AN EVALUATION OF CLINICAL VARIABLES AFFECTING AMALGAM ADAPTATION

O. Conrad Poe, D.D.S.

A dissertation submitted in partial
fulfillment of the requirements for
a certificate of pedodontics at the
University of Oregon Dental School

March 15, 1973

APPROVAL

[redacted]

A. E. Retzlaff, D. D. S.
Director, Graduate Pedodontic Program

[redacted]

R. J. Mathewson, D.D.S., M.S.
Associate Professor
Department of Pedodontics

ABSTRACT

A typical class II amalgam preparation was restored twice by twenty-three pedodontists and twenty-three general practitioners. The dentists used their customary amalgam systems and restored the preparations in their respective offices. Data collected from these samples indicated the first group and second group of restorations produced by the dentists were statistically similar. Likewise the performances of the pedodontists and the general practitioners were found to be the same. A correlation (r=.69) was established between precondensation mercury and residual marginal mercury. All other simple and multiple correlations involving precondensation mercury, residual marginal mercury, and adaptation were insignificant. Disregarding all other factors the method of condensation did not affect adaptation significantly. Adaptation was considerably poorer for micro-cut alloys than for other types of alloys. Fine cut, medium cut, and spherical alloys produced approximately equal results. The dentists that did not remove excess mercury from the amalgam mix prior to condensation (non-squeeze technique) produced alloys with better adaptation than those that removed excess mercury (squeeze technique).

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to:

Dr. N. Suurmeyer whose laboratory assistance and general guidance was invaluable to the success of this study;

Dr. R. J. Mathewson for assistance in the formulation and execution of this project;

the Department of Dental Materials, especially Mr. J. Van Eysden for aid and direction;

Dr. R. Talebi for his efforts in assimilating and analyzing data;

Dr. K. H. Lu for statistical council and aid in the design of this study;

Drs. J. H. Frick, J. A. Coll, and A. E. Retzlaff for their assistance in evaluating data;

Mrs. Ethyl Hauser for her fine photographic work which was so necessary to the success of this project; and to

the forty-six dentists who contributed their time, materials, and efforts to this undertaking.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

As early as 1896, G. V. Black[1] specified that the resistance to flow of amalgam was influenced by the proportion of mercury in its composition, with an excessive or insufficient amount weakening it. He noted that amalgam could be influenced by the "degree of perfection of its manipulation".

The basic chemical composition of dental alloys has varied little among commercial brands since the formula was suggested by Black.[2] Amalgam is the most universally used restorative material, with it being the restoration material of choice for 75 per cent of all teeth.[3,4] In spite of its long and extensive usage, many aspects of dental amalgam are still questioned.

The purpose of this investigation was to evaluate several factors of amalgam procedures that might influence the quality of dental amalgam as they might occur in a clinical environment. Materials for this evaluation were obtained from an equal number of general practitioners and pedodontists. The dentists used the amalgam system in their respective offices to restore a typical class II amalgam preparation. The variables of precondensation mercury content, residual mercury content, condensation methods, and alloy types were compared to the adaptability of dental amalgam in the class II amalgam preparation.

REVIEW OF THE LITERATURE

Marcus Ward[5], in 1908, after testing amalgam specimens produced by various brands of alloy concluded that: (1) the amount of mercury used in the trituration of amalgam should be in excess of that desired in the final restoration; (2) the quantity of mercury used in trituration should never be of a proportion sufficient to make a "sloppy" mercury-alloy mass; (3) alloys of like chemical composition may vary slightly in the amount of mercury required for amalgamation because of differences in the physical structure of the alloy; (4) slightly excessive amounts of mercury used during trituration increased the strength and stability of the restoration provided the excess was removed before condensation.

Southwell[6], 1911, using compressed air, tested the adaptation of amalgam. Leakage, (lack of adaptation), was noted by the bubbling of water when air pressure was placed on a submerged restoration. The first amalgams tested were done by several different dentists and showed leakage from pressures of four ounces to sixty pounds.

In 1912, Harper,[1] using a similar compressed air test, evaluated 400 amalgams placed with fifteen of the then best known available alloys. Employing a uniform condensing procedure, he found great variation in the results of his first restorations, indicating differences in the alloys. Harper found that adaptation generally improved with the age of the restoration up to six months. After this the restoration began to "leak" at lower pressures. Alteration of his condensation technique by using smaller pluggers and smaller increments of amalgam improved adaptation of the restorations.

McCauley[8], in 1912, investigated the manipulation and physical properties of amalgam; concluding that good restorations are produced by: (1) using the correct amount of mercury, (2) proper amalgamation, (3) proper packing condensation within the cavity, (4) good adaptation to the margins, and (5) correct finishing. He stated that "proper plasticity acquired by the right amount of mercury is our greatest aid in obtaining good margins."

Harper[9], in 1915, requested thrity practitioners to restore a test preparation. On observing the adaptation of the restorative material to the cavity, he found that two-thirds of the restorations showed imperfections apparent to the naked eye. He concluded that these defects were of such a magnitude as to necessitate a change in the amalgam technique used.

In a study done at the Bureau of Standards, Washington, D. C., Souder and Peters[10] demonstrated that manipulation of the dental amalgam was probably subject to greater carelessness than any other phase of the restorative procedure. They standardized a procedure for trituration and condensation noting the difference between the manufacturer's claims and the results of their tests.

Harper[11], in 1925, stated that "the use of an excess of mercury and mixing to practical completion in the mortar develops a smooth, well lubricated, plastic mass - - - - and by retaining the excess mercury in the mass up to the moment of insertion, the maximum adaptability to cavity walls is retained and may be secured by thorough, forceful, and orderly packing." He further stated that proper plasticity should be considered the key to perfect adaptation.

In 1932, Leroy[12] tested the adaptation of amalgam specimens prepared by practitioners using varying amalgam techniques. He subjected the specimens to several staining solutions as well as to a pneumatic testing machine. The degree of resistance to air leakage was found to vary enormously with different amalgams. Restorations produced by the most reputable manufacturers showed the best averages. The tests showed that the ingress of a 10 per cent mercurochrome solution could not be prevented and that dyes demonstrated leakages when air did not.

In 1932, Ward and Scott[13] investigated the effects of variations in the manipulation of amalgam on physical properties. They found that the percentage of mercury decreased with an increase in packing pressure. Their data indicated that little reduction in the amount of mercury beyond 28.3 per cent could be achieved by further increasing condensation pressure. The investigators found the amount of mercury used in the trituration and mulling processes is vital to the dimensional stability of the amalgam.

In evaluating amalgam failures, Humble[14], in 1933, examined 1000 extracted teeth having amalgam restorations. He subjectively concluded that 62 per cent showed evidence of poor condensation.

Mierley[15], in 1935, stated that packing pressure had a marked influence on the dimensional changes that take place in an alloy. The less the packing pressure, the greater the residual mercury content in the final restoration, with a resultant greater increase in expansion.

Ward, et al[16], listed variables in amalgam manipulation that included: (1) size and shape of the particles, (2) percent of mercury used to make the mass plastic, (3) condensation pressure and effect on mercury content, and (4) deferred packing and effect on mercury content. They stated that different amalgam techniques affect dimensional changes by altering residual mercury content.

Phillips and Boyd[17], in 1947, determined the percentage of residual mercury in restorations after condensation of amalgam with different mercury-alloy ratios. Six alloys were used for this study. Their manipulation, other than mercury-alloy ratio, was held constant. Results of the study showed: (1) that as the original mercury-alloy ratio increased, the percentage of residual mercury retained in the final restoration also increased proportionally; (2) for each additional 15 per cent of mercury used in the original mix, there was an average increase of 1-1.5 per cent of residual mercury; and (3) there was a definite though not excessive loss of strength and increase in flow caused by using improper mercury-alloy ratios.

