From: The Department of Technology, the Royal Dental College, Copenhagen, Denmark.

EXPERIMENTS ON THE RELATIONSHIP BETWEEN THE STRENGTH AND THE ANGLE OF AMALGAM MARGINS

by

KNUD DREYER JØRGENSEN

OLE P. PALBØL

It is obvious that the strength of an angular margin decreases with the size of the angle, a fact which for several decades has been taken into account in the preparation of amalgam fillings. At the same time, no experiments or calculations seem to have been made to analyze the closer relationship between these two factors, although the term edge strength is much used in dental amalgam literature.

The purpose of this work is to present a relatively simple method that gives a reproducible, numerical expression of the marginal strength. Special attention is given to the size of the marginal angle as a variable. In a previous study (Acta odont. scand. *23*: 347—389) of the process which leads to marginal fracture of amalgam fillings, the complex of factors involved in the destruction of the margin is dealt with on a theoretical and experimental basis.

METHODS

Cubic amalgam specimens with an edge length of 6 mm were prepared in a special steel mold (Figure 1), 15 mm high. The lower part of the mold could be closed with a 2 mm high piston attached to a circular foot. Two minutes after the mix was finished it was condensed in the mold with a piston, about 15 mm long, under a 60 kg pressure applied for 3 minutes. In the prin-

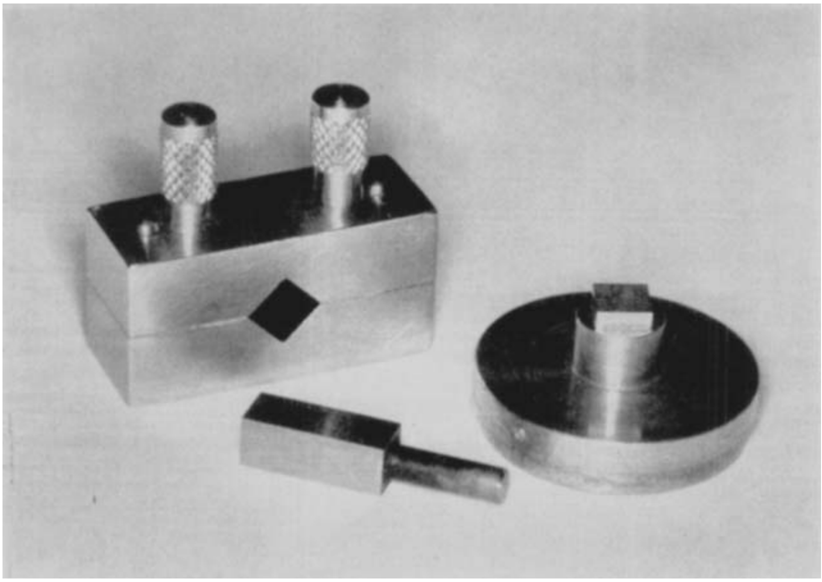

Fig. 1. Steel mold and pistons used in preparation of the cubic amalgam specimens.

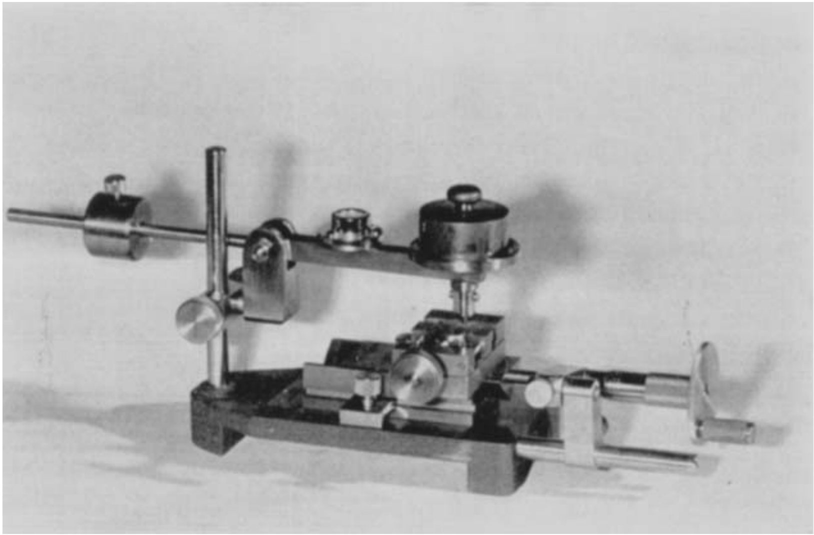

Fig. 2. Instrument used for testing the strength of the margin. The specimen, clamped on a precision V-block, is displaced by turning the micrometer screw on the right. The ball holder is seen just below the weight.

