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EDITORIAL

Good News for Good Dentistry

The announcement by Almore International, Inc, that Ferrier separators are again being manufactured is indeed good news. Almost two years have elapsed since S S White discontinued production of these useful instruments and consequently they have become exceedingly scarce. There is no good substitute for the Ferrier design of separator and their scarcity has caused concern among teachers that still advocate the use of cohesive gold as a restorative material and among dentists that provide restorations of cohesive gold as a service to patients.

The reason given for discontinuing manufacture of the separators was that the demand for them was so small their production had become unprofitable. Manufacturers should not be expected to lose money on their products but neither should the production of a necessary instrument be discontinued merely because its manufacture becomes inconvenient or difficult, or because it cannot be produced in batches of a million.

If we look at the demand for separators we can see why it is small. They are durable instruments and one set is likely to serve a dentist throughout his entire career. Separators are purchased primarily by dental students and thus dental schools provide the principal market for the manufacturer. American dental schools alone admit annually almost 6 000 first year students. That the annual demand for separators is substantially less than this is a sad commentary on the state of education in restorative dentistry today.

The main use of the separator is in the placement of cohesive gold in approximal cavities. Cohesive gold is still the best material by far for the treatment of these lesions, especially in anterior teeth and if the lesions are small. Its durability greatly surpasses that of its closest competitor—the filled resin. A well-placed restoration of cohesive gold will usually last for the life of the tooth. In addition, cohesive gold will preserve the mesiodistal width of the crown, which, by preventing teeth from drifting together and so encroaching on interdental papilla and bone, helps to sustain the health of the gingiva.

All dental students should become proficient in the use of cohesive gold for the treatment of class 3 lesions. Few do—a condemnation of the present curriculum of many dental schools. Unfortunately many of those involved in establishing dental curricula are not well versed in the details or importance of restorative dentistry, which is by far the largest part of dental practice.

The availability of Ferrier separators eliminates one excuse for not teaching the technique of cohesive gold restorations. Let us hope that those responsible for the dental curriculum will rediscover the usefulness of cohesive gold in the treatment of dental caries and reinstate instruction in the use of this valuable therapeutic agent.

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ORIGINAL ARTICLES

Experimental Silver Amalgams with Added Copper: A Two-Year Clinical Evaluation

Amalgams of alloys containing added copper resist marginal deterioration better than do amalgams of alloys of conventional composition.

KARL F LEINFELDER • CLARENCE L SOCKWELL
TROY B SLUDER • DUANE F TAYLOR

Summary

Amalgams of Dispersalloy and of four experimental alloys made by adding particles of silver alloy containing copper in various proportions to Pacs and Velvalloy were evaluated for compressive strength, tensile strength, dimensional change, working time, and microstructure, as well as for marginal integrity of the restorations after two years. These alloys were compared with Pacs and Velvalloy. The extent of marginal deterioration was determined by direct clinical observation and from photographs.

In all amalgams with added copper, including Dispersalloy, the compressive strength was higher, the tensile strength lower, and the working time less than in amalgams of conventional composition. Amalgams with added copper expanded on setting whereas those of conventional composition contracted. At the end of two years the deterioration of the margins of amalgams with added copper was less than that of amalgams of conventional composition but there was no difference in wear, surface texture, or discoloration. It is not necessary to eliminate the γ_2-phase entirely to obtain substantial improvement in the performance of amalgam restorations.

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INTRODUCTION

One of the most significant improvements in amalgam has been the recent development of alloys in which the γ_2-phase is suppressed by the addition of relatively large amounts of copper. The first commercial product of this type (Dispersalloy, Johnson & Johnson Dental Products Co, East Windsor, NJ 08520, USA) was a mixture of spherical particles of silver-copper eutectic and filings of a conventional alloy (Youdelis, 1967). The ratio of filings to spheres was approximately 2:1 by volume. Superior mechanical properties and improved clinical performance have been reported for this material (Innes & Youdelis, 1963; Mahler & *others,* 1970; Duperon, Nevile & Kasloff, 1971; Mahler, Terkla & Van Eysden, 1972). The objective of this study was to test whether these improvements are common to similar amalgams with added copper or whether they are unique to Dispersalloy.

MATERIALS

Three proprietary amalgam alloys and four of experimental formulation were used (Table 1). Dispersalloy is an alloy with added copper whereas Pacs (Lactona Corp, Morris Plains, NY 07950, USA) and Velvalloy (S S White, Philadelphia, PA 19102, USA) are lathe-cut alloys of conventional composition.

The four experimental alloys were prepared by adding spherical particles of alloy containing copper to both Pacs and Velvalloy in the proportion of 34% by weight. Two different additives were used: the silver-copper eutectic (Ag 72%; Cu 28%) and a silver-copper-tin ternary alloy (Ag 80%; Cu 10%; Sn 10%). The size of the particles of the additives ranged from 16 to 32 μm. The size and shape of the particles of the various alloys are illustrated in Figure 1.

METHODS

Preparation of Amalgam

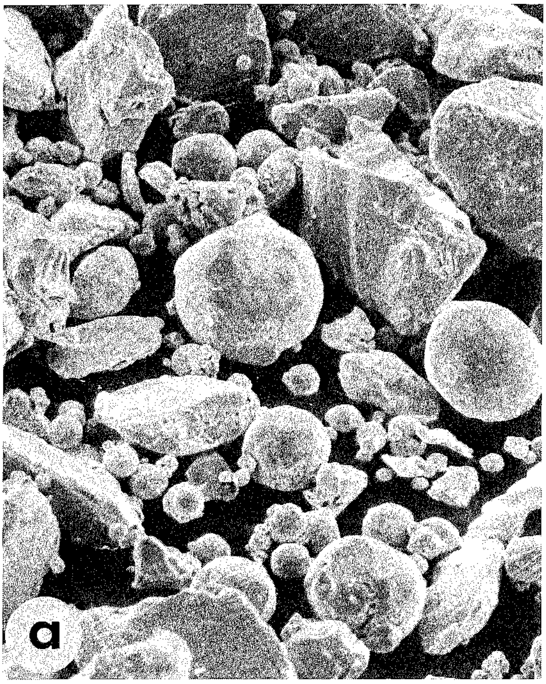
Amalgams of all commercial alloys were prepared according to the manufacturers' recommendations for ratio of mercury to alloy and time of trituration. All experimental alloys were mixed with mercury in a ratio of 1:1 and triturated for 20 seconds in a mechanical amalgamator at medium speed. Each capsule, regardless of the size of the cavity, contained 600 mg each of alloy and mercury. No attempt was made to express mercury before condensation. Specimens for mechanical testing were prepared according to ADA Specification No 1.

Physical Properties

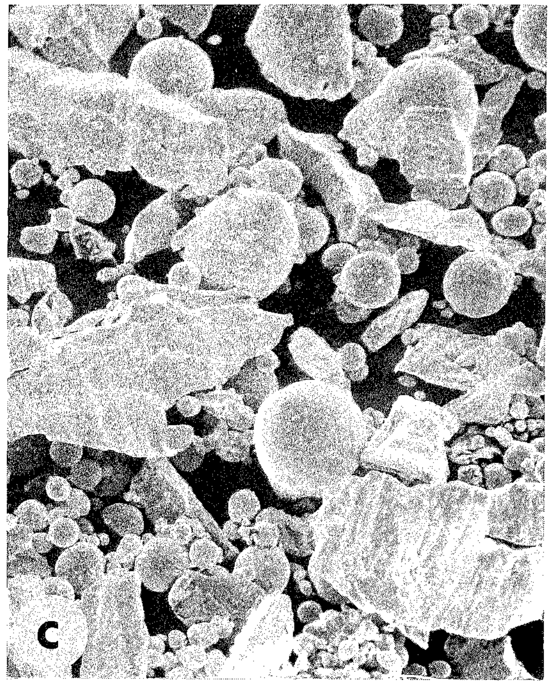
Compressive strength of each amalgam was determined at one hour and one week by loading 4 x 8 mm specimens axially with the load applied at a strain rate of 0.05 cm/min. Tensile strength was determined at one week by the test for diametral tensile strength of

Table 1. Proprietary and Experimental Amalgams

Alloy	Lot Number	Manufacturer
Dispersalloy	590	Johnson & Johnson East Windsor, NJ 08520, USA
Pacs	27712109	Lactona Corp Morris Plains, NJ 07950, USA
Velvalloy	1777407	S S White Philadelphia, PA 19102, USA
Pacs & Ag-Cu Eutectic	———	Experimental
Pacs & Ag-Cu-Sn Ternary	———	Experimental
Velvalloy & Ag-Cu Eutectic	———	Experimental
Velvalloy & Ag-Cu-Sn Ternary	———	Experimental

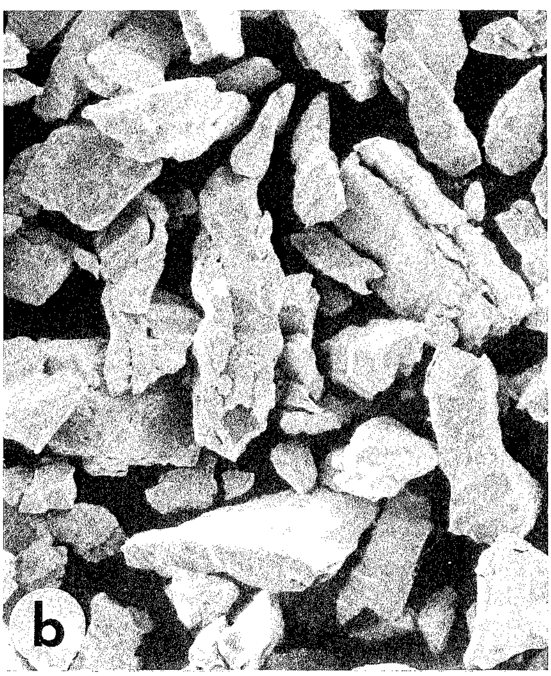


(a) *Velvalloy + Ag-Cu spherical particles*



(c) *Dispersalloy*

FIG 1. Scanning electron micrographs showing size and shape of alloy particles, X 600



(b) *Velvalloy*

ADA Specification No 1. The test for dimensional change during hardening was that of ADA Specification No 1.

Working Time

The plasticity test suggested by Eames (1965) was used as a measure of working time. The test determines the time at which separate portions of amalgam will first fail to cohere when shaken in an amalgamator capsule without a pestle. The time is presumed to correlate with the time at which amalgam is too dry and hard to cohere under clinical condensation. This is a measure of the rate of hardening of the amalgam.

Microstructure

Two specimens of each amalgam at least 30 days old were examined with a metallograph for evidence of the tin-mercury (γ_2) phase. In addition, x-ray diffraction was used to determine the effectiveness of the copper additives in reducing or eliminating the γ_2-phase.

Clinical Manipulation

Approximately 75 samples of each amalgam, for a total of 526 restorations, were inserted into classes 1, 2, 3, and 5 cavities by three clinicians over a period of 12 months. In general, only teeth requiring standard cavity preparations involving one, two, or three surfaces were selected. Restorative materials were assigned at random to particular sites. The resulting distribution of the various materials according to class of cavity is shown in Table 2. All teeth were prepared and restored under the rubber dam and all restorations were finished and polished after full hardening, between 24 hours and two weeks after placement. The restorations were finished with mounted stones of silicon carbide or aluminum oxide and finishing burs, and polished with wet flour of pumice and chalk.

Evaluation of Restorations

The restorations were evaluated by two methods: direct clinical observation and assessment of photographs.

CLINICAL EVALUATION

The clinical evaluation was essentially that proposed by Ryge (Cvar & Ryge, 1971). Each restoration was rated by teams of clinicians at the time of finishing and one and two years later. The clinicians were trained evaluators and during the course of the study were tested intermittently for agreement. Categories evaluated are: (1) wear or loss of materials; (2) marginal integrity or ditching; (3) surface texture; and (4) discoloration.

EVALUATION OF PHOTOGRAPHS

At each clinical evaluation black and white photographs of each restoration were taken at a magnification of 1.5. The prints were enlarged about 7 diameters and used to evaluate marginal integrity and surface texture.

The photographs of all restorations of a given age were ranked for marginal deterioration and surface texture by three evaluators who used a technique essentially the same as that described by Osborne & *others* (1976). Each characteristic was evaluated separately. The restoration showing the least marginal failure or discoloration was ranked one, the next two, and so on. The rank numbers obtained for each amalgam were averaged and the values arranged from lowest to highest.

A Kruskal-Wallis analysis of variance test was used to determine whether the amalgams differed in the various characteristics. In addition, a Spearman rank correlation test was employed to determine agreement between examiners.