Lee[18] reviewed the literature stating that an increase in the precondensation mercury-alloy ratio increased the percentage of residual mercury proportionally. If more mercury was used in the original amalgamation, more residual mercury remained in the completed restoration regardless of the method of condensation.

Healy and Phillips[19] visually examined 1521 clinically defective amalgam restorations. They concluded that the main factors which contributed to the failures were improper cavity preparation(56 per cent) and faulty manipulation of the amalgam (40 per cent) and/or its contamination at the time of insertion.

In 1949, Phillips and Swartz[20] evaluated the mercury content of 100 amalgam restorations removed from extracted teeth. The average residual mercury content of the amalgams was 45.4 per cent with a range of 28.6 per cent to 61 per cent. The investigators found the type of preparation (1, 2, or 3 surfaces) did not markedly alter the residual mercury content.

Swartz and Phillips[21], in 1954, found no correlation between physical properties (flow, strength, and dimensional change), residual mercury content of the amalgam, or the method of condensation.

Crawford and Larson[22], in 1954, investigated the relationship between condensation pressure, residual mercury content, and crushing strength of amalgam. Amalgam samples were produced using varying packing pressures. Once condensation forces reduced the residual mercury content of the specimens to 44 per cent little increase in strength was attained by further increases in condensation pressures.

Using three alloys mixed according to the manufacturer's specifications, Ware and Docking[23] showed that residual mercury content: (1) decreased slightly with increased trituration when low condensation pressure was used; (2) substantially decreased with increased packing pressure until a limiting value was attained with extremely great condensation forces; (3) increased with increased mercury-alloy ratio.

McHugh[24], in 1955, investigated the effects of mechanical or hand condensation on hardness and adaptation of amalgam. Specimens were prepared by placing the amalgam in either small and/or large increments. Micro-hardness tests on specimens prepared by hand and by mechanical condensation showed little difference in the central areas. Tests on the edge of the specimens showed that one type of mechanical condenser produced restorations which were 20 per cent better adapted and harder than restorations produced by hand condensation. The results also showed that condensing amalgam in small increments gave better results compared to large increments.

In 1956, Swartz and Phillips[25] investigated the residual mercury content of amalgam samples prepared at varying mercury-alloy ratios. Between the ranges of 50 per cent - 55 per cent residual mercury content, the compressive strength of the specimens was not appreciably altered. There was a serious loss of strength when the residual mercury exceeded 55 per cent. The authors investigated the residual mercury content of seventeen "good to average" class II amalgams obtained through extraction. Analysis indicated the restorations were not homogeneous, and that residual mercury in marginal areas approached 60 per cent.

Phillips[26], in 1958, in an overall review of amalgam, stated that probably the greatest influence on the physical properties of amalgam was final mercury content of the restoration. He pointed out that excess mercury used in the original mix resulted in a higher percentage of mercury in the final restoration regardless of the condensation pressure or the technique employed. Phillips also noted that the residual mercury content of restorations was invariably higher at the marginal areas by 2 or 3 per cent.

In 1959, Eames[27] reported on a laboratory and clinical study of four years duration. In this investigation, amalgam was triturated using slightly less than 50 per cent mercury and was condensed without mulling or removing excess mercury from the mass. Eames believed this procedure to produce restorations that had the acceptable aspects of conventional amalgam technique; plus, it eliminated the time consuming and rather erratic task of removing excess mercury.

Hatt, et al [28], in 1959, found that within specific ranges the amount of mercury removed had little effect on adaptation whether mechanical or hand condensation was utilized. Variations in the condensation procedures did have a marked influence on the relationship of the amalgam to the cavity wall.

In a 1961 clinical study, Nadal, et al [29,30], placed 257 amalgam restorations in cavity preparations with uniform dimensions. The restorations were done by three different techniques which produced amalgams of low, medium, and high mercury content. The restorations were polished after twenty-four hours and examined periodically over a one year period. Deterioration was noted in restorations placed by all techniques. Both the number and severity of the marginal failure increased as the residual mercury content of the restorations increased. Compressive strength values were obtained from similar restorations done *in vitro*. Results showed a steady decrease in strength as the residual mercury content increased from 48 per cent to 62 per cent.

Sweeney and Burns [37], in 1961, showed the original mercury-alloy ratio to have little effect on flow, dimensional change, or residual mercury content; provided that the excess mercury was removed through squeezing, and the amalgam was well condensed. Samples from four different alloys of widely different particle sizes and five mercury-alloy ratios ranging from one to one through ten to one were used. Physical properties were similar for the tested alloys.

Heim [32], in 1962, compared condensation of amalgam into round and acute retentive grooves. Hand or mechanical condensation was used.

Results indicated mechanical condensation to be slightly better than hand condensation for the eighteen preparations. Heim found the type of alloy, whether high or comparatively low in mercury, made little difference on condensation of amalgam into retentive grooves.

Mahler and Mitchem[33], in 1964, found as the residual mercury content of amalgam increased, the compressive, tensile and transverse (edge) strengths decreased with a sharp drop at approximately 54 per cent mercury content. There was a great similarity of the strength mercury-content relationships between compressive, tensile, and transverse strength.

Jorgensen[34], in 1964, investigated the influence of condensation pressure on crushing strength and mercury content of amalgam. He prepared specimens of six different alloys using standardized procedure varying only the condensation pressures. As the mercury content decreased, the crushing strength of all the amalgam samples tested increased with increased condensation pressure. The resulting mercury content depended on the type of alloy used e. g., one alloy gave a 50 per cent mercury content while another resulted in a 39 per cent mercury content under similar conditions. This study demonstrated that amalgams with the same mercury content may have widely different crushing strengths. The investigation also demonstrated that different amalgams with the same crushing strength may vary considerably in residual mercury content.

In 1965, Jorgensen[35] presented a method for objectively registering the adaptability of amalgam. This system was based on the roughness, or lack of adaptation, that resulted when an alloy was condensed against a smooth, flat, polished, steel surface. The roughness was measured by means of a diamond cone drawn across the steel surface of the tested material. He concluded that roughness values are essentially different for different commercial brands of alloy. He found that fine grains, preamalgamation, and possibly zinc content reduced roughness. Prolonged mixing, high condensing pressure, and mechanical condensation also reduced roughness, especially when the predetermined properties of the alloy produced a relatively rough surface.

Jorgensen,[36] in 1965, examined 1200 extracted first permanent molars with amalgam restorations. He felt the greatest factor leading to marginal breakdown was corrosion with resulting mercuroscopic expansion. The amalgam surface facing the cavity wall acted as an anode in a concentration cell element, with the cathode the free surface of the restoration. Due to anodic corrosion metallic mercury was set free. The mercury diffused into the amalgam from the cavity side and caused a unilateral expansion of the wedge-shaped amalgam margin. As a result the margins moved away from the supporting cavity wall. In an effort to reduce mercuroscopic marginal deflection, Jorgensen recommended that the mercury content in the margins be reduced to a minimum. He further suggested that the amalgam be as well adapted as possible in an effort to reduce the amount of electrolytic solutions from the interface between the amalgam and the tooth.

Mahler and Mitchem[37], in 1965, studied the effect of precondensation mercury on the physical properties of amalgam. They tested the one hour and seven day strengths and dimensional change comparing the Eames and conventional squeeze techniques. Samples were made of fine cut and medium cut alloys with different precondensation mercury values.

