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Aim and Scope

Operative Dentistry publishes articles that advance the practice of operative dentistry. The scope of the journal includes conservation and restoration of teeth; the scientific foundation of operative dental therapy; dental materials; dental education; and the social, political, and economic aspects of dental practice. Review papers and letters also are published.

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EDITORIAL

We Have Met the Enemy

The major changes that have occurred in the practice of dentistry in the past 20 years or so have not all been universally acclaimed. Some of the innovations, such as the air-turbine handpiece and the elastomeric impression materials, are undoubted successes, and most dentists so rate them. Dental insurance, third parties, and expanded duties for dental hygienists and dental assistants have been accorded a mixed reception. Allowing dental technicians to provide dentures directly to the public has been generally condemned.

Usually the blame for introducing unpopular measures is directed outside the dental profession. Those subject to disapproval may be the government, industry, trade unions, insurance companies, or even the people themselves. Take the case of the denturists. This change was initiated by dental technicians who were able to influence the government sufficiently to bring the matter before the public. On the promise of lower fees for dentures the public supported the technicians in their bid for licensure. Note, however, it was the technicians—not the public—that clamored for the change.

Dental technicians provide a valuable service for dentists and are a necessary adjunct to the practice of dentistry. Over the years, however, for various reasons, including inadequate skill, insufficient training, laziness, and shortsightedness focused mainly on short-term economic motives rather than the maintenance of professional standards, dentists have asked technicians to supply services which, more properly, should be provided by the dentist. The rest is history. Dentists have given away the construction of dentures.

The introduction of expanded functions for dental hygienists and dental assistants presents a somewhat similar phenomenon. In this instance the impetus was provided mainly by academic dentists supported by hygienists and assistants—again not by a clamoring public. This time it is operative dentistry that is in jeopardy.

Nor would the story differ much for the introduction of national health insurance. Neither was it different in the establishment of dental licensure, which was obtained through the efforts of dentists, not the public. Nevertheless, we are frequently told that our privilege to practice dentistry has been granted by society and we must obey its wishes or society will revoke the privilege. This is unlikely. The danger lies elsewhere. We have met the enemy and they are us.

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Microstructure of Posterior Restorations of Composite Resin after Clinical Wear

The worn surfaces of restorations of composite resin exhibit roughness that can be attributed to loss of particles of filler, wear of the resin matrix, and exposure of porosities.

WILLIAM J O'BRIEN • JAMES YEE, JR

Summary

Examination of the worn surfaces of restorations of composite resins reveals that wear results from fracture and loss of particles of filler, wear of the resin matrix, failure of the matrix through cracking, and exposure of entrapped bubbles of air.

Introduction

Class 2 restorations of composite resin materials wear substantially more than do those of amalgam (Phillips & others, 1973). Recently there has been interest in learning more about the mechanism of this process of wear. One approach has been to study clinical wear by means of replicas (Kusy & Leinfelder, 1977); another has been to correlate microstructure with wear in the laboratory (Draughn & Harrison, 1978). In this study scanning electron microscopy was used to examine 10 worn restorations, from different patients, that had been removed after being in the mouth from three to eight years. The purpose was to look for indications of the mechanisms of wear rather than to determine the amount of material lost.

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Presented at the annual meeting of the International Association for Dental Research on March 31, 1979, in New Orleans.

Methods

The restorations were carefully removed from the cavities in the teeth and wrapped in a moist towel until examination. The restorations were then coated with gold and examined with a scanning electron microscope.

Results and Discussion

Four major types of surface failure were identified: loss of particles of filler, wear of polymer matrix, cracking of the polymer matrix, and exposure of entrapped bubbles of air.

Figure 1 is a 300X view of the surface of a class 2 restoration of Prestige (Lee Pharmaceuticals, El Monte, CA 91733, USA), which was placed in 1974 and removed in 1977 because of recurrent caries. Spherical particles of filler are seen, as well as craters, which indicate the loss of particles by dislodgment. The fibrous material on the surface is plaque. Figure 2 is a 1000X view of one of these craters showing the exposed opening of a pore, which most likely resulted from a bubble of air.

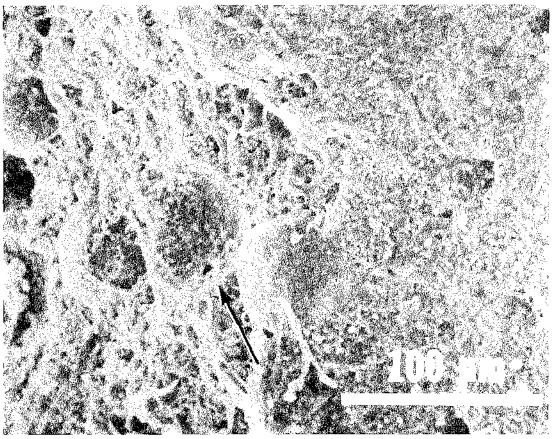

FIG 1. *Loss of spherical particles of filler (X300)*

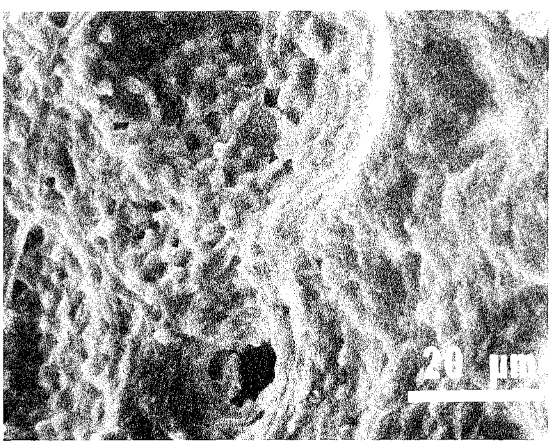

FIG 2. *Craters formed by loss of particles of filler. The opening of a pore at the base of crater is seen. The fibrous material on the surface is plaque. (X1000)*

Figure 3 is a 1000X view of the surface of a class 2 restoration of Adaptic (Johnson & Johnson Dental Products Co, East Windsor, NJ 08520, USA) placed in 1972 and removed in 1977 because of fracture of the occlusal surface. Particles of filler, held firmly in place, are shown protruding above a worn matrix. No plucking of the particles similar to that in Figure 1 is seen. The shape of the particles is irregular because the filler is ground quartz.

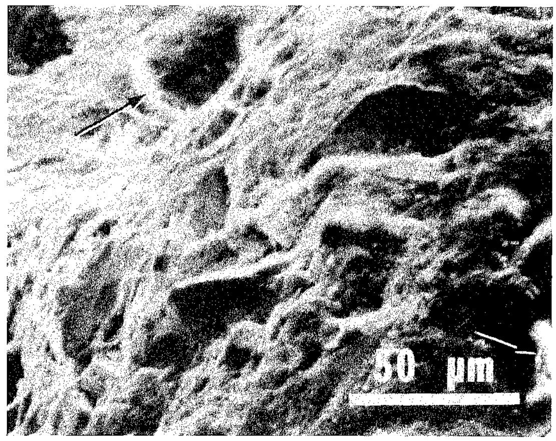

FIG 3. *Firmly held particles of filler and crazing in lower right and upper left corners (X1000)*

Figure 4 is a view of a region on the surface of the same restoration that shows a depressed area containing a network of microcracks. They are outlined in white by the

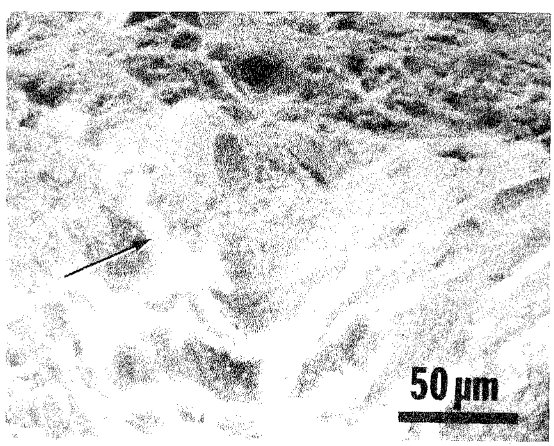

FIG 4. *Crazing in depressed area (center)*

charging of the electron beam. The gold coating does not penetrate well into these cracks, thus the polymer walls are nonconductors and lead to charging. Figure 5 is a view of an exposed pore surrounded by microcracks. The cracks adjacent to the pore may result from concentrations of stress around the pore. Figure 6 is a 2500X view of these cracks.

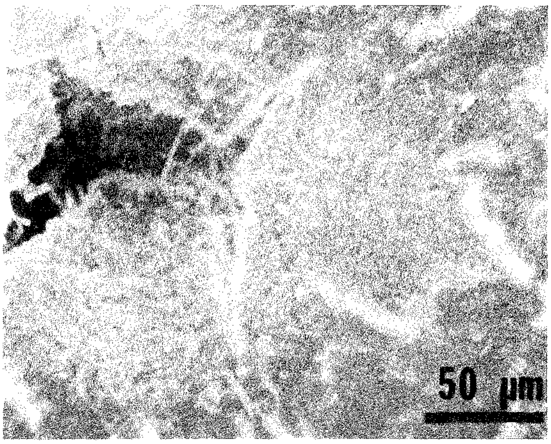

FIG 5. *Occlusal surface of worn restoration of composite showing crazing around a pore*

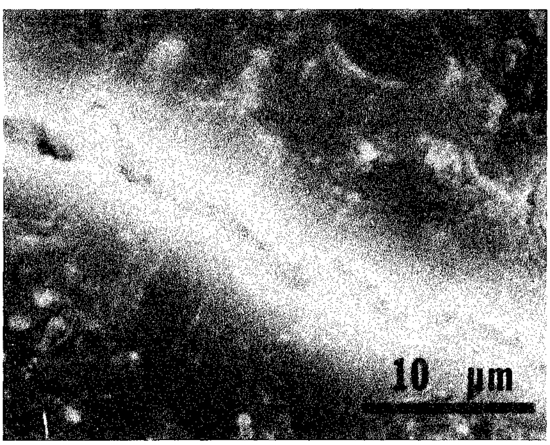

FIG 6. *Worn occlusal surface showing a microcrack (X2500)*

All illustrations are scanning electron micrographs

Figure 7 is an interesting view of the occlusal surface (upper area) and the cavity surface (lower area) of this restoration. Protruding particles of filler are seen on the occlusal surface and voids appear on the cavity surface.

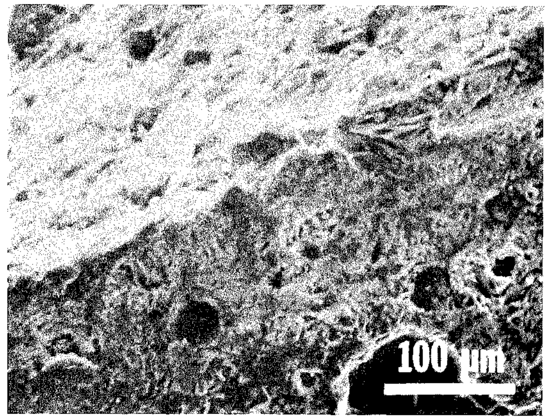

FIG 7. *Worn class 2 restoration showing cavity surface (lower) and occlusal surface (upper)*

Voids, depressed areas, and microcracks are seen on the surface of another restoration of Adaptic that had been placed in 1975 and removed in 1977. Figure 8 is a 300X view of the surface showing protruding particles of filler as well as craters apparently left by exposed bubbles of air. A microcrack contacting

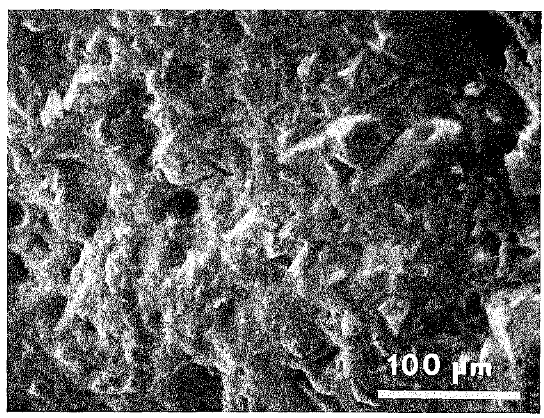

FIG 8. *Occlusal surface of composite resin showing a depression with microcracks (X300)*

a protruding particle of filler is seen in Figure 9, a 1000X view of an area on the worn surface. A depressed area containing microcracks is shown in Figure 10. Other microcracks are seen adjacent to this area.

Microcracks were found on the worn surface of another class 2 restoration of Adaptic placed in 1974 and removed in 1978. A depressed area visible in Figure 11 is outlined by a microcrack and smaller microcracks are seen in the bottom of the depression.

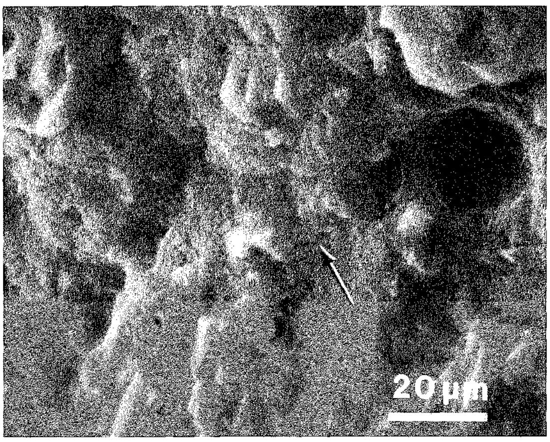

FIG 9. *Worn surface showing a protruding particle of filler with an adjacent microcrack (X1000)*

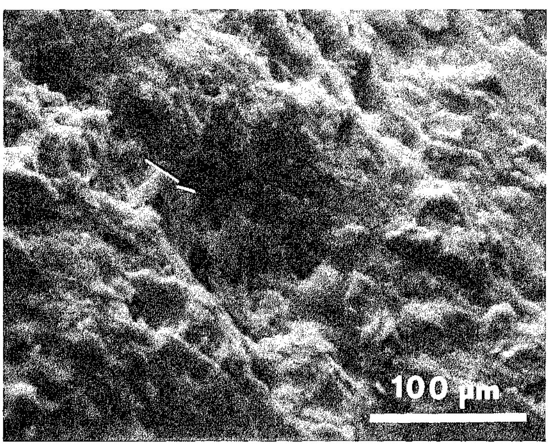

FIG 10. *Worn occlusal surface of a composite restoration showing a depressed area with microcracks (X300)*

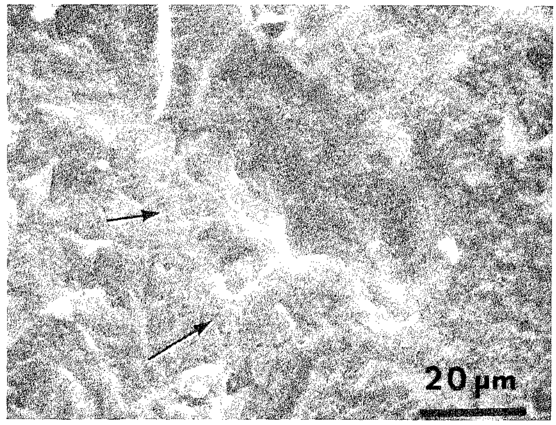

FIG 11. *Occlusal surface of composite resin showing depressed area outlined by microcracks*

Figure 12 is a 1000X view of an exposed void on the occlusal surface of this restoration.

The location of the microcracks only around areas of high stress and surface damage supports the conclusion that the cracks were involved in the wear process. If they had been artifacts introduced as a result of drying during the preparation for electron microscopy, a more random distribution would be likely. It is also unlikely that surfaces showing extensive damage would not show evidence of microcracks.

