A CLINICAL EVALUATION OF THE EFFECT
OF POLISHING PROCEDURES ON THE
MARGINAL BREAKDOWN OF TWO DENTAL AMALGAMS

by

George A. Adams

Submitted to the Faculty of the Graduate School in partial fulfillment
of the requirements for the degree of Master of Science in Dentistry,
Indiana University School of Dentistry, 1977.
ACKNOWLEDGMENTS
There are many people whom I would like to thank for their assistance in this study. Without them, this investigation would not have gotten off the ground.

I am grateful to the members of my graduate committee for their assistance; to Dr. John Osborne for his suggestions and aid in constructing and doing a clinical study; to Dr. Leonard Koerber for his help in the statistical analysis of the data and to Dr. David Avery and Professor Paul Barton for their assistance in preparing the outline and final manuscript of the thesis. I would especially like to thank Dr. James Roche for his friendship and words of encouragement throughout the investigation.

I wish to thank my classmates Doctors Rhett Fagg, Michael Johns, and Gunnar Richardson for a wonderful two years together. Their words of humor and our fellowship made my two years as a graduate student most enjoyable. I will always treasure their friendship.

I would like to thank my family for all the sacrifices they made so that I could be a student. I thank my parents-in-law, Mr. and Mrs. Lynn P. Bramblett, for their support and encouragement. To my parents, Mr. and Mrs. Bellwood C. Adams, thank you for everything. After all these years, we are finally through. I want to thank my wife Joy and my son George for living through this whole experience and putting up with me. My whole family had to make many sacrifices in order for me to carry on my graduate studies. I will be eternally grateful for this.
TABLE OF CONTENTS
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Review of the Literature</td>
<td>3</td>
</tr>
<tr>
<td>Methods and Materials</td>
<td>12</td>
</tr>
<tr>
<td>Results</td>
<td>18</td>
</tr>
<tr>
<td>Figures and Tables</td>
<td>21</td>
</tr>
<tr>
<td>Discussion</td>
<td>29</td>
</tr>
<tr>
<td>Summary and Conclusions</td>
<td>32</td>
</tr>
<tr>
<td>References</td>
<td>33</td>
</tr>
<tr>
<td>Curriculum Vitae</td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td></td>
</tr>
</tbody>
</table>
LIST OF ILLUSTRATIONS
LIST OF ILLUSTRATIONS

FIGURE 1  Occlusal view of amalgam restorations ........ 21
FIGURE 2  Series of photographs used for the
           Ridit Analysis  ............................. 22
TABLE I   Photographic evaluation
           Ridit Analysis
           Marginal Fracture Distribution ............. 23
TABLE II  Ridit Analysis results  .................... 24
TABLE III  Ridit Analysis comparisons ............. 24
TABLE IV  Rank Ordering of evaluator 1 ............ 25
TABLE V   Rank Ordering of evaluator 2 ............ 26
TABLE VI  Rank Ordering of evaluator 3 ............. 27
TABLE VII  Spearman Rho Rank Order coefficients
           of correlation between evaluators ........ 28
INTRODUCTION
A survey by the United States Public Health Service showed that 98 percent of the population has either had or will have dental caries. Another recent survey indicated that there are four million new untreated cavities per year in the United States. In 1969 Phillips, Swartz, and Norman reported that dental amalgam still accounted for 80 percent of all dental restorations used. Amalgam is a very popular restorative material because it is relatively simple to manipulate, versatile, and uniquely capable of reducing marginal leakage. Thus, unless a better restorative material is developed in the future, amalgam will be a much used material for the restoration of decayed teeth.

Demar reported that the Crawcour brothers in 1833 were the first to use silver amalgam in dental practice. Extensive research has been conducted in an effort to improve amalgam. Along with improvements in the material itself, the operator has been given a better understanding of the properties and manipulative techniques which will produce the best results.

The placement of an amalgam restoration requires several integrated steps, and success of the final restoration depends upon how carefully each step is carried out. The amalgam restoration is not considered complete until it is finished and polished.

In spite of the large amount of research that has been completed on dental materials, the beneficial effects of polishing amalgam restorations have been a largely neglected area of study. The present
investigation was undertaken to ascertain the effects of the polishing and finishing of dental amalgam in relation to its marginal breakdown, and to make a clinical comparison of the marginal integrity of Dispersalloy restorations and Twentieth Century Fine Cut Alloy restorations in both the polished and non-polished state.
REVIEW OF THE LITERATURE
The setting reaction of amalgam alloy with mercury may be expressed as follows:

\[
\text{Ag}_3 + \text{Hg} \rightarrow \text{Ag}_3\text{Sn} + \text{Ag}_2\text{Hg}_3 + \text{Sn}_8\text{Hg}
\]

\[(\text{gamma}) \quad (\text{gamma 1}) \quad (\text{gamma 2})\]

In 1973 Phillips stated:

The major defect in structure of dental amalgam is that it is multiphase in nature. Such a structure results in poor tensile properties and inferior resistance to corrosion. The physical properties of set amalgam are most dependent upon the relative percentages of each of these components. The strongest phase is that which is dominant in the original alloy, the \(\text{Ag}_3\text{Sn}\). The more of the gamma phase which is retained in the final structure, the stronger will be the amalgam. The weakest component is the gamma 2.

Philips defined corrosion as not merely a surface deposit but as an actual deterioration of a metal by reaction with its environment. Numerous studies have shown that the gamma 2 phase of amalgam is the most susceptible to corrosion.

