Effect of trituration on dimensional changes of dental amalgam

S. ESPEVIK

NIOM – Scandinavian Institute of Dental Materials, Oslo, Norway

Espevik, S. Effect of trituration on dimensional changes of dental amalgam. *Acta Odont. Scand.* 35, 251–255.

The dimensional changes of dental amalgams during setting was evaluated using different methods of specimen production, and measurement procedures. Amalgam specimens were prepared from 10 commercially available dental amalgam alloys by mechanical condensation. Dimensional change was measured on microcators with a measuring load of 1 g. The variation in dimensional change with trituration was substantial, and similar to the difference between various brands of alloys at the same trituration time.

Porosity seems to vary between 0.1 and 0.6 % independent of severity of trituration except for two alloys in which increased trituration time seemed to reduce porosity. It was therefore pointed out that even though trituration in most cases can be altered to make an amalgam expand, such procedures should not be followed since optimal values of other clinically significant properties may not be maintained.

Key-words: Dental materials; standardization; physical properties

S. Espevik, NIOM – Scandinavian Institute of Dental Materials, Forskningsveien 1, Oslo 3, Norway

The contraction or expansion during setting are important physical parameters of dental amalgam. Unduly high expansion may result in protrusion of the restoration or even fracture of the tooth. Contraction can lead to microleakage, and if it is large (60 μm/cm or more) the development of decay under restorations has been observed (*Rupp,* 1975).

The consensus has been that a slight expansion during hardening would be most desirable (*Phillips,* 1973) although clinical studies did not substantiate this view (*McDonald & Phillips,* 1950; *Rupp,* 1975). Studies, in vitro, have demonstrated that the plasticity of the amalgam mix is more important for the microleakage than a slight contraction (*Granath,* 1971). Defects in the order of 10–50 μm at the tooth/amalgam margin have been observed when an amalgam with a contraction of 20 μm/cm was used. These defects were caused by fractures of both the amalgam and enamel margins during polishing (*Øilo,* 1976).

The International Organization for Standardization Recommendation 1559 (ISO R 1559) has 0–20 μm/cm as the acceptable limit for expansion and thus no contraction is allowed. In the American Dental Association

Received for publication, February 25, 1977

Specification No. 1, Alloy for Dental Amalgam, the acceptable limits for dimensional change are ± 20 μm/cm. The method of determination of dimensional change are different for these two specifications and the limits may not be directly comparable.

The purpose of this investigation was to evaluate the dimensional change of dental amalgam during setting as a function of method and time of trituration. An evaluation of the porosity in the specimens was also carried out.

MATERIALS AND METHOD

Ten commercially available dental amalgam alloys were selected for the investigation. Table I gives the codes and alloy types employed. Mercury and 0.6 g alloy were either handtriturated or triturated 3, 5, 8 s in a Silamat® in plastic capsules manufacturered by Kerr®. The condensation was done mechanically according to American Dental Association Specification No. 1. Mercury droplets were observed on the walls of the condensation mold, and were collected on the specimen ends during ejection. Therefore caps (Fig. 1) were introduced during condensation, and two specimens without caps and two specimens with caps were made for each test condition.

The dimensional change was measured with microcators. The measuring pressure was adjusted to 1.0 g. The specimens were placed in the microcator at 37 °C ± 0.5 °C 4 min after end of trituration, and the measuring load was applied immediately. Both 5 and 15 min initial readings were used in the calculation of dimensional change.

Backscattered electron images were obtained on samples polished using standard metallographic methods. Nine images selected at random, for each specimen, were used to determine porosity quantitatively in 6 of the alloys. The total area analyzed was 0.35 mm² in size. A point counting method was used and the total number of points counted per specimen was 5150.

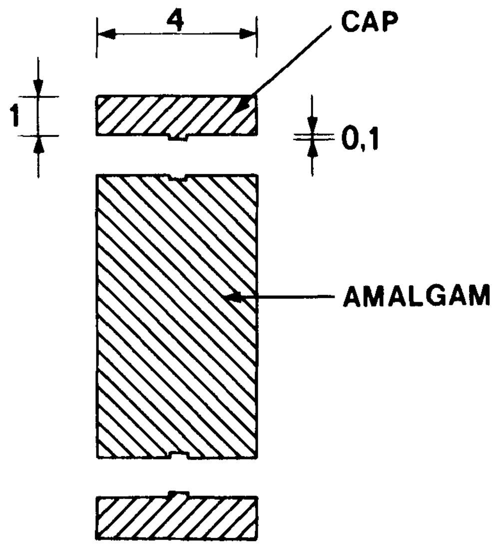

Fig. 1. Amalgam and steel caps incorporated during condensation (dimensions in mm).