Using the same test conditions, the Eames technique did not have any significant strength advantage when compared to the conventional technique. The use of 50 per cent, 52.5 per cent, and 55 per cent precondensation mercury contents did not significantly alter the dimensional behavior of the tested alloys. Testing indicated the hazard of excess mercury at the margins of restorations was not the result of excess mercury initially but probably the result of inadequate condensation technique.

In 1965, Jorgensen[38] used three medium grained alloys, prepared in a standardized manner, to study the interrelationship between the structure, the mercury content, and their mechanical properties. He microscopically viewed the γ- phase (unreacted particles) of the amalgam. The results demonstrated that the greater the percentage of γ-phase the greater was the crushing strength and the less residual mercury content. It was shown that increases in the condensation pressure increased the γ-phase, decreased the amalgam matrix, and decreased porosity.

Further studies by Jorgensen[39], in 1966, investigated the relation between crushing strength, mercury content, and porosity of a given composition of alloy. Variations in mercury content and porosity were obtained by altering: (1) the initial ratio of mercury to alloy, (2) the mixing time, (3) the time interval between the start of trituration and condensation, (4) the condensation pressure, and (5) the duration of condensation. Results indicated that crushing strength varied with both the mercury content and the amount of porosity. A 1 per cent increase in porosity reduced the strength approximately ten times compared to a 1 per cent increase in residual mercury content.

In an effort to arrive at a system for controlled precondensation mercury content of amalgam, Eastman and Callahan[40] accurately weighed out 500 amalgam pellets and 500 spills of mercury from a nonadjustable gravity dispenser. The theoretical mixes of amalgam derived from triturating the weighed mercury and alloy contained 49.05-51.92 per cent mercury 96.75 per cent of the time.

Mahler[41], in 1967, reviewed the basic concepts of dental amalgam. He indicated that as alloy particles were mixed with mercury they underwent a reaction to form essentially two new phases, a silver-mercury phase (Ag_2Hg_3) and a tin-mercury phase (Sn_7Hg_8). These phases, plus the original alloy particles (Ag_3Sn), compose the set amalgam. The matrix consisting of the new phases is weaker than the original alloy particles. Therefore, a minimum amount of matrix will result in a stronger amalgam. Mercury is common to the new phases that compose the matrix. Therefore, a measure of the amount of mercury present is a measure of the amount of matrix and consequently the strength of the amalgam.

Ontani and Jorgensen[42], in 1967, determined that the mercury in amalgam was directly proportional both to the γ_1, (silver-mercury) phase, and to the γ_2, (tin-mercury) phase. They uniformly prepared amalgam samples with varying amounts of mercury. The specimens were relief polished, and the γ_2 phase was determined by microscopic analysis. The γ-phase was determined after etching with 30 per cent nitric acid for fifteen seconds. After calculating the γ-phase and porosity, the γ_1 phase was computed by subtraction. Their findings indicate that the reaction phases of the amalgam have a constant proportion throughout the range of 38-62 per cent mercury content.

In 1967, Jorgensen and Saito[43] studied the occlusal marginal structure of amalgams. They prepared specimens using the Eames technique, a traditional technique, and a wet technique. The three techniques were combined with three marginal procedures: (1) the cavity was not overfilled nor burnished (2) the cavity was overfilled, the excess was removed with a carver, and the surface of the filling was smoothed; and (3) the cavity was overfilled, the margins were burnished, and the excess amalgam removed. The optimal structure of restoration margins,(the lowest possible porosity with the highest possible content of γ-phase), was obtained by systematic overfilling and burnishing of the margins with removal of the excess amalgam by carving. This method produced a similar quality of margin irrespective of technique (Eames, traditional, and/or wet).

Sardana and Provenza[44], in 1967, investigated the adaptation of amalgam to the cavity walls with different mercury-alloy ratios. In Group I, preparations were restored using a 7.3/5 mercury-alloy ratio with an increased dryness technique. In Group II, preparations were restored using the same mercury-alloy ratio; however, each increment of amalgam was squeezed completely dry prior to insertion. In Group III, a 5.8/5 mercury-alloy ratio was used with the Eames technique. All preparations were sectioned and optical micrographs taken. Group I amalgams produced the best replication of cavity walls, followed by Group III, and then Group II.

Mahler[45], in 1967, tested the plasticity of a fine cut, a micro-cut, and a spherical alloy prior to condensation. He used specimens made from the conventional and Eames techniques. An amalpress utilizing a 2 mm. indenter pin was used to calculate plasticity from the amount of indentation of the sample at a given load. The results demonstrated the following: An increased precondensation mercury content of amalgam produced increased plasticity; a micro-cut alloy produced mixes less plastic than fine cut alloys; spherical alloy mixes were extremely plastic but were not unique in this characteristic, since one conventional fine cut alloy had a similar plasticity.

Eames[46], in a 1967 marginal adaptation investigation, condensed amalgam samples into steel dies simulating a class II preparation. The dies were separated, and the specimens examined microscopically. He found better adaptation was produced with a 50-52 per cent precondensation mercury amalgam mix than with lower percentages. Better adaptation was produced with condensation of small increments than with large ones. Eames further demonstrated that eight pounds condensation thrusts were better than three pounds thrusts or one pound thrusts.

Mitchem and Mahler[47], in a 1968 laboratory investigation, examined the adaptation of amalgam restorations to cavity margins. A fine cut, a micro-cut, and a spherical alloy were used under varying amounts and types of condensation forces, with varying mercury-alloy ratios. The amalgam was packed into identical class II preparations using standard procedures. After two days the proximal surfaces were polished, and the adaptation evaluated. The findings were: (1) under optimum conditions of hand condensation, with low condensation forces, adaptation was influenced by the precondensation plasticity of the mix; (2) under these same conditions, the micro-cut alloys were poorly adapted with an excessive marginal mercury content, (3) with these test conditions, no significant difference was found between the fine cut and the spherical alloy as far as marginal mercury content and adaptation; (4) micro-cut alloys were better adapted when three pounds of condensation force was used compared to one pound, while six pounds of force or mechanical condensation was necessary to reduce marginal mercury contents within acceptable limits, and (5) in all instances, micro-cut alloys demonstrated 4-6 per cent higher marginal mercury content than either fine cut or spherical alloys.

Azar[48], et al, 1968, prepared amalgam specimens using a fine cut alloy with the Eames technique and a 52 per cent precondensation mercury content. The specimens were prepared by condensing amalgam into split metal dies with line angles of 30°, 45°, 60°, and 90°. The discrepancy between the amalgam and the edge of the die was photographed at a magnification of 84 times and measured. Adaptation to the 30° line angles was extremely poor. The areas of discrepancy decreased as the size of the angle increased until at 90° there was no apparent discrepancy.

Mitchem and Mahler[49], in 1969, investigated the influence of alloy type on marginal adaptation and final residual mercury content. Ten different brands of alloy were used. Alloys were classified on the basis of the amount of mercury required to give them a uniform plasticity (0.001 inches/pound). The alloys requiring 51 per cent or less of precondensation mercury were considered fine cut. Those requiring 54 per cent precondensation mercury or more were considered micro-cut. One alloy fell halfway between the fine and micro-cuts. Amalgam was condensed into a duplicated class II tooth model under controlled laboratory conditions and also by 81 dentists. Residual mercury and marginal adaptation was evaluated on the occlusal and proximal margins. Results demonstrated that under laboratory conditions, the micro-cut alloys produced restorations with 3-5 per cent higher occlusal marginal mercury content. Under simulated clinical conditions, the practitioners produced restorations with 3 per cent higher marginal content using the micro-cut alloys. These were less well adapted to the proximal margins then the fine cut alloys.

