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Aim and Scope

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

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EDITORIAL

Writing and Thinking

The dearth of articles with obvious relevance to clinical practice is not a misfortune unique to *Operative Dentistry* (Freeman, 1985; Weston, 1984). The perceived academic bias of many articles tends to discourage practitioners from reading them and may prompt some to decline to renew their subscriptions. This lamentable state of affairs is the consequence of two developments, one in the method of communicating information, the other in the method of discovering information.

Clinicians, the potential source of information on topics with clinical applications, can perform the astonishing feat of being able to speak but not to write. Their well-articulated presentations, sometimes accompanied by vigorous prowling back and forth across the stage, are often models of clarity, and are usually enhanced by superb illustrations in the form of colored slides displayed by at least 10^6 projectors. These contributions, with little statistical backbone or evidence of scientific method, have little to commend them other than success in treating dental problems.

The most successful clinicians become popular and thus are able to repeat the same message many times to different audiences across the country, with little need for change except occasionally to incorporate some new information. The audiences addressed by these clinicians are usually smaller than the number of subscribers to a journal and therefore the message needs to be repeated many times to cover an audience of equivalent size. If clinicians only realized that by learning to write they could be relieved of those boring journeys to exotic places, the dyspepsia accompanying gourmet cuisine, and the pittance received for services rendered, dental journals would not lack the good stuff so many practitioners desire. Clinicians must write!

On the other hand, dental practitioners, thirsting for knowledge, seem to have lost the ability to extract the clinical value from new scientific findings published in the literature, and seem willing to wait until someone prepares the feast for them. True enough, the scientific and statistical content of the articles published nowadays may be of higher proof than those of the past but this gives more credence to the reliability of the information presented. The new knowledge about the layer of smeared dentin on walls of cavities, for example, that has been obtained from studies with the electron microscope, gives food for thought on the use of cleansers and antiseptics in cavities prepared for restorations. All of this is exciting. If the practitioners of today, and tomorrow, are to take advantage of the scientific advances for the benefit of their patients, they must read critically and make an effort to search for relevance in the new discoveries. Yes, clinicians must write, but practitioners must also do their part. There is no easy way, practitioners must think!

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ORIGINAL ARTICLES

Marginal Seal of a Composite Resin, Clearfil: A Laboratory Study

Restorations of Clearfil, when placed with the use of an etchant and a bonding agent, remained free of marginal leakage for 90 days — the duration of the experiment

ARTEMIS KARANIKA-KOUMA • LEONIDAS PISSIOTIS

Summary

When class 5 cavities that had been prepared on the facial and lingual surfaces of 100 extracted teeth were filled with a composite resin, Clearfil (facial cavities), and a glass-ionomer cement, Chemfil (lingual cavities), and subjected to thermal cycling, the restorations of Clearfil were devoid of marginal leakage for up to 90 days (the duration of the experiment) whereas the restorations of the glass-ionomer cement, Chemfil, demonstrated various degrees of marginal leakage.

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Introduction

The efforts to develop a restorative material that can conform perfectly to the walls of a cavity have resulted in the introduction of a large variety of new composite resins. One of these is Clearfil (Cavex Holland B V, Keyr and Sneltzes Dental Mfg Co, Haarlem, Netherlands), which the manufacturer claims will adhere to both enamel and dentin with and without etching (Fusayama, 1980). Such a property in a restorative material restricts marginal leakage, which may be, at least in part, responsible for several problems, for example: marginal discoloration and decay; hypersensitivity, inflammation, and necrosis of the pulp; and, in extreme cases, loss of the restoration (Bowen & Molineaux, 1969; Vougiouclakis, 1975).

Materials and Methods

One hundred extracted teeth with the surface of the enamel free of microscopic cracks or developmental faults were selected, washed, cleaned of blood and calculus, and stored in tap water at room temperature to prevent dehydration.

Class 5 cavities were prepared on the facial and lingual surfaces of the teeth at about 1 mm above the cementoenamel junction. The cavities were prepared to a depth of 1.2-1.5 mm with burs Nos 555, 34, and 170 at high speed with a coolant of water spray. Neither undercuts nor bevels were placed.