Table 2. Distribution of Amalgams according to Class of Cavity

Alloy	Class of Cavity				Totals
	1	2	3	5	
Velvalloy	32	48	4	2	86
Velvalloy & Ag-Cu Eutectic	29	18	0	5	52
Velvalloy & Ag-Cu-Sn Ternary	41	31	1	11	84
Pacs	28	31	4	1	64
Pacs & Ag-Cu Eutectic	35	34	2	5	76
Pacs & Ag-Cu-Sn Ternary	44	28	1	4	77
Dispersalloy	49	59	4	2	114
Totals	258	249	16	30	553

RESULTS

Physical Properties

The physical properties of the amalgams are given in Table 3. The compressive strengths at one hour and one week of amalgams of the proprietary alloys were increased by the addition of spherical particles containing copper. Although none of the one-hour strengths of the amalgams of experimental alloys reached that of Dispersalloy, at one week the strengths are nearly equal. The tensile strengths of amalgams of experimental alloys and of Dispersalloy, however, were lower than those of the conventional amalgams. In general the amount of decrease depended on the amount of copper added. Although the conventional amalgams contract during setting, all the amalgams with added copper, including Dispersalloy, expand.

Working Time

The addition of spherical particles in the range of 16–32 μm reduces the working time of all amalgams to four to five minutes.

Microstructure

An examination of the microstructure of the various amalgams with a high content of copper, both experimental and proprietary, reveals an elimination or substantial reduction of the γ_2-phase. The addition of silver-copper eutectic to Velvalloy and Pacs resulted in nearly complete suppression of the γ_2-phase. The addition of the silver-copper-tin ternary also reduced the γ_2-phase but not to the extent that did the silver-copper eutectic. No evidence of the γ_2-phase was observed in Dispersalloy.

There is good agreement between observations of microstructure and measurements of x-ray diffraction. Slow rates of scan in the regions of the tin-mercury peaks revealed that the addition of the silver-copper eutectic to Velvalloy and Pacs caused a complete suppression of the γ_2-phase, also shown to be absent in Dispersalloy. By comparison the addition of the silver-copper-tin ternary to both Velvalloy and Pacs reduced the γ_2-phase by approximately 70%.

Table 3. Physical Properties of Proprietary and Experimental Amalgams

Alloy	Compressive Strength lbf/in² *(MPa)*		Tensile Strength lbf/in² *(MPa)*	Setting Expansion μm/cm	Working Time min
	1 h	1 wk	1 wk		
Pacs	16,500 *(113.85)*	50,100 *(345.69)*	7,460 *(51.47)*	−15.3	9.0
Pacs & Eutectic	17,400 *(120.06)*	58,500 *(403.65)*	5,980 *(41.26)*	0.1	5.0
Pacs & Ternary	21,000 *(144.90)*	59,800 *(412.62)*	7,340 *(50.66)*	9.0	4.0
Velvalloy	18,100 *(124.89)*	54,300 *(374.67)*	7,550 *(52.10)*	−3.7	6.0
Velvalloy & Eutectic	20,000 *(138.00)*	61,600 *(425.04)*	6,600 *(45.54)*	6.8	4.0
Velvalloy & Ternary	21,800 *(150.42)*	58,200 *(401.58)*	7,020 *(48.44)*	2.6	4.0
Dispersalloy	29,800 *(205.62)*	63,500 *(438.15)*	6,850 *(47.27)*	5.2	4.5

Table 4. Clinical Evaluation of Marginal Integrity

Alloy	Alpha* 1 Yr (%)	Alpha* 2 Yrs (%)	Bravo** 1 Yr (%)	Bravo** 2 Yrs (%)
Velvalloy	92	84	8	16
Velvalloy & Ag-Cu Eutectic	100	100	0	0
Velvalloy & Ag-Cu-Sn Ternary	98	94	2	6
Pacs	96	84	4	16
Pacs & Ag-Cu Eutectic	98	98	2	2
Pacs & Ag-Cu-Sn Ternary	96	94	4	6
Dispersalloy	96	96	4	4

*Alpha—The explorer does not catch when drawn across the surface of the restoration toward the tooth, or, if the explorer does catch, there is no visible crevice along the periphery of the restoration.

**Bravo—The explorer catches and there is visible evidence of a crevice into which the explorer will penetrate, indicating that the edge of the restoration does not adapt closely to the tooth surface.

Clinical Evaluation

The results of the clinical evaluation of marginal failure after one year are given in Table 4. Analysis of these data indicates no statistically significant differences among materials after one year. However, after two years there are statistically significant differences, at a 99% level of confidence, between amalgams of lathe-cut conventional alloys and amalgams of alloys with added copper, both proprietary and experimental. No differences in surface texture, rate of wear, or discoloration were observed, however, among any of the amalgams after either one or two years.

Evaluation of Photographs

The results of the evaluation of photographs also show differences in marginal integrity but not in the other characteristics. Rankings of the alloys for marginal integrity after one year are shown in Table 5. The values are means of three independent evaluations. The lowest possible score is 1.0 and the highest 7.0. These could be obtained if all specimens of one amalgam ranked above or below all others respectively. Intermediate values result from overlapping ranks between amalgams. A Kruskal-Wallis analysis of variance by rank indi-

Table 5. Ranking of Amalgams for Marginal Integrity after One Year

Alloy	Mean Rank
Pacs & Ag-Cu Eutectic	2.87
Velvalloy & Ag-Cu Eutectic	3.01
Dispersalloy	3.20
Pacs & Ag-Cu-Sn Ternary	3.54
Velvalloy	3.77
Pacs	3.96
Velvalloy & Ag-Cu-Sn Eutectic	4.27

The vertical bar connects values that are not statistically different.

cated no statistically significant differences ($P = 0.01$) in the marginal failure of the amalgams at the end of one year.

Ranking of the amalgams for marginal failure after two years can be seen in Table 6.

Table 6. Ranking of Amalgams for Marginal Integrity after Two Years

Alloy	Mean Rank
Velvalloy & Ag-Cu-Sn Ternary	2.68
Dispersalloy	2.87
Pacs & Ag-Cu Eutectic	2.97
Velvalloy & Ag-Cu Eutectic	3.02
Pacs & Ag-Cu-Sn Ternary	3.24
Velvalloy	4.91
Pacs	5.14

The vertical bars connect values that are not statistically different.

A Kruskal-Wallis analysis of variance demonstrated statistically significant differences ($P = 0.01$) between two groups of alloys. The amalgams of all alloys containing additional copper exhibited less marginal deterioration than their unmodified counterparts. No statistical difference could be demonstrated among the amalgams of any of the alloys with added copper, experimental or proprietary. Ranking of the amalgams for surface texture after one and two years revealed no differences among any of the alloys. A Spearman correlation test indicated statistically significant agreement, at a 99% level of confidence, among the three evaluators for both marginal deterioration and surface texture after one and two years.

Selected photographs of some of the restorations after two years of service are shown in Figure 2. Included are three amalgams with added copper and one of conventional composition.

DISCUSSION

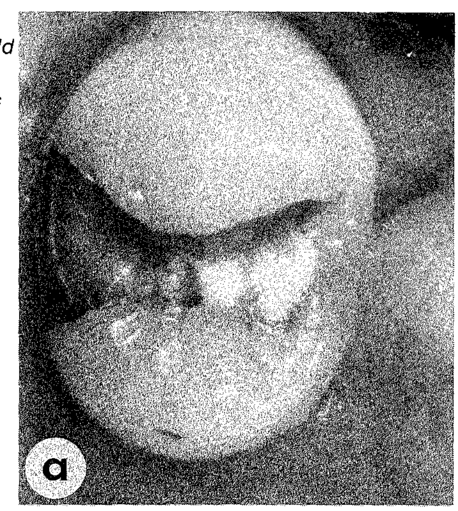
The effects of adding small spherical particles of alloy to filings of amalgam alloy vary with the composition, the size of particle, and the amount of additive. The limited number of combinations studied here precludes a clear identification of cause and effect, but some possible relationships can be inferred.

Physical Properties

The addition of copper-containing particles of appropriate size and amount to lathe-cut conventional alloys enhances compressive strength at both one hour and one week. The interspersion of small particles between the larger filings will reduce the space available for free mercury at the time of condensation. If the added particles are reactive they will also consume part of the free mercury during the process of hardening. Thus the setting time of the amalgam should be reduced and the strength increased. This is probably the cause of the increased strength at one hour, the effect being due mainly to the amount and size of the additive rather than to its composition. The increased compressive strength at one week is probably related to a reduction or elimination of the relatively weak γ_2-phase. The increased strength might also result from a reduction in the total content of mercury in the restoration. The mechanism by which increased mercury weakens amalgam is not known but probably includes factors other than increased formation of the γ_2-phase.

The effect of additives on tensile strength appears to depend on the extent to which the

FIG. 2. Two-year-old clinical restorations



(a) *Velvalloy + Ag-Cu-Sn additive*

weaker γ_2-phase is suppressed. In general, the greater the reduction of γ_2-phase, the lower the tensile strength. This is in agreement with Robertson & *others* (1976) who demonstrated the tensile strength of Dispersalloy to be lower than that of Velvalloy. Although there is yet no explanation for this phenomenon, a reduction of the γ_2-phase causes the amalgam to become more brittle and hence tensile strength may decrease.

Working Time

All the experimental alloys used in this study exhibited working times substantially shorter than those of the unmodified alloys. Shorter working time can be attributed to an increased rate of reaction of the spherical additives with mercury. Since working time is determined before condensation, changes cannot be due to the packing of small particles between large ones. The smaller the particles the greater the ratio of surface to mass, thus the fine additives increase the reactive surface of the alloy and shorten the working time.

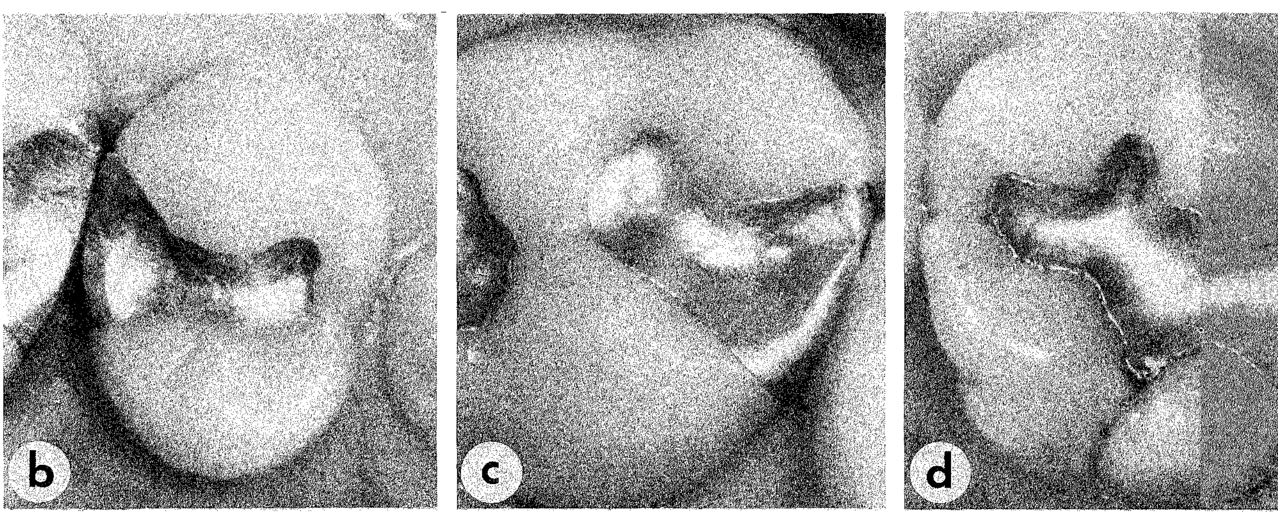
Microstructure

Although the γ_2-phase was eliminated in some amalgams but only reduced in others, the clinical performance of all amalgams with added copper was similar. Apparently the copper content of the ternary additive together with that in the original filings was sufficient to isolate the γ_2-phase and thus retard corrosion. It would appear that 12–13% of copper suffices to eliminate the γ_2-phase completely, but clinical performance may be enhanced appreciably by only 6–8% of copper.

Clinical Evaluation

Marginal integrity is the most sensitive and clinically significant characteristic of these amalgams. Regardless of the method of evaluation no difference of statistical significance could be demonstrated among any of the alloys after one year of service. Although the unmodified alloys (Velvalloy and Pacs) ranked lower than most of the alloys at one year, the differences among any of the alloys was not statistically significant at the 99% level of confidence. After two years of service the superiority of all alloys with added copper over the conventional alloys was apparent. Direct clinical evaluation as well as ranking of photographs revealed differences of statistical significance between the two groups of alloys.

Of the two methods of evaluation, the photographic method appears to be more sensitive. It also has the advantage of permitting direct comparisons of specimens of different ages. Perhaps the greatest advantage lies in the capability of evaluating restorations retrospectively for some characteristic not identified at the time the photographs were taken.



(b) *Dispersalloy* (c) *Velvalloy + Ag-Cu additive* (d) *Velvalloy unmodified*

The effectiveness of direct clinical evaluation was somewhat hampered in this study by our use of criteria originally established for evaluating restorations of all ages and degrees of clinical performance. The relatively new, carefully controlled, restorations studied here fell predominantly into the categories of highest quality. The distinctions between categories need to be redefined. The validity of the method itself is confirmed by the internal consistency of the measurements and by agreement with the photographic evaluations.

CONCLUSIONS

The addition of particles of silver and copper of appropriate sizes to lathe-cut conventional alloys enhances certain physical properties and also clinical performance.