In 1969, Azar, et al,[50] studied the effects of hand and pneumatic condensation techniques using a spherical alloy with six different mercury-alloy ratios. He employed the Eames technique creating specimens with 45-52 per cent precondensation mercury. These amalgam samples were uniformly condensed into a split steel die with an acute line angle of 30^{o}. After compaction, the die was separated. The discrepancy between the die and amalgam was measured from an enlarged photograph of the area. Twenty specimens were used for each mercury-alloy ratio. Results demonstrated that between 48-52 per cent mercury adaptation did not significantly change for either hand or pneumatic condensation technique.

Jorgensen[51], in 1970, created amalgam samples containing 50,55, and 60 per cent mercury using 24 different brands of alloy. The specimens were chemically treated with sodium citrate to dissolve the γ_2 (tin-mercury) phase of the amalgam. Microscopic examination showed that in all cases the dissolution (corrosion) of the γ_2 phase advanced according to the length of time spent in the sodium citrate solution with complete dissolution of this phase in 32 weeks. It appears all γ_2 grains anastomose with each other and this can be selectively dissolved by corrosion. This was true for all the amalgams tested. The volume of the γ_2 phase varied only relatively little with the mercury content. Thus, Jorgensen felt it unlikely that the rather modest variations of mercury content occuring in amalgam restorations could have a major influence on the corrosion of the restorations. He thought that porosity in an amalgam considerably accelerated corrosion by permitting the penetration of electrolytic solutions into the interior of the restoration; thus increasing the contact area between these solutions and the γ_2 phase.

Simon and Welk[52], in 1970, used six different brands of alloy with nine mercury to alloy ratios to evaluate line angle adaptation. The Eames technique was employed to create amalgam with precondensation mercury contents of 48-62 per cent. Six samples of each proportion were prepared. These were mechanically condensed into a split metal die containing a simulated class II cavity preparation with an exaggerated retention groove. After condensing the adaptation was evaluated from photographic enlargements of the line angle areas. They found for all alloys studied, the lowest proportion of mercury that would give the best adaptation varied from 51-54 per cent. All alloys but one demonstrated an optimum content of residual precondensation mercury in relation to adaptation.

In 1971, Grieve[53] restored twenty class II preparations on preserved extracted teeth. A fine cut alloy was mixed at one to one mercury-alloy ratio, and a non-squeeze technique was used. One-half of the amalgams were polished and one-half were left unpolished. The teeth were treated with a dye solution, sectioned, and viewed under a microscope. All margins, both the polished and unpolished, showed some degree of leakage. Statistically, less leakage occurred around the unfinished margins than the finished ones. However, the degree of frequency was greater for the unfinished restorations.

Granath,[54] in 1971, used nine brands of alloy in an <u>in vitro</u> study of microleakage. The alloys were prepared in a standardized manner and condensed using a wet technique. The degree of plasticity was subjectively evaluated during the condensation procedure. Leakage was measured by a compressed air method. Results indicated that the greater the degree of plasticity of the amalgam at the time of insertion, the greater the quality of marginal seal.

Granath[55], in an in vivo study, did occlusal restorations on twenty-eight bicuspids that were to be extracted for orthodontic purposes. He used two different alloys; one had been shown to produce a good marginal seal and the other a relatively poor seal. Histological examination following extraction revealed no statistical difference in the pulpal inflammatory response to the two amalgams. Granath concluded that clinical leakage was of little importance in the resultant inflammation. He attributed the pulpal irritation to the high precondensation mercury content of each alloy.

Hanson and Richards[56], 1971, compared the adaptability of amalgam into acute or rounded retentive grooves. Three different alloys were condensed into a simulated three surface amalgam preparation in a split steel die. Each proximal box of the preparation had one acute and one rounded retentive groove. Either hand or mechanical condensation was employed in preparing the specimens. All rounded grooves regardless of alloy or manner of compaction were completely filled. Filling of acute grooves was comparatively poor. However, mechanical condensation was far superior to hand condensation with acute grooves.

In 1972, Jorgensen[57] investigated the effects of selective total dissolution of the γ_2 (tin-mercury) phase in dental amalgam on tensile strength. He tested four alloys whose mercury content varied from 38.9-46 per cent. The mean reduction in strength was 16.4 per cent. A positive correlation was established between the reduction in tensile strength and the mercury content of the specimens. Jorgensen theorized that corrosive dissolution of the γ_2 phase in margins of amalgam restorations with a higher content of mercury might result in a considerable reduction in their tensile strength far beyond 16.4 per cent.

METHODS AND MATERIALS

Twenty-three general practitioners were selected at random from the Portland, Oregon area. An equal number of pedodontists from the State of Oregon participated in the investigation. Each dentist was requested to condense two amalgam restorations in a typical Class II preparation in a resin tooth model of a maxillary first permanent molar (fig. 1). The proximal surface of the tooth model was ground flat to facilitate adaptation of a piece of semi-rigid metal shim material (0.05 mm. thick). The metal served as the matrix for the preparation. The tooth model and matrix were embedded in a plaster duplication of a maxillary posterior arch. Two identical preparations were restored by each participating dentist. The first model was mailed to the dentist with a questionnaire to be completed concerning his amalgam system (Table I, Appendix). This model was restored using his usual amalgam procedure. The second restoration was completed with the investigator present, observing the amalgam insertion. At this time an additional questionnaire was completed (Table II, Appendix). The purpose of the two separate restorative procedures was an attempt to clarify any difference in the dentist's performance with or without an observer present.

Samples of amalgam were collected prior to the placement of all restorations following any squeezing of excess mercury and/or mulling. These samples were to be used for evaluation of precondensation mercury content.

The teeth were removed from the models without finishing or polishing the proximal surfaces. Black and white photographs were taken of the proximal surfaces which were magnified fourteen times. These photographs were to be used as the basis for evaluating the adaptation of the amalgam. Four photographs were selected from the combined sample which were judged to represent excellent (group I), good (group II), fair (group III), and poor (group IV) adaptation (fig. 2). Three evaluators, independent of the study, examined the photographs and placed each in one of the four groups. The photographs were then ranked from best to worst within each group. The first and second restorations were evaluated and ranked separately.

The rankings of the three evaluators were statistically examined for inter-examiner agreement according to the method of Lu[58] (1971), (Table III). The coefficient of agreement (A) was calculated by the formula:

$$A=\frac{\sigma H^2-Si^2}{\sigma H^2}$$

where

Si^2=the observed within subject variance

σH^2=expected within subject variance under conditions of maximum entropy.