The facial cavities of all teeth were filled with Clearfil, the enamel and dentin first being etched for one minute with a paste of phosphoric acid. After the etchant was washed away, the bonding agent was applied and dried by a mild stream of air, the Clearfil then being placed in the cavity.

The lingual cavities were filled with a glass-ionomer cement, Chemfil (AD International Ltd, DeTrey Division, Weybridge, Surrey, England), for comparison. We used glass-ionomer cement as a control because it also bonds chemically to enamel and dentin (Crisp, Lewis & Wilson, 1976). Such a material is expected to present a similar, or better, marginal seal than most of the composite resins commercially available (Hembree & Andrews, 1978; Kidd, 1978; Karanika-Kouma, 1982).

The teeth were divided into four groups of 25 and stored in distilled water at 37 °C for periods of 1, 7, 30, and 90 days, respectively. During these periods, each specimen was stressed by immersing it alternately for one minute in water at 4±1 °C and 58±1 °C for 100 cycles, with the exception of five specimens in each group that were used as controls for the thermal cycling test. The thermal cycling was employed to subject the restorations to dimensional change before testing for marginal leakage rather than to examine their integrity during thermal cycling. The same procedure has been used by Swartz and Phillips (1961); Going and Sawinski (1966); Lee, Swartz & Smith (1969); Lee and Swartz (1970); Harris, Phillips & Swartz (1974); McCurdy and others (1974); Hembree and Andrews (1978); Karanika-Kouma (1982).

To determine marginal leakage we employed a radioisotope, ^{45}Ca, and autoradiographs as described by Phillips and others (1961). Each specimen was soaked for two hours in a solution of ^{45}Ca in the form of calcium chloride at a concentration of 0.1 mCi ml^{-1} of solution with the pH adjusted to 6.5. Before the teeth were immersed in the solution of isotope, the roots and all surfaces except the restorations were sealed carefully with a combination of wax, nail polish, and tin foil. After the tooth was removed from the solution of isotope the tin foil was stripped away and the tooth then brushed with a detergent and immersed in warm tap water for an hour. The teeth were sectioned longitudinally through the restorations with a wet diamond wheel. The sectioned surface of the tooth was then placed on an ultraspeed film for dental periapical radiographs for 17 hours to produce the autoradiograph. The film was processed in the usual way. One hundred autoradiographs were produced.

The marginal leakage of each specimen was determined by the presence of isotope, as revealed by the autoradiograph, at the interface of tooth and restorative material. The extent of the leakage was evaluated by the following method of Andrews and Hembree (1975, 1980):

0 = No evidence of the isotope at the interface of tooth and restorative material
1 = Evidence of the isotope penetrating the interface of tooth and restorative material at the cavosurface angle
2 = Evidence of the isotope at the interface of tooth and restorative material along the cervical or occlusal walls but not penetrating to the axial wall
3 = Evidence of penetration of the isotope to the axial wall

Results and Discussion

The results are shown in the table. The restorations with the composite resin, Clearfil, did not show any marginal leakage for a period of up to 90 days, the duration of the investigation. The glass-ionomer cement, Chemfil, demonstrated marginal leakage at all time intervals examined.

The lack of marginal leakage with Clearfil shows that the cavity is sealed by the material bonding mainly to the enamel.

Another factor that may prevent marginal leakage is the pattern of shrinkage during polymerization of this composite resin, which does not produce any gap at the interface of resin and dentin (Fusayama, 1980; Iwaku & others, 1981). The tags penetrating the tubules

Marginal Leakage of Clearfil and Chemfil

Material	Degree of Penetration of Isotope*			
	0	1	2	3
Clearfil (with thermal cycling)				
1 day	20	—	—	—
7 days	20	—	—	—
30 days	20	—	—	—
90 days	20	—	—	—
Clearfil (without thermal cycling)				
1 day	5	—	—	—
7 days	5	—	—	—
30 days	5	—	—	—
90 days	5	—	—	—
Chemfil (with thermal cycling)				
1 day	12	2	6	—
7 days	9	5	4	2
30 days	7	5	7	1
90 days	15	3	2	—
Chemfil (without thermal cycling)				
1 day	2	1	—	2
7 days	1	1	1	2
30 days	1	2	2	—
90 days	4	—	1	—