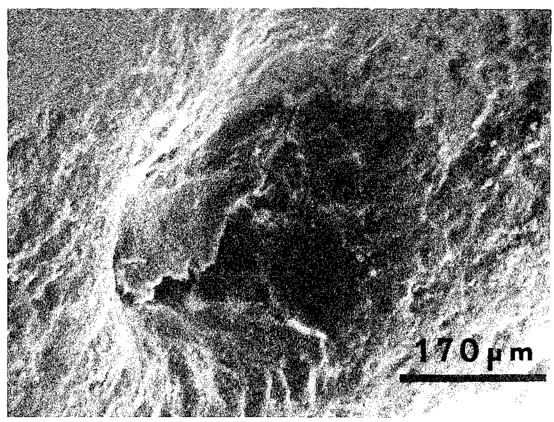

FIG 12. *A void on occlusal surface of four-year-old composite restoration (X1000)*

Conclusions

On the basis of the observations on microstructure noted in this study, and on previous observations, wear of restorations of composite resin may result from the following mechanisms (Fig 13):

- Wear of the resin matrix
- Loss of filler by failure of its bond to the matrix
- Loss of filler through shearing of exposed particles
- Loss of filler through cracking and failure of the matrix
- Exposure of air bubbles

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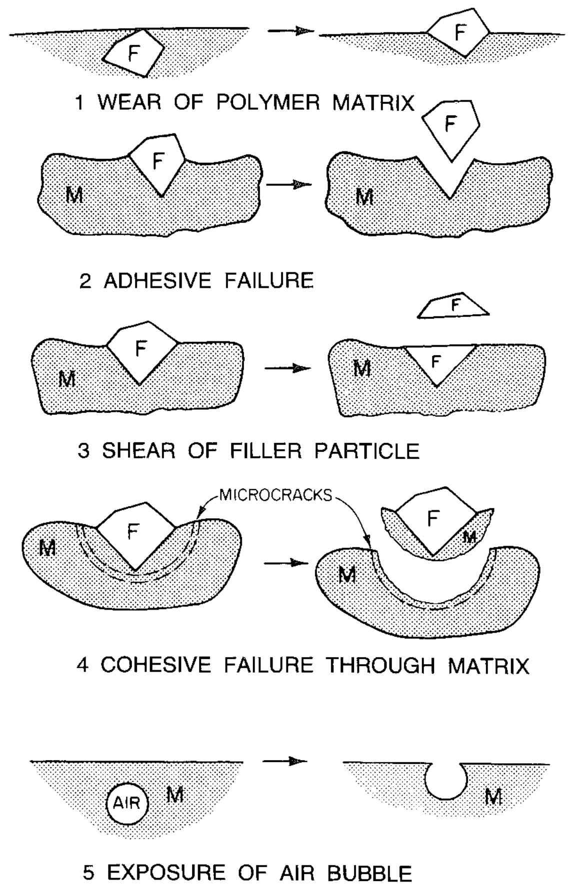

FIG 13. *Classification of possible mechanisms of wear of composite restorations*

Influence of Matrix Bands, Dehydration, and Amalgam Condensation on Deformation of Teeth

Circumferential matrix bands when tightened around a tooth can deform the crown elastically, but dehydration of less than four hours and condensation of amalgam have no deforming effect.

G L POWELL • J I NICHOLLS
M P MOLVAR

Summary

A circumferential matrix band tightened on a tooth with a retainer such as the Tofflemire can deform a tooth with an MOD cavity so that the occlusal portion becomes narrower. The deformation is elastic so the tooth regains its original form when the band is loosened. A custom-made matrix band, a T-band matrix band, or the condensation of amalgam does not deform teeth nor does dehydration unless over four hours. The deformation of the tooth and its subsequent recovery could have an adverse effect on the adaptation of amalgam to the wall of the cavity.

INTRODUCTION

Research has shown that enamel and dentin are elastic (Peyton, Mahler & Hershenov, 1952; Stanford & others, 1958). Research has shown also that tooth structure can be deformed by the load that results from tightening a circumferential matrix band around a tooth, and that the tooth regains its original shape when the matrix band is loosened (Bell, 1977; Powell, Nicholls & Shurtz, 1977). Restorations of amalgam are known to leak at the margins because the amalgam is not adapted tightly to the walls of the cavity. Possibly the deformation of a tooth by the band of a circumferential matrix retainer, such as the Tofflemire (Teledyne Dental, Elk Grove Village, IL 60007, USA) that is held in place by tightening it around the tooth may increase the discrepancy between amalgam and tooth and thus contribute to marginal leakage and marginal fracture of the restoration.

This research was initiated to determine:

1) the amount of elastic deformation of teeth caused by Tofflemire, custom-made, and T-band matrix bands (Tee-bands, PN Condit Co, Warrenton, VA 22186, USA)

2) the time for elastic rebound to occur after the removal of a matrix band from the tooth

3) how much elastic rebound occurs in teeth after the removal of a matrix band

4) if dehydration can cause elastic deformation of teeth

5) if the placement of an expandable amalgam affects the elastic deformation of a tooth that has been caused by the placement of a Tofflemire matrix band.

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METHODS AND MATERIALS

Extracted human teeth were used in this experiment. All teeth were lower molars having standard MOD cavities prepared in them with Nos 34 and 56 carbide burs in a high-speed, air-driven handpiece. The prepared cavities were of various widths at the mesial marginal ridge measured from the cavosurface margin on the facial aspect to the cavosurface margin on the lingual aspect. For ease of handling the teeth were mounted in a dentoform with clear acrylic as the cementing medium. Between tests, all the teeth were stored totally immersed in tap water. The maximum time the test teeth were out of the water for testing was one hour, and between tests a minimum of 24 hours in water was a standard requirement.

By measuring the distance between two triangular markers of lead foil (points A and B, Fig 1) before and after tightening the matrix band, elastic displacement of the tooth could be computed. Since the measured distance between A and B is affected by the orientation of these points in relation to the axis of measurement (Nicholls, 1977), a special jig was used to hold the tooth rigidly in place during measurement.

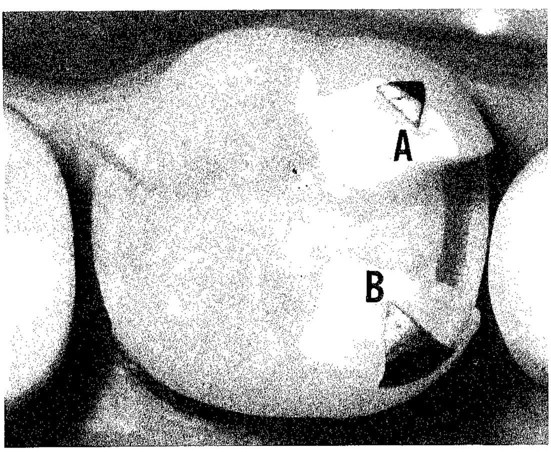

FIG 1. *Triangular markers of lead foil in position*

The positions of points A and B (Fig 1) were measured with a Nikon Optical Comparator (Nikon Inc, Garden City, NY 11530, USA), which is capable of being read to an accuracy of 2 micrometers (μm). By interpolation, however, accuracy can be obtained to 1 μm. To eliminate errors in reading the markers, two precautions were taken: the areas used for the placement of markers were ground flat and parallel to the base as well as to each other (Fig 1), and the markers were aligned parallel to the horizontal axis of the optical comparator and held in that position for all of the measurements on a particular tooth.

All of the cavities were prepared and the markers placed by one operator. Similarly, all of the matrix bands used during an experimental series were applied by one operator.

Once the tooth had been secured in the special jig and placed on the optical comparator, the first measurements were taken. Next, the matrix band was tightened and the second set of measurements taken. Depending on which phase of the experiment was being conducted the matrix band could then be loosened and removed, loosened and retightened, or left on the tooth and amalgam condensed into the cavity. The measurements for these operations could be taken quickly because most of them could be performed while the tooth was on the optical comparator. This allowed for a very small lapse of time between measurements and a short interval of time for the tooth to be out of water.

The format for collecting data and for statistical analysis of a complete set of experimental measurements on any one phase of the procedure is illustrated in Figure 2. This format clearly establishes the independence of the original and final sets of measurements and, in particular, eliminates errors in measuring as the source of the elastic displacement, or deformation, of the tooth. Each of the four sets in Figure 2 contains 10 measurements of the width A-B. Sets 1 and 2 are the measurements taken before tightening the matrix band, and sets 3 and 4 are the measurements taken at some point in the procedure. The two means, 1 and 2, are the mean values of the 20 measurements in each category.

Student's *t* test was used to establish independence of the sets of measurements. For example, in step 1, sets 1 and 2 and sets 3 and 4 were tested for statistical significance to determine if the error of measurement was significant; a statistically significant difference in either test would indicate an unacceptable error. Step 2 required the computation of the means and standard deviations of the 20 measurements in each category. Next, step 3 tested for any significant difference of the means computed in step 2. Each procedure of each phase of the experiment was computed in this fashion. All readings at any one phase on a particular tooth were compared with the original reading on that tooth. This provided a check at various points such as the removal of the matrix band, the placing of amalgam, or the tightening of a matrix band, and served as an additional source to check the accuracy of measurement.

Matrix Bands

Two categories of matrix band were tested: 1) matrix bands retained by circumferential pressure as represented by the Tofflemire matrix band and 2) matrix bands retained passively or without pressure as represented by the custom-made matrix band (Sweeney, 1940) and the T-band matrix band.

Three teeth were selected to confirm the results of a previous experiment with Tofflemire matrix bands (Powell & others, 1977). Cavities were prepared and the teeth marked and stored in tap water for at least 24 hours before the first measurement. Measurements were taken before placing the Tofflemire matrix band, after the band had been placed and tightened, and again after the band had been released and removed. Two teeth were selected on which to observe and measure the effects of a custom-made matrix band and two additional teeth were selected to be used with a T-band matrix band. These last four teeth were tested in a procedure similar to that used for a Tofflemire matrix band and the results compared. The custom-made matrix band was fashioned and applied as suggested by Sweeney (1940). The T-band matrix bands were applied according to the manufacturer's directions.

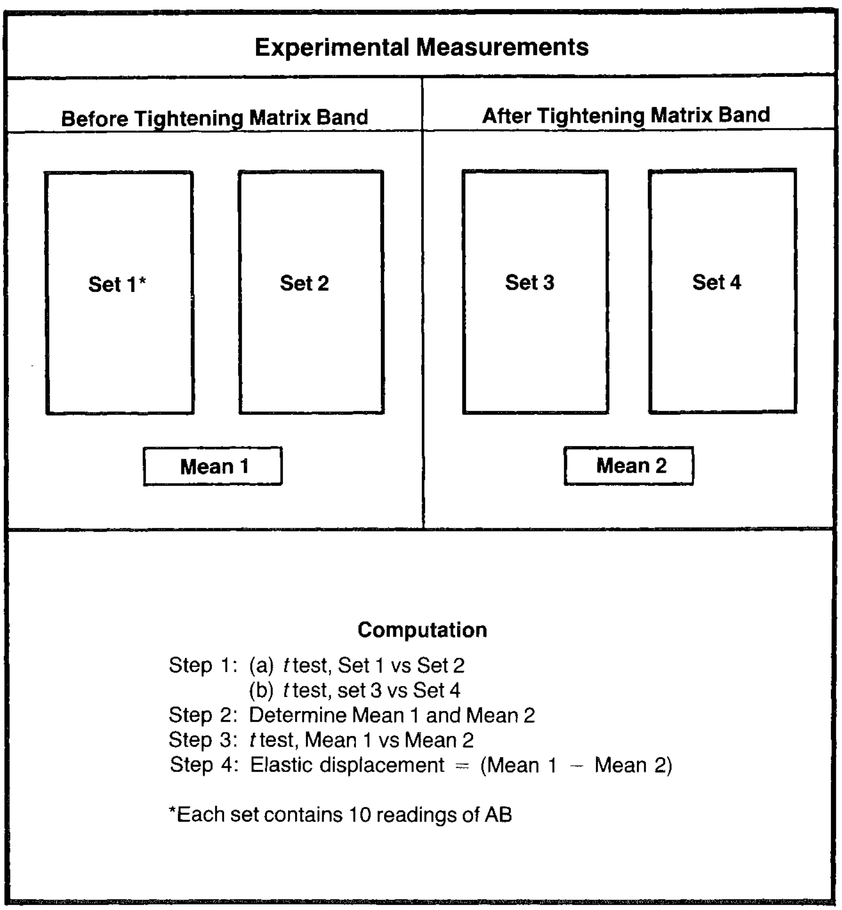

FIG 2. *Determination of elastic displacements*

Dehydration

To test the effects of dehydration, two teeth were prepared with the standard cavity and markers, and mounted in the standard manner. After the initial set of measurements, the tooth remained on the optical comparator and out of water for the next 20 hours. A second set of measurements was taken 30 minutes after removal from the water, and subsequent measurements were taken every hour for the next four hours. Another set of measurements was taken the following morning at the end of the 20 hours of dehydration, giving a total of seven measurements during the 20-hour period. The tooth was then placed back in water for 24 hours and a final set of measurements taken to complete the experiment. This entire procedure was repeated with the second tooth.

Elastic Rebound of Tooth Structure

Because extracted human teeth display elastic deformation and subsequent rebound, an experiment was conducted with four teeth to test the effects of repeated applications of a Tofflemire matrix band. Each of the teeth was prepared and mounted in the standard manner. On two of these teeth a Tofflemire matrix band was applied and released a total of three times. At each application and release of the matrix band, a standard set of 20 measurements was taken. For the two remaining teeth in this experiment the hand pressure applied to tighten the band was altered with each application and designated either 'clinically light' or 'clinically tight' to determine if the elastic deformation could be consciously affected.

Condensation and Expansion of Amalgam

Since it has been suggested that the condensing and the subsequent expansion of an amalgam might affect the action of a Tofflemire matrix band, an experiment was designed to test the effect of condensing amalgams that are known to expand on setting—Dispersalloy, Johnson & Johnson, East Windsor, NJ 08520, USA; and Phasealloy, Phasealloy, Inc, El Cajon, CA 92021, USA (Eames & MacNamara, 1976). Three teeth were prepared and mounted in the standard manner. After the Tofflemire matrix band was applied and the second set of measurements taken, amalgam was condensed into the preparation with hand condensers. Immediately after condensing and carving, a third set of measurements was taken. The matrix band was then removed and a fourth set of measurements recorded. The tooth was placed in water for 45 minutes and a fifth set of measurements taken. Finally the restoration was placed in water and the sixth and final set of measurements made 24 hours later. All measurements were compared with the original set.

RESULTS

Matrix Bands

The experimental results confirm the previous findings that a Tofflemire matrix band, retained by circumferential pressure, causes elastic deformation of tooth structure in individual extracted human teeth. These results are given in Table 1.

Table 1. Elastic Displacement by Tofflemire Matrix Band

Cavity Width	Displacement	
mm	μm	μm · cm^{-1}
2.134	3.7	17.3
2.428	6.1	25.1
2.676	9.4	35.1
3.157	13.9	44.0
3.416	10.6	31.0
3.994	18.5	46.3

Custom-made matrix bands and T-matrix bands tested under the same conditions as the Tofflemire matrix band showed no significant difference between the measured distance A-B, before and after application of either of these two bands. These matrix bands caused no measurable elastic deformation of teeth.

Dehydration

The experiments showed that dehydration has little or no effect on altering the width of the isthmus of the experimental teeth until the tooth has been removed from water for more than four hours. Table 2 demonstrates that a change has taken place after 20 hours and that the change is elastic; it can be completely reversed by hydrating the tooth for 24 hours. This change was found to be in the same direction as that due to the loading by the matrix band.

Table 2. Relation between Dehydration Time and Tooth Deformation (Isthmus Width = 2.654)

Hours from Start	Displacement from Start	
	µm	µm · cm⁻¹
0.5	NS	NS
1.0	NS	NS
2.0	NS	NS
3.0	NS	NS
20.0	25.5	96.1
Hydrated 24 hours	NS	NS

NS (Not Significant)

Elastic Rebound

The elastic rebound of the teeth tested is presented in Table 3. This table shows that when a Tofflemire matrix band is applied the distance A-B contracts. Upon removal of the band the tooth returns to its original position. This elastic rebound is immediate as the measurements were taken immediately after removal of the band. The elastic rebound occurred each time the band was applied and removed.