TABLE III

Examiner Agreement for Proximal Adaptation

	A
Prep. I	.75
Prep. II	.70
Preps. I & II	.72

A=Coefficient of Agreement

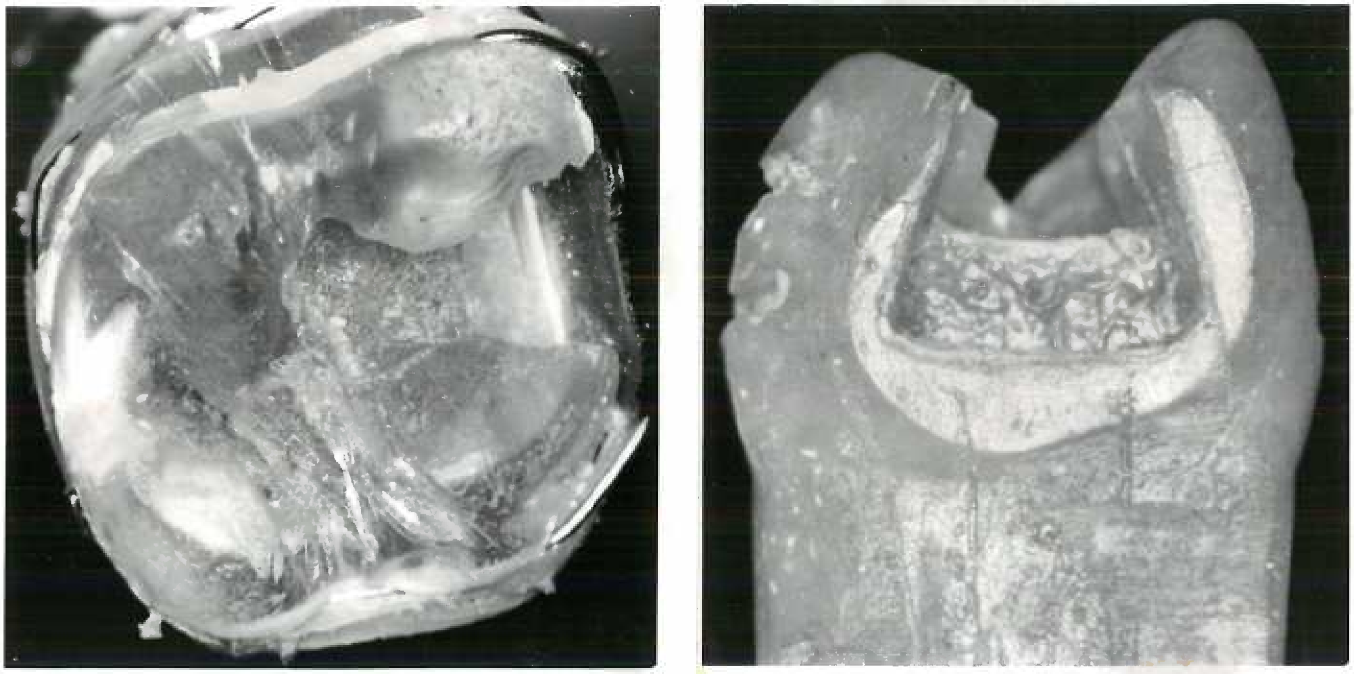

Fig. I Preparation restored by participating dentists

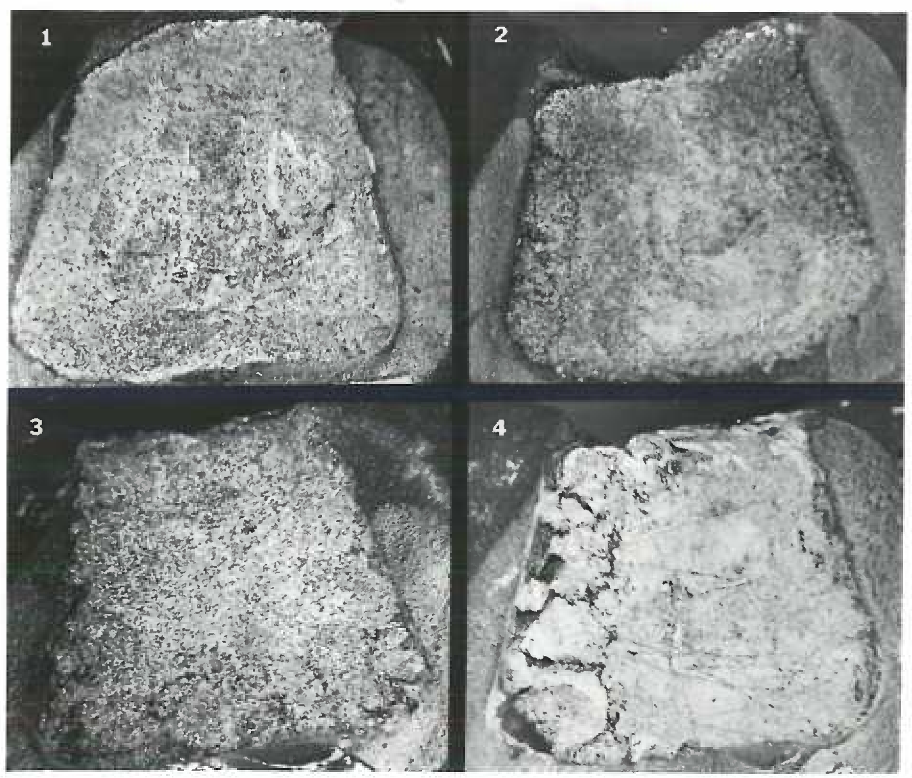

Fig. 2 Proximal surface of restored preparations representing excellent(group I), good(group II), fair(group III), and poor(group IV) adaptation

After completion of the photographs, the occlusal margin of each restoration was carefully removed with a number eight round carbide bur and collected in a large Petrie dish for subsequent weighing (fig. 3). These specimens were analyzed for residual mercury content.

Mercury content of the samples was computed using the mercury analysis of Crawford and Larsen[59] (1955). The accuracy of this procedure has been shown to be 0.039 ± 0.016 per cent. All samples were weighed, then heated to 1100°F for one hour in an argon atmosphere (fig. 4). The mercury content was calculated from the weight loss of the samples following the volitization of mercury at 1100°F.

From the questionnaires, the method of amalgam condensation was grouped into either hand or other methods of compaction. Other methods included pneumatic, mechanical, or a combination of hand, mechanical, or pneumatic condensation.

The commercial alloys used by the participating dentists were grouped into fine, medium, micro, or coarse cuts as reported in the investigation of Mahler[45] in 1967. Spherical alloy was considered as another classification.

The restorations were grouped on the basis of those that had excess mercury removed, (the "squeeze technique"), prior to condensation and those that did not.

The adaptation rankings were given numerical values by transforming them into ridit scores. A ridit analysis was performed.[60] This calculation compared performance, as expressed by adaptation, between the general practitioners and the pedodontists; between the "squeeze technique" and the "non-squeeze technique;" between hand condensation and other

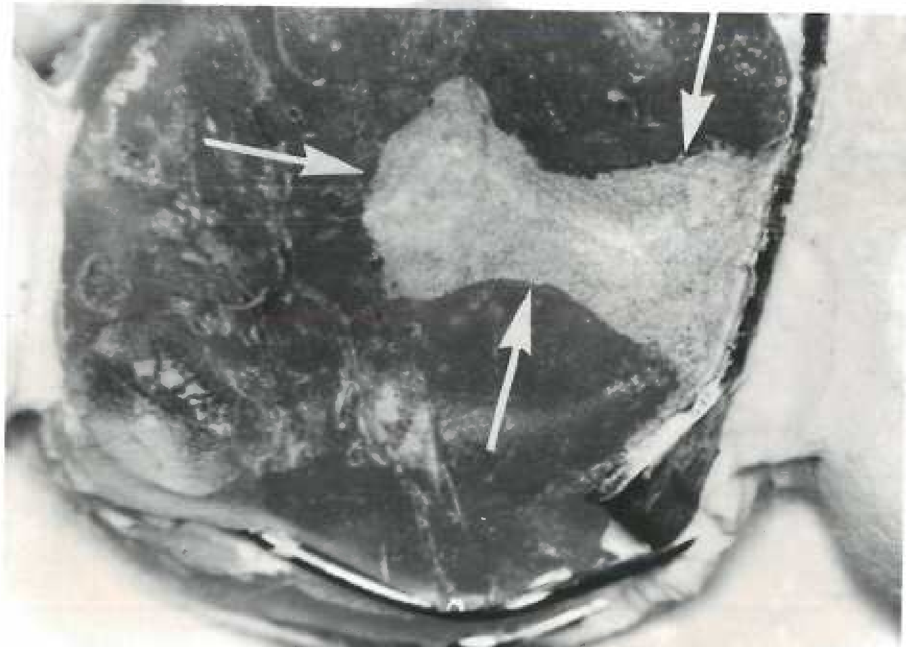

Fig. 3 Restored preparation. Arrows indicate areas of occlusal margin removed for residual mercury analysis

Fig. 4 Horizontal oven used to heat amalgam specimens

methods; and between the various types of alloys utilized.