Phillips stated that the clinical significance of the corrosion phenomenon of dental amalgam is much greater than simply a discoloration of the exposed surface. The degradation effect of the corrosion process is of particular concern at the margins, and may well be the primary cause for marginal "ditching" so commonly seen in dental amalgam restorations.

Jorgensen related corrosion and the marginal fracture of amalgam fillings according to the following theory. The electropotential differences which exist between dissimilar metals in the oral cavity, or
even between the various phases with amalgam itself, initiate the corrosion process. Oxidation is centered on the gamma 2 phase, and apparently in time tin ions are released. These ions migrate to form corrosion products at the margins. When the tin is released from the gamma 2 phase, free mercury is left behind. This mercury can then react with the residual alloy particles to form additional gamma 1 and gamma 2 phases. A resulting expansion (referred to as mercuroscopic expansion) in or near the amalgam-tooth interface produces a protrusion of the restoration away from the supporting tooth structure. Being unsupported and weakened by corrosion products, these margins may be easily fractured by occlusal stress.

Mateer and Reitz in 1972 explained corrosion as the galvanic degradation of amalgam. According to their theory, amalgam restorations are influenced by two electrolytes, saliva, and tissue fluid of the dentin. The amalgam-dentin interface develops a negative charge which produces decomposition of the gamma 2 phase and migration of tin into the dentin. A positive galvanic current exists through the body-tissue saliva circuit to the oral amalgam interface. Common cavity liners do not block this current flow. The corrosion process destroys the interconnected gamma 2 phase and deposits tin-rich compounds. Over a period of years, the corrosion process progresses toward the center of the restoration, causing a degeneration of the matrix structure. Prospects for increasing the life of amalgam restorations depend upon the reduction of the corrosion process. The solution should be found through a reduction in the amount and degree of interconnection of gamma 2 particles, and through better liners to block the galvanic circuit.
Stoner, Lawless, and Warner\textsuperscript{10} stated that to stop the destructive corrosion of amalgams the gamma 2 phase must be eliminated.

Innes and Youdelis\textsuperscript{14} introduced the concept of the dispersion strengthened dental amalgam alloys which included eutectic fillings composed of 71.9 percent silver and 28.1 percent copper. This alloy had a 30 percent increase in compressive strength and a 600 percent decrease in flow.

Today, the dispersion strengthened dental amalgam, Dispersalloy\textsuperscript{a}, contains silver/copper eutectic spheres in combination with the conventional cut alloy. The composition of Dispersalloy is: 70 percent silver, 16 percent tin, 13 percent copper, and 1 percent zinc.

Since the corrosion of dental amalgam has now been linked to the gamma 2 phase,\textsuperscript{7-12} the addition of spheres of silver/copper eutectic to conventional amalgam alloy replaces 40 percent of the tin. During the amalgamation process, the copper attracts and locks virtually all of the unreacted tin responsible for corrosion.\textsuperscript{15}

Mahler and associates\textsuperscript{16} in a clinical study have shown that the creep values of the amalgam appear to be more indicative of marginal fracture than any other physical property. In their study the dispersed phase alloy, which had the lowest creep value, provided superior to the two other alloys evaluated in relation to marginal fracture. Duperon, Neville, and Kasloff\textsuperscript{17} in another clinical study indicated that the dispersion type alloy had less marginal breakdown than either a conventional alloy or spherical alloy.

\textsuperscript{a}Dispersalloy, Dental Products Company, Johnson and Johnson, East Windsor, New Jersey.
Proper polishing of a dental amalgam is generally considered essential to the durability of the restoration. It is important not only for the appearance of the dental amalgam but also for its contribution to the mechanical and biological properties of the restoration.

It is generally believed that amalgam restorations should not be polished until at least 24 hours after insertion. This time lapse is considered necessary to allow the amalgam surface to reach a hardness necessary for good and lasting polish.\textsuperscript{18,19} Polishing amalgam before 24 hours will produce burnishing of the material which will bring mercury to the surface.\textsuperscript{18}

Many polishing techniques have been reported in the literature.\textsuperscript{18-27} The lack of agreement as to the best agent and correct manner of progression indicates that there is no one ideal polishing procedure. It is commonly agreed that at least three to four agents of different but close degrees of abrasiveness should be used and in a descending order of abrasiveness.

Mahler\textsuperscript{28} has reported that rough surfaces of dental amalgam will cause a concentration of stress in mastication, and an increased susceptibility to fracture.

Swartz and Phillips\textsuperscript{29} have reported that rough surfaces are difficult to clean and tend to collect bacterial plaque. These rough surfaces thus provide very favorable conditions for concentration cell corrosion.\textsuperscript{7,30}

Besides leading to possible fracture of an overhanging margin, rough surfaces of a restoration may increase the chances for a recurrence of dental caries about the margins through acid formation due to fermentation of the retained food.\textsuperscript{31,32} An amalgam that is properly polished will have its margins brought to the level of the cavity margins.\textsuperscript{33}
Research\textsuperscript{34-41} has indicated that poor polish or lack of polish of
dental amalgam restorations is often an etiological factor in periodontal
disease. The proposed cause of this condition is the retention of
bacterial plaque which irritates the soft tissue.\textsuperscript{42,43,44}

Markley\textsuperscript{45} stated that polishing a dental amalgam produces a homo-
geneous layer, the Beilby layer, over its entire surface. This layer is
composed of highly condensed and burnished particles and is quite
resistive to local factors.

Wing\textsuperscript{46} reported in 1965 that polishing amalgam does not make the
surface structurally homogeneous but does make it smoother, thus reducing
the active surface area and hence the potential for tarnish and corrosion,
as well as debris retention.