Table 3. Elastic Rebound (Isthmus Width = 2.676)

Status	Displacement	
	µm	$\mu m \cdot cm^{-1}$
Band off	NS	NS
Band on	11.2	41.8
Band off	NS	NS
Band on	9.4	35.1
Band off	NS	NS

NS (Not Significant)

In addition to the demonstrated effects of the Tofflemire matrix band on teeth (Tables 1 & 3), Table 4 shows than an operator can consciously alter or control the amount of contraction across the width of the isthmus by tightening the band with a greater or lesser amount of clinical pressure or force. The more force ap-

Table 4. Effect of Different Pressures by Tofflemire Matrix Band (Isthmus Width = 2.134)

Status	Displacement	
	µm	$\mu m \cdot cm^{-1}$
Band on light	1.8	8.4
Band off	NS	NS
Band on slightly tight	3.7	17.3
Band off	NS	NS
Band on tight	6.6	30.9
Band off	NS	NS

NS (Not Significant)

plied in tightening the band, the greater the amount of contraction across the isthmus and the greater the resulting elastic deformation.

Condensation and Expansion of Amalgam

Table 5 shows that condensing an amalgam into a cavity does not alter the elastic deformation caused by the Tofflemire matrix band. Also the setting expansion or contraction of these amalgams does not affect the measurable elastic deformation. Both amalgams produced similar results in all of the teeth tested.

Table 5. Effects of Condensation and Expansion of Amalgam (Isthmus Width = 2.658)

Status	Displacement	
	µm	µm · cm^{-1}
Tofflemire band placed	13.3	50.0
Condensed and band on	12.9	48.5
Band removed	NS	NS
45 minutes after band removed	NS	NS
24 hours in water after condensation	NS	NS

NS (Not Significant)

DISCUSSION

The results of this series of experiments confirm earlier research that a matrix band retained by pressure (Tofflemire matrix band) when applied to a class 2 cavity for amalgam can cause elastic deformation of tooth structure. The amount of deformation is affected by at least two factors: the first is the amount of pressure used when applying the matrix band, the second is the width of the cavity. Generally, the greater the width of the cavity or the pressure applied to the band, the greater the deformation across the isthmus. Earlier experiments (Powell & others, 1977) had five dentists apply the matrix bands with normal clinical pressure to a prepared tooth. In each case the tooth contracted across the isthmus and demonstrated elastic deformation. It was decided to use clinical pressure in applying the matrix bands since a measured force in pounds or kilograms is not conveniently transferred to the hands of the practicing dentist. This deformation is truly elastic and repeated application and removal of the matrix band causes predictable contraction and expansion of the tooth structure. Each time the band was removed the tooth rebounded to its original position. It was observed that elastic deformation did not readily take place in some extracted third molars with narrower cavity preparations. This was probably due to the exceedingly thick enamel or the unusual shape of these teeth. All first or second molars used in this experiment, however, showed measurable elastic deformation under the application of a Tofflemire matrix band.

The Tofflemire matrix is designed to constrict and tighten at the cervix of the tooth. We observed that the matrix band contacts and applies pressure to the tooth structure generally at a point occlusally to the cervical floor of the cavity. This allows pressure, or force, to be transferred to the remaining tooth structure at the point of contact, resulting in elastic deformation.

Although teeth are subject to drying and dehydration when a rubber dam is used, the results of our experiments show that dehydration does not affect or cause elastic deformation during the interval of normal operative procedures. Almost all the procedures of restoring teeth with amalgam, including quadrant dentistry, are accomplished in less than two or three hours.

Condensing and carving silver amalgam does not alter the elastic deformation seen with the Tofflemire matrix band, although the use of a contracting alloy may compound the effects of the matrix band and increase the space between tooth and amalgam.

If a Tofflemire matrix band is used, elastic deformation of tooth structure can be reduced by applying as little pressure as possible to the matrix band. This will decrease the effect of contraction and expansion of tooth structure across the width of the isthmus, but may allow amalgam to be forced beyond the proximal cavosurface margins. This excess can be removed with suitable carving instruments. Some dentists feel that this procedure creates a longer-lasting amalgam restoration because the mercury-rich excess is removed much like the excess at the occlusal margins.

A custom matrix band and T-matrix band produced no significant dimensional change across the width of the isthmus. Bearing in mind that amalgam does not adapt perfectly to the walls of the cavity and form a perfect seal, an expanding alloy used in conjunction with a matrix band that does not apply a load to the tooth should produce a restoration with the best possible adaptation of amalgam to tooth.

The advice given almost 40 years ago is still worth considering: "A carelessly-made amalgam always fails. A carefully-made amalgam makes a filling of the highest order. The time consumed is essentially the same" (Sweeney, 1940).

CONCLUSIONS

The results of this experiment should help the practitioner to produce better and longer-lasting amalgam restorations. The conclusions are:

1) Tofflemire matrix bands can cause elastic deformation of extracted human teeth. Generally the tighter the band is applied or the wider the prepared cavity, the greater this deformation.

2) Dehydration does not cause measurable elastic deformation of the tooth during the interval of normal cavity preparation and restoration.

3) Human tooth structure that has been deformed by a matrix band will immediately rebound to its original shape when the band is removed.

4) The condensing of an amalgam alloy into a prepared cavity does not affect the measurable elastic deformation of tooth structure.

5) A custom-made matrix band or a T-matrix band does not cause measurable deformation of teeth.

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Rebonding Composite Resin to Enamel at Sites of Fracture

The shear strength of the rebonding of composite to enamel can equal the strength of the original bond if the surface is re-etched.

DANIEL B BOYER • ABBAS A HORMATI

Summary

The strength of the rebonding of composite resin to enamel from which composite has fractured was measured after repreparing the enamel by (1) rinsing and drying, (2) pumicing, (3) re-etching, (4) pumicing and re-etching, or (5) disking, pumicing, and re-etching. Specimens whose repreparation included re-etching all showed strengths of rebond equal to that of the original bond. Specimens that were rinsed and dried showed strength of rebond somewhat lower than that of the original bond but still relatively high. Specimens that were pumiced but not re-etched showed very low strengths of rebond.

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INTRODUCTION

A few restorations of composite resin retained solely by bonding to etched enamel can be expected to fail as a result of faulty techniques of placement, insufficient area of enamel, use of materials whose shelf life has expired, insufficient or contaminated etch, variations in the structure of enamel, or adverse forces of occlusion. Restorations of incisal edges fail at the rate of 1–5% over periods up to three years (Sheykholeslam, Oppenheim & Houpt, 1976; Dogon, Nathanson & Henry, 1976; Eden & others, 1976; Suzuki, Jordan & Gwinnett, 1976).

Replacing failed restorations retained by etched enamel presents a problem similar to that of replacing pit and fissure sealants and orthodontic brackets bonded to etched enamel. All involve rebonding to enamel that is covered to varying extent with resin and whose superficial layers may contain tags of resin extending 10–50 micrometers (μm) into the enamel (Gwinnett & Matsui, 1967; Retief, 1974; Caspersen, 1977; Gwinnett & Gorelick, 1977). The problem is whether the surface layer containing the resin should be completely removed before rebonding or whether the potential of bonding to the resin makes its removal unnecessary.

In reported studies of rebonding of resin to enamel the enamel has been resurfaced with abrasive strips, or pumice, or pumice and re-etching to remove the layer of resin (Bowen, 1965; Mulholland & DeShazer, 1968; Faust & others, 1978). The strengths of the bonds after resurfacing the enamel have been found to be about the same as those of the original bonds. Tests of rebonding to etched enamel without removing the surface layer have not been reported though bonding of composite to cured resin has been demonstrated to have tensile strength as high as 83% of the cohesive strength of the resin when a composite is bonded to samples cured for 24 hours and the surface cut with a crosscut fissure bur (Boyer, Chan & Torney, 1978).

The purpose of the present study was to measure and compare the strength of the initial bond of composite resin to etched enamel with that of the subsequent bond after various procedures to reprepare the surface of the enamel at the site of fracture.

MATERIALS AND METHODS

Preparation and Testing of Specimens

Human anterior teeth that had been stored in 10% formalin were mounted horizontally in fast-setting acrylic with the facial surfaces exposed. Portions of the surfaces were flattened with a diamond disk, smoothed with cuttle disks of medium grit, and polished with a slurry of flour of pumice in a rubber cup for 30 seconds at 500 g pressure. The specimens were subsequently stored in water with thymol.

The specimens were divided into two groups of controls—79 etched and six unetched. The etching consisted of applying a solution of phosphoric acid for 60 seconds after which the surface was rinsed with a spray of water for five seconds and dried with air for five seconds. Unfilled resin (Bonding Agent, Batch No 1108D301, Johnson & Johnson, East Windsor, NJ 08520, USA) was applied to the surface and reduced to a thin layer with a brief blast of air from an air syringe. A cylindrical peg of composite resin (Adaptic, Batch No 0958D003, Johnson & Johnson) 3 mm in diameter and height was formed on each tooth using a rubber mold. The specimens were stored in water at 37 °C for a week before testing.

Prior to testing, the specimens were cycled 200 times between water baths at 10 and 50 °C. The immersion time was 30 seconds in each bath per cycle.

The shear strength of the bond between the composite and the enamel was measured by loading to failure with an Instron Universal Testing Machine (Instron Corp, Canton, MA 02021, USA) with a cross-head speed of 0.1 centimeters per minute ($cm \cdot min^{-1}$). The technique of measuring the shear strength has been described by Mitchem & Turner (1974).

After testing the control specimens, the specimens of group 1 (etched) were divided into three lots according to the site of fracture—whether in enamel or composite, or at the interface. Those that fractured within the enamel (10) were discarded. Those that fractured within the composite were assigned to group 3, a group consisting of five specimens that had about half of their surfaces covered with composite. Most of the specimens broke cleanly at the interface. These were randomly assigned to groups 4 through 8. The surfaces of the fractured specimens were reprepared according to the treatments given in Table 1. The treatments and the preparation and testing of the composite specimens were the same as already described.

Microscopic Analysis

Two specimens in each group of fractured specimens were covered with a colored composite (Prosthodent, Lee Pharmaceuticals, South El Monte, CA 91733, USA) and mounted in clear resin. A single section was made through each tooth with a diamond blade on a thin-sectioning machine (Gillings Hamco, Hamco Machines, Rochester, NY 14602, USA). The cut surface was polished with slurries of flour of pumice and chalk and etched for two minutes with a 37% solution of phosphoric acid to remove a superficial layer of enamel and to expose the tags of resin if present. The colored composite served to support the layer of tags after the enamel was dissolved and to confirm that the tags were a result of the initial placement of unfilled resin and composite. The specimens were examined

Table 1. Comparison of Bond Strengths (Shear) with Rebond Strengths of Composite Resin to Fracture Sites of Enamel and Resin

Groups	Treatment of Enamel Surface	N	Bond Strength MN · m^{-2} SD	Rebond Strength MN · m^{-2} SD	*t* probability
Control					
1.	Etched	79	35.1±5.7	—	—
2.	Unetched	6	1.4±0.2	—	—
Experimental					
3.	Rinse/dry, (R/D), ½ composite	5	38.2±8.7	27.8±0.7	.002
4.	R/D	10	38.0±2.2	26.9±6.3	.000
5.	Pumice, R/D	10	35.1±4.6	4.9±2.2	.000
6.	Etch, R/D	10	33.5±5.4	33.6±3.7	.972
7.	Pumice, etch, R/D	10	32.3±7.1	34.7±5.8	.307
8.	Disk, pumice, etch, R/D	10	34.6±6.4	35.8±3.9	.613

with light microscopy at ×500 and ×800 magnification and were photographed.

RESULTS

The strengths of the original bonds and of the subsequent rebonding of the same specimens for each group are given in Table 1. Student's *t* test was used to compare bonding and rebonding to determine if they are statistically different. *t* probabilities less than 0.05 are indicative of significant differences between the strengths of bonding and rebonding. The groups that were not re-etched had statistically lower strengths of rebonding. The groups that were re-etched had strengths of rebonding statistically similar to initial bonding.

The shear strengths of the groups were compared using a one-way analysis of variance and the Duncan multiple range test (Table 2). All of the groups of specimens that were etched had similar strengths regardless of the other treatments they were given prior to re-etching. The fractured specimens that were pumiced only (group 5) had very low strengths of rebonding, no different from the unetched control specimens.

The average maximal length of tags in unbroken samples was 17.6 ± 3.3 μm. The average maximal length of tags remaining in enamel in fractured surfaces (Fig 1) was 10.2 ± 1.9. Average maximal length of tags in fractured surfaces that had been pumiced (Fig 2) was 7.5 ± 0.9 μm. The layer of tags in unpumiced specimens, both fractured and unfractured, was of fairly uniform width and was present the entire length of the etched surface. The layer of tags in the pumiced specimens

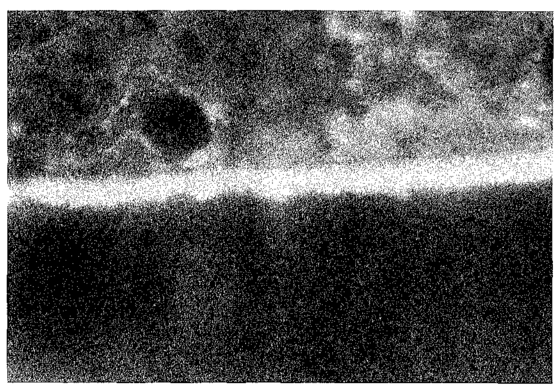

FIG 1. *Layer of tags remaining in enamel of a fracture site of composite and enamel. The enamel was embedded, sectioned, and dissolved leaving the layer of tags supported by a new resin. Original magnifications X500.*

Table 2. Comparison of Treatments for Repreparing Fracture Sites of Enamel and Resin for Bonding

Group	Treatment of Enamel Surface	N	Shear Strength $MN \cdot m^{-2}$ SD	Duncan Test*
2	Control, no etch	6	1.4±.2	
5	Pumice, R/D	10	4.9±2.2	
4	R/D	10	26.9±6.3	
3	R/D, ½ composite	5	27.8±0.7	
6	Etch, R/D	10	33.6±3.7	
7	Pumice, etch, R/D	10	34.7±5.8	
1	Control, etched	79	35.1±5.7	
8	Disk, pumice, etch	10	35.8±3.9	

* Lines connect groups that are not statistically different at the 5% level of significance.

that had fractured was not of such uniform width and was missing altogether in many areas. Disked surfaces had no layer of tags at all (Fig 3).

DISCUSSION

The data show that re-etching is sufficient to give maximum strength of rebonding between composite and enamel from which composite has been fractured. It was not necessary to remove the layer of tags by disking or pumicing

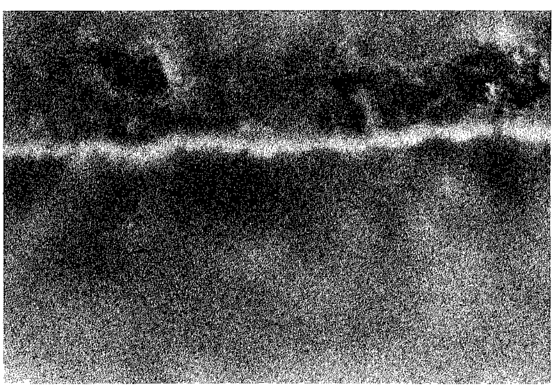

FIG 2. *Layer of tags remaining in enamel after pumicing the fracture site for 30 seconds at 500 g. Original magnification X500.*

to gain rebonding strength as high as that of the original. Since tags of resin remained in the enamel at the sites of fracture, there must be

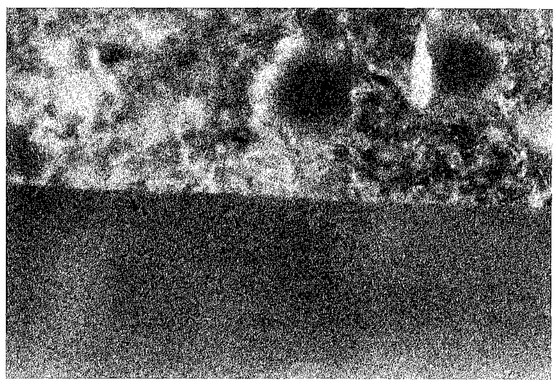

FIG 3. *No layer of tags was found in enamel of fracture sites that were refinished with a diamond disk. Original magnification X500.*

good bonding between the new resin and the tags in the enamel.