An analysis of variance was then done comparing the described variables to marginal adaptation.

A path coefficient analysis[61] was completed to evaluate any interrelationship between precondensation mercury, residual marginal mercury, and proximal adaptation.

RESULTS

Table III indicates a significant coefficient of agreement between the three examiners regarding proximal adaptation. The agreement is slightly better for preparation I than preparation II.

Mean values for the percentage of precondensation mercury and residual marginal mercury are given in Table IV. Adaptation means as indicated by ridit numbers are shown. There is a marked consistancy between the means of the two preparations.

TABLE IV

Mean Values for Precondensation Mercury

Residual Marginal Mercury and Adaptation

	N	Hg-P	Hg-R	A
Prep. I	46	50.15±2.97	48.72±3.16	0.47±0.25
Prep. II	46	50.60±2.97	48.85±3.14	0.53±0.21
Prep. I & II	92	50.37±2.96	48.79±3.13	0.50±0.23

N=number of dentists

Hg-P=percentage of precondensation mercury

Hg-R=percentage of marginal mercury in completed restoration

A=ridit score of proximal adaptation

Tables V, VI, and VII present correlations involving precondensation mercury, residual marginal mercury, and proximal adaptation. The only statistically significant correlations are those between precondensation mercury and residual marginal mercury. The correlation between adaptation and precondensation mercury minus residual marginal mercury was $r=0.28$.

TABLES V, VI, and VII

Correlation Coefficients for Precondensation Mercury, Residual Marginal Mercury, and Adaptation

Table V

Prep. I

	HgR	A
HgP	0.71*	-0.14
HgR		0.12
HgPA	0.12	

Table VI

Prep. II

	HgR	A
HgP	0.62*	0.05
HgR		0.27
HgPA	0.10	

Table VII

Prep. I & Prep. II

	HgR	A
HgP	0.69*	-0.04
HgR		0.19
HgPA	0.09	

HgP=precondensation mercury

HgR-residual marginal mercury

A=proximal adaptation

HgPA=precondensation mercury and proximal adaptation

*=$P < 0.05$

A comparison of performance based on proximal adaptation is given in Table VIII. The higher ridit values indicate poor adaptation (performance)and correspondingly low values indicate good performance. Table VIII indicates significantly better adaptation by those practitioners who did not squeeze excess mercury from their alloy mix as opposed to those that did squeeze. Micro-cut alloys are also noted to give considerably poorer adaptation than fine cut, medium cut, or spherical alloys.

No difference in performance was noted between the general practitioners and the pedodontists, between hand condensation and other means, and between preparation I and preparation II.

TABLE VIII

PERFORMANCE OF ADAPTATION

Ridit Analysis

Variable	Mean Ridit Value
General Practitioner	0.51
Pedodontist	0.50
Excess Hg Removed	0.57
No Excess Hg Removed	0.45*
Hand Condensation	0.48
Other	0.56
Fine Cut	0.50
Micro-Cut	0.67*
Medium Cut	0.47
Spherical	0.46
Prep. I	0.47
Prep. II	0.53

Results are based on the degree of adaptation.

DISCUSSION

The results indicate that there is virtually no difference in the performance of the general practitioners and the pedodontists. Members of both groups were divided approximately equally throughout the range of adaptation.

The difference in performance between the restoration of preparation I and preparation II was insignificant. This finding indicates that the dentists as a group were consistent in their restorative procedure. It further shows that performance was not appreciably affected by the presence or absence of an observer. The dentists performed as well alone as when they were watched; thus, no "halo" effect was evident.

The mean precondensation and residual marginal mercury values obtained in this investigation are within the range of optimum according to most studies.[25,29,33,37,39,46,52] However, these values showed very low correlations with proximal adaptation. This indicates it was difficult to attempt to predict the quality of adaptation from the amount of mercury in amalgam either before or after condensation. Residual mercury percentages were slightly higher than those found by Phillips and Swartz[20] in 1949 (45.6 per cent). This was understandable in view of the fact that in the present study the residual mercury was measured at the occlusal margins, an area that usually has a higher mercury concentration. Phillips and Swartz determined residual mercury for the entire amalgam restoration.

It was originally thought that a large difference between precondensation mercury and residual marginal mercury might indicate a thorough condensation and consequently a better adaptation. This theory proved to be incorrect. The correlation between adaptation and the difference between precondensation mercury and residual marginal mercury was found to be r=0.28.

The only meaningful correlation coefficients were found between precondensation mercury content and residual marginal mercury. These findings are in agreement with those of Phillips and Boyd[17] who found the percentage of precondensation mercury determined the amount of mercury in the final amalgam restoration. Ware and Docking[23] made similar determinations in 1954. Sweeney[31] found no correlation between the original mercury/alloy ratio and residual mercury. However, Sweeney calculated precondensation mercury before any excess was removed. In this study precondensation mercury was evaluated after the excess mercury was removed for those dentists who used this procedure.

It was found that the dentists who did not squeeze excess mercury from the amalgam mix prior to condensation had statistically better adaptation than those that used the "squeeze technique". This could possibly be related to the greater reproducibility of the "no squeeze technique" as suggested by Eames.[27]

Hand condensation was compared to all other methods of condensation including pneumatic, mechanical, and combination techniques. Thirty-six of the dentists in the study used hand condensation; ten used "other" methods. The hand condensation group produced slightly better results, but this difference was not statistically significant. McHugh[24], in 1955, found adaptation to be 20 per cent better only for one specific type of mechanical condenser when compared to hand condensation. The present investigation did not compare specific brands of condensers but rather examined mechanical and pneumatic condensers as a group. Hatt[28] found no difference between hand and mechanical condensation. His investigation mechanically measured the proximity of the alloy to the cavity wall. Heim[32] obtained slightly better results with mechanical than hand condensation in his study. However, this evaluation was based solely on the adaptation of alloy to round and acute retentive grooves and not on adaptation of other areas of the preparation. Azar[50] compared hand and pneumatic condensation and found no difference in adaptation between the precondensation mercury ranges of 48-52 per cent. Adaptation, as in the present study, was measured from enlarged photographs. Azar was concerned primarily with marginal adaptation, measuring the discrepancy between the alloy and a steel die. The present investigation was concerned with adaptation of an entire surface although marginal adaptation was a major consideration. Hanson and Richards[56] found mechanical condensation superior to hand condensation. However, this judgment was based only on the adaptation of retentive grooves.

The alloys used by the participants in the study were divided into fine cuts (N=15), medium cuts (N=20), and micro-cuts (N=6), and spherical alloys (N=4). Only one dentist used a coarse cut alloy, and for this reason, it was discarded. Adaptation of the micro-cut alloys was strikingly poorer than for the other alloys as can be seen in Table VIII. Mahler and Mitchem,[47,49] tested the same types of alloys under controlled conditions and also found the micro-cuts to exhibit poorer adaptation.