The marginal integrity of the amalgams of all the alloys with added copper was superior to that of the conventional alloys. However, no difference in the rate of marginal failure could be demonstrated between Dispersalloy and the four experimental alloys.

In general, differences between the amalgams of alloys of conventional composition and those of alloys containing increased amounts of copper were not statistically significant until the second year.

Complete elimination of the γ_2-phase is not necessary for substantial improvement in clinical performance.

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Penetrativity of Sealants and Glazes

The effectiveness of a sealant depends on its ability to penetrate into fissures.

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Summary

Penetration coefficients (PC) were determined for the following materials, which are listed in order of penetrativity: Adaptic Bonding Agent, Delton, Concise Enamel Bond, Nuva-Seal, and Adaptic Glaze. The penetration coefficients ranged from 11.5 to 0.57 cm/s. Penetration coefficients were also determined for four experimental sealants and related to their ability to fill fissures. A penetration coefficient of 1.31 cm/s was adequate to fill 93% of a fissure.

All of the sealants tested had penetration coefficient values sufficient for deep penetration. The Adaptic Glaze was less penetrating and the Adaptic Bonding Agent more penetrating than the sealants tested.

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Presented March 31, 1977, at Symposium II "Restorative Dental Materials," International Association for Dental Research, Copenhagen, Denmark.

INTRODUCTION

The effectiveness of a sealant is determined by its ability to penetrate into narrow crevices. Adhesion of a sealant depends on its ability to penetrate into the rough surface of etched enamel and to form microscopic projections or tags. Penetrativity, therefore, is an important property of sealants.

The penetration coefficient (PC) of a liquid is a measure of its rate of capillary penetration and is given as

$$PC = \frac{\gamma \cos\Theta}{2\eta}$$

where γ is the surface tension, η the viscosity, and Θ the angle of contact of the sealant with the substrate (O'Brien, 1973).

In this study the relation between the penetration coefficient and the degree of penetration of experimental sealants into fissures of extracted teeth was determined and compared with the penetration coefficients of commercial sealants, glazes, and bonding agents. The formation of tags was observed and related to the penetration coefficients.

MATERIALS

The commercial materials used are listed in Table 1.

Table 1. Commercial Sealants, Glazes, and Bonding Agents for which Penetration Coefficients Were Determined

Adaptic Bonding Agent	Johnson and Johnson, East Windsor, NJ 08520, USA
Adaptic Glaze	Johnson and Johnson, East Windsor, NJ 08520, USA
Concise Enamel Bond	3M Co, St Paul, MN 55101, USA
Delton	Johnson and Johnson, East Windsor, NJ 08520, USA
Nuva-Seal	L D Caulk Co, Milford, DE 19963, USA

Four experimental sealants (A, B, C, and D) with different penetrativity were formulated from Bis-GMA and methyl methacrylate. An indicator dye (Rose Bengal, Eastman Chemical Company, Rochester, NY 14650, USA) was added to facilitate observation.

METHODS

Penetration Coefficient

The penetration coefficients of the five commercial products were measured at 22 °C by a method using glass capillary tubes (Fan, Seluk & O'Brien, 1975). Each material was mixed according to its manufacturer's directions and allowed to penetrate, directly from the mixing well, into horizontal capillary tubes. The penetration coefficients of the experimental sealants were determined by the same method but at 23 °C.

Contact Angles

The contact angles of the experimental sealants on glass and enamel were determined from photographs of the menisci in tubes and fissures, respectively.

Penetration of Experimental Sealants into Fissures

The penetration of each of the four experimental sealants was observed on extracted teeth. Molars with sharply inclined occlusal planes were sectioned longitudinally with a water-cooled carborundum disc, and five faciolingual sections selected for their deep fissures. The same sections could be used repeatedly to test the penetration of sealants having different penetration coefficients because the sealants, lacking an initiator, did not polymerize. Before each penetration test, the sections were cleaned ultrasonically in distilled water and dried in oil-free air. The sectioned surfaces were sealed with adhesive cellophane tape to permit observation of the penetration of the sealant into the fissures. Sealants were applied with a fine camel hair brush and the penetration was recorded every 15 seconds by photomicroscopy under oblique lighting. After each experiment the sections were immersed in chloroform, then distilled water, and finally cleaned ultrasonically.

Penetration of Sealants into Etched Enamel

The penetration of two commercial sealants, Delton and Adaptic Glaze, having different penetration coefficients in etched enamel, was observed by scanning electron microscopy on sectioned enamel. Extracted human teeth were cleaned by the use of silex (J Bird Moyer Co, Philadelphia, PA 19132, USA) and rubber cup (Young Dental Mfg Co, Maryland Heights, MO 63043, USA) and quartered longitudinally. The sealants were applied to sections of the same tooth after etching with liquids supplied with

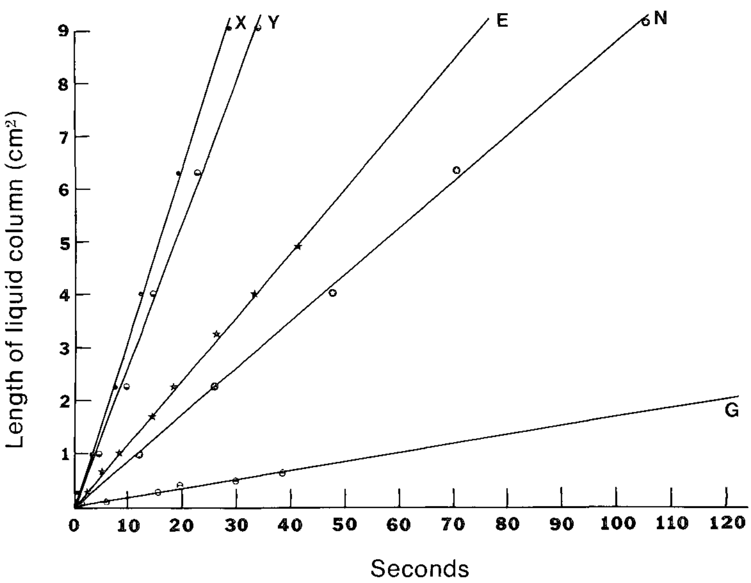

FIG. 1. Plots of length of liquid column compared with commercial sealant at 22 °C

the sealants. The sections were then embedded in polyester resin and bisected with a water-cooled carborundum disc. The junction of enamel and sealant was treated with 1N HCl for one minute, rinsed with distilled water and dried in oil-free air (Myers, Rossi & Cartz, 1974). The sections were coated with gold for observation under a scanning electron microscope.

RESULTS AND DISCUSSION

Penetration Coefficients

Penetration coefficients were obtained by linear regression analysis from the slopes of the lines in Figure 1. The values for the commercial materials are given in Table 2 and those for the experimental sealants in Table 3.

The penetrativity of sealants increases with monomer content. But, the polymerization shrinkage of the materials will also increase with increased monomer content (Asmussen, 1975), which is undesirable.

Contact Angles

For the experimental sealants, the contact angle on glass was found to be 49° with a standard deviation of 6° and on enamel 47° with a standard deviation of 6°.

Table 2. Penetration Coefficients of Five Commercial Materials at 22 °C

Material	No of Samples	Penetration Coefficient	
		cm/s	SD
Adaptic Bonding Agent	6	11.5	0.7
Delton	4	8.8	0.4
Concise Enamel Bond	6	4.5	0.4
Nuva-Seal	8	2.9	0.2
Adaptic Glaze		0.57	0.06

Table 3. Penetration Coefficients and Percent Penetration of Experimental Sealants

Sealant	Penetration Coefficient	Penetration	
	cm/s	%	SD
A	1.31	93	16
B	0.24	30	25
C	0.13	23	18
D	0.07	21	16

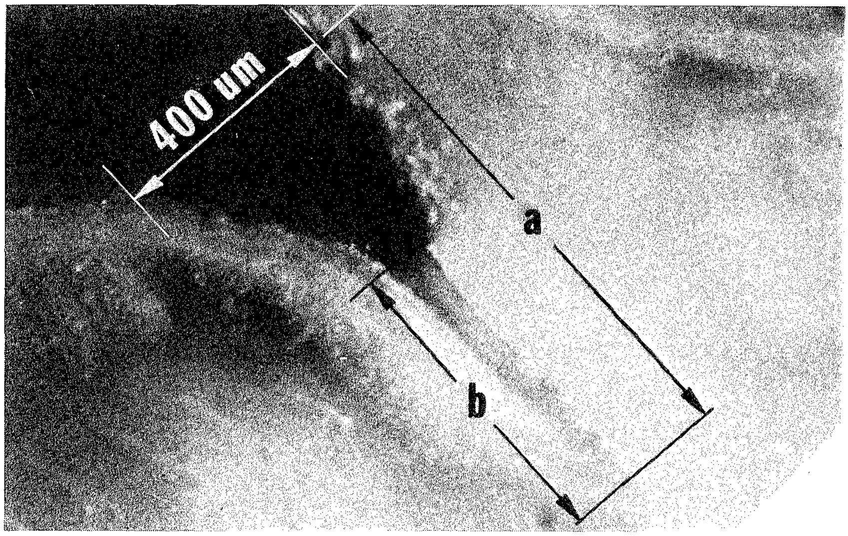

FIG. 2. Penetration of a sealant in a fissure
a = length of fissure
b = length unfilled

Penetration of Experimental Sealants into Fissures

The depths of penetration of the experimental sealants into fissures relative to the depths of the fissures is expressed as a percentage. This is defined as

$$\text{penetration} = \frac{100\,(a - b)}{a}\,\%$$

where 'a' is the distance from the bottom of the fissure to the point where its cross section is 400 μm wide and 'b' is the distance from the bottom of the fissure to the meniscus of the sealant (Fig 2).

The results show that penetration of a sealant into fissures depends greatly on its penetration coefficient, the higher the penetration coefficient the greater the penetration. For sealant A (PC = 1.31 cm/s), complete penetration was observed one minute after applying the sealant in four of the five fissures, all of which had different geometric configurations. The penetration of sealants B, C, D, with penetration coefficients less than or equal to 0.24 cm/s, after one minute was no higher than 65% and thus the fissures were incompletely filled. The depth of penetration was calculated from measurements made one minute after application because this simulates clinical conditions in which the sealants are polymerized.

Since the four sealants were each applied to all five fissures, we can compare the penetration of all the sealants into each fissure as well as into different fissures. In the former there is no influence from the geometric configuration of the fissure and the penetration depends entirely on the penetration coefficient of the sealant; in the latter, four out of the five fis-

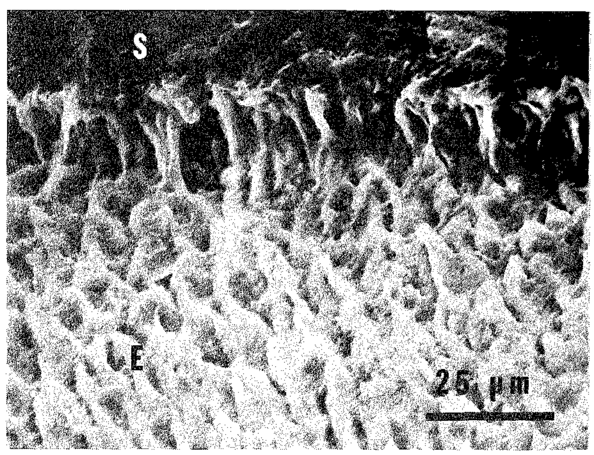

FIG. 3. Scanning electron micrograph of the interface of sealant (S) and enamel (E) showing formation of rod-shaped tags by material Y in the etched surface of enamel of type 1 etching pattern.

sures, all having different configurations, showed complete penetration by sealant A but not by the other sealants.

Taylor and Gwinnett (1973) have shown that wide, shallow fissures are usually completely filled by sealants whereas narrow, constricted fissures are not. However, our observations show that even a narrow fissure can be completely filled when a sealant with a high coefficient of penetration is applied at a proximal edge of the occlusal surface and allowed to flow to the other edge. When the sealant is painted on the occlusal surface, trapped air in the fissures prevents further penetration after an equilibrium position is reached, resulting in incomplete penetration even for sealants with high coefficients of penetration. This probably explains the incomplete penetration by sealant A in one of the fissures. Therefore, sealants should be applied at a proximal edge of the occlusal surface and allowed to flow along the fissure in order to reduce entrapment of air.

In clinical practice, such scrupulous cleaning of fissures before applying the sealant is not possible. Entrapped materials such as debris, water, or etchant in narrow, deep fissures can prevent the complete filling of fissures even for sealants with high coefficients of penetration. The experimental model thus reflects the optimal conditions for penetration that may not be clinically possible.

Penetration into Etched Enamel

Sealants that have penetrated into etched enamel form tags upon polymerization. Etched human enamel exhibits three patterns which determine the shapes of these tags (Silverstone, 1974; Silverstone & *others*, 1975; Silverstone, 1975). Figure 3 shows formations of tags in type 1 etched enamel where prism cores have been etched away. Tags formed in these cores are rod shaped and were exposed when the prisms were dissolved by HCl. Figure 4 shows formation of tags in type 1 etched enamel by a sealant with a lower coefficient of penetration. There are fewer tags and their dimensions are smaller than those of a sealant with a higher coefficient of penetration. Figure 5 shows formation of tags in type 2 etched enamel where prism peripheries have been etched away. Tags formed in this region are in the shape of sheaths surrounding the prisms which were subsequently dissolved by HCl.