* 0 = No penetration
1 = Penetration at cavosurface angle
2 = Penetration short of axial wall
3 = Penetration to axial wall

copy exactly the shape of the walls and have hollow depressions at the ends, indicating that the polymerized resin adheres tightly to the walls of the dentin.

Not all of the teeth used in this investigation were freshly extracted. Teeth that have been stored exhibit more deeply etched surfaces (Iwaku & others, 1981), and tags of resin penetrate to the depth of several hundred micrometers compared with 60-100 μm in freshly extracted teeth.

The glass-ionomer cements, though they bond chemically to enamel and dentin, show a range of marginal leakage that decreases with time, which may indicate that the performance of these materials improves with time (Crisp & others, 1976).

Whatever the reasons for the lack of marginal leakage in teeth filled with Clearfil, an extensive seal between the material and the tooth will protect it from marginal leakage and the problems it causes.

Conclusions

- None of the restorations made with the composite resin, Clearfil, demonstrated marginal leakage within periods of time up to 90 days.
- Restorations with the glass-ionomer cement, Chemfil, demonstrated varying grades of marginal leakage despite the manufacturer's claim that a chemical bond is formed between the material and the enamel and dentin.

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Inhibited Set of the Surface of Addition Silicones in Contact with Rubber Dam

J E NOONAN • M H GOLDFOGEL
R L LAMBERT

Introduction

Many dentists use the rubber dam while preparing a tooth and making the impression for a cast restoration (Fig 1). The retraction of the gingiva and the control of moisture afforded by the use of heavy weight rubber dam are the primary advantages of this technique. The rubber dam confines the impression material, thus requiring less of it, and improves the over-

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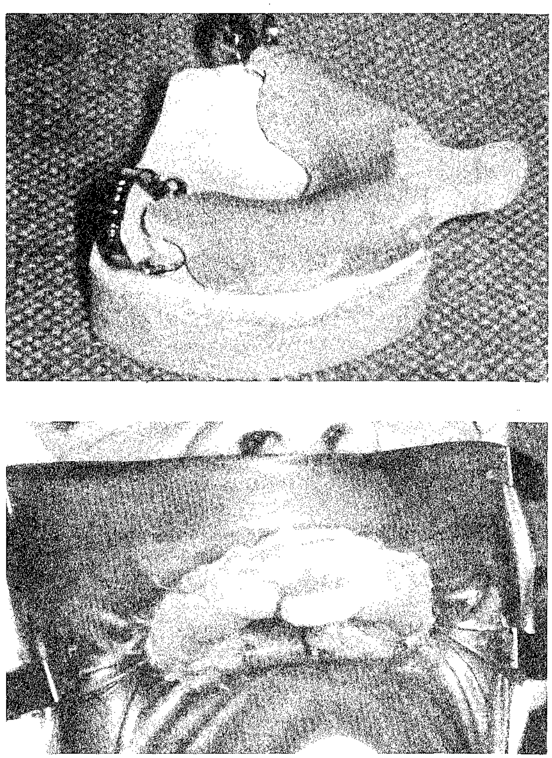

FIG 1. (A) *Acrylic impression tray relieved to accommodate rubber dam retainers.* (B) *Full arch impression with rubber dam in place (the bows of the retainers were blocked out with utility wax).*

all efficiency of the operation. A contraindication for making the impression with the rubber dam in place was first noted in the private practice of one of the authors. After the use of an addition silicone to make an impression with the rubber dam in place, it was apparent that the surface of the impression material did not set wherever it touched the rubber dam, whereas the remainder of the material set normally. The unset, sticky layer was approximately 1 mm deep and remained indefinitely in this condition of inhibited polymerization. A review of the literature did not provide an answer to this clinical problem and therefore we began an investigation to determine whether this experience was unique or whether the phenomenon was characteristic of this class of impression material.