The layer of tags in the fractured specimens was easily disturbed as shown microscopically and by the lack of rebonding strength to sites of fracture that had been pumiced. Judging from the difference in maximal lengths of tags in fractured specimens that had been pumiced and those that had not, pumicing removed about 3 μm of enamel. This agrees with the findings of others (Bailey & Phillips, 1950; Vrbic, Brudevold & McCann, 1967).

The data show that the strength of rebonding to sites of fracture of enamel and resin is high even without re-etching, though not as high as the strength of rebonding to fracture sites that have been pumiced or disked and re-etched. However, the success of bonding to enamel that has not been re-etched depends upon the integrity of the layer of tags of resin. This layer is easily disrupted, for example, by pumicing, or by abrasion from chewing or brushing before the restoration is replaced. Thus it is best to re-etch the enamel because the condition of the layer of tags cannot be determined clinically.

CONCLUSIONS

In this laboratory study the enamel at sites where composite resin had fractured from the enamel was found to contain tags of resin. This layer of tags yielded high strength of rebonding to a new layer of composite resin with or without re-etching. It was not necessary to remove the layer of tags by pumicing or disking to achieve good strength of rebonding. However, it is best to re-etch the enamel before replacing the composite because the integrity of the layer of tags cannot be determined clinically.

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DENTAL PRACTICE

Direct Golds in Dental Restorative Therapy

GERALD D STIBBS

INTRODUCTION

In addressing the important subject of "Direct Golds in Dental Therapy," there is so much to tell that the greatest problem is deciding on the best approach. Some of you are highly competent, enthusiastic, direct gold users. What can I tell you! Others have an aversion to these materials, or have had limited or no exposure to the procedures involved. I cannot make expert direct gold operators of you in the few minutes at our disposal. What I hope to do is whet your appetite so you will progress from your present point, and become more competent, and more enthusiastic about the service you can render.

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Presented at the essay session of the annual meeting of the Academy of Operative Dentistry, Chicago, 14 February 1980.

REDUCED EMPHASIS ON DIRECT GOLD

Admittedly, there is now less emphasis on the direct golds than there was some time ago. Why?

In Schools

In many of the dental schools this material receives less attention because:

- There is constant encroachment by aggressive curriculum innovators on the time given to restorative training.
- There is a tendency to follow the example of elementary and high school methods, and teach as little as possible with the least effort possible.
- Many teachers do not know how to use direct golds or teach their use.
- Many licensing boards do not require evidence of refined competence in conservative, permanent, restorative procedures, or else make the direct gold restoration an alternative to more casual operations.

In Practice

- Many of us yield to economic pressures and the pursuit of the dollar, mistakenly thinking that direct golds do not fit into that picture.
- Many of the dental insurance programs do not support conservative, permanent, dental restorative therapy and, of course, they are assuming an ever-expanding place in dental practice today.

VALUE OF DIRECT GOLDS

In spite of these adverse influences and circumstances, the direct golds still constitute one of the best of the available restorative materials, if— if—

1. They are used where indicated.
2. They are manipulated properly.
3. The operator has, or is willing to acquire, the necessary expertise.

G V Black once wrote, "No other material can be so worked against the walls of a cavity as to make full use of the sustaining power of the elasticity of the dentin" (1908). That still holds true.

As you know, pure gold is one of the oldest restorative materials, yet it is still the standard-bearer, or the yardstick, or, in today's parlance, the *meter* stick. Other materials are compared with foil, the other forms of gold are compared with foil, so we should know how and where to use it. While I am a long-time disciple of foil in dentistry, I also recognize that, if foil is not used correctly, it is one of our least successful procedures. I extol its virtues, but I also caution against anyone thinking that going through the technic once or twice, or reading a few papers on the subject will make him adept or even semicompetent in its use. As W I Ferrier used to say, "It does not come by a 'laying on of hands.'"

HOW TO LEARN THE PROCEDURE

For the benefit of you who have received limited coaching in the procedure, or who have not given it any thought or attention recently, let me give you a few pros and cons and outline the state of the art. I want you who are interested to know that you are not alone. I encourage you to follow your inclination to use this excellent restorative medium.

Literature

There is a wealth of material in the literature, if you will take the time to look it up. It is fascinating reading. To assist you, a short list of representative articles to initiate or further your search is given at the end of this article. I could not be all-inclusive and have undoubtedly omitted some excellent presentations. In those listed you will find reference to other fine reports.

Instruments and Supplies

The second step in learning this technic is to assemble a basic kit of instruments and supplies (a list is available from the author) and a small amount of each type of gold. Such an introductory package is available from the manufacturer, Williams Gold Refining Co (2978 Main St, Buffalo, NY 14214, USA; 800/828-1538). By trial and error, determine which one, or ones, best suit your needs, and go from there.

Study Clubs

The third, and preferred, approach is to join an operating study club and, with the aid and guidance of the mentor or preceptor, develop your skills under his supervision. It will be the greatest thing you can do for your dental advancement, for improvement of your restorative service, and to stimulate your sense of accomplishment.

Each of us who talks about, and uses, direct golds acknowledges prime stimulus from one or other of the great operators who preceded us. Some of these leaders have been rather regional in their influence; others have had a nationwide or worldwide impact. Each, in his own way, has given unstintingly of himself, and we are all indebted to them.

OBSTACLES

The principal obstacles to the use of direct golds are:

1. The operator's lack of training and consequent lack of enthusiasm and comfort with the technic.
2. The patient's aversion to an unsightly display of metal.

3. Many carriers of dental insurance plans do not accept the direct golds, and the non-dental adjudicator thus arbitrarily excludes our superior preventive restorative medium.

4. Concern of some dentists that the present cost of gold will price foil and gold alloys out of the market.

These objections can be met by the operator becoming familiar with a good, sound technic, by having the proper armamentarium, and by knowing the possibilities of restoration outlines that minimize or eliminate the display of metal.

As to the third-party encroachment, we can keep working to enlighten the bureaucracy and in the meantime resume the good, old-fashioned, direct relationship of patient to dentist, and do what is best for the dental health, regardless of outside political and financial pressures.

As to the *cost,* it is still a minor consideration. For example, when gold sold for $35 an ounce, we bought foil for approximately $18 per 1/10th ounce. Since the average class 5 foil weighs about 0.05 pennyweight, and the average class 3 foil weighs about 0.06 pennyweight, they contained about 45¢ and 54¢ worth of gold, respectively. Today, even though the market fluctuates wildly, if we consider gold at $700 an ounce, our foil is priced around $140 per 1/10th ounce. The mat and powdered golds are priced at 4% to 10% over that. The gold in the same class 5 and 3 foils then would cost about $3.50 and $4.20, respectively. Hardly enough to talk ourselves out of using this excellent medium!

INDICATIONS

The indications for direct gold may be debated and may be different in different parts of the country. In general:

- The smaller the lesion the greater the indication.
- The greater the need for conservative, permanent restorations, the greater the indication for foil.

REQUISITES

Now, getting to specifics, there are a few fundamental requisites to be considered if we are to produce successful, lifetime restorations:

1. There must be a proper cavity preparation.
2. There must be a dry field.
3. The restorative material must be properly manipulated. Each of the forms presently available requires some slight differences in handling.
4. There must be the usual respect for protecting the health of the supporting and surrounding tissues.

Complying with these requisites is facilitated by:

1. Having in mind a picture of the proper cavity preparation, and the ultimate goal
2. An adequate armamentarium readily available to include:
   a. The best available cutting instruments, handpieces, and burs.
   b. A basic array of compacting instruments or condensers or pluggers, so that the gold may be inserted with proper and controlled line and degree of force.
   c. An efficient setup to contour, finish, and polish the restoration without injury to the tooth, the pulp, and the supporting tissues. This includes adequate coolant, proper operating illumination, and controlled speed of rotary instruments.

Cavity Preparation

In the cavity preparation, briefly the requisites are:

1. Mechanical retention
2. Harmonious or controlled outline form to meet the patient's needs in terms of esthetics
3. Adequate access for proper instrumentation
4. Concern for pulp protection

Operating Field

As for any restoration, the operating field is important. There are two essential factors to consider:

1. Cleanliness, including lack of moisture
2. Access for operating—preparation, insertion and finishing

The dry field is best attained with rubber dam. Different operators have different preferences about the details of obtaining such a field. Some find the frame type of holder to be adequate; others prefer the control of cheeks, tongue and lips afforded by the headband type of holder.

Ireland (1962) has said that the most time-consuming thing about the rubber dam is convincing dentists that they should use it.

To achieve a clear operating field for a gingival third lesion, a few operators make a surgical flap of the gingiva; however, most use a mechanical retractor, which, if well designed as is the Ferrier No 212, and if carefully applied, is less traumatic to the tissues. The matter of design, modification, and application of the retractor, while not complicated, does require training and guidance. There are several good sources of information in the literature if the assistance of an operator familiar with the technic is not available. If not used properly, the clamps or retractors can do much harm.

To achieve access to a proximal lesion, and to have a restricted preparation for it, a mechanical separator is an essential aid. It, too, must be well designed and correctly applied for maximum safety and optimal access. The Ferrier pattern has been the best design available for many years. For a time the separators did not measure up to specifications and required considerable modifying and refining. Now a new manufacturer, Almore International (Portland, OR 97225, USA), is producing three of the six patterns. In the literature there is information about the application of these instruments (Stibbs, 1967).

Types of Gold and Their Manipulation

TYPES OF GOLD

There are enough types or forms of gold to satisfy every taste and whim. Each will do a fine job if handled properly. Some are better than others. Basically there are three forms—foil, crystalline, and granular.

Gold foil, or fibrous gold, is one of the oldest, if not the oldest form we have. It is rolled and beaten by fascinating procedures. Gold leaf, as used in gilding or ornamentation, is about 1/250,000 in (0.1 μm) thick. Our dental foil (the usual No 4) is six times that thick, or 1/40,000 in (0.6 μm). It is available in several types:

- Sheets, usually for preparation in the dental office
- Manufactured pellets or cylinders
- Ropes
- Laminated—varying thicknesses of foil stacked and slightly precondensed

Crystalline, sponge, or mat gold. In use for many years, mat is a microcrystalline form, produced by electrodeposition, the crystals being dendritic or fern-like in shape about 0.1 mm long. It can be used plain or sandwiched in gold foil to make it easier to handle, in which form it is designated as mat foil.

Granular, or powdered, gold. The first ones appeared in this country about 1960, having gone through a number of evolutionary forms. These irregularly shaped, precondensed pellets or clumps of particles (Biofil, Filoro, Karat) were prepared by one of three basic methods: comminution, chemical precipitation, or atomization from the molten state. With some of them a volatile liquid was provided to act as a carrying medium to convey the pellet to the cavity. In general they are difficult to control.

Goldent: The next type of granular gold, developed in this country about 1962, was called Goldent (originally by Morgan, Hastings Co, now by Williams Gold Refining Co Inc, Buffalo, NY 14214, USA). The individual particles or granules, averaging 15 micrometers (μm), are gathered into conglomerate masses of irregular shape ranging in diameter from 1 to 3 mm, lightly precondensed to facilitate handling. The masses are encased in an envelope of foil to make it easier to convey them to the cavity. The present form has some spherical atomized particles mixed with the granules to improve compacting properties.

Electraloy R V: The newest form of gold is known as Electraloy R V. All compacted golds develop increased hardness with the introduction of stresses. However, greater hardness occurs with the introduction of minute quantities of other elements, such as palladium, platinum, indium, silver, and calcium, without lessening desirable manipulative characteristics. In this product, the granular gold, alloyed with a trace of calcium, is manufactured electrolytically. *Sintering* (a method of heating under controlled pressure and time) changes the alloy into a mat. The strips of mat, of varying widths, are sandwiched between foil to improve handling properties.

MANIPULATION

As to the manipulation of the direct golds, there are a few principles to keep in mind:

1. The increments of gold need to be of proper size for insertion, and in proper condition for condensing, or 'compacting', a term introduced by Hodson (Hodson & Stibbs, 1962) that conveys a more accurate picture of the procedure since 'condensation' usually implies the conversion of a gas to liquid or solid state.

2. Gold has the property of cold welding, one piece to another, if the surface is free of contaminants and moisture.

3. Gold flows under pressure, so it will seal the cavity and be securely locked in place if the compacting force is correct in direction and amount. Improper line of force will loosen or dislodge the foil, and if we try to hurry too much or do not control the stepping of the condenser the end product will be a poorly condensed mass that will be pitted and will fail.

So, you must have a means of cleansing the surface of the gold, and you need to apply *controlled* force.

Annealing. The cleansing or annealing to remove the volatile protective coating may be done pellet by pellet over an open flame of pure alcohol or en masse on an annealing plate having an electric, gas, or alcohol source of heat. The annealing temperature ranges from 650–700 °C (not Fahrenheit) depending on the method and length of time of heating (Smith, 1973).

The easiest way is to have the chairside assistant anneal the gold as it is needed, over an open flame, heating just until the gold becomes a dull red. Care to not overheat it is important. If the protective coating is not driven off, the gold will not cohere, one piece to another. It is then considered *noncohesive.* The noncohesive type is useful to line and protect peripheral cavity walls in class 1 and class 5 preparations, and to rapidly build the proximal portion of a class 2 restoration.

Compacting force. The source of force can be by hand pressure alone (which becomes very tiring), or by hand mallet (which is strongly favored by many operators), or by a mechanical device that is activated by spring (Snow), pneumatic pressure (Hollenback), or electronically (Electromallet).

The direction, amount, and pattern of application of the compacting force are all highly important.

Direction: It is essential to direct the compacting force *into* the cavity, utilizing the property of flow of gold under pressure, in the direction of the force. The handle of the condenser should be at about 45° to the wall of the cavity. The direction should *never* be *out* of the preparation.

Amount: We recall from our early reading of G V Black and others that with a condenser having a face of 1 mm^2, the optimal force is 15 lb. But our condensers are not that large. A round-faced condenser of 1 mm diameter (which is still too large) has an area of 0.8 mm^2, so it would require a compacting force of 12 lb. The usual 0.5 mm diameter condenser has a face area of 0.2 mm^2, so the required force is but 3 lb. For Goldent, some recommend hand pressure only, using a larger-faced condenser (0.016 x 0.045 mm = area 0.465 mm^2) and a force of 6-8 lb.

The condensers vary widely in shape and size. They can be straight, curved, or angled; they can be round, square or rectangular; they can be smooth or serrated; they can be flat-faced or convex-faced. It is well to begin with a basic minimal set and add to that as needs arise.

Hodson has pointed out that the plastic flow of gold occurs for only short distances under the face of the condenser (Hodson, 1961). Areas not covered by the face of the condenser remain porous (Hodson & Stibbs, 1962). Condenser penetration is less than the thickness of the increment (Hodson, 1964). The welding *depth* is not over 0.2–0.3 mm. Final density is influenced greatly by the direction and the magnitude of the compaction force, and by the size and shape of the face of the condenser (Hodson & Stibbs, 1962). The quality of compaction depends strictly on the operator's manipulative technic (Hodson, 1964).

Pattern: It is important to step the condenser in a controlled pattern. Methodical backstepping or overlapping, one half the diameter of the condenser face, produces the finest specimens (Hodson, 1964). Not only will this ensure uniform compaction and a dense mass, but also it will achieve optimal flow of metal, and sealing of cavity walls.

Porosity is inherent in any compacted gold restoration. In foil, the porosities are of the 'closed' or cell variety. In the granular or powdered golds, porosities are of the 'open' type and therefore are more dangerous if not controlled (Hodson, 1964).