CONCLUSIONS

Four experimental sealants with coefficients of penetration ranging from 0.07 cm/s to 1.31 cm/s were used for a penetration study into the same fissures. The experimental sealant with a 1.31 cm/s coefficient of penetration

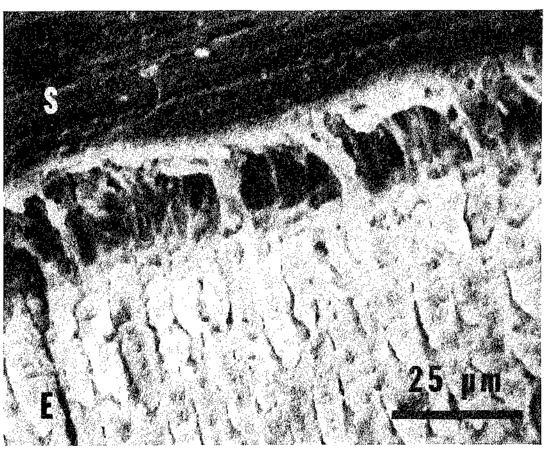

FIG. 4. Scanning electron micrographs of the interface of sealant (S) and enamel (E) showing formation of rod-shaped tags by material G in the etched surface of enamel of type 1 etching pattern

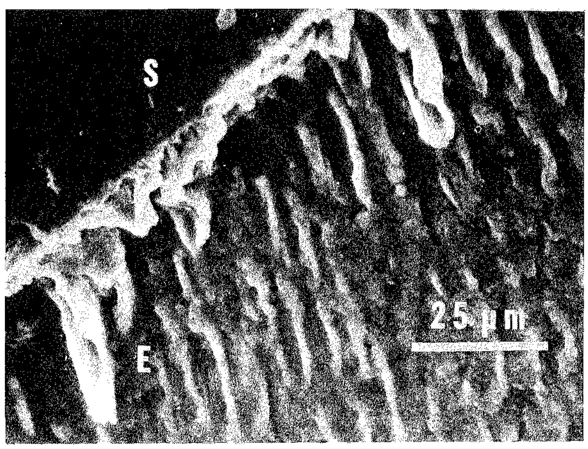

FIG. 5. Scanning electron micrograph of the interface of sealant (S) and enamel (E) showing formation of sheath-shaped tags by material Y in the etched surface of enamel of type 2 etching pattern

completely penetrated all but one of the fissures. Penetration was incomplete for sealants with low coefficients of penetration and in fissures where air had been trapped.

The commercial materials, except the glaze, are more penetrating than the experimental sealants. The bonding agent had the highest penetration coefficient. Therefore, all the commercial sealants tested showed adequate penetrativity.

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OPERATIVE DENTISTRY, 1978, 3, 57-59.

DENTAL PRACTICE

Finishing Procedures that Compensate for Deficiencies in Stone Dies

It is possible to improve the fit of castings that have small discrepancies resulting from abrasion of stone dies during fabrication of wax patterns.

MARVIN A JOHNSON

Of all the die materials available these days, densite, or refined dental stone, is used more than any other. It has advantages over other materials in cost, compatibility with most impression materials, accuracy, hardness, and ease of handling. Densite is a fine die material that will yield adequate clinical results if one is aware of its inadequacies and has a method of compensating for them in clinical or laboratory procedures.

In order to compensate for these inadequate physical properties, it is necessary to be acquainted with them. Briefly, densite does not reproduce sharp margins and is easily abraded. This is particularly evident at the proximal margins of dies for onlays and three-quarter crowns. The resultant deficiencies are directly related to the sharpness of these margins. Simply stated, the sharper the margins, the greater the problem.

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Clinicians, routinely placing three-quarter crowns that have been constructed on stone dies, have noticed that a crown may appear to fit very nicely on the die but when placed upon the tooth may fit very nicely everywhere except at the incisal or occlusal margin. This particular problem could possibly be the result of a distorted impression but the chances are almost 100% that the apparent discrepancies are the result of the physical properties of the stone die and the way in which it was handled.

This particular problem—open incisal or occlusal margins—results directly from failure of the stone to produce sharp margins and loss of die margins by abrasion during the production of the wax pattern. The process begins as dies are withdrawn from resistant impression materials, particularly the rubber and polyether materials, continues during the carving of the pattern, and is magnified when the wax margins are polished with silk or nylon before investing. This combination of procedures results in a die that is reduced at the proximal margin. The resulting casting will bind at the facial cavosurface margins and keep the occlusal as well as the gingival margins open.

Some clinicians have compensated for these problems by very careful handling of the die during waxing or by overexpansion during casting, or both. When limited to the same expansions used to make a very well-fitting casting by the direct waxing method nearly all castings made on stone dies will fail to seat completely when placed on the tooth. This problem can be corrected in the finishing phase provided that the dies and castings are accurate and the discrepancies due to abrasion of the die margins are kept to a minimum.

By the use of finishing procedures designed to compensate for the poor physical properties of stone dies, adequate clinical results can be obtained. Given a carefully produced casting that fits the die well, place the casting firmly on the tooth, hold it securely, and disc the proximal margins on the facial surface to smooth continuity with the tooth from the gingival to the occlusal or incisal corner (Figs 1 & 2). When this has been completed, place an orangewood stick on the incisal edge and mallet with a sharp dead blow. *Caution: All bubbles or irregularities must be removed from the inside of the casting, particularly of onlays, before malleting.* This is easily accomplished with a sharp spoon or discoid carver. Chemical etching at this time is valuable (Ostlund, 1974). After being malleted the crown should exhibit a gold flashing, which can be observed on the proximal margins incisal or occlusal to the height of contour, and the crown will be seated

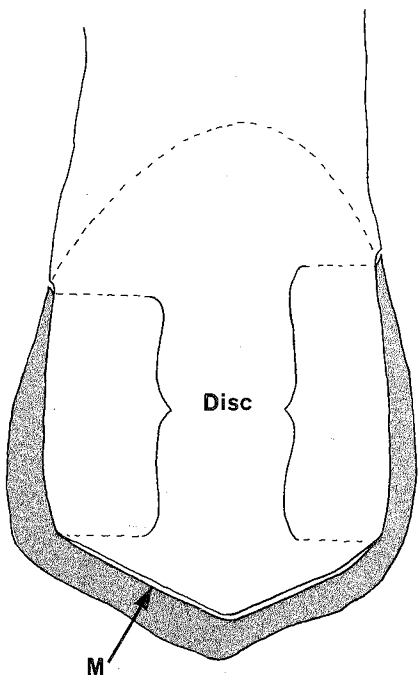

FIG. 1. Disc proximal margins on facial surface from gingival to occlusal over the incisal corner. Note slightly open margin (M).

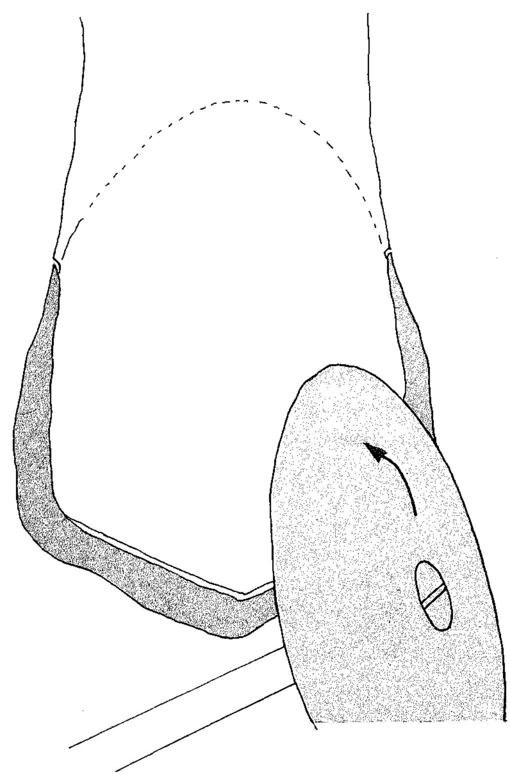

FIG 2. Rotate a ½" extra fine garnet disc mounted face in on contra angle mandrel from gold to tooth.

further upon the tooth (Fig 3). This step is repeated until no more flashing appears when the casting is malleted. At this point the occlusal margin and thus the gingival margin should be closed and can be finished in an expeditious manner. A fine hard carborundum stone at low speed and with water can be used to advantage if turned parallel or nearly parallel to the occlusal margin or on those margins which are inaccessible to discs or strips (Fig 4).

Castings made on stone dies that at first seem to fit well can almost always be seated further on the tooth by application of the above procedures. Many potentially adequate castings have been rendered unserviceable by trying to close the incisal or occlusal opening by "pulling" the gold. Even if this were possible, it would still leave the gingival open with no corrective measures available. Problems listed here for three-quarter crowns apply also to onlays. Discrepancies are usually less obvious because margins of onlays on posterior teeth are usually not as sharp as margins of three-quarter crowns on anterior teeth; however, there are twice as many and the use of similar procedures will result in better seating and thus a better finished product.

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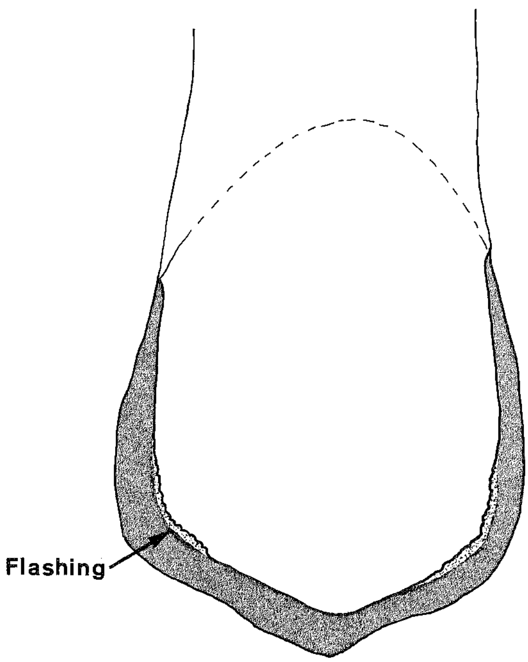

FIG 3. Note flashing, or metal curl, on proximal margin. The crown will seat further on the tooth and the gingival margin will close.

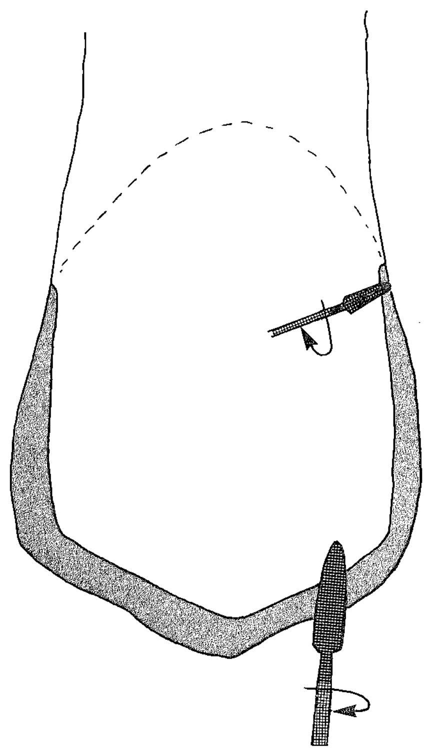

FIG 4. An extra fine carborundum stone with water can be used as shown.

OPERATIVE DENTISTRY, 1978, *3*, *60-65*.

SPECIAL ARTICLE

The Current Status of Cariology

Recent advances in methods of preventing dental caries signal renewed efforts to eliminate the disease.

LOUISE BREARLEY MESSER

Summary

Among the advances in the study of dental caries, some of the most promising are:

- **Establishing departments of cariology in dental schools**
- **Early detection of carious lesions by means of ultrasonic probes**
- **Increased knowledge of the way in which fluoride protects the teeth by inhibiting enzymes needed for bacterial metabolism and by lowering the surface energy of teeth and thus making attachment of bacteria difficult**
- **New methods of applying fluoride to teeth by mouth rinses and intraoral devices that release fluoride slowly**
- **Sealing pits and fissures with resin**
- **Substituting other sweeteners for sucrose in the diet**
- **Developing immunity against the organisms that produce caries**

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Presented at the Academy of Operative Dentistry, 2 February 1978, Chicago

Introduction

The concept of cariology dates from as early as 1890, when W D Miller recognized that dental caries involves two fundamental processes. First, fermentable carbohydrate entering the mouth can be rapidly converted to acid by plaque bacteria on the tooth surface. Second, acid produced in this manner can dissolve enamel mineral and thereby initiate a carious lesion. Since that simple description was developed, remarkable advances in the concept of cariology have occurred in the classroom, in the laboratory, and in the dental clinic. The areas in which many of these advances are occurring are listed in the table. I should like to highlight a few of the recent advances that I think are of particular interest and pertain to operative dentistry.