A polished amalgam has a greater resistance to tarnish and
corrosion.\textsuperscript{47,48} This decrease in corrosion potential has been attributed
to the reduction in electric couples in the polished amalgam.\textsuperscript{49}

Improper polishing of dental amalgam can produce a degeneration of
its physical properties. It is considered hazardous to overheat amalgam
by friction while polishing.

Black\textsuperscript{50} stated in 1895 that dental amalgam, upon being heated to the
temperatures of boiling water, underwent a noticeable and permanent change
in its surface crystallization. This was manifested as a permanent change
in both the surface appearance and volume of the amalgam. This phenomenon
could be attributed to something other than ordinary thermal expansion.

Mitchell, Dickson, and Schoonover\textsuperscript{51} reported in 1955 on the influence
of excessive heat generated in amalgam by polishing procedures. They
found that heat in excess of 65° C. (140° F.) caused residual mercury to
be attracted to the surface and margins. The increased mercury causes a loss of strength in the amalgam and makes it more susceptible to fracture. 52

Gray 53 studied the effects of temperature changes on the physical properties of silver amalgam. He found that when a temperature of 70° C. was reached, a decrease in the physical properties occurred. Cannon 54 believed that this amount of heat could be generated from polishing procedures. He also stated that the decrease in physical properties is due to the excessive heat which brings the residual mercury to the surface.

Keys 55 studied the metallurgical phenomenon of polishing the amalgam restoration. He likewise reported that excessive frictional heat from polishing will bring the mercury to the surface and marginal areas, which produces a loss of strength and surface appearance of the restoration. Kilpatrick 56 maintained that an important cause of marginal ditching and failure is the overheating of the amalgam during polishing which brings mercury to the surface and margins.

El-Bahloul 57 in 1963 studied the effect of polishing procedures on the distribution of residual mercury in dental amalgam. His mercury determination procedures showed excessive amounts of mercury at the surface of silver amalgam when certain polishing agents and procedures were used. The effects of these agents on the mercury distribution were found to be limited to the most superficial layer of amalgam. The author stated that the rubber wheel discs impregnated with pumice brought the greatest concentration of mercury to the surface of the amalgam restorations. Fine sandpaper discs produced similar but less pronounced effects. No appreciable change in mercury content was found when finishing burs, carborundum stones and coarse sandpaper discs were used.
The recent literature casts considerable light on how to avoid the generation of excessive frictional heat during the polishing of dental amalgam restorations. Using epoxy steel teeth and a thermocouple as a thermal detector, Alpin found that when moisture was excluded from the polishing procedure with dental amalgam, a substantial increase in temperature was noted. Grajower and associates reported that higher temperatures were observed when there was continuous polishing with appliances made of rubber than when there was intermittent polishing with cup brushes.

Christensen and Dilts constructed an experimental device to determine the increase in heat rise within the pulp chamber while dental amalgam was being polished. They listed the following group of instruments in order of increasing tendency to produce heat in the dental pulp: (1) stones and brushes, (2) coarse and fine cuttle disks and rubber cups with moist pumice, (3) dry rubber cups with polishing material, and (4) rubber disks.

Eames, Minnock, and Wasden studied the thermal response of amalgam to polishing instruments and reached the following conclusions:

a. Polishing temperatures exceeding 150°F produce an immediate surface softening of amalgam with a subsequent hardening surpassing the original hardness.

b. Temperatures above 150°F produce a surface graininess without luster.

c. Polishing instruments, used at continuous high speed, can produce excessively high temperatures.

d. Intermittent polishing techniques using disks or brushes for short periods result in lower temperatures that do not influence initial
surface harness or reflection. Intermittent polishing with rubber wheel disks impregnated with pumice produces high temperatures quickly, which initially causes a surface softening of amalgam with subsequent increased hardening and graininess.

Research has shown that the polishing of a dental amalgam restoration does not necessarily improve all of its properties. Charbeneau found that all carved amalgam surfaces, whether burnished or not, were found to have a lower surface hardness as a result of polishing.

Kantorowicz, in his study of the finishing of amalgam restorations, explained how the corrosion process can still occur with a polished amalgam restoration.

An amalgam filling with most of its surface polished, and part not polished, is as susceptible to corrosion as one which has not been polished at all. In such cases, the unpolished and the polished surfaces act as electrodes in a voltaic cell with the saliva acting as the electrolyte. The polished surface thus corrodes. When this surface is corroded more than the unpolished surface, the polarity reverses and the process continues, the unpolished surface becomes the negative electrode and corrodes further.

Russo and co-workers in 1970 studied the influence of burnishing and polishing on the marginal infiltration of radioactive sodium iodide solution ($^{131}$I$_{Na}$) in silver amalgam restorations. Their results showed that burnishing done immediately after carving reduced the amount of marginal leakage, both in specimens stored for short periods (48 hours) and longer ones (73 days). Polishing did not alter the results.

Ottolengui reported in 1925 that 5 percent of the amalgam restorations that he examined were polished. Easton, in a similar study in 1941 reported that 11 percent of the amalgam restorations were polished.
This review of the literature contains many references to the techniques of polishing dental amalgam restorations and the possible hazards from the excessive frictional heat generated during polishing procedures. No scientific data were found to relate the polishing of dental amalgam restorations and their marginal breakdown. That was the purpose of this investigation.
METHODS AND MATERIALS
Patient Selection

The experimental group was selected from patients registered at the Indiana University School of Dentistry. Patients were chosen who lived within a reasonable distance from the School and stated that they would be available for evaluation during a three-year period.