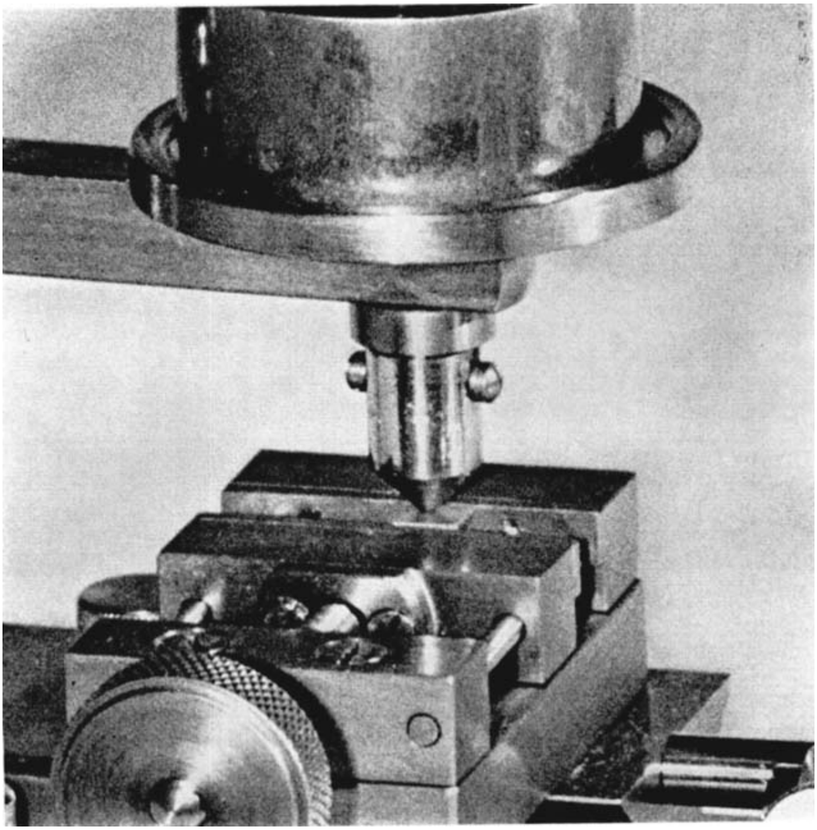

Fig. 3. Close-up of the instrument in Fig. 2. Note the specimen placed with the wedge angle pointing right.

cipal tests only one alloy brand was used (True Dentalloy®, S. S. White Dental Mfg. Co., Ltd., G.B.). In a minor series of tests a copper amalgam was used (Ash Globe®, Amalgamated Dental Co., Ltd.). The alloys were treated according to the manufacturers' directions.

Four days after preparation the amalgam cubes were filed to give wedge-shaped specimens with wedge angles of 15, 22, 45, 60, or 75°. The wedge angles occupied in all cases the same place in relation to the original cube faces, viz. parallel to and about 2 mm from one of the upper edges of the cube ("upper" referring to the position of the cube during condensation). Finally, the surfaces of the wedge specimen were gently polished on fine

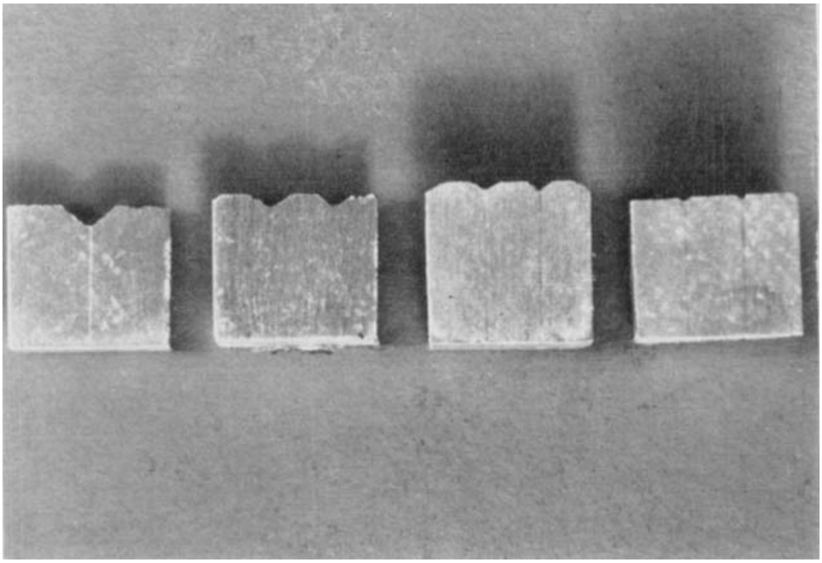

Fig. 4. Fractures in amalgam margins with angles of 15°, 22°, 30° and 60°, respectively.

silicon carbide paper using plenty of water. Special scratch hardness tests showed that this treatment produced no detectable change in the mechanical properties of the amalgam.