Materials and Method

Seventeen materials representing each of the four types of impression material were purchased from local suppliers (see table). Each material was mixed according to the manufacturer's instructions and allowed to set in contact with rubber dam as well as with a glass slab. Both washed and unwashed rubber dam of extra heavy and medium weight (Hygenic

Ability of Impression Materials to Set in Contact with Rubber Dam

Product	Type*	Surface Reaction
Polysulfide		
Permlastic (Kerr)	L,H	set
Coe Flex (Coe)	L,R	set
Neoplex (Columbus)	R	set
Polyethers		
Impregum (Premier)	R	set
Polyjel (Caulk)	R	set
Silicone, condensation reaction		
Optosil (Unitek)	P	set
Xantopren (Unitek)	R	set
Cutter Sil (Cutter)	L,R	set
Accoe (Coe)	L,R,P	set
Citricon (Kerr)	P	set
Silicone, addition reaction		
President (Union Broach)	L,R,H,P	unset
Cinch (Parkell)	L,R	unset
Reprosil (Caulk)	L,R,H,P	unset
Reflect (Kerr)	R	unset
Permagum (Premier)	L,H	unset
Mirror 3 (Kerr)	L,R,H,P	unset
Exaflex (G C International)	L,R,H,P	unset

*L = light, R = regular, H = heavy, P = putty

Corp, Akron, OH 44310, USA) were included in the study. The impression material allowed to set on the clean glass slab served as a control (Fig 2).

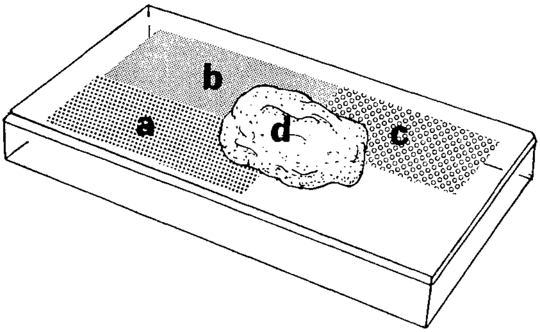

FIG 2. *Illustration of glass slab containing three pieces of rubber dam* (**a,b,c**) *and impression material being tested* (**d**).

Fifteen minutes after being mixed, the impression material was removed from the rubber dam and glass slab. The surface of the material that had contacted the rubber dam and glass slab was examined visually and probed with a flat instrument to determine if the setting was complete.

Results

The results of the investigation presented in the table demonstrate that all addition silicones were inhibited from polymerization by contact with rubber dam, both washed and unwashed. No difference was observed for the different weights of rubber dam. Samples of the addition silicones that were allowed to contact the rubber dam for as long as 24 hours continued to exhibit an unset surface. All of the other impression materials, on the other hand, set completely.

Discussion

The inhibition of the setting of addition silicones is not explained in the dental literature. Duncan Waller, chemist for the Kerr Corporation, has provided the following hypothesis. The catalyst used for polymerizing addition silicones contains platinum. This ingredient is converted to a complex of chloroplatinic acid during the curing reaction. Rubber dam is vulcanized rubber containing sulfur compounds, which contaminate the platinum catalyst thereby inhibiting the setting reaction.

Although the addition silicones will reproduce the surfaces of the tooth, the unset material adjacent to the cervical margins of the prepared tooth produces a poor model and therefore the use of rubber dam is contraindicated with this impression material. The other three types of elastomeric impression material will provide superior results when the rubber dam is used.

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DENTAL PRACTICE

Manipulation of Cohesive Gold Foil in Dental Restorations

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Summary

The requirements for the manipulation of cohesive gold foil are the selection and preparation of the desired form of gold, a suitable array of instruments, a good means of annealing and purifying the surface of the foil before carrying it to the cavity, correct and controlled force of compaction, an awareness of the importance of line of force, rhythmic teamwork by operator and assistant in placing and compacting the foil, a control of excess so that minimal surplus gold is added, and finally, standardized technics of contouring, finishing, and polishing. Last but not least is the instruction to the patient, so he is aware of the quality of the service received, and of his responsibilities in maintaining the restoration.