Patients were screened for their cooperation and interest. They ranged in age from 4 to 29 years, with an average age of 15. Most were of school age and from varied backgrounds. Individual oral hygiene was not a factor in the selection of patients and was not monitored during the investigation.

A total of 40 patients having at least one pair of Class I carious lesions were used for the study sample. Restorations were limited to maxillary and mandibular permanent molars, bicuspid s, and primary molars. Posterior bitewing radiographs of the study teeth were taken to substantiate that the selected lesions were confined to the occlusal surface. A record was completed prior to cavity preparation as to whether the tooth was in occlusion. Each pair consisted of one Dispersalloy restoration and one Twentieth Century Fine Cut Alloy restoration. The following plan was designed for this study.

Group I
- 40 Dispersalloy restorations polished
- 40 Dispersalloy restorations unpolished

\(^a\)Dispersalloy, Dental Products Company, Johnson and Johnson, East Windsor, New Jersey.

\(^b\)Twentieth Century Fine Cut Alloy, L. D. Caulk Company, Milford, Delaware.
Clinical Procedure
1. Cavity Preparation

The following principles of cavity preparation as outlined by McDonald were used.

a. Cavity preparations should be extended sufficiently to include all pits and fissures. The preparation should include those areas that have carious involvement and in addition, those that will retain food and plaque material and may be considered as areas of potential carious involvement.

b. The cavity walls and base of the preparation should be essentially parallel and perpendicular to a flat pulpal floor.

c. Rounded angles throughout the preparation will result in less concentration of stresses and will permit more complete condensation of the amalgam restorative material into the extremities of the preparations.

d. The depth of the occlusal portion of the preparation should be carried approximately .5 mm. pulpal from the dentinoenamel junction.

e. Enamel walls are that portion of the lateral cavity walls that are in or are composed of enamel. These walls are to be supported by sound dentin and are to be composed of complete enamel rods from the cavo-

surface angle to the dentinoenamel junction.

The technique of the operator who placed the restorations was standardized in the laboratory with respect to cavity preparation and amalgam condensation prior to the start of the clinical study.

Following the administration of a local anesthetic, preparations were made by the same clinician, with the rubber dam in place at all times. Air cooling from the air turbine handpiece was utilized. The following carbide burs were used for the cavity preparations.
A Number 245 fissure bur with the high speed air turbine handpiece was positioned perpendicular to the preparation base, and the lateral cavity walls were reduced and extended to the desired plane and location. A Number 2 or 4 round bur was used with the slow speed contra-angle handpiece to remove any remaining carious material.

The Number 245 fissure bur was used with the slow speed air turbine contra-angle handpiece to remove any overhanging enamel and ensure that the walls of the preparation were essentially parallel and perpendicular to a flat pulpal floor.

If pulpal protection was necessary in deep-seated cavities, a calcium hydroxide base was placed.

All preparations were coated with a cavity varnish and re-applied once, using a cotton pellet to apply the material, prior to the placement and condensation of the alloy. The cavity varnish was permitted to coat the cavosurface angle.

2. Determination of the Alloy to be Placed

The choice of which alloy to be used for each pair of preparations was determined by the dental assistant, who used a random table. The restorations were placed by the same clinician, and he was unaware of which material he was using. The random table was also used to determine which restorations would be polished.

\textsuperscript{a}Dycal, L. D. Caulk Company, Milford, Delaware.

\textsuperscript{b}Copalite, H. J. Bosworth Corporation, Chicago, Illinois.
3. Material Preparation and Placement

The mercury/alloy ratio was 1:1 for both alloys. Trituration was 12-14 seconds using a capsule and a cylindrical metal pestle\(^a\) in a high speed amalgamator.\(^d\) No mercury was expressed from the mass and the alloy was placed in a metal well to facilitate handling with the amalgam carrier. If one mix was not sufficient to restore the tooth, a second mix was made. The amalgam was condensed by hand using Black's Number 1 and 2 condensors. The preparation was overfilled. The amalgam was burnished with an "appleseed" ball burnisher and the back of the size 0 condenser until it appeared homogeneous and smooth.

4. Carving and Finish of the Restoration

The restorations were carved to ideal occlusal form with small discoids, cleoids, and blade carvers. The margins were then reburnished with the back of the size 0 condenser. When the restorations were completed, the rubber dam was removed and the restorations were carefully checked and adjusted for proper occlusion using articulating paper. Any dark blue records on the freshly carved amalgam were eliminated with a carver. The restorations were then smoothed with a wet cotton roll. A record was made at this time and at every future evaluation as to whether the restoration was in occlusion at the margins.

5. Polish of the Restorations

Restorations were polished not earlier than 48 hours after insertion. The rubber dam was in place throughout the polishing procedure. The

---

\(^a\)S. S. White Company, green nylon capsule and metal pestle.

\(^b\)Wig-L-Bug, Crescent Dental Manufacturing, Chicago, Illinois.
pairs of restorations to be polished were determined from a random table. In Group I, 41 of the Dispersalloy restorations were polished and 39 were not polished. In Group II, 44 of the Fine Cut alloy restorations were polished and 40 were not polished. Every effort was made for each patient to have one Dispersalloy restoration polished and one not polished, and also to have one Twentieth Century Fine Cut alloy restoration polished and one not polished.