The strength of the margins of the four days old specimens was tested by means of the scratch apparatus shown in Figures 2 and 3. The specimen is mounted in the tester with one wedge surface placed horizontally. Resting on this surface is a steel ball one mm in diameter, which is subjected to a 500 g load. During

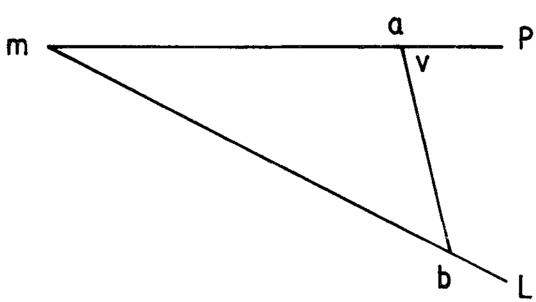

Fig. 5. Diagrammatic section of amalgam margin illustrating the technique used in measuring angle v.

the test the specimen is slowly displaced in the horizontal plane, so that the loaded ball gradually approaches the angular margin. The movement is stopped when the margin breaks. In all the experiments the fracture formed a notch in the margin (see Figure 4). The depth of this notch in the horizontal plane was measured in a microscope and taken to express the marginal strength. Ten measurements were carried out for each angle; for angles of 22° or more the same specimen could sometimes be used for two measurements, so that the number of specimens was smaller than the number of measurements.

The effect of alloy grain size upon the marginal strength was examined by separating two fractions from the alloy powder, viz., one below 50 μ, and one above 120 μ. With these fractions specimens with marginal angles of 30° were prepared and tested as described.

The experimental series with copper amalgam included only specimens with a 30° marginal angle.

When testing was completed the angle between the horizontal plane of the specimen and the surface of fracture was measured in the following way: In a measuring microscope the specimen was viewed from the underside perpendicular to its original horizontal plane (P, Figure 5). The distances am and bm projected on the horizontal plane were measured and used for reconstruction of figure amb in an enlarged drawing of the angle m. In this figure, angle v was measured by means of a protractor; a and b are the deepest points of the fracture in the surfaces P and L. The angle was measured for all fractures in silver amalgam specimens from nonseparated powder, except for specimens with a marginal angle of 75°, where the measuring error was found too great.

RESULTS

The results of the various measurements are presented in Table I and in Figures 6 and 7. The depth of the marginal fracture was 545 ± 80 μ for copper amalgam, while it was 332 ± 68 and 367 ± 56 for the fine and coarse fractions of silver amalgam, respectively. The fracture angle was also below 90° for all unmeasured specimens.

Table I

Depth of fracture and angle of fracture for silver amalgam specimens with different marginal angles

Marginal angle (degrees)	15	22	30	45	60	75
Depth of fracture (microns)	790	467	333	272	95	50
Standard deviation	54	83	64	74	18	17
Angle of fracture (degrees)	63	63	69	70	83	—
Standard deviation	8	10	8	4	3	—