Educational Advances in Cariology

With Sweden leading the way, European countries have pioneered in combining training in clinical research with specialized courses in cariology. The term cariology orginated in 1940 at the dental school of the Karolinska Institute in Stockholm when the Department of Operative Dentistry (Swedish: 'Tandfyllningskonst', art of filling teeth) had its name changed to the Department of Karieslara (Swedish: 'lara', similar to the English 'to learn'). This reorganization emphasized prevention rather than the symptoms of the disease and its treatment. In the 1950s another change of name at the same institution resulted in the present Department of Cariology. Currently efforts are underway in Sweden to encourage public health officials to recognize cariology as a specialty. Projections for the 1990s have indicated the need for approximately 30 such individuals in the Dental Health Service in Sweden. In Norway, cariology is a component of the training required for the degree of Licentiate of Odontology. More recently, certain European dental schools have combined training in clinical research with specialized courses in cariology. Although only a few centers for caries research have been established, most European dental schools include cariology in departments of conservative dentistry.

In the United States there is only one Division of Cariology in a dental school, and two postdoctoral training programs in cariology. The Division of Cariology was established in 1976 at the University of Iowa School of Dentistry; the two postdoctoral training programs are located in the dental schools of the University of Minnesota and the University of Alabama.

In the early 1970s the National Caries Program (NCP) of the National Institute of Dental Research was organized; the mission of the program was to eliminate caries as a major problem of public health. The general strategy of the research employed by the NCP involves four measures of control: (1) combating the microbial agent, (2) increasing the resistance of the host, (3) altering the dietary environment, and (4) improving delivery and public acceptance of preventive methods.

The National Caries Program determined by 1974 that trained individuals are needed to carry out and coordinate multidisciplinary research on caries. During that year the NCP was authorized to promote the postdoctoral training of cariologists through the National Research Service Award (NRSA) Institutional Training Grant. Cariologists are knowledgeable in all aspects of dental caries and are capable of designing, implementing, and directing teaching programs in dental caries. The training is unique in that it is related to a disease rather than to a discipline.

The training program in cariology begun at the University of Minnesota in 1975 produced its first graduates in the summer of 1978. Training is provided for up to 10 persons who already hold either a degree in dentistry or a doctoral degree in basic science. Three years of study incorporate both instruction and research. A clinical phase of instruction has been developed also, since trainees with the basic science background have little knowledge of dental caries and its implications. This phase of instruction provides an understanding of the clinical nature of dental caries and the current status of its management by the dental profession. Graduates will seek employment in academia, industry, and public health organizations.

Approaches to Prevention of Dental Caries

I. Protecting the Teeth
   A. Early detection
   B. Fluoride
   C. Sealants

II. Modifying the Diet
   A. Sucrose reduction
   B. Sucrose replacement
   C. Anticariogenic additives

III. Combating the Bacteria
   A. Antibacterial agents
   B. Metabolic regulators
   C. Enzymes
   D. Immunization
   E. Mechanical removal

Early Detection of the Carious Lesion

One of the greatest handicaps in preventive treatment of carious lesions has been the difficulty thus far of early detection. Demineralization must be substantial before a carious lesion is detectable in a radiograph, but by then the lesion is well advanced toward the pulp. Large-scale clinical trials to determine the value of agents with cariostatic potential are time-consuming and expensive; and new regulations concerning experiments on humans are further limiting the scope of large studies. The two years that must elapse before definite conclusions can be drawn represent the time it takes a carious lesion to become apparent. If incipient lesions could be detected **before** becoming clinically manifest, preventive treatment could be instituted before a frank cavity develops.

One approach is to measure changes in the ability of a tooth to conduct small electrical currents. Tooth resistance to electrical currents is highest in highly mineralized tissue and lowest in carious areas. George White (Tufts University) has reported successful use of an instrument developed by David L Williams for measuring the resistance of teeth to the conduction of electricity (Abcor, Biomedical Div, Wilmington, MA 01887, USA). An imperceptible current of less than one microampere, much less than that used in vitality testers, passes through the patient. A hand-held ground and dental explorer are used. A buzzing signal indicates a carious region. The report of White and Williams, which will be published during 1978 in the *Journal of Dental Research*, shows that the equipment will reliably detect a pre-carious lesion before it can be detected clinically. Substantial funding from the National Institute of Dental Research has been received to develop further the application of this instrument. As clinicians I think we can anticipate exciting developments here.

Fluoride as a Preventive Agent

Fluoride continues to be our major preventive agent, both as a public health measure and in the dental office. The experience with penicillin in the 1950s has demonstrated that for the prophylactic treatment of dental caries the dental profession will not be able to use a medically important agent to which patients may become sensitized or to which organisms may become resistant. Fluoride, however, is a chemotherapeutic that has no important medical uses. It appears to be an unusually safe and effective cariostatic agent. After more than 30 years of clinical use, there have been no reports of host sensitivity, bacterial resistance, or superinfections.

In spite of extensive epidemiological, clinical, and laboratory studies over this period, the precise mechanism by which fluoride protects against caries remains unknown. To date the actions which have been documented may be summarized as follows:

(1) The fluoride ion can exchange with a hydroxyl group in the apatite crystal, forming a more stable and less soluble crystal.

(2) The fluoride ion can enter void spaces in the apatite crystal and provide stability by additional bonds.

(3) Fluoride can contribute to the remineralization of early lesions.

(4) Fluoride can act as an antimicrobial agent against plaque bacteria.

Microbiological research demonstrates that fluoride inhibits many enzymes essential to bacterial metabolism and growth (Schachtele & Mayo, 1973). For example, fluoride inhibits enolase, an enzyme involved in intracellular metabolism of carbohydrate. If enolase is inhibited, phosphoenolpyruvate is not formed, and the cell is unable to derive energy via this glycolytic pathway. Phosphoenolpyruvate is also involved in the uptake of glucose via the cell wall into many plaque bacteria, including *Streptococcus mutans*. The inhibition of enolase then effectively eliminates from plaque those bacteria that preferentially ferment carbohydrate. Secondly, fluoride may inhibit the formation of plaque. Laboratory studies have shown that fluoride lowers the energy of the tooth surface, making it harder for bacteria to attach (Rölla & Melsen, 1975). Swedish workers from Gothenburg have demonstrated that many oral bacteria will not adhere to each other in the presence of fluoride or to a tooth surface treated with fluoride (Olsson, Glantz & Krasse, 1976). These actions will have the net effect of reducing the potential for colonization of plaque on tooth surfaces.

These recent observations from the laboratory are now explaining why applications of fluoride result in a significant decrease in plaque scores and in caries reductions of 30–40%. However, frequent applications of fluoride and highly motivated patients are needed to maintain these results. Transferring some of the responsibility to the patient may provide an answer.

Mouth rinses of fluoride have been used extensively and very successfully in schools in the Scandinavian countries. A 10-year Norwegian study has just been reported (Birkeland, Broch & Jorkjend, 1977). The reported reduction in DMFS scores is comparable to that achieved with water fluoridation, that is, 60–70%. In June 1975 the National Caries Program instituted a school-based program of mouth rinsing with fluoride at 16 sites in the continental United States, and at a 17th site on the island of Guam. The technic is a weekly, one-minute, supervised mouth rinse with a dilute solution of fluoride. The costs are low, problems of delivery are modest, and acceptance is good. The results from the study have not been published yet, but preliminary figures presented at the 1977 meeting of the American Academy of Pedodontics suggest that the caries reduction may be as high as 50%. This compares favorably with office-based programs such as topical applications applied professionally and fluoride tablets. I hope that at the end of the research contract a nationwide program of supervised mouth rinsing with fluoride can be instituted in many of our schools attended by children of kindergarten age and older.

An entirely different approach to caries prevention with fluoride may be the use of devices that slowly release a predetermined dose of fluoride into the mouth. Donald Cowsar and coworkers (University of Alabama) have recently reported on a fluoride reservoir fixed to the tooth surface with composite resin (Lewis & *others*, 1977). The reservoir (developed by D H Lewis, Southern Research Institute, 2000 9th Avenue South, Birmingham, AL 35205, USA) consists of a core matrix containing particles of sodium fluoride and a double membrane of acrylic hydrogel, which controls the outward diffusion of fluoride. The release of fluoride is independent of the pH, composition, and rate of flow of saliva. Depending on the design, the device can provide a continuous topical application of 0.02–1.00 mg per day for at least six months without maintenance or adjustment. At present, animal studies have been completed and toxicology studies, which indicate the biocompatibility of the system, are concluding. The group is now filing with the Food and Drug Administration for permission to begin clinical trials. Such a device that can be applied or attached in the mouth by simple procedures would provide an economical approach to caries prevention to virtually all segments of the population. One can envision the day when laminated strips incorporating slow release of fluoride can be placed into existing restorations.

Sealing of Pits and Fissures

The introduction of sealants has been hailed as a milestone in preventive dentistry. The etching of the enamel surface with acid followed by the application of a polymerizing resin has been proved in many large-scale studies to be an effective measure of prevention. The possibility of inadvertently sealing in cariogenic bacteria remains a concern to many clinicians. In 1976, Stanley Handelman and coworkers (Eastman Dental Center, Rochester, NY) reported in the *Journal of the American Dental Association* on the growth of organisms in samples of carious dentin taken from minimally carious teeth that were **not** sealed, and from teeth that **were** sealed, up to two years after the sealant was placed. The major reduction in cultivable organisms occurred during the first two weeks. At the end of two years there was a 2 000-fold decrease in the number of cultivable microorganisms. Clinical and radiographic findings suggest that there was no progression of carious lesions. Certainly this study does not suggest that we depart from conventional operative procedures, but it **does** indicate that concern over inadvertently sealing undetected carious lesions does not appear to be warranted.

The successful application of sealants still requires meticulous attention to detail and is widely challenged on its cost-effectiveness. Sealants that are easily applied (perhaps even by the patients themselves) and well-retained on all susceptible surfaces need to be developed.

Replacing Sucrose in the Diet

The association of dental caries with the consumption of sugar now appears firmly established. Patterns of consumption of sugar are changing in the United States. In particular, data from the National Academy of Sciences covering the period 1920 to 1975 show that there have been major changes over the last 50 years in the ways in which refined sugar is used (Bohall & *others*, 1977). In 1920, approximately 70% of all sucrose consumed was purchased for home use. By 1970, only 25% was purchased for use in the home. More sucrose is now consumed in soft drinks alone than in all home-prepared foods. The consumption of soft drinks has now surpassed that of milk and is expected soon to overtake the rate of consumption of water. There has been a dramatic shift toward the use of commercially prepared foods, including convenience foods, many of which contain sugar substitutes.

Among the sugar substitutes of interest to dentists is the group of sugar alcohols, which include sorbitol, mannitol, and xylitol. All three are widely used in the artificial sweetening of chewing gums. Initial reports of the effectiveness of xylitol in reducing caries and plaque in humans have been extremely favorable but must be regarded as tentative since they have not yet been confirmed. In a two-year trial in Finland, in which xylitol was substituted completely for refined sucrose in the diet of young adults, the caries increment was zero in the xylitol group compared with 7.2 new DMF surfaces in the sucrose group (Scheinin & Makinen, 1975). Attempts to duplicate these findings in the United States by the National Institute of Dental Research were suspended in November 1977 following reports from British studies of carcinogenicity of xylitol. At the time of writing, the American studies have not been resumed pending further information.

However, there are at least six to ten other compounds, such as monellin and the dihydrochalcones, which show promise at the research stage. None of these is yet ready for clinical trials.

Immunization Against Dental Caries

Work on the control of human dental caries by immunization with bacterial antigens is proceeding rapidly. Protective immunization of both rodents and nonhuman primates has been achieved, but for humans many problems remain to be overcome.

The methods proposed to date are based on the theory that antibodies could control the causative organisms in the mouth by destroying them by lysis or by interfering with their metabolism. A third approach currently favored is interference, by antiglucosyltransferase antibody, with the mechanism that causes adherence of the organism to teeth. However, several organisms in addition to *Streptococcus mutans* have been implicated in dental caries and an antigen would need to be developed for each one. Since the immune response depends on antibody secreted into the saliva, which is constantly being swallowed, a large amount of specific antibody must be available to be effective. Direct placement of the glucosyltransferase antigen into the parotid gland, to induce antibody formation, has been attempted. This poses obvious problems of technique, biocompatibility, and patient acceptance.

An exciting development was presented at a Symposium on Secretory Immunoglobulin A and Caries Immunity, held in Alabama in December 1977. The ingestion of attenuated *Streptococcus mutans* cells via a capsule in the gut to induce an oral secretory antibody response in humans was reported by Gerry McGhee's group from the dental school in Alabama. This is a remarkable advance, since the production of a serum antibody response is thought to contribute to auto-immune lesions in cardiac and renal tissues. These complications would be avoided with a strictly oral secretory response.