Each type of gold requires some slight variation in technic. If mat or powdered gold is compacted in the same manner as foil, it is very easy to have incomplete sealing of cavity walls, and incomplete compaction of the gold. Better results are achieved with condensers with a slightly larger face and finer serrations when working with mat. The powdered or granular pellets need to be opened up in the cavity before compaction begins, to minimize voids in the mass.

Some find that these golds crumble too readily in transporting them to the cavity, and that they are difficult to manage. Some operators obtain a dense hard restoration using only mat or powdered gold; others find that if these forms are used it is easer to obtain a better surface and polish if they apply a surface lamination of cohesive foil to the compacted mass of mat or powdered gold.

Finishing. In the finishing of any of the direct golds, the principles that have been used for many years for foil apply to the other forms as well.

- A controlled amount of excess is built up to allow for restoration of normal contour and a smooth surface.
- The excess is removed with very sharp knives and files of suitable design, and with abrasive discs, stones, and strips. Whenever the strips are used, adequate coolant must be supplied to avoid overheating the metal and consequently traumatizing the pulp.
- Separation is increased slightly to enable passage of the strips through the contact but is removed as soon as possible to minimize harmful stress on the periodontal ligament and injury to the interdental papilla.
- Care must be exercised when discing to not cut into the surface of the tooth. Careless finishing can also injure the adjoining soft tissues.
- For final polish, a satin finish is preferable to a high gloss. This minimizes reflection of the light rays and creates a more esthetic and harmonious end result.

CONCLUSIONS

- The direct golds offer one of the most conservative, permanent, and serviceable means of restoring teeth to proper contour, function, and appearance.
- If you haven't been using direct gold to any extent, start with simpler, smaller lesions, and work your way into the more complex situations. Ask for assistance and guidance.
- Keep in mind that the technic for providing this restoration for your patients, while exacting, is not unduly difficult to acquire. On the other hand, you cannot become proficient by reading about it once.
- Familiarize yourself with the various forms of gold now available and determine which ones best meet the needs of the patient.
- Operating dexterity can be improved and refined by practice and particularly by participating in study club activity.
- In this endeavor we should keep in mind that improving our competence with the direct golds will also improve our service with other materials and will provide our patients with superior restorative therapy and us with an unparalleled inner glow of satisfaction in a job well and beautifully done.

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PURE GOLD

A New Method of Using Gold Foil

Second in a series of articles by leaders in operative dentistry
This is the article that first described the use of gold foil in a cohesive form.

ROBERT ARTHUR

Some few months since a short article on "sponge gold," written by me, was published in the *News Letter*. It was simply intended for the purpose of doing my part in calling the attention of the profession to it as a desirable improvement, and to express my confidence in it as a reliable material for filling teeth. I did not pretend to go at any length into the subject, but made some simple general statements, promising to prepare a detailed account, at some future time, of methods of using it which had enabled me to employ it with success. I had very soon found, after beginning to use the "sponge gold," that it could not be relied upon if the directions by which it had been accompanied, when sold, were followed; and I was not at all surprised that disappointment in the expected result occurred as a consequence of its use in this way. Heavy demands upon my time, however, have prevented me from preparing such an article as I intended, and it will now be rendered unnecessary, I presume, by a publication in preparation by Messrs Watts & Co, of which I have seen a part of the proof-sheets. I have, indeed, within a short time past, fallen upon a new field of experiment, and find that by using gold foil in a way somewhat differing from that in which it is ordinarily used, it can be worked precisely like "sponge" or "crystallized" gold.

I have never regarded gold foil, as ordinarily used, as a perfect article for the purpose intended. There are very few members of our profession, I presume, who are not aware of its defects. That it has answered the purpose of filling teeth better than any substance brought before the profession, until lately, I am well aware; but still it has always been my desire, as I know it has been that of many others in the profession, to find something free from its defects.

It is well known that no adhesion takes place between the layers of gold foil, as ordinarily used; and the retention of the whole mass of a filling depends upon the form of the cavity, or upon the lateral force it is made to exert upon the walls. The manner in which most good operators proceed to fill a cavity with foil, no matter how they may prepare it, is to begin at one side and condense the filing toward that side, making sure to allow some of the gold to extend above the mouth of the cavity, far enough to make it level with it after it is condensed at the surface and properly burnished.

Now, it is impossible, if the filling is well condensed, to add more gold directly to the surface. The layers of foil, as ordinarily used, will not adhere to that portion which is previously condensed. It becomes necessary, in such cases, to remove the whole filling, or to cut away so much of it, if it be large enough, as to furnish a reliable hold for the additional gold. This is a defect in foil for which I have always been anxious to find a remedy.

I found, by experiment, some few years ago, that by using heavy numbers of gold, a result might be obtained approximating, at least, what was desired in this way. I proposed to employ No 30 gold foil, with sharp pointed instruments, as I found that by forcing the single strip of heavy gold into contact with portions previously introduced into the cavity, a kind of union between the different portions might be effected. In this way I found myself enabled to add strip after strip of gold to a filling, until I had accomplished the object in view. I made use of this form of gold foil in this way for nearly two years, exclusively, and only abandoned it in consequence of the difficulty of keeping myself supplied with suitable instruments, which it is impossible to have properly made by an instrument maker. The points required are necessarily very hard and easily broken. Still I accomplished with this form of gold all I expected from it, and abandoned its use for the reason stated alone. It is not improbable that gold in this form may still be found desirable, if used as I am about to propose.

I again went back to gold foil as I had formerly used it, and employed it in this way until my attention was called to the article introduced to the profession under the name of "sponge gold." The first I used was made by White, of Utica, and it at once struck me as being a most desirable improvement, in many respects, upon gold foil. A specimen of Watts & Co's gold was then put into my hands by the inventor, and I found it free from the objection of great friability, one of the most defective features of White's preparation. It was a beautiful specimen of this material, and I have never since found any which in all respects satisfied me so well. I took hold of the new form of gold eagerly, and soon found that by using it (very differently, however, from the manner described) I could obtain better results in my operations than I had ever been able to reach before. I used the "sponge gold" with greater satisfaction, for more than a year, than any other material I had ever taken hold of. I have seen my operations repeatedly, and at long periods of time, after they have been performed, and I have never in a single instance observed any change in its appearance or consistency, except when from unfavorable circumstances the operation was imperfectly performed. I feel no hesitation, therefore, in saying, that the confidence I have expressed in it, in the article alluded to, I still retain.

But "sponge gold" has unquestionably, with all its advantages, its own defects, which have interfered with and must prevent its general adoption. Its friability leads, in many cases, to more or less waste. As far as my experience goes, it is exceedingly difficult to work, if it gets at all wet during the performance of an operation, and it certainly consumes more time to perform reliable operations with it, in the great majority of cases, than gold foil. Still its advantages, with all these defects, as I have said, were so great in bringing about desirable results, that I have been willing to devote the additional time for the sake of making more perfect operations when completed. If these difficulties can be overcome, and an article found free from the defects of "sponge gold," which can be worked in the same way as this material, that is, if adhesion can be obtained between the portions placed in a cavity, a further advance unquestionably is made.

In making some experiments for the purpose of testing the relative solidity, when condensed in a cavity, of gold foil and "sponge gold," I found the foil may be made to work in precisely the same way as the sponge gold, and as perfect adhesion obtained between the different portions of gold put into a cavity as with this material. Nothing more is necessary than to cut the sheets of the ordinary numbers of foil into two or three pieces, roll up very loosely, and hold it in the flame of a spirit lamp until it reaches a red heat. It will at once be found to have become so adhesive that, with small and sharply serrated instruments, it may be made to adhere as readily as the best specimens of "sponge gold." It is necessary, however, when gold foil is used in this way, that it should be cut into small portions, for the very adhesiveness which it acquires when treated as I have proposed prevents it from working well if an attempt is made to use it in the ordinary manner.

The instruments which I have found best adapted to the use of gold in this way are small flattened pluggers, with two sharp points cut at the end, and made so hard that they will not turn. The gold may be picked up with such instruments, carried to the desired place, and condensed precisely as "sponge gold." It is well to go over each piece added with a single sharp point.

Although I have been making use of gold foil in this way for only about a month, I am exceedingly gratified at the results I have obtained and am urged to call attention to it.

It seems very strange that so desirable an improvement as this should have been in our hands for so long a time, and yet not discov-

 *OPERATIVE DENTISTRY, 1980, **5**, 118–124.*

PRODUCT REPORTS

A Comparison of Eight Ultrasonic Cleaners

WILMER B EAMES • SCOTT Q BRYINGTON
NEAL B SUWAY

Summary

Eight commercially available ultrasonic cleaners of the bath type were investigated to determine their cleaning efficiency and cleaning characteristics as related to dentistry.

Laboratory tests of the erosion of gypsum, aluminum foil, and zinc phosphate cement show that L & R LU, Neysonic, Dri-Clave, and Sonicor are most effective because they possess the highest capacity for cleaning and their power is uniformly distributed across the tank.

The Health Aids cleaner exhibited even distribution of energy but possesses the least power of the eight.

Jelenko, Buffalo, and L & R T14 had intermediate capacities for cleaning and less even distribution of energy than found in the other five units.

In actual cleaning tests using appropriate solutions, no clinical differences between brands were found.

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INTRODUCTION

Ultrasonic cleaners are being used extensively in dentistry, not only for routine cleaning, but for sterilizing instruments and burs as well (Perkulis, Engelhard & Kramer, 1970). The increased use of ultrasonic cleaners by dentists has resulted in a proliferation of these products. The purpose of this investigation is to evaluate the performance of the leading ultrasonic cleaners for dental use.

NATURE OF ULTRASONIC CLEANING

Ultrasonic cleaners employ vibrations of sound of a frequency higher than can normally ered. I presume many operators have attempted to restore gold foil, which had become impaired, by reheating it. I did so myself years ago, but found that the very adhesiveness it acquired by this process interfered seriously with its use in the ordinary way.

I have felt it necessary to make this long statement in order to protect myself against the charge of vacillation, as I have at various times earnestly advocated several different methods of filling teeth. My strong desire has always been to improve, for my own benefit and that of others, the methods of performing the operations of our profession. I always have been, and always shall be, ready to take hold of any new thing which promises advantages, and to test it as thoroughly as I am capable of doing. I have not changed my ground in relation to any of the forms of gold I have advised to be used. Each has certainly the advantages that I attributed to them. I do not now take the ground that I have been mistaken in my expressed views of "sponge gold"; I still regard it as perfectly reliable, when properly used. But for ordinary use, I am convinced that gold, in the form I am now recommending it, is a decided improvement upon any method of using gold hitherto known. Whether it will be regarded as superior to "sponge gold," in the hands of those who have successfully used this material, is a question which time and trial can alone decide.

I have no idea that gold will be used generally in the manner I now recommend. It is exceedingly difficult to induce men to change a course which they have successfully pursued for years, and the difficulties of which they have learned to encounter and overcome, for any new thing. And, even if they are disposed to make a trial of a new process, it is often so imperfect a trial, that it is unsatisfactory. With regard to the matter in hand, simple as it is, I confidently say to every operator in the profession, that if fairly tried it will afford advantages in the use of gold foil of which few have dreamed.

I may say that the foil of different manufacturers present a remarkable difference in regard to this quality of adhesiveness. It is certainly advisable to try several kinds, if that in hand does not work well. The profession may rely upon the full truth of the statements I have made. I have never, in the course of practice of fifteen years, made use of any material for filling teeth which has so fully satisfied me as foil used in the manner I have described.

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be heard. These vibrations induce rapid formation and collapse of countless microscopic cavities. The formation and collapse of the cavities is called 'cavitation'. The collapse of the cavities produces the high energy that results in hydraulic shocks. These shocks constitute the scrubbing action that erodes residue from the surface of objects submerged in the liquid.

MATERIALS

The leading brands of ultrasonic cleaners for dental offices and laboratories are listed in the table. Three units of each brand were provided for testing.

Products and Manufacturers

Buffalo Model 773	Buffalo Dental Mfg Co Brooklyn, NY 11207, USA
Dri-Clave Model SS-2	Columbus Dental Co Columbus, OH 43206, USA
Health Aids Model T3.3	Health Aids, Inc Hayward, CA 94545, USA
Neysonic	J M Ney Co Bloomfield, CT 06002, USA
Sonicor Model SC-100T	Sonicor Instrument Corp Copiague, NY 11726, USA
Ultra-Cleen 320 LU	L & R Mfg Co Kearney, NJ 07032, USA
L & R T14	L & R Mfg Co
Vector 55	J F Jelenko & Co New Rochelle, NY 10801, USA

TEST METHODS

Power Performance and Distribution of Energy

The power of an ultrasonic cleaner is best revealed by its ability to erode mechanically the surface of materials immersed in a cavitating liquid. A test for mechanical erosion also reveals the distribution of energy within the liquid. Uniform distribution of energy is important because cleaning is more effective and the orientation of objects in the tank is not critical.

The mechanism of ultrasonic cleaning can operate in liquids that are completely neutral, such as water, but generally detergents are added to reinforce dissolving action (Pohlman, Werden & Marziniak, 1972). In most tests of erosion, however, the action of solvents (physical wetting or chemical attack on the surface) is excluded so that only mechanical erosion induced by cavitation itself is measured. Therefore, degassed water was used as the working liquid for comparing powers of cavitation.

For industrial ultrasonic cleaners, erosion of lead blocks has been used for comparing cavitation activity. Dental units, however, generate less energy than required for eroding lead, so gypsum was used instead (Fig 1).

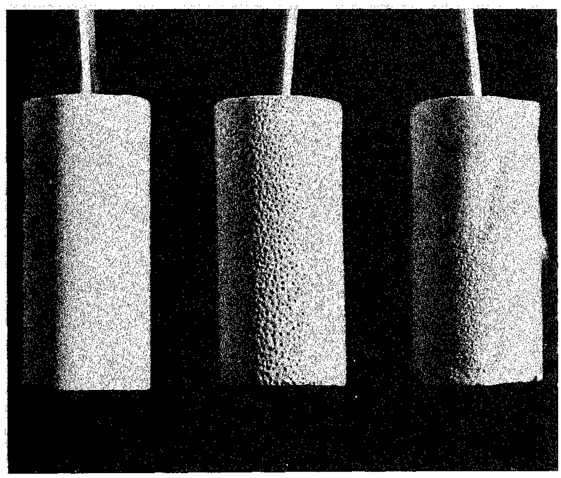

FIG 1. *Gypsum specimens before (far left) and after cleaning*

Erosion of foil illustrates graphically the intensity and distribution of energy (Delta Sonics, Technical Bulletins Nos 101 & 108; Crawford, 1964). Sheets of aluminum foil were placed vertically in the midline of the tank of each cleaner tested.

Zinc phosphate cement, applied to a stainless steel plate in a layer 130 μm thick, was used to evaluate the effectiveness of the units in cleaning surfaces. The time taken to remmove all the cement was measured.

Simulated Usage Tests

The power required for erosion is, in many cases, much higher than that needed for cleaning. Standard tests for removing soil are described in the literature as being the most accurate means of comparing cleaners (Delta Sonics, Technical Bulletin No 101). In such methods, known quantitites of a residue are used. The time required for the units to produce 100% cleanliness is the basis for comparison. These tests closely approximate dental use and are considered the most acceptable.

BLOOD

Removal of tissue debris and blood from instruments is a common and unappealing task in the dental office. An easily duplicated soil of blood deposited on stainless steel was the most clinically relevant of the test methods employed in this investigation.

Whole blood labeled with a radioisotope was dried on threaded bolts of stainless steel to simulate dental instruments. To simulate clinical cleaning, a solution of detergent (2% Joy Liquid, Procter & Gamble, Cincinnati, OH 45202, USA) was used as the cleaning medium and three extraction forceps were placed in the tank for all tests (Fig 2). The radioactivity of the forceps was measured with a gamma well counter (Nucleus 1000 Spectrometer, Nucleus, Oak Ridge TN 37830, USA) (Fig 3).