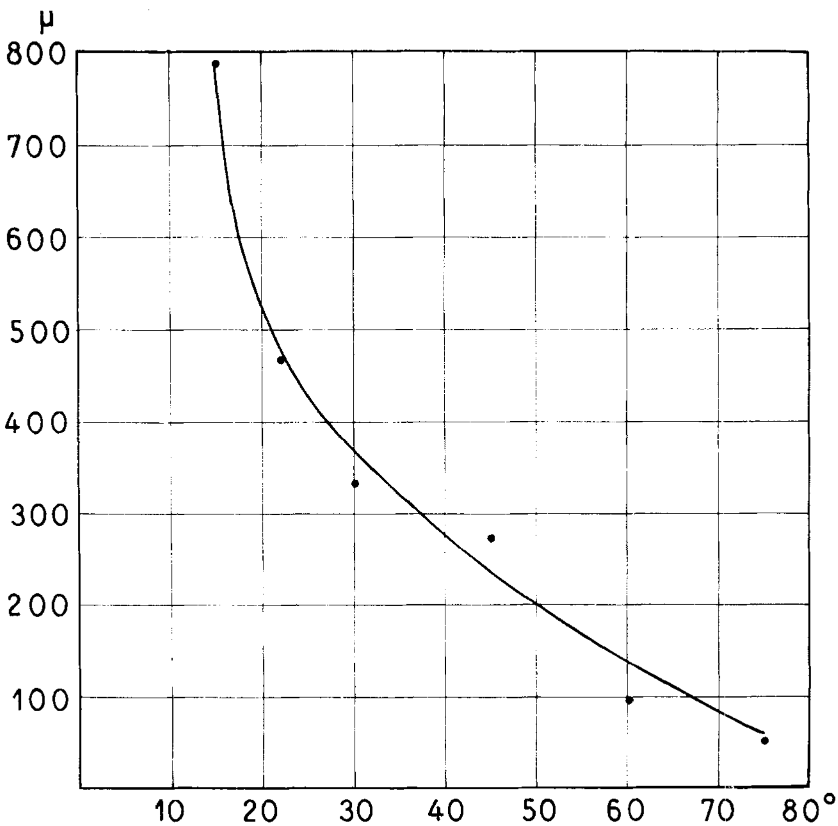

Fig. 6. Relation between marginal angle and depth of fracture.

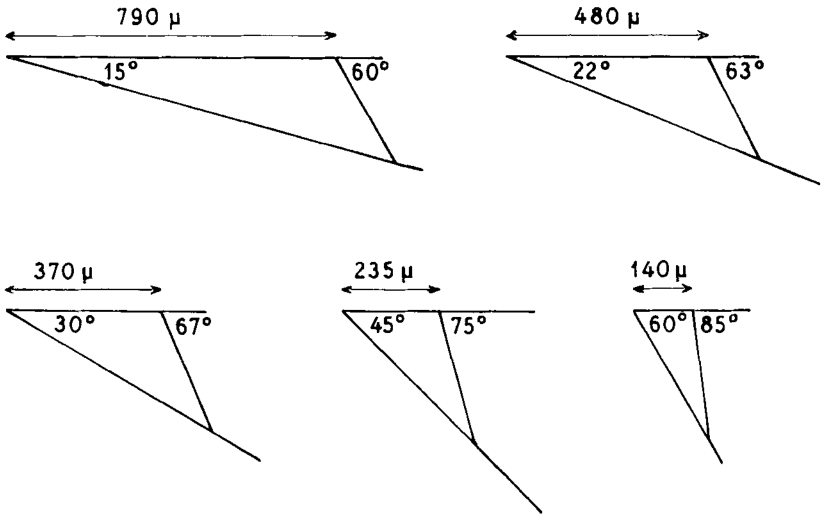

Fig. 7. Sections of the fractured area in amalgam margins with different angles. The depth of fracture and the angle of fracture for each wedge angle are geometric mean values.

DISCUSSION

The measurements demonstrate that, under conditions of the experiments, all dimensions of the fracture increase with a reduction of the marginal angle. Taken together, Figures 4 and 7 illustrate how much the amalgam fragment broken off by the fracture increases in volume as the marginal angle is reduced. Measurements of crushing strength carried out for another purpose showed that the silver amalgam had a crushing strength of approximately 3550 kg per cm², while the copper amalgam had a crushing strength of approximately 2300 kg per cm². These figures point to a certain degree of proportionality between crushing strength and marginal strength. The difference in marginal strength between specimens from the coarse-grained and the fine-grained fractions of silver alloy is not statistically significant.

SUMMARY

This is a description of an experimental method for measuring the strength of amalgam margins. It is shown that under the experimental conditions the depth of a fracture in an amalgam

margin increases strongly when the marginal angle is reduced. The fracture angle, i.e. the angle between the loaded surface and the fracture surface, is approximately proportional to the marginal angle and in all experiments below 90°.

RÉSUMÉ

EXPÉRIENCES SUR LE RAPPORT ENTRE L'ANGLE DES BORDS D'AMALGAME ET LEUR RÉSISTANCE

Le présent article décrit une méthode expérimentale destinée à mesurer la résistance des bords d'amalgame. Il a été mis en évidence que, dans les conditions expérimentales actuelles, la profondeur d'une fracture dans un bord d'amalgame augmente fortement lorsque l'angle marginal est diminué. L'angle de fracture, c'est-à-dire l'angle formé par la surface soumise à la charge et par la surface de fracture, est approximativement proportionnel à l'angle marginal et inférieur à 90° dans toutes les expériences.

ZUSAMMENFASSUNG

VERSUCHE ÜBER DIE FESTIGKEIT VON AMALGAMKANTEN IN ABHÄNGIGKEIT VOM KANTENWINKEL

Es wird eine experimentelle Methode zur Messung der Festigkeit von Amalgamkanten beschrieben, und es wird gezeigt, dass die Tiefe eines Bruches in einer Amalgamkante unter den gegebenen Versuchsverhältnissen stark zunimmt, wenn der Kantenwinkel abnimmt. Der Bruchwinkel, d.h. der Winkel zwischen der belasteten Fläche und der Bruchfläche, ist mit dem Kantenwinkel annähernd proportional und in allen Versuchen unter 90°.