The following standardized technique was used for polishing all selected restorations, with care being taken not to overheat the alloy:

a. Number 4 round finishing burs (6 flutes) were used both to establish the final margins and to create the contour and direction of cusp planes.

b. Numbers 1/2 or 1 finishing burs were used to accentuate or produce grooves in the restorations and obtain anatomic harmony with the opposing teeth.

c. Slurries of a mixture of flour of pumice and water were then applied with a rubber cup and pointed brush. The restorations were considered smooth after all scratches were removed.

d. Slurries of a mixture of amalgloss and water with rubber cups were the final polishing agent.

Method of Clinical Evaluation

The restorations were evaluated at one year. Black and white photographs were taken of each restoration at the evaluation period by the investigator. All pictures were taken with a Medical-Nikkor\textsuperscript{a}

\textsuperscript{a}Nikon Incorporated, Garden City, New York.
Auto 200 mm. f/5.6 lens at 1.5x magnification, using 35 mm. film. The pictures were then enlarged to a standard 4 x 5 inch print (Figure 1), and trimmed so that only one restoration appeared on each photograph. The photographs were coded on the back as to patient, alloy, polish or non-polish, and the evaluation period.

The photographs were examined and evaluated for marginal breakdown. All restorations were first evaluated for marginal breakdown by the Ridit Analysis. The method of analysis was described by Mahler, Terkla, Van Eysden, and Reisbick. Each examiner compared each photograph with a series of five photographs depicting restorations with increasing degrees of marginal deterioration (Figure 2). He then placed each photograph into one of four groups of marginal breakdown.

The photographs were also examined and evaluated by the Rank Ordering Analysis. All photographs were ranked in descending order on the basis of the marginal breakdown of the restoration. In other words, the best was 1, next best was 2, and so on. Three examiners ranked the restorations, without knowledge of study group identification or one another's evaluation.
Ridit Analysis

The results of the photographic evaluation are shown in Table I. Some photographs were of poor quality and could not be used for evaluation and a few patients did not respond to recall appointments. Therefore, of the 164 total restorations placed, 33 were eliminated from the study resulting in a total of 131 photographs for analysis. This explains the discrepancy in the number of restorations used in the study and the number used in the evaluation. The distribution of the two alloy systems and the polish and unpolished techniques were determined by use of the Ridit Analysis. 16 The results of this analysis are shown in Tables II and III.

Student's t-test was applied to the Ridit means to show significant differences in marginal breakdown between the two alloy systems and to compare the polish and nonpolish technique.

For statistically significant differences using the t-test, a t of 2.05 was required at the .05 level, and 2.76 at the .01 level with 29 degrees of freedom (number of pairs minus one, 30 pairs = 29 d.f.). At 63 d.f. a t value of 2.00 was required at the .05 level, and 2.65 at the .01 level.

The results of the Ridit Analysis are as follows. There was no significant difference between the Dispersalloy restorations in the polished and unpolished state in regard to marginal breakdown. Also, there was no significant difference in marginal breakdown of the
Twentieth Century Fine Cut Alloy restorations in the polished and unpolished state. In comparing the polished and unpolished restorations overall, no significant difference was noted.

The Dispersalloy restorations were superior to the Fine Cut Alloy restorations overall, at the .01 level.

In regard to marginal breakdown, the inference to be drawn from these data is that polishing of the amalgam restorations is not critical. The important factor is the choice of alloy systems.

At the one-year evaluation, the Dispersalloy restorations exhibited less marginal breakdown than the Twentieth Century Fine Cut alloy restorations. Polishing did not enhance marginal integrity of either the Dispersalloy or the Fine Cut Alloy restorations one year after placement.

Rank Ordering Analysis

The results of the Rank Ordering analysis are shown by evaluator in Tables IV, V and VI. The Spearman Rho Rank Order Correlation comparison was used to check the agreement among evaluators on the results. The formula is \( \rho = 1 - \frac{6 \sum D^2}{N(N^2-1)} \) where \( D \) is the difference in ranking of subjects by two evaluators and \( N \) refers to number of pairs. The procedure was to assign a rank for each score, take one set of scores and two evaluators at a time, square the difference and do the computations.

Correlations were performed for each type of alloy and technique comparing each pair of evaluators: Evaluator Number 1 versus 2, Evaluator Number 1 versus 3, and Evaluator Number 2 versus 3. The differences in rank are shown in Table VII. The coefficients of correlation between evaluators on each category using the Spearman Rho
Rank Order Correlation are shown in Table VII. The correlations extend from .1571 which is not significant, to .7947, which is significant well beyond the .01 level. All but two were significant. Thus there was a high level of agreement between the evaluators.
FIGURES AND TABLES
FIGURE 1. Occlusal view of amalgam restorations.
FIGURE 2. Series of photographs used for the Ridit Analysis.
<table>
<thead>
<tr>
<th>Alloy</th>
<th>Technique</th>
<th>Evaluator</th>
<th>Categories</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>Dispersalloy</td>
<td>Polished</td>
<td>1</td>
<td>7 17 5 1</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>6 16 8 0</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>8 18 4 0</td>
<td>30</td>
</tr>
<tr>
<td>Dispersalloy</td>
<td>Unpolished</td>
<td>1</td>
<td>7 21 6 0</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>7 21 6 0</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>9 21 4 0</td>
<td>34</td>
</tr>
<tr>
<td>Fine Cut</td>
<td>Polished</td>
<td>1</td>
<td>2 17 15 2</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>0 18 15 3</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>3 18 13 2</td>
<td>36</td>
</tr>
<tr>
<td>Fine Cut</td>
<td>Unpolished</td>
<td>1</td>
<td>2 17 9 3</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>0 16 13 2</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>2 15 12 2</td>
<td>31</td>
</tr>
</tbody>
</table>
### TABLE II