Other than the correlation between precondensation mercury and residual marginal mercury, there appears to be no meaningful interrelationship between precondensation mercury, residual marginal mercury, and adaptation. Acceptable adaptation, as well as poor adaptation, was obtained with alloys of varying mercury contents. The most logical explanation for this seems to be within the condensation process. Adaptation was virtually the same with both hand condensation and "other" methods. It was fairly safe to assume that the condensation forces of the "other" methods were uniform and of sufficient magnitude to obtain good adaptation of the alloy. This hints that condensation pressure may not be a highly significant factor in adaptation. Possibly the manner in which the alloy was condensed may be a prime consideration as suggested by Eames.[46] The diameter of the pluggers, direction of condensation forces, and the size of the amalgam increments placed are perhaps the most important factors of adaptation in a clinical situation. However, these variables were not included in this investigation. Mahler[41] stated that of all the procedures involved in amalgam technique, condensation was most important; some errors in procedure can be corrected by optimum condensation, whereas nothing can compensate for less than optimum condensation procedure.

CONCLUSIONS

(1) A statistically significant correlation exists between precondensation mercury and residual marginal mercury.

(2) Micro-cut alloys produce restorations that are statistically poorer in adaptation than fine cut, medium cut, or spherical alloys.

(3) The dentists who did not squeeze out excess mercury prior to condensation produced restorations that were better adapted than those who did remove excess mercury.

(4) Relationships between (a) precondensation mercury and adaptation, (b) residual marginal mercury and adaptation, (c) precondensation mercury minus residual marginal mercury and adaptation, and (d) precondensation mercury, residual marginal mercury and adaptation are all statistically insignificant.

(5) Hand condensation is not significantly different from mechanical, pneumatic, or combination condensation based on marginal adaptation.

(6) The presence of an observer has no effect on the restorations produced.

(7) Restorations produced by pedodontists and general practitioners are statistically the same.

BIBLIOGRAPHY

(1) Black, G. V. The physical properties of the silver-tin amalgams. Dent. Cosmos, 38:965-92, 1896.

(2) Peyton, F. A., and Craig, R. G. Restorative dental materials. 4th ed. St. Louis, Mosby, p. 358-397, 1971.

(3) American Dental Association Guide to dental materials and devices. 5th ed. Chicago, p. 18-34, 1970-1971.

(4) Skinner, E. W., and Phillips, R. W. The science of dental materials. 6th ed. Philadelphia, Saunders, p. 312-57, 1967.

(5) Ward, M. L. The effect of an excess of mercury upon shrinkage, expansion, strength, change in composition, and stability of dental amalgam alloys. Dent. Cosmos, 50:109-116, 1908.

(6) Southwell, C. C. The field of compressed air test. Dent. Rev., 25:427-447, 1911.

(7) Harper, W. E. The character of the adaptation of amalgam to the walls of cavities attained by present methods of instrumentation and the use of the best known alloys, as indicated by the air pressure test. Dent. Rev., 26:1179-1198, 1912.

(8) McCauley, C. M. Amalgams: their manufacture, manipulation, and physical properties. Cements: their manipulation and physical properties. Dent. Cosmos, 54:174-188, 1912.

(9) Harper, W. E. Photographs of amalgam surfaces packed against cavity walls, showing many defects which indicate the necessity of a change in our amalgam technic. Dent. Rev., 29:236-246, 1915.

(10) Souder, W. H., and Peters, C. G. An investigation of the physical properties of dental materials. Dent. Cosmos, 62:305-335, 1920.

(11) Harper, W. E. The significance to dentists of physico-chemical changes incidental to amalgamation and the hardening of dental amalgams. Am. Dent. A. J. 12:34-38, 1925.

(12) Leroy, R. P. Practical adaptation of dental amalgam. Northwest J. Dent., 20:3-7, Aug. 1932.

(13) Ward, M. L., and Scott, E. O. Effects of variations in manipulation on dimensional changes, crushing strength and flow of amalgams. Am. Dent. A. J., 1683-1705, Oct. 1932.

(14) Humble, T. W. The manipulation of amalgam. Dent. Digest, 39:377-82, Oct. 1933.

(15) Mierley, O. M. Amalgam restorations and the effect of manipulation on alloys. Dent. Cosmos, 77:325-33, Apr. 1935.

(16) Ward, M. L., et al. New concepts of mercury content in amalgams. J. Dent. Res., 16:316-17, 1937.

(17) Phillips, R. W., and Boyd, D. A. Importance of the mercury-alloy ratio to the amalgam filling. Am. Dent. A. J. 34:451-58, 1947.

(18) Lee, R. Effects of mercury on dental alloy. Contact Point, 27:108-111, Jan. 1949.

(19) Healy, H. J., and Phillips, R. W. A clinical study of amalgam failures. J. Dent. Res., 28:439-46, Oct. 1949.

(20) Phillips, R. W., and Swartz, M. L. Mercury analysis of one hundred amalgam restorations. J. Dent. Res., 28:569-72, Dec., 1949.

(21) Swartz, M. L., and Phillips, R. W. A study of amalgam condensation procedures with emphasis on the residual mercury content of the increments, I. Strength, flow, and dimensional change. J. Dent. Res., 33:12-19, Feb. 1954.

(22) Crawford, W. H., and Larson, J. H. Dental restorative materials: amalgams, acrylics. J. Dent. Res., 33:414-22, Jun. 1954.

(23) Ware, A. L., and Docking, A. R. The effect of manipulative variables on dental amalgam. Part 2 - Dimensional change. Austral. J. Dent., 58:355-60, Dec. 1954.

(24) McHugh, W. D. Experiments on the hardness and adaptation of dental amalgam as affected by various condensation techniques. Brit. Dent. J., 99:44-48, 1955.

(25) Swartz, M. L., and Phillips, R. W. Residual mercury content of amalgam restorations and its influence on compressive strength. J. Dent. Res., 35:458-66, Jun. 1956.

(26) Phillips, R. W. Amalgam. Dent. Clin. No. Am., 547-59, Nov. 1958.

(27) Eames, W. B. Preparation and condensation of amalgam with a low mercury-alloy ratio. Am. Dent. A. J., 58:78-83, Apr. 1959.

(28) Hatt, S. D., et al. The relationship of amalgam to the cavity wall. Dent. Pract. and Dent. Rec., 10:76-88, Dec. 1959.

(29) Nadal, R., et al. Clinical investigation of the relation of mercury to the amalgam restoration. Am. Dent. A. J., 63:8-21, Jul. 1961.

(30) Nadal, R., et al. Clinical investigation of the relation of mercury to the amalgam restoration: II. Am. Dent. A. J. 63:488-96, Oct. 1961.

(31) Sweeney, W. T., and Burns, C. L. Effect of mercury-alloy ratio on the physical properties of amalgam. Am. Dent. A. J. 63:374-81, Sept. 1961.

(32) Heim, R. L. Condensation of silver amalgam into rounded and acute retentive grooves. J. Dent. Child., 29:140-45, 2nd Quar. 1962.

(33) Mahler, D. B., and Mitchem, J. C. Transverse strength of amalgam. J. Dent. Res., 43:121-30, Jan.-Feb. 1964.

(34) Jorgensen, K. D. The influence of the condensation pressure upon crushing strength and mercury content of amalgam. Acta Odont. Scand., 22:539-45, Nov., 1964

(35) Jorgensen, K. D. Adaptability of dental amalgams. Acta Odont. Scand., 23:257-70, 1965.