The procedure should not be unduly arduous for either the patient or the operator. It should conserve the tooth structure, maintain pulpal health, and avoid damage to the tooth and supporting and surrounding tissues. The objective is to provide a lifetime, superlative service for the tooth concerned.

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Introduction

The principles and technics of fabricating gold foil restorations have been published and taught for many, many years. However, the articles tend to become dusty treasures in libraries, and the incoming generation of restorative dentists do not have ready access to the masterful teachings of the past, though many are eager to increase their knowledge of this valuable phase of restorative therapy. Further, regional technics are apt to be exhibited and taught only to geographically limited groups, yet it is of interest to others to learn the details of these procedures. A third reason for recounting the steps in the exhilarating but demanding technic of working with pure gold is the hope that the repetition will encourage other clinicians to tell of their contributions to the art and science, with resultant benefit to all. Therefore the objective of this treatise is to record some of the details that are seldom described in papers and which can be lost to the profession as those who are familiar with the technic fade out of the dental picture. Perhaps some benefit will occur before this, too, joins the forgotten publications in dental library stacks. The procedures to be described have come from the inspired teachings of the author's instructors, and from refinements or alterations that have evolved from over half a century of clinical application.

All three phases of the gold foil operation are vitally important. Without a properly prepared cavity, without proper manipulation of the gold, and without proper finishing to attain a contoured, functional, polished restoration the service will be a failure. The greatest amount of time and attention tends to be given to the preparation of the cavity. However, the technic of inserting, compacting, finishing, and polishing the foil restoration is also precise and demanding. Attention must be given to a multitude of seeming trivia if restorations of optimal quality are to be produced.

Materials and Instruments

The selection of the type of direct gold is important. It may be foil in either hand-rolled or manufactured form, or mat gold, mat foil, laminated foil, or powdered gold. Described here is the use of cohesive gold foil that has been prepared by office personnel from sheets of No 4 gold (4 grains per 4-inch square).

The instruments required include an assortment of compacting, or condensing, instruments of varied shapes, sizes, and forms to enable effective compaction of the gold, and a suitable passing instrument to convey the foil from the annealing medium to the cavity. Finishing instruments and polishing materials should also be of the highest quality and must be kept in peak condition.

Finally, an annealing medium is required. It can be either an electric annealer, or a mica or enameled metal plate that will hold the foil over an alcohol or gas flame, or it can be the flame of an alcohol lamp. Clinical experience by many foil operators, supplemented by research by Hollenback and Collard (1961), has shown that the most satisfactory annealing is accomplished by heating the gold to a dull red (1200 °F or 649 °C), pellet by pellet, over an open shielded alcohol flame.

Insertion and Compaction of the Gold

G V Black (1908) stated that "much hammering of gold will make a hard mass, but no amount of hammering of gold, that is available in the mouth, will make close adaptation to cavity walls, unless the laying of the gold, stepping of the plugger point on the gold, and the direction of force are correlated to this end."

E K Wedelstaedt, in his voluminous writings and lectures, emphasized the importance of precise, careful technic in the compaction of gold foil. In a paper written 12 April 1917, he stated that the principal objective when using gold foil for dental restorations is to make watertight margins. He advocated "acquiring such habits as will enable operating with the greatest facility." He observed, however, that "a high percentage of operators use their pluggers in anything but a scientific way. They may here and there make tight margins, but everything about their results is uncertain." The same holds true today.

There are several methods of applying compacting force to gold. It can be done with hand pressure by the operator alone, hand pressure supplemented by malleting by the chairside assistant, or with one of the mechanical instruments, such as the Snow spring mallet, or the Hollenback Pneumatic Condenser, or the McShirley Electro-Mallet. With any of the technics excellent restorations can be produced **if** the technical procedure is adjusted to the requirements of the particular instrument.