RIDIT ANALYSIS RESULTS

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Technique</th>
<th>N</th>
<th>R</th>
<th>S</th>
<th>Sx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispersalloy</td>
<td>Polished</td>
<td>30</td>
<td>.4136</td>
<td>.2521</td>
<td>.04814</td>
</tr>
<tr>
<td>Dispersalloy</td>
<td>Unpolished</td>
<td>34</td>
<td>.3967</td>
<td>.2307</td>
<td>.04016</td>
</tr>
<tr>
<td>Fine Cut</td>
<td>Polished</td>
<td>36</td>
<td>.5944</td>
<td>.2462</td>
<td>.04162</td>
</tr>
<tr>
<td>Fine Cut</td>
<td>Unpolished</td>
<td>31</td>
<td>.5881</td>
<td>.2460</td>
<td>.04491</td>
</tr>
<tr>
<td>Both</td>
<td>Polished</td>
<td>66</td>
<td>.5036</td>
<td>.1884</td>
<td>.02337</td>
</tr>
<tr>
<td>Both</td>
<td>Unpolished</td>
<td>65</td>
<td>.4823</td>
<td>.2875</td>
<td>.03594</td>
</tr>
<tr>
<td>Dispersalloy</td>
<td>Both</td>
<td>64</td>
<td>.4203</td>
<td>.2405</td>
<td>.03029</td>
</tr>
<tr>
<td>Fine Cut</td>
<td>Both</td>
<td>67</td>
<td>.5887</td>
<td>.2455</td>
<td>.03022</td>
</tr>
</tbody>
</table>

### TABLE III

RIDIT ANALYSIS COMPARISONS

<table>
<thead>
<tr>
<th>Alloy and Technique</th>
<th>S</th>
<th>D</th>
<th>t</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP vs DUnP</td>
<td>.06168</td>
<td>.0169</td>
<td>0.2740</td>
<td>N. S.</td>
</tr>
<tr>
<td>FP vs DP</td>
<td>.06264</td>
<td>.1803</td>
<td>2.2863</td>
<td>**</td>
</tr>
<tr>
<td>FUnP vs DP</td>
<td>.06488</td>
<td>.1745</td>
<td>2.6857</td>
<td>*</td>
</tr>
<tr>
<td>FP vs DUnP</td>
<td>.05784</td>
<td>.1977</td>
<td>3.4183</td>
<td>**</td>
</tr>
<tr>
<td>FUnP vs DUnP</td>
<td>.06025</td>
<td>.1914</td>
<td>3.1768</td>
<td>**</td>
</tr>
<tr>
<td>FP vs FUnP</td>
<td>.06123</td>
<td>.0063</td>
<td>0.1023</td>
<td>N. S.</td>
</tr>
<tr>
<td>Polish vs Unpolish</td>
<td>.04237</td>
<td>.0213</td>
<td>0.4068</td>
<td>N. S.</td>
</tr>
<tr>
<td>Fine Cut vs Disp.</td>
<td>.04279</td>
<td>.1634</td>
<td>3.9353</td>
<td>**</td>
</tr>
</tbody>
</table>

* significant at the .05 level  
** significant at the .01 level

- **DP** - Dispersalloy restorations polished  
- **DUnP** - Dispersalloy restorations unpolished  
- **FP** - Twentieth Century Fine Cut Alloy restorations polished  
- **FUnP** - Twentieth Century Fine Cut Alloy restorations unpolished
TABLE IV

RANK ORDERING OF EVALUATOR 1

<table>
<thead>
<tr>
<th>Dispersalloy Polished</th>
<th>Dispersalloy Unpolished</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 29 64</td>
<td>2 38 66 97</td>
</tr>
<tr>
<td>6 31 68</td>
<td>3 40 67 101</td>
</tr>
<tr>
<td>7 32 85</td>
<td>4 42 71 115</td>
</tr>
<tr>
<td>10 34 98</td>
<td>13 46 72 120</td>
</tr>
<tr>
<td>11 45 100</td>
<td>15 49 73</td>
</tr>
<tr>
<td>18 48 102</td>
<td>16 51 75</td>
</tr>
<tr>
<td>21 50 105</td>
<td>17 60 76</td>
</tr>
<tr>
<td>24 52 106</td>
<td>30 61 78</td>
</tr>
<tr>
<td>26 55 110</td>
<td>33 62 90</td>
</tr>
<tr>
<td>27 59 122</td>
<td>37 63 91</td>
</tr>
</tbody>
</table>

Mean score = 51.53

<table>
<thead>
<tr>
<th>Dispersalloy Polished</th>
<th>Dispersalloy Unpolished</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 54 88 118</td>
<td>5 74 99 128</td>
</tr>
<tr>
<td>14 56 93 119</td>
<td>9 77 107</td>
</tr>
<tr>
<td>23 57 96 123</td>
<td>12 80 108</td>
</tr>
<tr>
<td>35 65 103 129</td>
<td>19 83 111</td>
</tr>
<tr>
<td>36 69 104 130</td>
<td>20 84 114</td>
</tr>
<tr>
<td>39 70 109 131</td>
<td>22 87 121</td>
</tr>
<tr>
<td>41 79 112</td>
<td>25 89 124</td>
</tr>
<tr>
<td>43 81 113</td>
<td>28 92 125</td>
</tr>
<tr>
<td>44 82 116</td>
<td>53 94 126</td>
</tr>
<tr>
<td>47 86 117</td>
<td>58 95 127</td>
</tr>
</tbody>
</table>