CEMENTS

Measured amounts of polycarboxylate cement (Durelon, Premier Dental Products Co, Norristown, PA 19401, USA) and zinc phosphate cement were coated evenly on dental spatulas and allowed to set. The spatulas were cleaned in a solution designed to remove cement (Sonicor Tartar and Stain Remover). The time required for thorough cleaning of the spatulas was recorded.

Sound Test

The sound level of each brand of cleaner cavitating a general purpose liquid without a

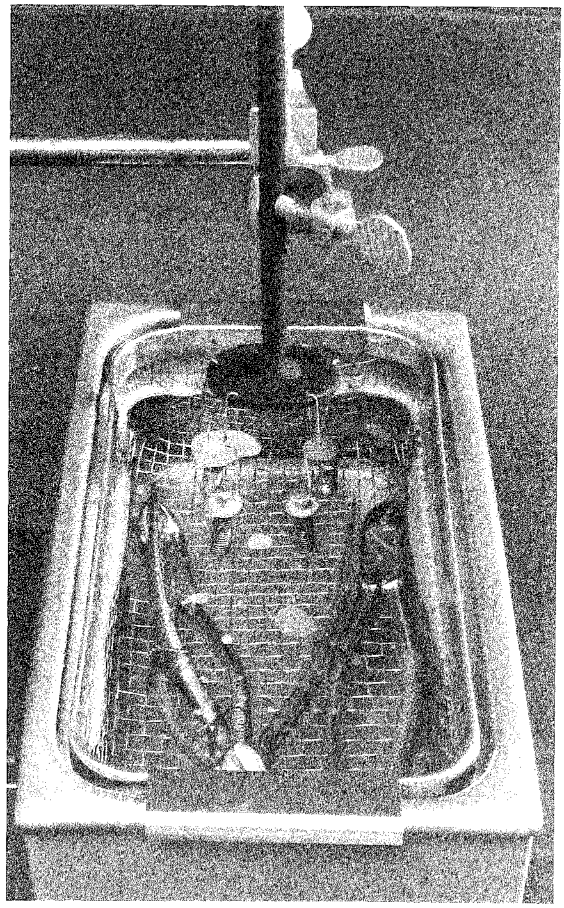

FIG 2. *Arrangements for testing blood removal*

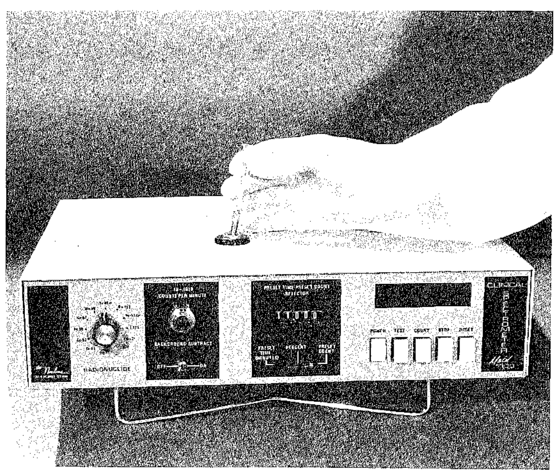

FIG 3. *Recording the radioactivity of the test specimen with a spectrometer*

load in the tank was recorded (General Radio-Type 1933 Precision Sound-Level Meter and Analyzer, Concord, MA 01742, USA). Both dB output and dBA (OSHA "A" weighted frequency) output at 4 kHz were recorded at a uniform distance of six inches from the tank.

RESULTS

Power Performance and Distribution of Energy

A comparison of the weight of gypsum lost in the erosion test is shown in Figure 4.

The erosion of aluminum foil resulted in characteristic patterns of perforation (Fig 5), which are indicative of both the force of cavitation and the distribution of energy. A cleaner adequately powered for dental use should be able to perforate a smooth sheet of regular household aluminum foil in two minutes (Shaner, 1967). All of the units tested were capable of this.

There was good correlation between the results of the erosion tests on gypsum and foil. The cleaners with the highest potential for cavitation—Neysonic, Dri-Clave, L & R LU, and

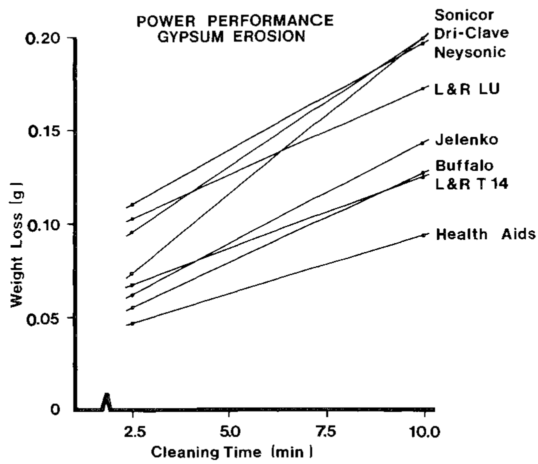

FIG 4. *Comparison of power performance of ultrasonic cleaners*

Sonicor—also showed the most even distribution of energy across the midline of the tank. The Health Aids cleaner possessed an even distribution of energy but produced the lowest potential for cavitation of the eight cleaners. Jelenko, Buffalo, and L & R T14 have an intermediate potential for cavitation and a distribu-

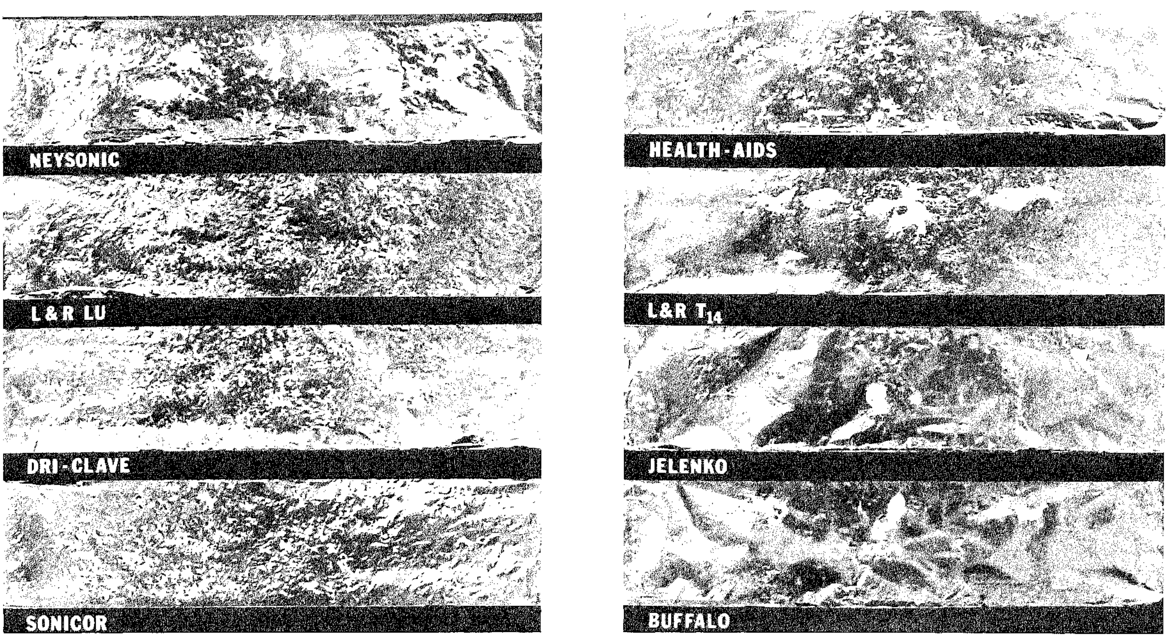

FIG 5. *Patterns of performance of foil. Neysonic, L & R LU, Dri-Clave, Sonicor, and Health Aids show even distribution of energy, while L & R T14, Jelenko, and Buffalo have a more localized distribution.*

tion of energy that is less even than that of the other five cleaners.

The length of time required for total removal of the zinc phosphate cement from the stainless steel plate is shown in Figure 6. Times ranged from approximately five minutes to over 15 minutes, L & R LU and Neysonic being the most effective. Again there was good correlation with the erosion tests—the cleaners showing the most activity in erosion being the most effective in removing cement.

Simulated Usage Test

BLOOD

Ultrasonics ensured rapid and thorough cleaning of blood-soiled instruments. Removal of dried blood proved not to be difficult for any of the cleaners tested. The differences between them are not clinically significant; all removed 99.99% of the blood within three minutes.

CEMENTS

The time required for thorough cleaning of a thin coat of Durelon from spatulas varied from 1.25 to 2.0 minutes. For the spatulas coated with zinc phosphate cement the cleaning times were less than a minute. This cement was more easily cleaned than was Durelon and tended to flake from the surface. The cleaners showing the highest activity in the erosion tests also required the least time for removing cement. The difference among the cleaners, however, is too small to be clinically significant.

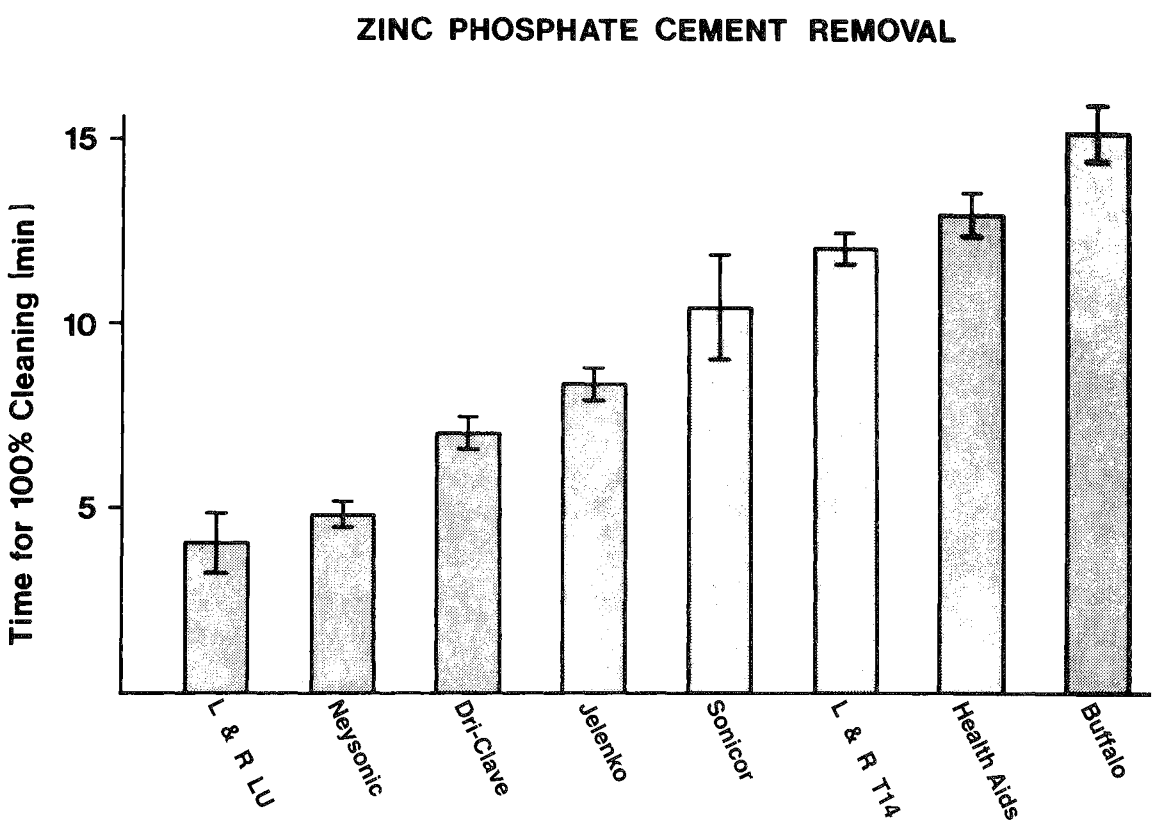

FIG 6. *Comparison of ability of cleaners to remove cement*

Sound Test

The results of the sound test are shown in Figure 7. The Dri-Clave and Jelenko cleaners exhibited the highest intensities of sound. However, the levels of sound diminished in proportion to the load placed in the tank.

DISCUSSION

Although no differences of clinical significance were found among the units in the cleaning of dried blood or of thin layers of cement when used with a solvent, the machines possessing the highest powers of cavitation, as shown by the tests for erosion and the test using zinc phosphate and degassed water, are advocated because ultrasonic cleaners lose power with age and because the stronger machines can remove more difficult soils.

There are several other factors in cleaning efficiency:

- Cleaning efficiency is related to both the strength of cavitation as well as to the solvent power of the solution. This is an important consideration in evaluating solutions for dental ultrasonics. It was found that those solutions designed for specific tasks cleaned much more effectively than the all-purpose solutions.
- Carrier baskets or suspended beakers are required for all ultrasonic cleaning. The transducers, which convert sound into the mechanical vibrations that are transmitted through the cleaning liquid, are placed in intimate contact with the undersurface of the cleaning tank. Consequently, nothing should be placed directly on the bottom of the tank because the

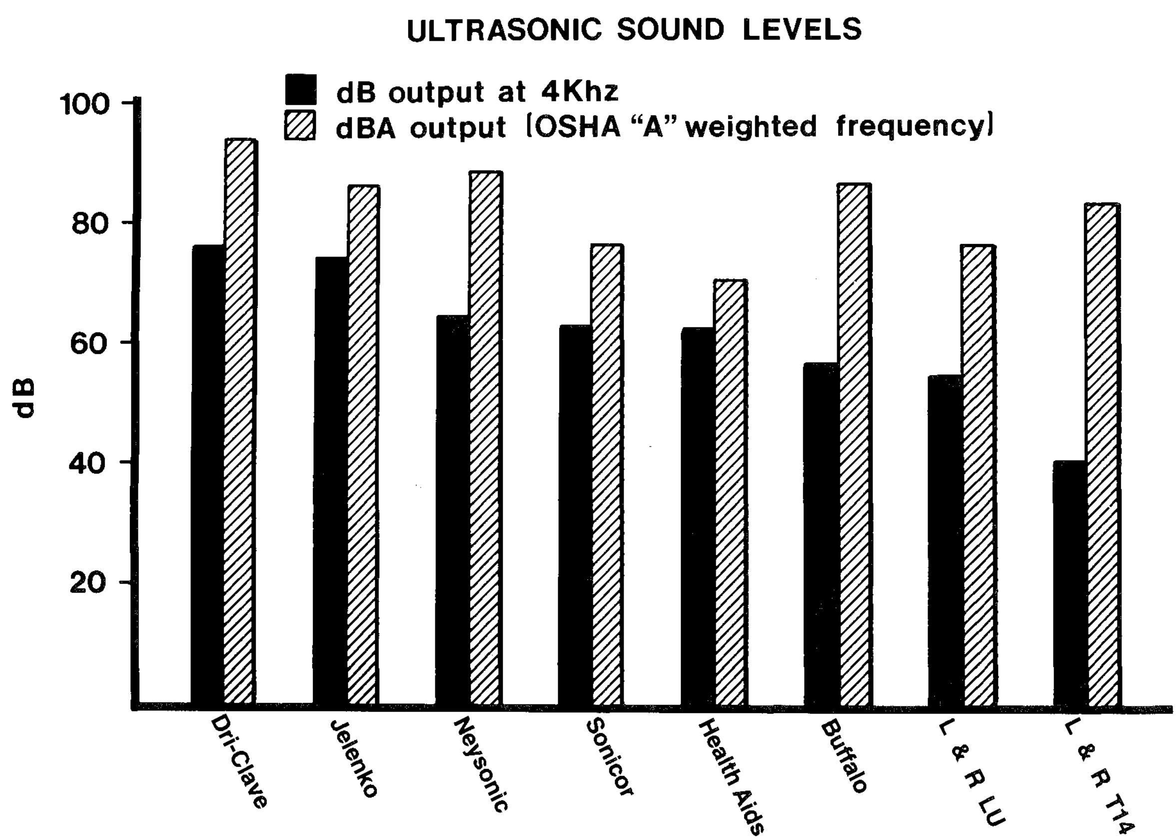

FIG 7. *Comparison of sound of ultrasonic cleaners*

generation of waves will be disrupted and life of the transducer will be shortened. This is analogous to placing a brick on the cone of a stereo speaker.