The long-handled condenser in the hand of the operator, with proper initial finger pressure, and supplemented by mallet force with a leather-faced or plastic-faced mallet in the hand of the assistant, gives as fine a result as does any method and has the further advantage of sharing the work. With the malleting being done by the assistant, the operator is able to concentrate on the control of the compacting instrument, the line of force, and the protection of the tooth and the supporting structures. Another advantage of hand malleting is that it is much easier for the operator to change compacting instruments than to change points in one of the automatic devices; and it is important, when considering the line of force, and the shape and size of condenser, that we do change back and forth. For example, while it is desirable to use the simplest design of condenser — and in a large portion of a class 5 a straight condenser can be used — certain areas will dictate the use of other designs. For sharp occlusoproximal angles, the 0.4 mm monangle is a desirable condenser; and in many class 5s an offset or bayonet design of instrument is more suitable than a straight or monangle condenser to achieve the proper line of force of 12½ centigrades (45°) against the occlusal wall. If an operator has to take the time to remove a straight condenser point from the chuck of a handpiece and change to another design, he is more apt to try to get by without a change, and hope the line of force will be adequate, and he may or may not — likely will not — seal the gold well against the cavity wall.

The mallet we use is the one designed by W I Ferrier, which is presently available from J V Gourley, 12238 Olympic View Road NW, Silverdale, WA 98382, USA, or American Dental Mfg Co, Missoula, MT 59806, USA. It is somewhat different from the Prime mallet, which has a longer handle and is heavier. It varies, too, from the Woodbury design. The head of the Ferrier mallet weighs 2½ ounces (71 g). The handle is delicate, well turned, finely finished. The head and handle are well balanced.

The assistant using the mallet holds it between thumb and index finger of her malleting hand (the **left** hand, if the operator is right handed); she determines the point of balance and develops the ability to strike the end of the compacting instrument properly, with the mallet head traveling approximately 0.75 - 1 inch (2.0 - 2.5 cm). The amount of force is best when it is the equivalent of 15 pounds (66.7 N) with a condenser whose nib has a diameter of 1.0 mm at the face. Further, the most practical diameter of nib is 0.5 mm, and should rarely exceed 0.75 mm. This means that the mallet force on a 0.5 mm condenser would be approximately 4 pounds (17.8 N), actually 3.9604 pounds (17.6 N).

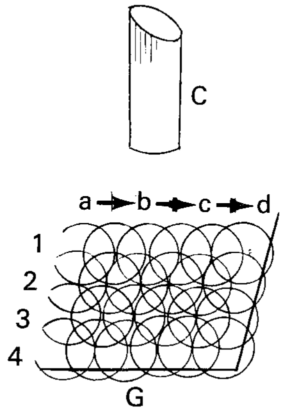
The technic of malleting must be developed. It should be practiced regularly by the assistant. The type of blow should be supervised constantly by the operator. This step is one of the weakest and least uniform among foil operators. Some assistants hold the mallet too close to the end of the handle or, occasionally, too close to the head of the mallet. Some hold the mallet between the thumb and third finger and use the index finger as a 'stop', holding it against the back edge of the handle, a method which produces a dead, heavy blow traumatic to the periodontal ligament.

Compaction depends not only on the amount of the force but also upon its velocity, so a suitable rhythm and technic must be worked out by the operating team. In essence, the operator institutes finger pressure with his condenser against the gold, taking up the slack or the compressibility of the periodontal ligament. Immediately thereafter the assistant strikes two blows with the mallet, two "tap, taps" with the mallet traveling parallel with the central axis of the handle of the condenser. It is a short, lively blow, with but split-second contact of the mallet on the condenser. It is executed so the mallet pivots between the thumb and finger; it is not a firm hammer grip; the mallet almost does its own work. The end of the mallet handle bounces against the base of the thumb, and this produces a rebounding action. After the two blows the operator lifts the condenser and moves it half to two-thirds the diameter of the condenser face, exerts finger pressure, and receives two more taps. Again he lifts, moves, exerts finger pressure, and receives two more taps.