Table I. *Alloy types used in the investigation*

Code	Type	Particle Shape
1	Preamalgamated	Lathecut
2	Preamalgameted	Lathecut
3	Non-preamalgamated	Lathecut
4	Preamalgamated	Lathecut
5	Non-preamalgamated	Lathecut+spherical
6	Preamalgamated	Lathecut
7	Preamalgamated	Lathecut
8	Non-preamalgamated	Spherical
9	Non-preamalgamated	Spherical
10	Non-preamalgamated	Spherical

RESULTS

The dimensional change as a function of trituration is shown in Fig. 2. All amalgams (except no. 8) expanded when triturated by hand, and increasing trituration time in the Silamat reduced expansion or increased contraction.

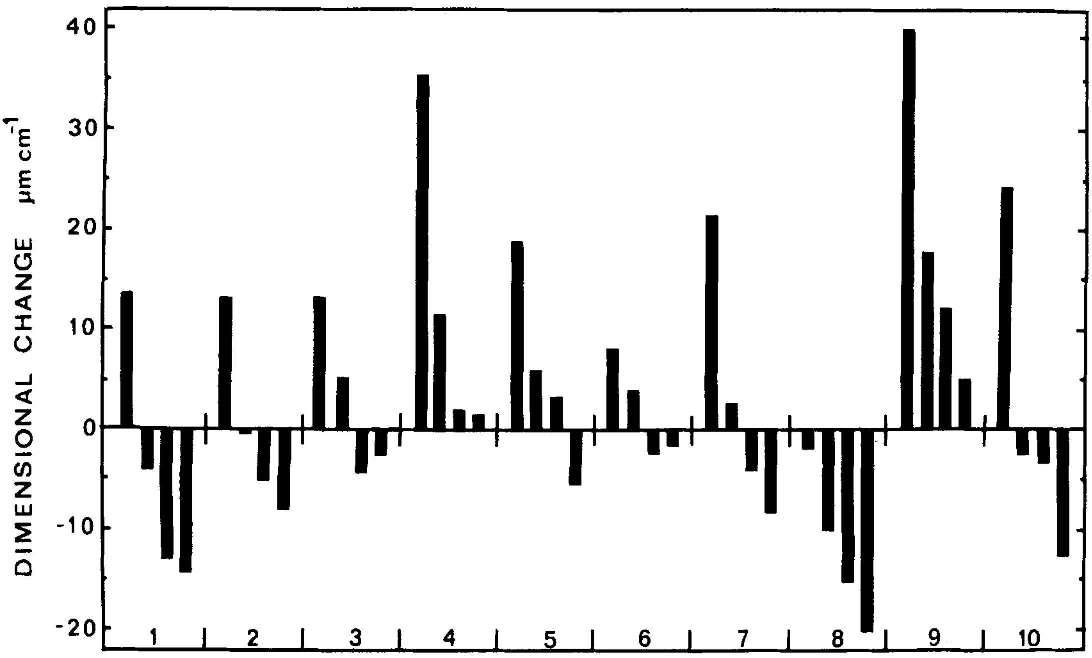

Fig. 2. Dimensional change as a function of trituration time and method. The number underneath the bars are code no. The four bars for each alloy represent handtrituration, 3 s, 5 s, and 8 s Silamat trituration respectively.

Table II. *Mean and standard deviation of differences in dimensional change for 10 alloys in µm/cm, where the 15 min – 24 h results are subtracted from the 5 min – 24 h for each test condition. These data are obtained with caps on the specimens*

Handtrituration	3 s Silamat	5 s Silamat	8 s Silamat
2.52 ± 4.42	−0.99 ± 0.80	−2.28 ± 1.86	−2.43 ± 1.16

The method of paired data analyses was used when the differences between the means with and without caps were tested (*Dunn*, 1964). The differences were obtained by subtracting the results on specimen without caps from the results on specimen with caps for the same test condition. The mean and standard deviation of 40 differences were 4.08 ± 4.32, which was significantly larger than zero (99.5 % confidence level). This shows that *larger* contraction was observed when caps were *not* used.

Paired data analysis was also used to evaluate the effect of changing the initial point of measurement from 5 to 15 min after the end of trituration. The data is shown in Table II as the 15 min–24 h result was subtracted from the 5 min–24 h result and expressed as a mean for the 10 alloys for each trituration time. The 5 min–24 h dimensinal change shows a somewhat larger contraction at the longer trituration times.

The porosity seemed to vary between 0.1 and 0.6 % independent of trituration time except for alloys 4 and 5 (Table III). These two amalgams had a higher porosity than the other amalgams, and the porosity decreased as the trituration time increased (Fig. 3).