The desirable age of immunization must also be determined. For the antibody to be most effective, the evidence suggests that immunization be given before the primary molar teeth fully erupt and establish interproximal contacts, which harbor *Streptococcus mutans* and presumably other causative organisms of dental caries. Microbiologists from the Great Lakes Naval Base in Illinois have suggested that it might be easier for the antibody to prevent infection and colonization of the teeth rather than to control the infection once it is established (Shklair & Keene, 1976).

Another new approach to immunization is based on the discovery of passive transfer of protective antibodies from rat dams to their offspring by way of milk. One can envision the use of bovine milk supplemented with antibody or milk from cows previously immunized with cariogenic bacteria.

Conclusion

We must recognize that we, as both clinicians and patients ourselves, live in a world that is less than ideal. It is probable that neither caries immunization nor dramatic reduction in the cariogenic challenge of our diets will be feasible in the foreseeable future. In the interim, we need alternative agents, likely to be delivered slowly, that are highly effective against caries. The systems must be simple enough for personal use or for delivery through public health programs. We need improved ability to diagnose caries and to evaluate our clinical accomplishments. In the research ahead, high priority should be given to studies carried out in close cooperation with general and specialist practitioners. Only then can we attain a better understanding and enchanced application of our existing knowledge and develop methods that can be used in our daily clinical work.

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OPERATIVE DENTISTRY, 1978, 3, 66-72.

PRODUCT REPORT

Scraping Resistance of Dental Die Materials: A Comparison of Brands

Resistance to abrasion is a valuable property in a die because if its margins are abraded during the carving of the wax pattern the resulting casting is likely to be submarginal.

WILMER B EAMES
CLAUDE R EDWARDS, JR • WILLIAM H BUCK, JR

Summary

When nine die materials of gypsum were compared for scraping resistance under standardized conditions, Modern Materials Die-Keen and Die Stone were superior to all stones when mixed with water.

When two die hardeners were used, Lactona Indic-Die-Stone showed the highest resistance to scraping.

Die coating materials improved the resistance substantially, but a die lubricant did not.

An epoxy resin was shown to be relatively resistant to abrasion.

Silver-plated dies were superior to all other materials under the conditions of this experiment.

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INTRODUCTION

Dental dies are frequently damaged or abraded accidentally during the fabrication of wax patterns for restorations. Such abrasion causes discrepancies in the dies that may adversely affect the final adaptation of the restoration in the mouth.

This study measured and compared the resistance to abrasion of several commercial die materials under certain conditions and with different additives.

MATERIALS

The nine gypsum products tested are shown in Table 1. One product, Buff Labstone, is not designated by the manufacturer as a die stone,

Table 1. Materials Tested

Gypsum Products			
Super-Cal	Coe Lab Inc Chicago, IL 60658	Die Stone	Modern Materials Mfg Inc St Louis, MO 63104
Vel-Mix	Kerr Manufacturing Co Romulus, MI 48174	Glastone	Ransom & Randolph Toledo, OH 43691
Indic-Die-Stone	Lactona Corporation Morris Plains, NJ 07950	Silky-Rock	Whip-Mix Corporation Louisville, KY 40217
Buff Labstone	Modern Materials Mfg Inc St Louis, MO 63104	Super-Die	Whip-Mix Corporation Louisville, KY 40217
Die-Keen	Modern Materials Mfg Inc St Louis, MO 63104		
Hardening Solutions			
Stalite	Buffalo Dental Mfg Co, Inc Brooklyn, NY 11207		
Whip-Mix Gypsum Hardener	Whip-Mix Corporation Louisville, KY 40217		
Surface Additives			
Aron Alpha Rapid Bonding Adhesive No 202 (cyanoacrylate)	B Jadow & Sons, Inc New York, NY 10010		
Jelenko Model Spray	J F Jelenko and Company New Rochelle, NY 10801		
Ney Die Lube	Ney Company Bloomfield, CT 06002		
Epoxy Resin Die Material		**Silver Plating**	
Dentsply Epoxy Die Material	Dentsply International Inc York, PA 17404	Silver-tek	Yarter-Tek Corporation Denver, CO 80216

but was included as a general laboratory stone for comparison.

Products and techniques are available for increasing the hardness of dental dies. Included in this study were two gypsum hardeners, Stalite and Whip-Mix Gypsum Hardener. Also tested with several products were techniques that have been used empirically by dentists, namely, coating the die with cyanoacrylate cement, using a die lubricant, and using a model spray. Silver-plated dies and a die material of epoxy resin were also included.

METHODS

Six samples of each product were prepared using each of the three liquids included in the study: Stalite, Whip-Mix Gypsum Hardener, and water. The samples were then tested for resistance to abrasion at 90 minutes and 24 hours. The die lubricant, the cyanoacrylate cement, and the model spray were each tested on a product that was moderately resistant to scraping.

Preparation of Gypsum Specimens

Stone powder was carefully weighed into portions of 100 g. An appropriate amount of either Stalite, Whip-Mix Gypsum Hardener, or water was added. The liquid/powder ratios used are shown in Table 2. These are within the ranges suggested by the manufacturers, allowing individual preference in consistency. This mix was spatulated for 20 seconds under vacuum with the Whip-Mix Vacuum Investor. The material was vibrated into a 50 ml plastic syringe, then expressed into molds which were held on a vibrator. Molds were made from 5 ml plastic syringes with a constant diameter of 12 mm and cut to a length of 22 mm. The same molds were used throughout the experiment. Six specimens were made of each material.

After the excess material had been removed, the molds were set aside until the specimens were sufficiently hard to expel. They were placed on a tray in a circulating air oven (Precision Thelco Model 18) at 52 °C for one hour to drive off excess water, which otherwise would evaporate during the test and affect the results adversely, sometimes by as much as 300%. Once dried, the specimens were numbered and weighed on a Mettler analytical balance (Mettler Instrument Corp, Hightstown, NJ 08520, USA).

Testing for Resistance to Abrasion

A machine was adapted (Fig 1) to pass a

Table 2. Liquid/Powder Ratios of Gypsum Products

	Stalite	Whip-Mix Gypsum Hardener	Water
	ml g	ml g	ml g
Super-Cal	20/100	22/100	24/100
Vel-Mix	18/100	22/100	24/100
Indic-Die-Stone	18/100	19/100	22/100
Buff Labstone	20/100	28/100	30/100
Die-Keen	18/100	20/100	22/100
Die Stone	20/100	22/100	24/100
Glastone	20/100	22/100	25/100
Silky-Rock	15/100	20/100	22/100
Super-Die	19/100	20/100	21/100

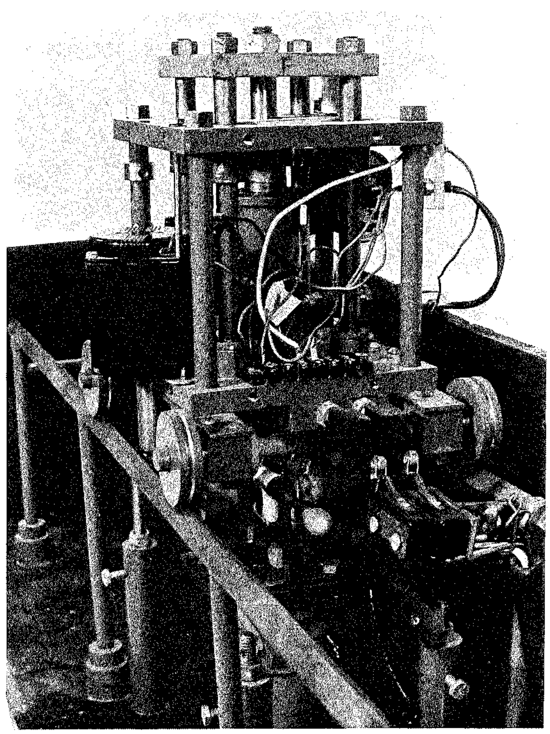

FIG 1. A machine constructed to scrape die samples under standard load and traveling at a constant rate

sharp blade (Stanley Break Away Blade 910, Stanley Tools, New Britain, CT 06050, USA) across the surface of the sample at an angle of 90°, scraping in one direction only. Each sample was scraped 10 times, a new blade being used for each sample.

An attempt was made to simulate the action of a manual carving instrument or other laboratory procedure used on a gypsum die. The blades were mounted on a "floating" bar (Fig 2) of a constant weight of 155 g, which was attached to a motorized rolling carriage propelled automatically and mounted on tracks above the specimen platform. The carriage was driven a distance of 3 cm at a speed of 6 mm/s, automatically reversing itself at each end of the cycle and thereby continuously passing back and forth over the sample. When moving from left to right, the guide for the floating bar traveled down an inclined ramp, which was adjusted to let the blade begin scraping the sample 1 mm from its edge, running lengthwise at a tangent to the surface (Fig 3). When the blade touched the surface of the sample it was loaded by only the weight of the floating bar and blade. After a distance of 15 mm had been scraped, an air cylinder lifted the bar guide from the surface of the sample. The carriage then reversed itself and held the blade off the sample while the carriage moved from right to left. When the carriage reached the left side, or starting point, the air cylinder turned off and lowered the blade guide onto the inclined ramp, and the machine started back toward the right, allowing the blade to scrape the sample as described above (Fig 4). This cycle continued for 10 repetitions on each sample.

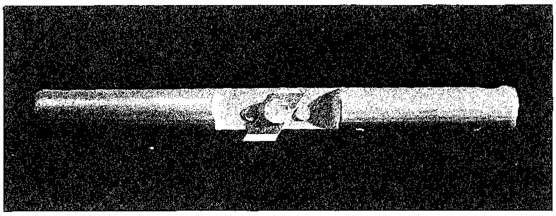

FIG 2. A blade used to scrape die specimens is shown mounted on a floating bar weighing 155 g

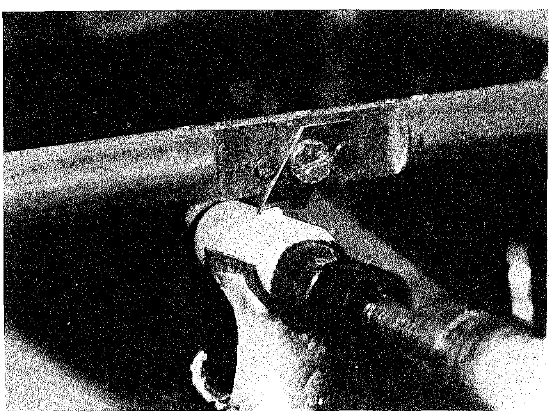

FIG 3. The blade scraping the die sample for a distance of 15 mm, under constant conditions

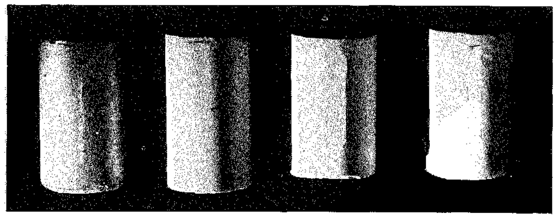

FIG 4. Examples of four typical specimens, which have been scraped, showing varying resistance to abrasion determined in the study as weight loss

Each sample was weighed before and after scraping, and the loss of weight calculated. Samples to be tested with cyanoacrylate, die lubricant, and model spray were prepared in the same manner. Samples of the epoxy die material and the silver-plated dies were made in a rubber base impression (Permlastic, Kerr Manufacturing Co, Romulus, MI 48174, USA) of six of the gypsum samples to avoid handling problems with the epoxy and silver-plating techniques.

RESULTS

All products shown in Tables 3 through 6 were more resistant to scraping after 24 hours than after 90 minutes. Most products proved more resistant to scraping when mixed with Stalite or Whip-Mix Gypsum Hardener, and of these Stalite produced slightly higher resistance.

When mixed with water, Die-Keen was the most resistant to scraping both at 90 minutes and after 24 hours. This product, as well as Die Stone, which also proved highly resistant to scraping, were less resistant to scraping when mixed with either of the gypsum hardeners.

Tables 3-6. Products are listed by rank. The higher resistance to scraping is shown as less weight loss (lower numbers) in milligrams.