- Baskets with solid bottoms of polished stainless steel proved to be more effective than mesh baskets. A basket with a solid bottom reduced erosion by 30% whereas a basket made of mesh ½-inch square reduced erosion by 50%.

CONCLUSIONS

Dri-Clave, L & R LU, Neysonic, and Sonicor are considered to be most effective in that they possess high potential for cavitation along with even distribution of energy. These cleaners are well designed and capable of handling even more difficult tasks than those found daily in the dental office.

For both presterilization and routine cleaning, all of the cleaners tested are considered effective when combined with the appropriate solution. This being so, cost and warranty are important factors in the selection of a cleaner.

This study was supported in part by the National Institutes of Health, National Institute of Dental Research, research grant No 5 RO 1 DE 03504-09, and by the Fifth District Dental Society of Atlanta.

The authors appreciate the use of the Nucleus 1000 Spectrometer provided by Nucleus, Inc, Oak Ridge, TN 37830.

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OPERATIVE DENTISTRY, 1980, ***5****, 125–130.*

Clinical Performance of Amalgams with High Content of Copper

Alloys with enough copper to eliminate most of the γ_2 phase produce amalgam restorations with less failure of the margins than do alloys of traditional composition, but different handling characteristics require modified techniques of manipulation.

K F LEINFELDER

Summary

Ten different amalgam alloys, including one conventional lathe-cut alloy (Velvalloy) and nine with a high content of copper (Aristaloy CR, Cupralloy, Dispersalloy, Indiloy, Micro II, Optaloy II, Phasealloy, Sybraloy, and Tytin) were evaluated for clinical performance over a period of two years. Based on the extent of marginal failure the alloys fell into three groups. Cupralloy, Dispersalloy, Indiloy, Phasealloy, and Tytin exhibited the least marginal failure; Sybraloy was next; and Aristaloy CR, Micro II, Optaloy II, and Velvalloy exhibited the greatest marginal failure. In addition to exhibiting varying levels of clinical performance, many of the alloys differed in their handling characteristics. Physical properties of each alloy and their relation to the clinical use of the amalgam are discussed.

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Published concurrently in the *Journal of the Academy of General Dentistry*

Introduction

Many new amalgam alloys have been introduced to the dental profession within the last five years. These alloys can be differentiated from alloys of traditional composition by several unique characteristics. First, the content of copper ranges from 9 to 30%, compared with 3 to 5% for most standard alloys. Secondly, they purportedly contain little or no γ_2 phase (tin-mercury) and therefore should be more resistant to corrosion in the oral cavity. In addition, most manufacturers claim a value for creep significantly lower than that of previous compositions. Some manufacturers frequently refer to this property since it is predictive, to some extent, of the long-range clinical performance of a given amalgam (Mahler, Terkla & Van Eysden, 1973).

The purpose of this report is to compare clinical and manipulative characteristics of some commercially available amalgam alloys with a high content of copper.

Materials

All the alloys included in this report, their respective manufacturers, content of copper and mercury, as well as selected mechanical properties, are given in the table. The first nine alloys contain a high content of copper (9–30%), whereas the last is an alloy of conventional composition certified by the American Dental Association and was included as a point of reference.

Methods

Approximately 50 restorations of each material were inserted into class 1, 2, and 5 cavity preparations. A total of 523 restorations was placed over a period of 12 months. Tooth site, operator, and material were assigned randomly.

All teeth were prepared and restored in a dry field obtained with a rubber dam. An effort was made to include only those teeth requiring cav-

Alloys Evaluated, Content of Copper and Mercury, and Mechanical Properties

Alloy	Manufacturer	Cu Content (%)	Hg Content (%)	Mechanical Properties* Creep (%)	Compressive Strength ($lbf \cdot in^{-2}$) 1 hr	1 wk
Aristaloy CR	Baker Dental Carteret, NJ 07008	13	50.0	0.28	33,000	73,800
Cupralloy	Star Dental Conshohocken, PA 19428	19	50.0	0.22	18,200	63,900
Dispersalloy	Johnson & Johnson East Windsor, NJ 08520	12	50.0	0.25	32,000	64,500
Indiloy	Shofu Dental Products Menlo, CA 94025	13	45.0	0.06	31,600	62,600
Micro II	L D Caulk Co Milford, DE 19963	9	54.5	1.40	25,000	63,300
Optaloy II	L D Caulk Co	9	54.5	1.77	28,800	63,500
Phasealloy	Phasealloy, Inc El Cajon, CA 92021	18	50.0	0.37	12,900	65,700
Sybraloy	Kerr Manufacturing Co Romulus, MI 48174	30	45.0	0.02	46,500	67,000
Tytin	S S White Philadelphia, PA 19102	13	43.5	0.07	34,900	77,500
Velvalloy	S S White	4	50.0	1.00	18,000	55,000

*LEINFELDER, K F, STRICKLAND, W D, SOCKWELL, C L & EAMES, W B (1979) Two-year clinical evaluation of high copper content amalgams. *Journal of Dental Research,* **58**, *Special Issue A, Program and Abstracts of Papers,* Abstract 425, p 199.

ity preparations of standard size involving one, two, or three surfaces. Teeth requiring pins or capping of cusps were generally not included. All restorations were polished by conventional methods at periods ranging from 24 hours to two weeks after placement.

Black and white photographs of each restoration at a magnification of 1.5 were taken at the time of final polishing. Photographs were taken again of each restoration after one and two years. Each print was enlarged to increase the diameter of the tooth five times. The photographs were analyzed for marginal integrity.

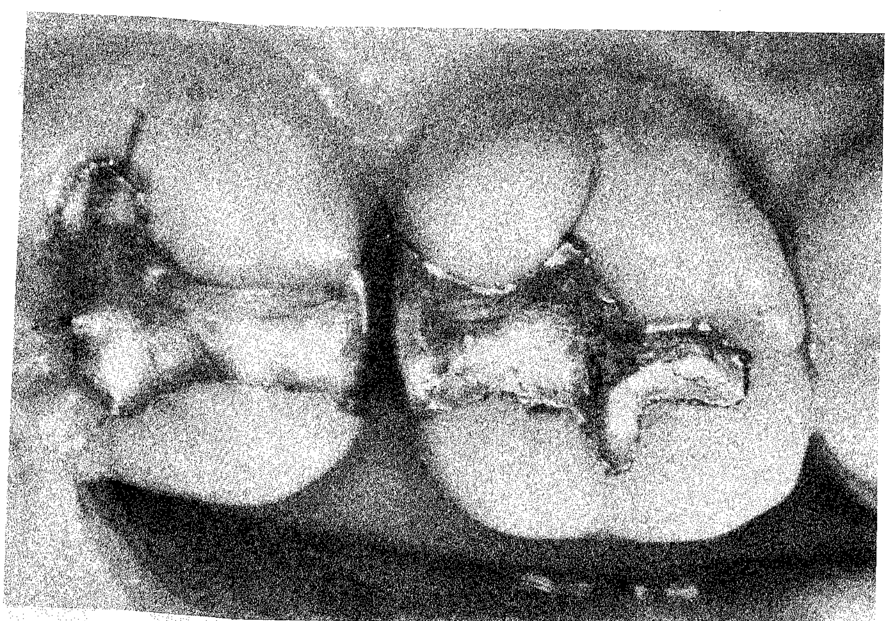
The photographs of all restorations were ranked according to clinical performance. The restoration showing the least marginal failure was ranked number 1 and that with the greatest as number 523. The rank numbers for each alloy were averaged and the mean values arranged from the lowest to the highest. The photographs were ranked by three evaluators using a technique essentially the same as one described by Osborne & others (1976).

The statistical significance of differences in marginal deterioration among the various amalgams was determined by analysis of variance (Kruskal-Wallis test), and the consensus between examiners was determined by a rank correlation test (Spearman).

Results and Discussion

The data derived from ranking the clinical photographs of the various alloys at the end of the first year fell into three groups. The first group, the one exhibiting the least amount of marginal deterioration, included Cupralloy, Dispersalloy, Indiloy, Phasealloy, and Tytin. The second group consisted of Optaloy II and Sybraloy, while the last group, which exhibited the most ditching, included Aristaloy CR, Micro II, and Velvalloy. Differences among the various groups were statistically significant ($P < 0.05$).

The ranking of the same amalgams after two years of service showed that the alloys again fell into three separate groups. Essentially, the ranking after two years was the same as that observed after one year, except for Optaloy II. Though grouped originally with Sybraloy, Optaloy II was now in the group showing the most ditching (Aristaloy CR, Micro II, and Velvalloy). Differences among the various groups were statistically significant ($P < 0.05$). A typical comparison of the relative amount of marginal fracture between an amalgam with a high content of copper and one of traditional composition is illustrated in the figure. The restoration on the right (first maxillary molar) is of Velval-



Note the obvious difference in the marginal integrity: to the right, the disto-occlusal restoration is of Velvalloy; on the left, the mesio-occlusal restoration is of Dispersalloy. Both amalgam restorations were placed at the same time and are shown after five years of service.

loy and the restoration on the left (second maxillary molar) is of Dispersalloy. The age of both restorations is approximately five years.

In addition to differing in clinical performance, the alloys also differed in characteristics of manipulation. Each alloy will be discussed individually.

Aristaloy CR: This alloy consists of 60% silver, 27% tin, and 13% copper. Its composition is essentially the same as Tytin. Unlike Tytin, whose particles are spherical, particles of Aristaloy CR are flake-like. The particles of Aristaloy CR are formed by atomizing or spraying the alloy liquefied by heat into a cold environment and allowing the particles to freeze against a solid surface. The morphology of the particles so treated permits closer packing and causes the pre-set mix to condense in a manner similar to that of a fine-cut alloy. Since the average diameter of the particles is generally less than 10 micrometers (μm), the carved surface has a smooth texture, which is relatively easy to burnish or polish.

The reflectivity of the surfaces of Aristaloy CR and Tytin are similar but superior to that of any other alloy presently on the market, even after four years of service. The marginal integrity of Aristaloy CR, however, is similar to that of Velvalloy. Most of the ditching associated with Aristaloy CR occurs during the first year of service and thereafter becomes relatively constant; however, its less-than-ideal performance in this regard is probably related to the manufacturer's recommended amount of mercury (50%) for trituration. When the mercury is reduced to 47.5–48% and the freshly triturated mass condensed more critically, the restoration can be expected to exhibit a lower rate of ditching.

Cupralloy: This amalgam alloy with a high content of copper is classified as an additive alloy since small spherical particles containing 50% copper and 50% silver have been added to a conventional lathe-cut alloy. The ratio between the lathe-cut particles and the spherical particles is approximately 2:1. The lathe-cut particles consist of silver, tin, copper, and zinc. The ratios of the elements are essentially the same as in most amalgam alloys certified by the American Dental Association. The condensing characteristics of this alloy are similar to those of a fine-cut alloy such as Velvalloy. The original compositions, however, were considerably coarser and presented a somewhat grainy texture. The marginal integrity of Cupralloy over a period of two years was similar to that of Dispersalloy, Indiloy, Phasealloy, and Tytin.

Dispersalloy: The oldest of the amalgam alloys with a high content of copper (13%) on the market, this product has been commercially available since 1962. It has been recognized since the early 1970s as an alloy of superior performance and has been investigated more than any other product on the market. Like Cupralloy, it is categorized as an additive alloy since it contains two phases or components. The lathe-cut component contains silver, copper, tin, and zinc (the latter element is optional), whereas the spherical portion is made of a silver-copper eutectic (approximately three parts silver and one part copper). The condensing and carving characteristics of this alloy are similar to those of most other alloys with spherical additives. Occasionally, the polished surfaces of Dispersalloy, like those of Cupralloy and Phasealloy, take on a light pink or copper color.

Indiloy: Manufactured by Shofu, this Japanese product contains silver, tin, copper, and indium. Indium has been included in the formulation for the purpose of rendering the alloy resistant to tarnish and corrosion in the same fashion that aluminum forms a protective layer of oxide on its surface. The particles of alloy are elliptical or tadpole in shape, which allows ready condensation into the cavity preparation using relatively light pressure. Thus, the preset mix offers more resistance to condensation than do alloys that have particles that are completely spherical. After two years of service, the marginal integrity of Indiloy was found to be similar to that of Cupralloy, Dispersalloy, Phasealloy, and Tytin. The reflectivity of its surface, however, was inferior. In each case, the entire surface of the restoration became uniformly light gray shortly after polishing. Since this characteristic remained unchanged over four years of observation, it probably has little or no clinical significance.

Micro II: Like Cupralloy and Dispersalloy, this is an alloy with a copper additive. Unlike those two, however, the additive portion also contains small amounts of tin, which, among other things, facilitates trituration. The lathe-cut component essentially consists of a modified Micro alloy. The clinical performance of this alloy was similar to that of Velvalloy, the control.

Optaloy II: Like Micro II, this alloy is also an additive in which the spherical component contains tin as well as silver and copper. Its clinical performance after two years of service was similar to that of Micro II and Velvalloy. Although the texture of the surface is similar to that of alloys of traditional composition, some of the restorations of Optaloy II and Micro II took on a light gray hue.The handling characteristics of Optaloy II are similar to those of Micro II and Velvalloy.

Phasealloy: This alloy is similar to Cupralloy since its additive phase also contains 50 parts silver and 50 parts copper. In general, Phasealloy has a longer working and carving time than any alloy in this study. It is interesting to note that, although its compressive strength at one hour is lower than that of all other alloys—13 000 pounds per square inch ($lbf \cdot in^{-2}$)—its long-range clinical performance is similar to that of Dispersalloy and Tytin.

Sybraloy: Classified as a microspherical alloy, this product contains 40% silver, 30% tin, and 30% copper. Its low content of silver and high content of copper is a major departure from conventional compositions. Furthermore, its small spherical particles necessitate some special considerations during insertion into a cavity. First of all, instead of using condensers of traditional size, the freshly mixed amalgam must be condensed with relatively large instruments. Since the small spherical particles readily flow past one another under pressure, a small instrument will simply penetrate the surface and result in undercondensation. Generally speaking, the largest condenser that can be inserted within the confines of the cavity preparation should be used for condensation. Occasionally the freshly triturated mass exhibited a mercury-deficient consistency, which could be generally alleviated by extending the trituration time.

Due to the size and shape of the particles of the alloy, Sybraloy is relatively easy to carve. For the same reason the surface is readily burnished and polished. Although Sybraloy has the lowest creep of all products currently on the market (0.02%), its marginal integrity was judged to be intermediate between Tytin and Velvalloy after two years of service.

Tytin: Like Sybraloy, Tytin is a microspherical alloy, but its composition resembles Aristaloy CR. The same rule that applies to Sybraloy for condensing also applies to Tytin. However, since the pre-set flow of Tytin is greater than that of Sybraloy, even more modifications in technique should be considered. For example, the alloy does not readily resist pressure during condensation, and open contacts in the interproximal area may occur unless adequate compensation is made for the thickness of the matrix band. This can be accomplished by wedging the interproximal areas before the cavity preparation is initiated, thereby providing sufficient time for adequate displacement of adjacent teeth.

Tytin readily carves to an extremely smooth surface, which in turn is readily burnished or polished. Although the marginal integrity of Tytin over a period of four years was considered to be at least as good as that of Dispersalloy, the reflectivity of its surface was shown to be superior.

Since completion of this study, a number of manufacturers have significantly improved their alloys by either altering the size of particle or modifying manufacturing techniques. For example, by reducing the range of sizes of particles of the copper additive, the manufacturer of Micro II and Optaloy II has increased the ratio of surface area to volume. This, then, increased the amount of copper available for reaction with tin. Correspondingly, both the γ_2 phase and creep have been significantly reduced. Likewise, by reducing both the content of mercury and the ratio of surface area to volume of the particles of alloy, the manufacturer of Aristaloy CR has substantially improved its clinical performance. A two-year study recently completed at the University of North Carolina has demonstrated that, in addition to exhibiting excellent marginal integrity, the newer alloy retained the same high luster of surface characteristic of the older formulation and of Tytin. This modified product, however, is not as yet commercially available.