DISCUSSION

The data indicate that the method and time of trituration may be altered to obtain different values for dimensional change, It is also indicated that increases in the trituration time of only a few seconds in a high speed amalgamator (Silamat®) results in substantial contraction for certain amalgams.

Trituration should not be chosen on the basis of dimensional change values only; it must give optimum values for other clinically significant properties such as creep and porosity. It has been found that a trituration degree which gives minimum creep of the amalgam exist (*Osborne et al.*, 1974). This trituration degree is usually similar to the manufacturers' instructions for trituration. When handtrituration is used, more porosities are observed for some alloys, indicating that optimum properties may not be achieved by this method of mixing. It has previously been found that increased amount of porosities reduces strength (*Jørgensen, Esbensen & Borring-Møller,* 1966) and increases creep (*Jørgensen,* 1976). The trituration time should therefore not be reduced to less than that recommended by the manufacturer to make the amalgam expand during setting.

The variation in dimensional change as a function of the trituration time appears to reflect how easily this property can be altered. An attempt was made to correlate this variation to particle shape of the powder, but no correlation was found.

The increased contraction observed when caps were not used can be explained by the extra mercury droplets on the surface which make the specimen a few micrometers longer to start with. As this mercury film disappears during setting, less expansion or larger contraction is recorded.

In ISO R 1559 it is specified that the initial measurement must be made 15 min after start of mixing. In the American Dental Association Specification No. 1 the initial measurement is made 5 min after end of trituration. Significant differences between these two methods could only be observed at the longer trituration times and the actual magnitude was 2–3 μm/cm more contraction for the 5 min to 24 h measurements. These differences can be attributed to contraction at the beginning of the setting reaction.

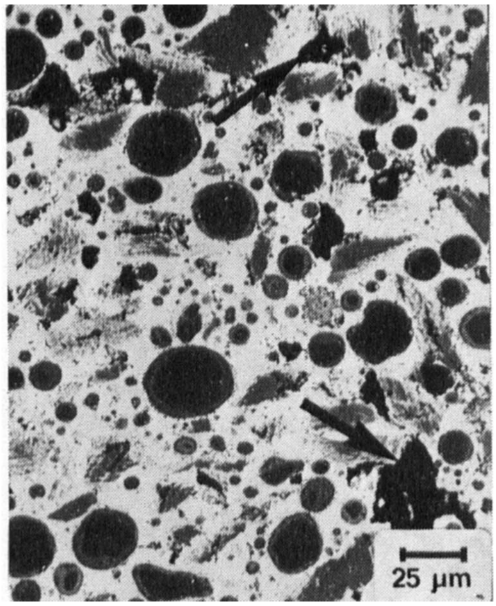

Fig. 3. Backscattered electron images showing amount of porosities (arrows) from handtrituration for alloy 5.

Table III. *Porosity in six dental amalgams (%)*

	Trituration		
Alloy	Hand	3 s Silamat	8 s Silamat
1	0.5	0.5	0.6
3	0.2	0.2	0.6
4	1.4	1.1	1.2
5	2.0	2.0	1.2
8	0.6	0.1	0.3
9	0.5	0.6	0.2

REFERENCES

Dunn, O. J. 1964. Basic statistics: A primer for the biomedical sciences. John Wiley & Sons Inc., New York, p 90

Granath, L.-E. 1971. Studies on microleakage with restorative materials. Acta Odontol. Scand. 29, 65–73

Jørgensen, K. D. 1976. Dentale Amalgamer. Odontologisk Forlag, København p 69

Jørgensen, K. D., Esbensen, A. L. & Borring-Möller, G. 1966. Indflydelsen af porøsitet og kvikksølvindhold på sølvamalgams styrke. Tandlægebladet 70, 274–288

McDonald, R. E. & Phillips, R. W. 1950. Clinical observations on a contracting amalgam alloy. J. Dent. Res. 29, 482–485

Osborne, J. W., Phillips, R. W., Swartz, M. L. & Norman, R. D. 1974. Annual Meet. Int. Assoc. Dent Res., Abstr. No. 30, p 62

Phillips, R. W. 1973. Skinner's Science of Dental Materials. W. B. Saunders Philadelphia, Seventh Ed. p 316

Rupp, N. V. 1975. Research on clinical amalgam restorations (Abstract). Proceedings of the international symposium on amalgam and tooth-coloured restorative materials. Nijmegen pp 77–78

Øilo, G. 1976. Adaptation of amalgams to cavity walls. J. Oral Rehabil. 3, 227–236