Table 3. Die Weight Lost by Scraping

Gypsum Materials Mixed with Water

90 min	mg Mean	mg SD	24 h	mg Mean	mg SD
Die-Keen	24	3	Die-Keen	14	3
Die Stone	39	4	Die Stone	27	6
Super-Cal	40	4	Indic-Die-Stone	33	5
Super-Die	47	5	Super-Die	36	11
Glastone	59	5	Super-Cal	39	4
Indic-Die-Stone	68	4	Silky-Rock	42	11
Vel-Mix	72	6	Glastone	43	4
Silky-Rock	83	15	Vel-Mix	66	11
Buff Labstone	197	15	Buff Labstone	80	16

Table 4. Die Weight Lost by Scraping

Gypsum Materials Mixed with Stalite

90 min	mg Mean	mg SD	24 h	mg Mean	mg SD
Indic-Die-Stone	17	5	Indic-Die-Stone	7	3
Super-Die	25	5	Super-Die	19	4
Super-Cal	34	5	Silky-Rock	24	3
Silky-Rock	35	9	Super-Cal	28	5
Die Stone	47	4	Die Stone	33	6
Die-Keen	49	4	Die-Keen	35	6
Vel-Mix	51	4	Vel-Mix	37	4
Glastone	53	4	Buff Labstone	37	4
Buff Labstone	77	4	Glastone	40	3

Table 5. Die Weight Lost by Scraping

Gypsum Materials Mixed with Whip-Mix Gypsum Hardener

90 min	mg		24 h	mg	
	Mean	SD		Mean	SD
Indic-Die-Stone	25	5	Super-Die	12	3
Silky-Rock	36	3	Indic-Die-Stone	25	3
Super-Die	42	5	Silky-Rock	26	3
Super-Cal	44	4	Die-Keen	33	4
Glastone	49	4	Super-Cal	41	7
Buff Labstone	57	5	Glastone	42	2
Vel-Mix	58	4	Vel-Mix	44	5
Die Stone	59	9	Die Stone	44	5
Die-Keen	68	5	Buff Labstone	46	3

Table 6. Die Weight Lost by Scraping

Die Coatings, Epoxy Dies, and Silver Plating

	mg	
	Mean	SD
Die-Keen (Mixed with Stalite) Coated with Jelenko Model Spray		
without coating	50	5
with coating	19	6
Die Stone (Mixed with Stalite) Coated with Aron Alpha Rapid Bonding Adhesive No. 202 (Cyanoacrylate)		
without coating	56	5
with coating	13	2
Glastone (Mixed with Water) Coated with Ney Die Lube		
without coating	50	3
with coating	58	12
Dentsply Epoxy Die Material	14	3
Silver-plated Dies	4	1

These were the only two products that gave this result.

When mixed with Stalite, Indic-Die-Stone exhibited the highest values of resistance at both 90 minutes and 24 hours. When mixed with Whip-Mix Gypsum Hardener, the Indic-Die-Stone was the most resistant at 90 minutes, but after 24 hours Super-Die had the highest resistance.

When mixed with Stalite, 24-hour samples of Glastone were least resistant to scraping, and when mixed with Whip-Mix Gypsum Hardener, the 90-minute samples of Die-Keen gave the poorest results. Except for these, Buff Labstone was least resistant to the scraping test.

The nongypsum products and die coating techniques were found to give high resistance to scraping, with the exception of the die lubricant. As might be expected, the silver-plated dies were the most resistant of all to scraping.

DISCUSSION

Most gypsum products, with the exceptions previously noted, proved more resistant to scraping when mixed with either of the products for hardening. Although both die products of Modern Materials, when mixed with water, were the most resistant of all gypsum products to scraping, they responded adversely to the hardeners. The cause of this disparity is not known.

Buff Labstone was included in the study essentially as a control. It is classified as a Type III stone whereas the other gypsum products tested were Type IV stones. The Type IV stones are categorized as being denser, harder, and probably more resistant to abrasion than Type III stones. This proved to be basically true. When the Type III Labstone was mixed with either of the hardening solutions, the resistance to scraping approached that of many of the Type IV products. Buff Labstone is not designated by the manufacturer as a die material. Due to lack of knowledge of other physical properties of the stone, such as setting expansion, this stone cannot be recommended as a die material without further testing.

The model spray and the cyanoacrylate both increased resistance to scraping. The results were far better when the coating materials were applied heavily, so as to leave a glossy surface. Care must be exercised, however, to avoid increasing the size of the die by using excessive amounts of coating.

The epoxy die material was moderately resistant to scraping but was somewhat more difficult to mix and required five hours to set.

The silver-plated dies were the most resistant to scraping of any product tested. Dies fabricated in this manner require much more time and special equipment. Those who use this technique feel that the benefits outweigh the additional steps that are necessary.

Since resistance to scraping was determined by measuring loss of weight, the density of the products must be considered. The difference in density among the gypsum products is considered negligible. Silver plating is obviously denser than stone and thus scrapings of silver weigh more than an equal volume of scrapings of stone. Silver, therefore, may be more resistant to scraping than the data indicate. Conversely, the epoxy die material is slightly less dense than stone and therefore may not be as resistant to scraping as the data show.

The density of gypsum products is affected by the liquid/powder ratio. In this study, ratios within the ranges offered by the manufacturers were selected to allow a mix as thick as could be conveniently handled. A mix of higher viscosity results in a denser die, which is more resistant to abrasion.

CONCLUSION

Indic-Die-Stone and Super-Die, when mixed with hardening solutions, gave the highest scraping resistance of the gypsum products tested. All gypsum products tested exhibited improved resistance when hardeners were used, except Die-Keen and Die Stone, which gave the highest values of all of the stones tested when mixed only with water.

Silver-plated dies, of all materials tested, showed superior resistance to scraping.

An epoxy die material was highly resistant to scraping, to approximately the same degree as die coatings of cyanoacrylate and as a model spray.

POINT OF VIEW

A Plan for Chaos

Improvements in dental service should be made by those with knowledge and experience of dental practice—not by educators and the government.

MARVIN A JOHNSON

It has become increasingly fashionable for dental educators to publish articles about the failures of dentistry and dental education. The educators reason that as leaders in the dental profession they are the ones that are best qualified to effect the appropriate changes for the advancement of dentistry. Anyone with a knowledge of dental education today knows that federal grants and controls allow little if any independent thinking or planning by the educators. Consequently "they" in the above sentence becomes not only the educators but also the federal government, and the planning includes not just education but the entire system of delivering dental care.

The spectre of this combination making plans for dental health in this nation is enough to give any thinking man a continuous nightmare. The track record of the government in delivering anything is one of inefficiency and waste, expediency and corruption. A check of government operations in agriculture, commerce, procurement of armed forces, the Veterans Administration, or the environment makes this vividly clear. Combine these inadequacies with the contributions of educators, most of whom have never delivered any care to a patient outside the walls of an institution but nevertheless suddenly become authorities on the delivery of dental care, and the possibilities for chaos are astronomical.

No one can deny that a large segment of our population is without dental care, but explanations for this can be deceptive. In the armed services, where dental care is offered free, the proportion that takes advantage of the service is almost identical to that in the civilian population, who must pay for it. Cost is not the only factor—and probably not the main one—limiting dental service as it is now supplied. On the other hand, cost could become a very limiting factor if our planners decide to adopt an institutional system of delivery such as used today by the armed forces and the Veterans Administration. If principles of cost accounting were applied at our military centers of treatment we could reduce costs of administration, salaries, education, equipment, supplies, real estate, retirement, and fringe benefits to an hourly figure. These figures are not available to anyone outside of government but to those of us that have spent any time at one of these centers the result would be obvi-

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ous—true cost of treatment at a government dental center is much higher than in a private practice. As taxpayers we cannot afford such high-cost dental treatment.

Planners as a group have failed to consider one of the important facets of the private practice of dentistry that has attracted many of our most qualified people to the profession. Historically, dentists have been rugged individualists, attracted to a profession where there were continued options. Dentists could be part of a group or practice solo and still excel. Many of our greatest contributors have been of this type—Fauchard, Hollenback, Woodbury, Wedelstaedt, Ferrier, Jones, and Stibbs, to name just a few. It is questionable how many of these men would be interested in practicing dentistry as our planners foresee it. Any plans for dentistry must include a place for solo private practice as an option, with monetary incentives for quality, efficiency, and dedication.

Perhaps a different point of view is needed in our planning. Politicians, whose views change with pressures from the electorate and from lobbies, even though honest and concerned are not in a position to plan for dentistry or the dental health of the nation. This does not mean that politicians are without value in dental health. They should be aware of measures in public health that could be implemented for the benefit of everyone. National fluoridation of water and preventive dental education on television and in the public schools would be good beginnings. Mandatory peer review and mandatory continuing dental education for licensure are other measures that could help. Increased commitment of funds is needed for legitimate basic research into the causes of disease. We need methods of alleviating costs to low-income groups and increased support of dental education without the strings that are presently attached. These are measures that the political planners could institute without draining the national treasury, enslaving the profession, or doing anything but good. Dental educators could then turn their entire attention to dental education and research, dismiss their public relations staffs, and cover their crystal balls. The time that deans of dental schools spend in public relations, politics, social welfare conferences, and grant acquisitions could be more profitably spent in research and clinical supervision. Their planning could be directed toward overall improvement of the products of their schools. Concepts of team practice should be emphasized, but planning a system that would eliminate private practice would be tragic. Not every good practitioner will fit into the neat "zoo" type designs for Health Maintenance Organizations currently in vogue, and many of our small communities cannot or will not support even a single practitioner. Ignoring the age-old relationship of doctor and patient could result in a loss of quality, personal pride, and communication. There is no doubt that the best dental care in the world comes from some of the small dental offices in this country; there is little doubt that some of the poorest care is rendered in others. The complete resources of planning for dental health should be directed toward bringing all care up to the highest levels, not trying to fit everyone into a system to deliver mediocrity to all.

DEPARTMENTS

Press Digest

Calcium hydroxide and potassium nitrate as desensitizing agents for hypersensitive root surfaces. Green, B L, Green, M L & McFall, W T (1977) *Journal of Periodontology* (48), 667–672.

Hypersensitive teeth of six patients, two with gingival recession and four having had periodontal surgery, were treated with a paste of either calcium hydroxide or potassium nitrate for five minutes. Control teeth were treated with sterile water. Sensitivity of the teeth was measured by applying heat and cold with a thermoelectric stimulator and by applying mechanical stimulation with a device whose force could be controlled. The sensitivity of the teeth was measured before application of the desensitizing agents, immediately afterwards, and at intervals of one week, two weeks, one month, two months, and three months. Both calcium hydroxide and potassium nitrate reduced the sensitivity of the teeth but calcium hydroxide was consistently more effective.

Restorative dentistry procedures used by Kentucky dentists. Gullett, C E & Podshadley, A G (1978) *Journal of the Kentucky Dental Association* (30), 17–20.

Of questionnaires sent to all Kentucky dentists 421 were returned. From this survey the following information was obtained: 23% employ three or more dental assistants, 35% employ two, 37% employ one, and 5% employ none; 33% delegate packing and carving to dental assistants; about 67% perform restorative procedures while seated most of the time; 7% use gold foil for restorations and 10% use it for repairs; 62% use the rubber dam; about 33% use electrosurgery; 81% use threaded pins for retention, 15% use friction lock pins, and 13% use cemented pins; 84% use composite resin for most of their anterior restorations; 63% use silver amalgam for nearly all posterior restorations and 71% use an alloy with a high content of copper, 58% use gold inlays or onlays up to one-fourth of the time, 14% use gold inlays up to one-half of the time, 27% do not use gold inlays or onlays at all, 52% do not use composite resin at all for posterior restorations, 45% use composites less than half the time for posterior restorations; 38% use zinc phosphate cement most of the time for final cementation, 33% use polycarboxylate cement most of the time, about 5% use zinc oxide and eugenol cement most of the time; 10% use porcelain to metal crowns for nearly all posterior bridge retainers and single restorations, 27% use these crowns up to one-fourth of the time, 28% use them from one-fourth to one-half the time, 13% do not use them at all on posterior teeth, 5% use full gold crowns nearly all the time, 31% use them between one-fourth and one-half the time, 15% use them between one-half and three-fourths of the time, 12% do not use them at all; 67% depend on water spray most of the time for cleaning cavities, 3% use cotton pellets and water, 6% use cotton pellets with a cleaning or sterilizing solution.

Role of preventive endodontics in maintenance of the teeth. Grossman, L I (1978) *Oral Surgery, Oral Medicine and Oral Pathology* (45) 448-451.

A combination of prevention and therapy can reduce substantially the incidence of dental caries and the loss of teeth. Protection of the crown is the first line of defense. The integrity of the enamel can be preserved by fluoridating communal supplies of water, by brushing the teeth with fluoride dentifrice, by rinsing the mouth daily with a 0.3% solution of neutral fluoride, by the use of sealants on occlusal surfaces, by restricting the consumption of fermentable carbohydrates and sticky, pasty foods, and by eliminating snacks between meals. Periodic prophylaxis and examination will help to detect lesions when they are small. Mouth guards can protect teeth from accidental trauma.

The second line of defense is protection of the pulp. Irritants should be avoided, such as heat from cavity preparation, from the setting of zinc phosphate cement, and from polishing; chemicals used for dehydrating dentin, cleaning cavities, excessive phosphoric acid in cement, or excessive monomer or other liquid in acrylic or composite restorative materials; debris from cavity preparation. Shallow cavities should be lined—zinc oxide and eugenol being better than varnish. Deep cavities should have a lining of calcium hydroxide or zinc oxide and eugenol (calcium hydroxide is preferred) covered with a base of zinc phosphate cement.

The third line of defense is capping the pulp after exposure or, in young teeth, by pulpotomy.

The final line of defense is root canal treatment.

Reduction of mercury vapour in a dental surgery. Wilson, J (1978) *Lancet* (1) 200-201.

Levels of mercury vapor were measured by a Model MV-2 J W Bacharach Mercury Sniffer at 11 standard sites in a dental operatory to obtain baseline data. The average level was 0.0357 mg/m^3. The operatory was then modified by replacing the carpet with linoleum, installing a fume cupboard (75 x 75 x 50 cm) of plexiglass for storing amalgamator, bottles of alloy and mercury, container for waste amalgam, and the amalgam carrier. The cupboard was connected by flexible ducting to an exhaust fan installed in an outside wall. The fan operated continuously during the day but was turned off at night. Under this system the average level of mercury vapor was lowered to 0.0074 mg/m^3.

