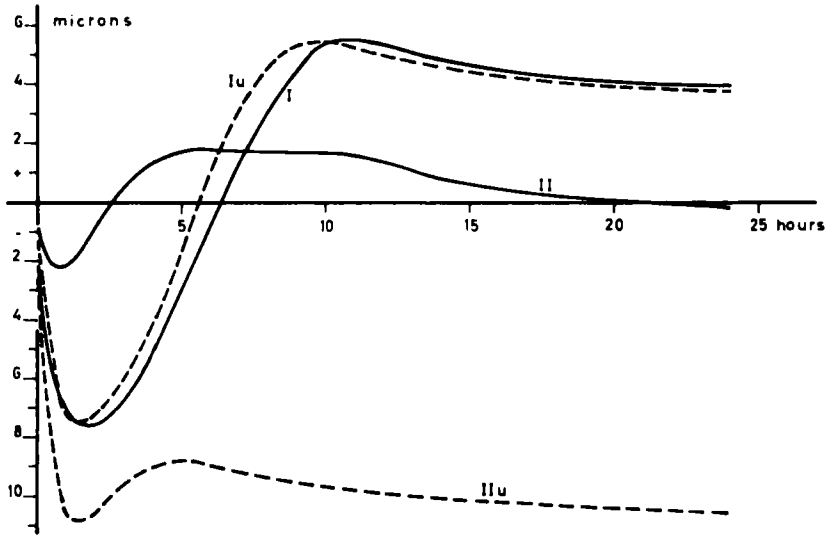

Fig. 1.

Dimensional changes of amalgam I and II as described in the text. Zero time according to the A. D. A.-specification.

RESULTS AND COMMENTS

1. *Dimensional changes*

The results of the measurements of dimensional changes are seen in Fig. 1. Amalgam I was practically uninfluenced by the ultrasonic treatment, while the values for amalgam II were remarkably decreased. Additional tests have shown that if the optimal time for trituration in a mechanical amalgamator is doubled, corresponding results are obtained. The mercury content for I and I u was about 41.5 %, and for II and II u about 49 %.

2. *Experiments on micro-leakage*

The specimens packed by hand showed insignificant leakage with both amalgams. After ultrasonic treatment leakage could be registered in only one specimen with amalgam II. After temperature variations, however, demonstrable leakage occurred around all specimens. It is difficult to correlate these results with those given above. In any case, the negative effect of ultra-

sonic treatment on amalgam II concerning dimensional changes could not be verified in experiments designed to reproduce clinical conditions. Accordingly, a final evaluation has to be deferred.

3. *Condensation of amalgam with decreased mercury content*

The results of the mercury analyses are given in Table 1.

Table 1.
Mean values of mercury analyses in per cent.

Series	C I	C I u	C II	C II u	N I	M I	N II	M II
Mean values	40.5	38.8	45.9	44.5	43.6	42.8	48.5	48.7

From Table 1 can be seen that it is possible to lessen the mercury content of amalgam in a clinically acceptable way (by means of ultrasonic condensation). This was performed without difficulty.

At this stage it can thus be concluded that it is possible to decrease the mercury content in dental silver amalgams by means of ultrasonic vibration.

RÉSUMÉ

EFFET SUR L'AMALGAME D'ARGENT DE LA CONDENSATION ULTRA-SONIQUE

Les auteurs rendent compte des résultats d'expériences préliminaires sur l'emploi des ultra-sons pour la condensation de l'amalgame. Avec une fréquence de 30.000 périodes par secondes et une puissance de 4 à 6 watt, une diminution nette de la teneur en mercure a été obtenue dans la condensation ultra-sonique par rapport à la condensation manuelle. Un certain type d'alliage a semblé ne pas convenir à la condensation ultra-sonique, une contraction marquée pouvant être observée lors des mesures des variations de volume. Dans des expériences sur les défauts microscopiques d'herméticité, faites dans le but de reproduire les conditions cliniques, cet effet négatif n'a pu être vérifié. Les séries d'expériences se poursuivent.

ZUSAMMENFASSUNG

DER EFFEKT DER ULTRASCHALLKONDENSIERUNG AUF DENTALES SILBERAMALGAM

Die Verfasser geben einen Rapport über vorläufige Versuche mit Ultraschall für die Kondensierung von Amalgam. Bei einer Frequenz von 30.000 c/Sek. und einem Effekt von 4—6 Watt wurde eine klare Senkung des Quecksilbergehaltes verglichen mit Handkondensierung erhalten. Ein gewisser Typ von Alloy (Mutterliegierung) schien für die Ultraschallkondensierung nicht geeignet zu sein, da eine markante Kontraktion bei Volumenveränderungsmessungen wahrgenommen werden konnte. In Versuchen über die Mikrolekage, um die klinischen Verhältnisse zu reproduzieren, konnte dieser negative Effekt nicht bestätigt werden. Die Versuchsserien werden fortgesetzt.

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