Finally, the manufacturer of Sybraloy has improved both the long-range clinical performance of the alloy and its handling characteristics. By incorporating a number of modifications in the processing technique, the manufacturer has improved the wetting of the alloy by mercury during trituration. A subsequent two-year clinical study in our facility involving nearly 200 samples has shown that no significant differences could be detected among the improved Sybraloy, Tytin, and Dispersalloy. Consequently, the ranking of Sybraloy has changed from an intermediate position to one that is the same as the better-performing alloys described in this study.

Conclusion

The new amalgam alloys with a high content of copper differ not only in clinical performance but also in handling characteristics and consequently require modifications in their techniques of manipulation.

This research was supported in part by NIH Research Grant No DE 02668 from the National Institute of Research and by NIH Grant No RR 05333 from the Division of Research Facilities and Resources.

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POINT OF VIEW

Contributions always welcome

Advertising in Dentistry

LUDLOW W BEAMISH

Should we or should we not allow advertising in dentistry? It has taken dentistry a long time to graduate from the era of the barber-surgeon and to be recognized as one of the more important professions. Presently dentistry enjoys a very special place in the healing arts, and this special place has been achieved only after many years of upgrading by those who have gone before us.

In many places in Europe dentistry is seen by the public as something a little short of tooth carpentry. Even now in North America the question occasionally arises: "Are you a dentist or are you a real doctor?" The implication is that still among some the dentist is an entrepreneur who sells his wares and not a professional who sells his services.

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The *modus operandi* of the man of commerce is different from that of the man of learning. In no way does this downgrade one or the other, but that there is a difference there is no doubt. In many ways this adds to their mutual advantage. While both wish to be compensated for their efforts, the dominant objective of the professional should be to render a service. It differs from selling a product in that rendering a service implies a one-to-one relationship. If one is selling a topflight line of shoes it matters little if the shoes are sold by Mr X or Mr Y. However, if one is rendering a topflight service it matters tremendously whether the service is given by Dr A or Dr B. The personal relationship between dentist and patient is of the greatest significance. This rapport is an elusive and intangible quality built up between patient and dentist over a significant span of time. Advertising here contributes nothing.

Dentistry has passed through the degrading years when "plates," "fillings," and "pullings" were advertised. Some of us recall the price war that existed between the dentists of Spokane, Washington, and those of the interior border towns of British Columbia. "Come in the morning—no appointment required—have your plates by evening—guaranteed success—fillings $1.00, tooth pullings 50¢." These advertisements were prominently displayed in the papers and on the billboards of the buildings. A bit shocking, isn't it?

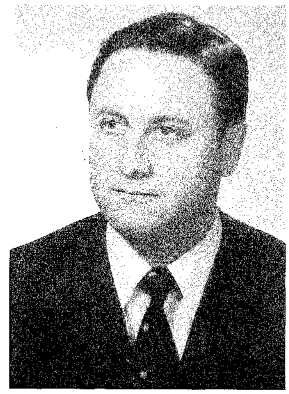
That we disallow our colleagues to advertise has frequently resulted in having the profession branded as being "stuffy." The public will often suggest that we are afraid of facing competition. But how grossly wrong this is! The dentist must be able to operate in the market place of service or he will not survive. Time will soon prove whether or not he is considerate, kind, and competent in rendering his service.

Advertising allows too many opportunities to exaggerate and overembellish the virtues of a service. It panders to the dramatic, and to the desire to upstage one's service without justification. We hear rumors of dental clinics being established in the large department stores in the United States—these of course are started with advertising campaigns. Advertising lends itself to production line procedures. Inevitably the consequence will be mass stereotyped service, with a subsequent falling off of professional standards. Advertising panders to mass production whether it is pointed to selling cars or shoes, medicine, or dentistry. Get the patient in and out of the office in the least possible time and reduce to a minimum the personal contact between dentist and patient. Unfortunately, advertising encourages the commercial and financial aspects of any enterprise, and when directed to a profession will result in minimizing personalized service.

To permit the reintroduction of advertising into the profession of dentistry will allow again the rise of commercialism and nonprofessional attitudes. Our profession enjoys a very special place in our society—we are respected for our knowledge and professional skill. The good rapport we have established with our patients through fine personal contact is something we must maintain and cherish. Advertising has nothing to contribute to this excellent patient-dentist relationship. In fact, advertising has no legitimate place in our profession.

Letter from Europe

ADAM J SPANAUF



In a recent meeting of the Association for Dental Education in Europe many subjects were discussed, but one topic in particular has caught my attention: "Care in Western Society in the Next 30 Years, Problems and Prospectives."

An attempt was made to define the word 'care' as applied to dental health services. Care is the provision of support and assistance to individuals to improve their situation in life or promote their environment.

Considering the present economic climate in most Western European countries, the quality of dental care is on the decline.

In national health systems that are run by the government, the first priority is to save money and to allocate it to the areas of high urgency. Dental care is not one of these.

Most of the national health systems of Western Europe restrict the provision of a comprehensive dental service on the basis of economics.

The quality of the service provided by the general dental practitioners is varied and it is the quantity that matters.

Preventive dentistry has the lowest financial reward. The only solution in the next 30 years will be to place a greater responsibility on the patients for their dental health. However, this will require dental practitioners to become behavioral scientists in order to educate their patients in preventive techniques. The present national health systems are only geared to repairing the damage after it has occurred. The standard of operative dentistry provided under the various national health schemes in some countries is more iatrogenic than curative. Some national health systems have divided patients into two classes, those who according to their income may use the national health services and those who must pay privately for their dental treatment. Expanding the services by creating a large number of dentists with insufficient basic training in operative dentistry is no solution to the problem.

Most dental schools in Western Europe are trying to shorten their dental courses. The fact is that having a large supply of dental practitioners without adequate training in the basic procedures, be it operative dentistry or preventive dentistry, will not solve the problem of dental health within the next 30 years.

In an expanding consumer society the health resources have to expand and will be immediately used up. The next 30 years may prove to be a time of grave danger and a test of all our ideas and ideals in dentistry.

Factors related to the patient, the dentist, the economic and social setting where dentistry is part of a national health program will have to be reviewed.

University of Nijmegen, Faculty of Medicine and Dentistry, Department of Periodontology, Nijmegen, The Netherlands

ADAM J SPANAUF, BDS (Sydney), DS, PhD, senior lecturer in periodontology

DEPARTMENTS

Dear Woody

New Question

Dear Woody:

Frequently, when taking a hydrocolloid impression, I observe tears in the hydrocolloid at the margin of the cavity preparation and into the gingival crevice. What can I do, short of changing impression material, to prevent these tears?

A MEL GAMB
Copperville, CO 296354

Editor's note: Any reader with an answer to this question—or with another question—is asked to communicate as soon as possible with: Dr. Nelson W Rupp, National Bureau of Standards, Dental Research Section, Washington, DC 20234.

Letters

Product Reports

To the editors of *General Dentistry* and *Operative Dentistry:*

May I give you some feedback on the duplication of Dr Eames' articles in your journals? I happen to be a member of all of the three academies represented by your two very fine journals. Because of this, it is my feeling that I am short-changed one article every time an article is reprinted. Of course my opinion is of necessity a minority opinion, but I still wish that because of my membership, I would not be so penalized.

If I were to be asked in which of the two journals I would prefer to see the articles published, I would choose *Operative Dentistry* because illustrations (especially radiographs) are reproduced better on its quality of paper.

Please don't misunderstand me. My reason is purely selfish. The truth is that we really need a dentists' *Consumer Reports*, which would do for us what the Consumers Union does for the general population. The popularity of Dr Gordon Christensen's newsletter attests to that. In our current economic climate price comparisons would also be welcome. With all of the laboratories and clinics that are actively researching dental materials and devices such a publication would seem to be limited only by psychological and ethical considerations. Maybe someone would try publishing such a journal—perhaps as an annual at first.

From the point of view of financial advantage, have you ever considered combining both journals?

Finally, I do want to thank both of you for your very fine efforts in publishing two very fine journals.

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Book Reviews

ATLAS OF COMPLETE DENTURES

By Gino Passamonti

Published by Quintessence Publishing Co, Chicago, 1979. 140 pages. Illustrated. $50.50

The Atlas uses copious color photographs to explain the construction of immediate dentures, and how to perform relines and rebases. The strength of the Atlas is its use of the photographs, but this is also one of its serious drawbacks. The photographs can be useful to explain procedures to one who is constructing a prosthesis; however, the photographs no doubt substantially increase the cost of the Atlas.

The Atlas seems disjointed and several procedures necessary to construct a prosthesis were either omitted or the descriptions were too brief or not very lucid. For example, basic anatomy of the edentulous mouth, examination and diagnosis of the edentulous patient, treatment of mucosa prior to impressions, vertical dimension, selection of anterior teeth, and so forth, are some of the critical areas of prosthetic dentistry that were either omitted or superficially discussed. Fewer pictures and more detailed explanations of prosthodontic procedures would have strengthened the Atlas.

There are always questions about techniques and materials used to construct a prosthesis and the Atlas presents viable techniques but leaves areas open to question. An example is shown on page 109 where a class 2 occlusal relationship is used to explain posterior tooth position and complete denture occlusion. Would it not have been more ideal to illustrate a class 1 relationship for a beginning dental student or lab technician? As mentioned previously, more detailed explanations of several topics are necessary if the Atlas is intended for beginning students. It is questionable that the Atlas could be used as a foundation for prosthodontics. Perhaps it could be used to serve as a visual aid if a more detailed text were included.

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MANAGEMENT OF THE GERIATRIC DENTAL PATIENT

by Kenneth Freedman

Published by Quintessence Publishing Co, Chicago, 1980. 148 pages. Illustrated. $42.00

With the recent increased awareness of the needs of the geriatric dental patient, a short, basic, and well-illustrated text suitable for the general practitioner is most welcome. The depth of material on demographics and the physical manifestations of aging is sufficient to enable the dentist to deal with other health care professionals in an informed manner.

The chapter on oral manifestations of aging is particularly well done with a great many color illustrations covering the most commonly seen clinical situations. Special emphasis in the broad area of drugs and the elderly is essential in a reference text of this sort and is well outlined.

The last half of the book deals with the mechanics of providing treatment to the institutional patient and the home-bound. Lists of desirable equipment, including portable units and mobile vans, are extensive and could provide a dependable nucleus for clinicians, state or local dental societies or government agencies beginning programs of geriatric care.

The text concludes with an extensive reading list for those interested in studying the geriatric patient in greater depth.

While this excellent text is most likely to be used as a reference for the general practitioner, it is also suitable for didactic courses in geriatric dentistry in dental schools.

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FUNDAMENTALS OF REMOVABLE PROSTHODONTICS

by Dean L Johnson and Russell J Stratton

Published by Quintessence Publishing Co, Chicago. 1980. 504 pages. Illustrated. $46.00

This textbook has been written primarily with the undergraduate dental student in mind, stressing basics in complete and partial dental construction. The book is comprehensive in that it does touch on most of the topics pertinent to removable prosthodontics; however, the sequence of the basic information leaves something to be desired. Section 1 deals clearly and well with psychology, anatomy, and physiology of removable prosthodontics—subjects appropriately located at the beginning of the book. The authors then chose to address the complex and controversial topic of removable partial dentures in Section 2 without setting the stage for this more advanced and controversial issue. Subjects such as partial overdentures, removable periodontal splints, stressbreakers and precision attachments, not to mention concepts of partial denture design, have been presented in advance of information on the fabrication of complete dentures.

While the problem of the sequence does not detract a great deal from an overall accurate and fine basic textbook, the lack of subject continuity may be a source of confusion for the undergraduate dental student. If topics such as "Artificial Tooth Selection and Arrangement" and "Balanced Occlusal Patterns" had been considered together in one chapter, or even adjacent chapters, continuity would have been gained, and conversely, fragmentation of information and the need for extensive cross-chapter referencing eliminated. In the section on removable partial dentures, "Characteristics of Impression Materials" and "Making the Impression" are considered far in advance of more basic information such as "The Philosophy of Removable Partial Denture Treatment" and "Gathering Diagnostic Information."

While the text does not flow smoothly from cover to cover, it will act as an excellent reference for the undergraduate student in providing clear, concise, and step-by-step descriptions of widely accepted techniques used in the fabrication of removable prosthodontic devices. To accompany concise descriptions of techniques and philosophies of treatment, excellent schematic diagrams have been provided throughout. The schematics are useful in clarification of confusing concepts, techniques, and methodology, but the overall quality of the book suffers without photographs of actual patients, devices, and materials used.

Excellent detailed texts of various aspects of removable prosthodontics have been available for years in the works of Sharry, Boucher, Prieskel, McCracken, Brewer, and Marrow, to mention a few; however, these will not detract from the high level of conciseness and clarity of fundamental information provided in this textbook of removable prosthodontics.

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Press Digest

Relative caries experience of sealed versus unsealed permanent teeth: a three-year study. Messer, L B & Cline, J T (1980) *Journal of Dentistry for Children* (47) 175–182.

Complete retention of the sealant was relatively poor with retention in premolars exceeding that in molars, 57% and 26% respectively at the end of three years. Regardless of the presence or absence of the sealant, the reduction in occlusal caries compared wih untreated teeth was statistically significant, 64% for premolars and 23% for molars.

Influence of overhanging posterior tooth restorations on alveolar bone height in adults. Hakkarainen, K & Ainamo, J (1980) *Journal of Clinical Periodontology* (7) 114–120.

A study of orthopantomograms of 43 patients revealed that about 50% of all approximal restorations in posterior teeth had overhangs. The overhangs were associated with loss of height of bone, compared with that around restorations without overhangs. The relative difference in height of bone was maintained as age increased.

Announcements

NOTICE OF MEETINGS

Academy of Operative Dentistry

Annual Meeting: February 12 and 13, 1981
Hyatt Regency Hotel
Chicago, Illinois

American Academy of Gold Foil Operators

Annual Meeting: October 21–23, 1981
Oklahoma City, Oklahoma

INSTRUCTIONS TO CONTRIBUTORS

Correspondence

Send manuscripts and correspondence about manuscripts to the Editor, Professor A. Ian Hamilton, at the editorial office: OPERATIVE DENTISTRY, University of Washington, School of Dentistry SM-57, Seattle, Washington 98195, U.S.A.

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Manuscripts

Submit the original manuscript and one copy; authors should keep another copy for reference. Type double spaced, including references, and leave margins of at least 3 cm (one inch). Supply a short title for running headlines. Spelling should conform to *Webster's Third New International Dictionary,* unabridged edition, 1971. Nomenclature used in descriptive human anatomy should conform to *Nomina Anatomica,* 4th ed., 1977; the terms 'canine', 'premolar', and 'facial' are preferred but 'cuspid', 'bicuspid', and 'labial' and 'buccal' are acceptable. SI (Système International) units are preferred for scientific measurement but traditional units are acceptable. Proprietary names of equipment, instruments, and materials should be followed in parentheses by the name and address of the source or manufacturer. The editor reserves the right to make literary corrections.

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Arrange references in alphabetical order of the authors' names at the end of the article, the date being placed in parentheses immediately after the author's name. Do not abbreviate titles of journals; write them out in full. Give full subject titles and first and last pages. In the text cite references by giving the author, and, in parentheses, the date, thus: Smith (1975) found . . .; or, by placing both name and date in parentheses, thus: It was found . . . (Smith & Brown, 1975; Jones, 1974). When an article cited has three authors, include the names of all of the authors the first time the article is cited; subsequently use the form (Brown & others, 1975). Four or more authors should always be cited thus: (Jones & others, 1975). If reference is made to more than one article by the same author and published in the same year, the articles should be identified by a letter (a, b) following the date, both in the text and in the list of references. Book titles should be followed by the name of the place of publication and the name of the publisher.

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