(36) Jorgensen, K. D. The mechanism of marginal fracture of amalgam fillings. Acta Odont. Scand., 23:347-89, Aug. 1965.

(37) Mahler, D. B., and Mitchem, J. C. Effect of precondensation mercury content on the physical properties of amalgam. Am Dent. A. J. 71:593-600, Sept. 1965.

(38) Jorgensen, K. D. Structure studies of amalgam, I. Correlation between structure and physical properties. Acta Odont. Scand., 23:501-12, Oct. 1965.

(39) Jorgensen, K. D., et al. The effect of porosity and mercury content upon the strength of silver amalgam. Acta Odont. Scand. 24:535-53, 1966.

(40) Eastman, R. F., and Callahan, F. L. Controlled mercury content dental amalgam. J. Ala. Dent. A., 50:27-33, Jul. 1966.

(41) Mahler, D. B. Physical properties and manipulation of amalgam. Dent. Clin. No. Am., 213-28, Mar. 1967.

(42) Ontani, H., and Jorgensen, K. D. Structure study of amalgam. IV. Quantitative determination of the phases in silver amalgam. Acta Odont. Scand., 25:105-9, Jun. 1967.

(43) Jorgensen, K. D., and Saito, T. Structure studies of amalgam. V. The marginal structure of occlusal amalgam fillings. Acta Odont. Scand. 25:233-45, 1967.

(44) Sardana, R. C., and Provenza, D. V. Mercury/alloy ratio and adaptability of dental amalgam. Baltimore Col. Dent. - Surg. J., 22:64-71, Jul. 1967.

(45) Mahler, D. B. Plasticity of amalgam mixes. J. Dent. Res., 46: 708-713, Jul. - Aug. 1967.

(46) Eames, W. B. Factors influencing the marginal adaptation. Am. Dent. A. J. 75:629-37, Sept. 1967.

(47) Mitchem, J. C., and Mahler, D. B. The adaptation of amalgam. Am. Dent. A. J. 76:787-91, Apr. 1968.

(48) Azar, E. S., et al. Quantitative evaluation of the adaptation of dental amalgam into line angles. J. Dent. Res., 47:533-36, Jul. - Aug. 1968.

(49) Mitchem, J. C., and Mahler, D. B. Influence of alloy type on marginal adaptation and final residual mercury. Am. Dent. A. J. 78:96-100, Jan. 1969.

(50) Azar, E. S., et al. Effect of compaction technic and mercury: alloy ratio on the adaptation of spherical alloy dental amalgam. J. Dent. Res. 48:879-82, Sept. - Oct. 1969.

(51) Jorgensen, K. D. Structure and corrosion of dental amalgams. Acta Odont. Scand. 28:129-42, Mar. 1970.

(52) Simon, J. F., and Welk, D. A. Influence of mercury to alloy ratios on line angle adaptation of dental amalgam. J. Dent. Res., 49:1055-59, Sept. - Oct. 1970.

(53) Grieve, A. R. Marginal adaptation of amalgam in relation to the finish of cavity margins. Brit. Dent. J., 130:239-42, Mar. 16, 1971.

(54) Granath, L. E. Studies on microleakage with restorative materials. III. In vitro experiments on the sealing of 9 brands of silver amalgam. Acta Ocont. Scand. 29:65-73, Apr. 1971.

(55) Granath, L. E. Reaction of the human dental pulp to silver amalgam restorations. Effect of insertion of amalgam of high plasticity in shallow cavities. Acta Odont. Scand. 29:165-72, Jun. 1971.

(56) Hanson, L., and Richards, D. Adaptability of amalgam. Dent. Stud. 50:56, Oct. 1971.

(57) Jorgensen, K. D. The strength of corroded amalgam. Acta Odont. Scand. 30:33-38, Mar. 1972.

(58) Lu, K. H. A measure of agreement among subjective judgments. Educ. Psychol. Measurement. 31:75-84, Spring 1971.

(59) Crawford, W. H., and Larson, J. H. Residual mercury determination process. J. Dent. Res. 34:313-17, Jun. 1955.

(60) Bross, I. D. J. How to use ridit analysis. Biometrics 14:18-37, 1958.

(61) Lu, K. H., and Savara, B. S. A statistical analysis of relative importance in factors affecting weight changes in children from three to eight years old. Human Biology. 34:1-19, Feb. 1962.

APPENDIX

Table I   Questionnaire mailed to dentists

Table II   Questionnaire completed at visit to the dental office

TABLE I

1. Dental Office No.____________________

2. Name of Dentist__________________________

3. Year of Graduation____________________

4. Name of Assistant_________________________

5. Name of Amalgamator used---------------------------Dento mate____________

SS White____________

Wig-L-Bug____________

Torit____________

Silamat____________

Caulk Vari-Mix____________

Toothmaster____________

Other(Specify)____________

____

____

6. Name of Capsule & Pestle Used---------------------____________

7. Name of Alloy------------------------------------____________

8. Mercury/Alloy Ratio
(Spills of Mercury/Pellets or Spills of Alloy)-----____________

9. Mixing Time of Alloy----------------------------____________

10. Squeeze Mix---Yes______ No______

Mull Mix--Yes______ No______

11. Type of Alloy Dispenser---------------------------Kerr Spheraloy____________

Pre-proportioned____________

Pellets____________

Filings____________

Other____________

TABLE I (con'd)

12. Type of Mercury Dispenser------------------------Kerr Spheraloy__________

SS White__________

Crown__________

Caulk__________

Slide__________

Other(Specify)__________

____

____

13. Setting of mercury dispenser---------------------__________

14. Condensation---------------------------------------Hand__________

Mechanical__________

Pneumatic__________

Combination__________

15. Brand Name of Mechanical or Pneumatic Condenser---Midwest__________

Kerr__________

Hollenback__________

Adec__________

Cavitron__________

Other(Specify)__________

____

TABLE II

I. Name of Dentist______________________________

Address______________________________

Telephone Number______________________________

Type of Practice______________________________

Years in Practice______________________________

Dental Education:

A. Dental School______________________________ Year Graduated__________

B. School of Specialty Training if Any______________________________

II. Name of Assistant______________________________

Certified? Yes___ No___

Formal Training Yes___ No___

Level of Education __________

Years of Experience __________

Taking Continuing Education Courses Yes___ No___

If yes, where?______________________________

Expanded Duties? Yes___ No___

If yes, what?______________________________

III. Equipment

A. Amalgamator

Amalgamator Time 1______ 2______ 3______ Avg.______

Stop Watch Time 1______ 2______ 3______ Avg.______

Cycles(1 min. Loaded) __________

Type High Speed______ Low Speed______

B. Capsule and Pestle System:

Visual Inspection of Cleanliness No old alloy__________

Slight__________

TABLE II (con'd)

	Moderate ____________
	Great ____________
Leaking Hg	Yes ______ No ________
C. Hg Dispenser:	
Cleanliness	Clean ____________
	Moderate ____________
	Dirty ____________
Amount of Hg in Dispenser	0-$\frac{1}{4}$ full ____________
	$\frac{1}{4}$-$\frac{1}{2}$ full ____________
	$\frac{1}{2}$-full ____________
IV. Amalgamation Check List	
A. Assistant	
Time spent for mixes	1 pellet ____ 2 pellets ____
Does Assistant invert after each spill of Hg	Yes ______ No ________
Squeeze excess Hg	Yes ______ No ________
Mull	Yes ______ No ________
B. Dentist	
Condenser Type ____________________	
Amount of Overpack ____________________	