Book Reviews

DENTAL RADIOGRAPHY: AN INTRODUCTION FOR DENTAL HYGIENISTS AND ASSISTANTS

By Richard C O'Brien, DDS

Published by W B Saunders, Philadelphia, 1977. Third edition. 257 pages. Illustrated. $10.50.

At first glance, O'Brien's text looks as if it might be an excellent reference for auxiliaries to learn about radiography. Closer examination reveals, however, that a necessarily simplistic approach to the subject, a common problem in textbooks for auxiliaries, has created inaccuracies, half-truths, and omissions.

The material on the x-ray unit is an example of this problem. The author keeps his explanation of ionization so brief that the idea of frequency, energy, and penetrating power of x rays is not sufficient for anyone without some background in physics. The reader may learn the parts and terminology of the x-ray machine, but be left with voids in understanding how they all function together. He makes little discrimination between acute and chronic effects of radiation. Information on irradiation of the whole body versus specific areas is not included. Notably absent is a discussion of factors pertaining to techniques that should be practiced in all offices to reduce the amount of radiation received by patients during exposure.

The author states that the paralleling technique produces the most accurate images of the teeth and surrounding structures, yet he fails to develop the material to any degree, or even to encourage the reader to use this technique. Although O'Brien goes to great lengths in discussing bent-film images and errors of elongation and foreshortening, he does not mention that use of the paralleling technique substantially reduces the probability that these errors will occur. Errors occur more often when the bisecting technique is used, especially by an inexperienced operator. The author no doubt gives more space to the bisecting technique because, as he states, "most dentists use this technique."

The major portion of the book is concerned with exposure techniques. Included are the intraoral techniques of bisecting the angle, paralleling, and occlusal radiographs, and the extraoral techniques of panoramic and lateral jaw radiographs.

Some statements in the book may be questioned as to acceptable procedure. "After placing the film, put your hands on the sides of the patient's head and, using a gentle downward force, tell him to lower his head." Usually, operators try to keep their hands as clean as possible during intraoral procedures and the above suggestion does not take this into account. "The cone tip should always contact the patient's skin for each intraoral exposure." Anyone who has worked with a 16-inch cone knows that it often produces jerky motions that could result in hitting an object with much more than a gentle touch. "XCP instruments, undoubtedly, may also be used with a unit having an open-ended short cone, however the image will not be as accurately produced." The short cone is inappropriate when utilizing XCP equipment and the paralleling technique since the size of the image can be increased by 10–15% depending upon object-film distance. This may result in root apices being projected off the film. "If this problem (maxillary torus) does arise, you have no choice but to replace the long cone with the short cone and bisect the angle." There is no reason to suggest that a short cone must be used with the bisecting technique. A long cone will always produce images with reduced penumbra regardless of the technique utilized. In addition, the average-sized maxillary torus does not interfere with utilization of the paralleling technique if a slight adaptation in film position is made.

The section on anatomical landmarks is presented with good illustrations. Diagrams and pictures of the skull are used to denote the structures of the images on actual radiographs. It would be advantageous to have more than one sample radiograph for each area, as only one example may limit the viewer's understanding of the wide range of normal variations that are seen in practice.

Undoubtedly the best chapter in the book is the last one, titled, "Eighty-five Per Cent of Your Success—Your Personality." Although it would probably be more appropriate in a book on office management, communications, or behavior modification, many good points concerning attitude, interest, and enthusiasm are expounded upon in relation to success in life and the dental office. The first chapter of the book, which contains information on how to handle the reluctant patient concerned about exposure to x rays, is also worth reading.

Previous editions of this book have been used by many schools of dental assisting and dental hygiene. In the school setting, supplemental material in the form of lectures, seminars, and exercises is incorporated to augment any missing information. Misconceptions are clarified by the teacher and judgmental thinking is stimulated. With the same careful guidance by the dental employer or other knowledgeable individual, this book can be useful in private practice for training the neophyte dental assistant.

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BRIGHTER WRITING FOR DENTISTRY

By Robert C McGiffert

Published by Council on Journalism, American Dental Association, 1971. 55 pages.

This small booklet of but four chapters comprises a delightful criticism of the dental writing of today along with sound advice on ways in which an author can express his message with clarity and economy—to the great benefit of the reader. Chapter 1 deals with the problem of organizing the communication and covers the following topics: the direct approach, early introduction of the central theme, the needless warm up, laboring the obvious, wordiness, meandering and repetition, "hanging gardens" structure, dullness, lack of unity, inconsistency, and organization of paragraphs and sentences. This chapter is the most valuable because it uses specific examples from the literature of dentistry to expose many of the faults of current dental writing. Professor McGiffert complains that the message or news—the part of the article of greatest interest to the reader—is often buried in an impenetrable structure that is more suited to a thesis or dissertation. In but 19 pages of easy and interesting reading a prospective author can obtain an insight into what is needed for a lucid exposition of his message.

The remaining chapters, on wordiness, diction, and the future, contain material that can be found in most books on writing. The use of the dental literature, however, to exemplify the points being made adds greatly to the value of these chapters.

Professor McGiffert has given us a superb document that should help greatly in improving communication in dentistry. All contributors to the dental literature should read his booklet and apply his principles.

A Ian Hamilton

Wit and Wisdom

Murphy's Law

Sometimes people call it Murphy's Law. Sometimes they have other names for it. It comes with variations according to the person quoting it, but the basic form is like this:

"If something can go wrong, it will."

Some nonpurists will say, "If something can *happen,* it will," but that is not the same. And some say, "If *anything* can happen, it will," which is worse.

We prefer the original form and offer this corollary, which we have derived from bitter experience: If *nothing* can go wrong, something will anyway. And this extension of Murphy's original realism: When you have everything under control, watch out the most, because then things are most likely to go wrong.

Like when giving instructions.

Remember the incident during the series when the restaurants and snack bars were filled to capacity, and the owner of one ice cream parlor had hired a genie to augment his beleaguered crew. Sure enough, the first customer to come into the shop said to the genie, "Make me a chocolate malted." The genie, having been cautioned that the customer is always right and being unfamiliar with the ways of humans, shrugged his shoulders and replied as he gestured a magic gesture, "Okay. You're a chocolate malted."

Or the manager of the convention a few years ago who realized at the very last minute that he had no signs to indicate where the delegations should sit. In a panic he called the sign painter and placed a rush order for 50 signs. What did he want on the signs? The 48 states plus Alaska and Hawaii, of course. And bright and early the next morning, the weary sign painter delivered his night's labor, 50 identical signs: "The 48 states plus Alaska and Hawaii."

We even have a further theory, which may challenge Murphy's Law. It is our thinking that all of the things that can go wrong, already have gone wrong. They are just waiting to be delivered.

—Robert R Jones, Editor
Industrial Research

(Reprinted from *Industrial Research*, May 1977)

Announcements

FERRIER SEPARATORS AGAIN AVAILABLE

In response to numerous requests the Ferrier mechanical separators are being manufactured by Almore International, Inc, Portland, Oregon.

At present the No 1 and No 3 are available, and the No 2 will be soon.

This will be a matter of real interest to schools and practitioners that are aware of the many advantages of these fine instruments.

NOTICE OF MEETINGS

American Academy of Gold Foil Operators

Annual Meeting: October 19 and 20, 1978
Pearl Harbor
Hawaii

Academy of Operative Dentistry

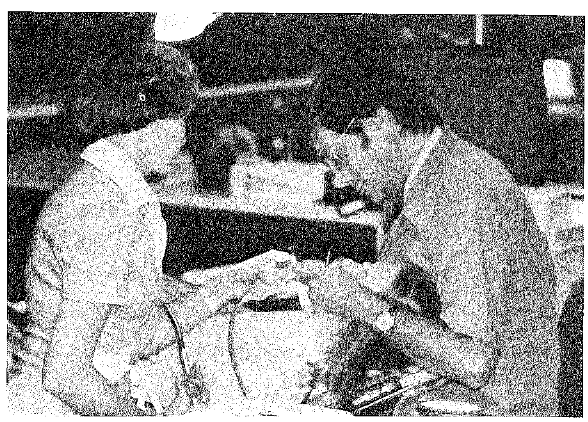
Annual Meeting: February 15 and 16, 1979
Hyatt Regency Hotel
Chicago, Illinois

NEWS OF STUDY CLUBS

Centennial Dental Study Club, Denver

The Centennial Dental Study Club, formed two years ago in Denver with Gregory E Smith as mentor, is an operative dentistry club in which members operate each month on patients to restore teeth with either amalgam or gold castings. All cavity preparations are photographed and at the subsequent meeting the slides are projected and discussed.

Dr Sheldon Carr prepares a cavity to receive an amalgam restoration



Dr Richard Kloehn examines a casting prior to cementation

Lester E Myers, DDS

Lester E Myers, 90, a prominent Omaha dentist for 50 years, died April 12 in Sun City, Arizona.

Dr Myers graduated from Creighton University Dental College in 1914. He was past president of the Nebraska State Dental Association and a member of the Hall of Fame of that organization. He was a fellow of the American College of Dentists, a life member of the American Academy of Restorative Dentistry, a past president of the American Academy of Gold Foil Operators, and a Director of the Woodbury Study Club for 15 years. After serving on the Nebraska State Board of Dental Examiners, he became a member of the faculty of the University of Nebraska College of Dentistry.

Dr Myers was a member of the Dundee Presbyterian Church for 29 years and was a life member of the Tangier Temple of Omaha. He also held memberships in the Omaha Rotary Club and in the Omaha Club.

In 1962 Dr Myers retired from active practice and with Mrs Myers moved to Sun City, Arizona. There he was a member of the Arizona State Dental Association and of the Sun City Rotary Club.

Survivors include his wife, Violet; a daughter, Norma Runge; a son, James; four grandchildren and two great-grandchildren.

RECIPIENTS OF 1978 STUDENT ACHIEVEMENT AWARDS

American Academy of Gold Foil Operators

Baylor College of Dentistry	Michael Parsons
Boston University	Ban T Vu
Columbia University	Ronald Gerhard
Fairleigh Dickinson University	Bradley Saisselin
Howard University	Hayden Blake
Loyola University	Gerald Elpert
Marquette University	Bryan Wierwill
University of Maryland	Theodore Grier
New Jersey Dental School	Fred Di Orio
State University of New York at Buffalo	Kenneth Elrod
University of Oklahoma	David Boone
Temple University	Nicholas Iula
University of Texas (Houston)	James Flaggert
Tufts University	John Dandona
Washington University	Robert Schellentrager
West Virginia University	William Queen

Academy of Operative Dentistry

University of Alabama	Larry Don Wilson
Baylor College of Dentistry	Gary Morgan Schwarz
University of California (Los Angeles)	Shizuka Koyama
University of California (San Francisco)	Frederick C Finzen
Case Western Reserve University	Myra Joan Larson
University of Colorado	Stanley Alan Ladd
University of Connecticut	Kenneth Kowalski
University of Florida	David C Sarrett
Medical College of Georgia	Charles A Ross
Indiana University	Daniel S Bennett
University of Kentucky	Nedra Ann Kimmel
Louisiana State University	Carney A Brice
Marquette University	John A Goeckermann
University of Maryland	Richard A Miller
Meharry Medical College	Roy McCray
University of Michigan	David W Dolan
University of Minnesota	Janell J Christiansen
University of Nebraska	Allen L Lorenz
New York University	Barry Wolinsky
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Ohio State University	John Richard Scuba
University of Oregon	Frederick T Young
University of the Pacific	Rodger A Solow
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Medical University of South Carolina	Richard D Ward, Jr
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Tufts University	Bruce Denis Gouin
Washington University	Edward Kuhn
West Virginia University	William F Queen
University of British Columbia	John Thiessen
Laval University	Lynda Nicholson
University of Manitoba	D A Carcary
University of Toronto	Walter L Vogl

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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.

Exclusive Publication

It is assumed that all material submitted for publication is submitted exclusively to *Operative Dentistry*.

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,* 3rd ed., 1966, and *Nomina Histologica,* 1975; 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 by the name and address of the source or manufacturer, in parentheses. The Editor reserves the right to make literary corrections.

Tables

Submit two copies of tables typed on sheets separate from the text. Number the tables with arabic numerals.

Illustrations

Submit two copies of each illustration. Line drawings should be in india ink or its equivalent on heavy white paper, card, or tracing vellum; any labeling should be on an extra copy or on an overleaf of tracing paper securely attached to the illustration, not on the illustration itself. Type legends on separate sheets. Photographs should be on glossy paper and should be cropped to remove redundant areas. For best reproduction a print should be one-third larger than its reproduced size. Maximum figure size is 15x20 cm (6 x 8 inches). The cost of color plates must be met in full by the author. On the back of each illustration, near the edge, indicate lightly in pencil the top, the author's name, and the figure number. Type legends on a separate sheet. Where relevant, state staining techniques and the magnification of prints. Obtain written consent from copyright holders to republish any illustrations published elsewhere.

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