Mean score = 78.6

Mean score = 55.1

Mean score = 77.3

*The highest quality restoration regardless of type was ranked number 1, the second highest was number 2, through the total of 131 restorations.
TABLE V

RANK ORDERING OF EVALUATOR 2

<table>
<thead>
<tr>
<th>Dispersalloy Polished</th>
<th>Dispersalloy Unpolished</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 32 81</td>
<td>2 28 69 118</td>
</tr>
<tr>
<td>5 39 83</td>
<td>3 29 71 119</td>
</tr>
<tr>
<td>6 40 95</td>
<td>4 34 72 124</td>
</tr>
<tr>
<td>8 41 97</td>
<td>7 46 73 126</td>
</tr>
<tr>
<td>11 43 101</td>
<td>9 48 74</td>
</tr>
<tr>
<td>13 51 102</td>
<td>10 53 75</td>
</tr>
<tr>
<td>14 63 104</td>
<td>12 55 76</td>
</tr>
<tr>
<td>15 64 109</td>
<td>21 56 79</td>
</tr>
<tr>
<td>19 70 120</td>
<td>23 57 107</td>
</tr>
<tr>
<td>25 78 125</td>
<td>27 59 114</td>
</tr>
</tbody>
</table>

Mean score = 55.2

<table>
<thead>
<tr>
<th>Fine Cut Polished</th>
<th>Fine Cut Unpolished</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 50 87 113</td>
<td>18 62 105 131</td>
</tr>
<tr>
<td>17 52 89 116</td>
<td>22 65 108</td>
</tr>
<tr>
<td>20 54 91 122</td>
<td>31 66 110</td>
</tr>
<tr>
<td>24 58 92 123</td>
<td>35 68 111</td>
</tr>
<tr>
<td>26 60 93 127</td>
<td>37 77 112</td>
</tr>
<tr>
<td>30 67 96 129</td>
<td>38 86 115</td>
</tr>
<tr>
<td>33 80 98</td>
<td>42 88 117</td>
</tr>
<tr>
<td>36 82 99</td>
<td>44 90 121</td>
</tr>
<tr>
<td>45 84 103</td>
<td>47 94 128</td>
</tr>
<tr>
<td>49 85 106</td>
<td>61 100 130</td>
</tr>
</tbody>
</table>

Mean score = 73.7

Mean score = 79.3
TABLE VI

RANK ORDERING OF EVALUATOR 3

<table>
<thead>
<tr>
<th>Dispersalloy Polished</th>
<th>Dispersalloy Unpolished</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>21</td>
<td>2</td>
</tr>
<tr>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>32</td>
<td>6</td>
</tr>
<tr>
<td>38</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Mean score = 54.9</td>
</tr>
<tr>
<td>Fine Cut Polished</td>
<td>Fine Cut Unpolished</td>
</tr>
<tr>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>20</td>
<td>29</td>
</tr>
<tr>
<td>23</td>
<td>34</td>
</tr>
<tr>
<td>31</td>
<td>36</td>
</tr>
<tr>
<td>35</td>
<td>37</td>
</tr>
<tr>
<td>46</td>
<td>42</td>
</tr>
<tr>
<td>51</td>
<td>44</td>
</tr>
<tr>
<td>58</td>
<td>45</td>
</tr>
<tr>
<td>64</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Mean score = 80.4</td>
</tr>
<tr>
<td></td>
<td>Mean score = 77.3</td>
</tr>
</tbody>
</table>
### TABLE VII

**SPEARMAN RHO RANK ORDER COEFFICIENTS OF CORRELATION BETWEEN EVALUATORS**

<table>
<thead>
<tr>
<th>Alloy and Technique</th>
<th>Evaluator</th>
<th>Total</th>
<th>$\xi^2$</th>
<th>Coefficient</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispersalloy Polished</td>
<td>1-2</td>
<td>2047</td>
<td>.5446</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-3</td>
<td>2812</td>
<td>.3744</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-3</td>
<td>2487</td>
<td>.4467</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>Dispersalloy Unpolished</td>
<td>1-2</td>
<td>2524</td>
<td>.6144</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-3</td>
<td>4801</td>
<td>.2665</td>
<td>**</td>
<td>N. S.</td>
</tr>
<tr>
<td></td>
<td>2-3</td>
<td>3397</td>
<td>.4810</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>Fine Cut Polished</td>
<td>1-2</td>
<td>1864</td>
<td>.7389</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-3</td>
<td>1972</td>
<td>.7238</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-3</td>
<td>2884</td>
<td>.5961</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>Fine Cut Unpolished</td>
<td>1-2</td>
<td>2777</td>
<td>.3822</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-3</td>
<td>3789</td>
<td>.1571</td>
<td>N. S.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-3</td>
<td>923</td>
<td>.7947</td>
<td>**</td>
<td></td>
</tr>
</tbody>
</table>

* - significance at the .05 level  
** - significance at the .01 level  
N. S. - nonsignificant
At least one study has indicated that there are four million new untreated cavities that occur each year in the United States. Phillips and associates have reported that dental amalgam still accounts for 80 percent of all the dental restorations. Much research has been conducted with dental amalgam in attempts to improve it as a restorative material. One factor that has not received much attention in the past is the correlation between polishing amalgam restorations and marginal integrity. Polishing amalgam restorations is advocated by many experts and taught in the dental schools of the United States. A clinical study to evaluate the effectiveness of polishing amalgam restorations in relation to marginal integrity would be a contribution to dental scientific knowledge.

One of the first items to be considered in conducting a clinical study was patient selection. The patients have to be dependable and available for future evaluation. The patients chosen for this study lived within a reasonable distance from the dental school. They all had jobs or backgrounds that would enable them to be living in the community for three years.

In an investigation of this kind, the technique of restoring the teeth with dental amalgam and the polish of the restorations must be standardized. Every tooth was prepared and restored in as similar a fashion as possible. The same types of instruments and burs were used for each tooth. A standard technique was used for amalgam placement and carving. The restorations to be polished all received the same order of
abrasives to produce the desired finish. In this study a tray set up system was used so that the same type of instruments could be used for each patient.

Osborne and co-workers\(^6\) have reported success in using the photographic evaluation of dental amalgam restorations. However, using it as the measure of marginal breakdown has its disadvantages. First, the photographic equipment is expensive, and better than average photographic skills are required. Taking these pictures requires a trained dental assistant to retract the oral tissues and maintain the tooth in a dry condition. The last point deserves emphasis: The tooth and restoration must be absolutely dry before a photograph of the quality necessary for proper evaluation can be produced.

The alloys selected for this study were Dispersalloy and Twentieth Century Fine Cut Alloy. Dispersalloy has been reported\(^{16,17,69,70}\) to be a clinically superior alloy which exhibits low marginal breakdown. The Twentieth Century Fine Cut Alloy has a higher creep value than Dispersalloy and thus is generally associated with more marginal breakdown. The study could have been expanded to use several other alloys and to see what part the selection of alloys may have played.

Osborne and Gale\(^7\) in a clinical study compared the marginal breakdown of two dental amalgam alloys over a period of three years. The results showed comparable marginal breakdown rates for the two alloy systems. However, the three dentists who placed the restorations had notable differences in marginal breakdown rates for their restorations. This study probably would have benefitted by the addition of one or two dentists.
The two correlations between evaluators that were not significant can be explained by the fact that one of the evaluators was a novice.

The results of this study show that the Dispersalloy system is superior to the Twentieth Century Fine Cut Alloy. Polishing the restorations did not significantly influence their subsequent marginal breakdown.

However, this does not justify the inference that polishing procedures should be discontinued for dental amalgam restorations. On the issue of polishing amalgams, there are other factors to be considered besides marginal breakdown. Polishing certainly contributes to the periodontal health of the patient in many instances. Also, the occlusion can be corrected for high spots that can occur as a result of the restoration.

A critical look at this study suggests avenues of further investigation that should be considered before the benefits of polishing amalgam restorations can be resolved. One such avenue would be a clinical study of Class II amalgam restorations, preferably a clinical study of at least three years.
SUMMARY AND CONCLUSIONS
The effect of polishing procedures on the marginal breakdown of two dental amalgams, Dispersalloy and Twentieth Century Fine Cut Alloy, was investigated. Class I cavity preparations were used as the type of restoration for the evaluation, which was performed by examining enlarged black and white photographs of the restorations.

The results of the clinical study at the one-year evaluation are as follows:

1. The Dispersalloy restorations had less marginal breakdown than the Twentieth Century Fine Cut Alloy restorations.

2. The Dispersalloy restorations showed no significant difference in marginal breakdown when they were polished or unpolished.

3. The Twentieth Century Fine Cut Alloy restorations showed no significant difference in marginal breakdown when they were polished or unpolished.

4. In comparing the polished and unpolished restorations overall, no significant difference was noted in marginal breakdown.


50. Black, G. V.: An investigation of the physical characters of the human teeth in relation to their disease, and to practical dental operations, together with the physical characters of filling materials. D Cosmos 47:673, 1895.


CURRICULUM VITAE
GEORGE AUSTIN ADAMS

July 28, 1949
Born to Catherine and Bellwood C. Adams
New Albany, Indiana

1964-1967
New Albany High School
New Albany, Indiana

1967-1970
University of Kentucky
Lexington, Kentucky

December 30, 1971
Married Joy Bramblett

December 26, 1972
Son born, George Austin Jr.

1970-1974
Indiana University School of Dentistry
Indianapolis, Indiana

May 19, 1974
D.D.S., Indiana University
School of Dentistry
Indianapolis, Indiana

1974-1976
Graduate student, Department of Pedodontics
Indiana University School of Dentistry
Indianapolis, Indiana

September 13, 1976
Daughter born, Elizabeth Joy

1976-1977
Private Pedodontic Practice

Present address
Nashville, Tennessee

Professional Societies
American Academy of Pedodontics
American Dental Association
American Society of Dentistry for Children
Indiana University Pedodontic Alumni Association
Nashville Dental Society
Southeastern Society of Pedodontists
Tennessee Dental Association
ABSTRACT
A CLINICAL EVALUATION OF THE EFFECT
OF POLISHING PROCEDURES ON THE
MARGINAL BREAKDOWN OF TWO DENTAL AMALGAMS

by

George A. Adams

The investigation was undertaken to determine the effects of the polishing and finishing of dental amalgam in relation to its marginal breakdown. The study was also conducted to make a clinical comparison of the marginal integrity of Dispersalloy restorations as compared to Twentieth Century Fine Cut Alloy restorations in both the polished and unpolished state.

Forty patients with a total of 131 Class I amalgam restorations were used as the study group. The two alloy systems and polish or unpolish techniques were selected from a random table. Photographic evaluation of the restorations was used to judge the degree of marginal breakdown.

The results of the study at the one-year evaluation show two main findings: (1) the Dispersalloy restorations showed less marginal breakdown than the Twentieth Century Fine Cut Alloy restorations, and (2) there was no significant difference between the polished and unpolished restorations overall.