The sequence of malleting should be rhythmic and methodical. Figures 1 and 2 show the sequence of the steps used when beginning to condense from the central part of the cavity. Go along in rows from one edge of the pellet — a, b, c, d — over to the other edge; move one half the diameter of the condenser nib closer to the margin of the cavity into row 2; repeat — a, b, c, d — and move another row closer to the margin. So the progression from the central part of the cavity to the edge of the pellet is row 1, 2, 3, and 4, and the sequence of malleting is from left to right, or right to left, whichever is most convenient.

As the operator reaches the final row, say row 4 or 5, he comes to the margin. Rather than keep on to the very edge of the pellet, it is best to either double the pellet back on itself, and complete the compaction near the margin or, if he is close to the margin, scuff off the last edges of the pellet so he does not lose sight of the margin. Thus the amount of excess can be controlled.

In the case of a class 5, the gold is built up from the internal portion to the margins, banking or saucering it against the surrounding walls, and filling the central part of the cavity as the last step (Fig 3). The amount of gold, or the size of the pellet, should be determined by the convenience form, by the bulk of gold that can be accommodated effectively, and by the size of the condenser. The most useful size of hand-rolled pellet seems to be the '43rd', that is, $\frac{1}{43}$ of a 4-inch square of No 4 gold. Perhaps the most frequently used size is the $\frac{1}{64}$, but in the cavity of average size it is too small and therefore too time-consuming. The smallest size, the $\frac{1}{128}$, can be used for an initial starting point and for completing the coverage of margins. Of course, in very tiny cavities a considerable portion of the gold used may be the $\frac{1}{128}$ size.



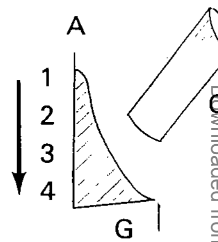


FIG 1. *Progression of compaction: C — condenser nib; P — proximal wall; G — gingival wall (see left)*

FIG 2. *Movement of foil by controlled compaction: A — axial wall; G — gingival wall; C — condenser nib (see right)*

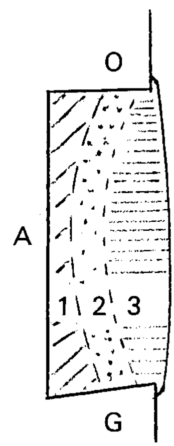


FIG 3. *Stages in building contour: A — axial wall; O — occlusal wall; G — gingival wall*

The Operating Team — Dentist and Assistant

The teamwork between the operator and the assistant is an extremely important consideration. When the operator receives the properly annealed gold, he tacks it on to the existing compacted mass and packs the pellet lightly by hand while the assistant is picking up another pellet, annealing it, and coming back to malleting position. At a given signal — a nod of the head or a move of the condenser or, if need be, a voice signal — the assistant mallets, with her left hand, until the pellet is compacted. Then (assuming that the operator is right handed), the assistant, with her right hand, conveys the next pellet into the cavity and places it at the spot designated by a motion with the condenser by the operator. She makes sure that he receives the pellet and that it remains in the cavity; then while he is packing it lightly with hand pressure, she picks up the next pellet, anneals it, comes to the 'ready' position, and awaits the signal to mallet. If this is done well the procedure is smooth, with minimal expenditure of time, minimal signaling, minimal talking, and maximum speed and efficiency.

The operator's responsibilities — aside from his hand-packing, controlling the proper sequence of movement of the condenser point, and his surveillance of the malleting by the assistant — include also a constant awareness of the direction of the compacting force. One of the primary considerations in the compacting of foil is the control of the line of force. Gold flows under properly directed compacting force, and our intent is to utilize this property of gold to make it move into the retentive areas of the cavity. Of course the gold must be in suitable condition, properly annealed and pure, and applied to a dry surface, so that the next pellet will cohere to the existing mass. The cold welding property is essential, but if the line of force is not controlled, foil can be tipped out of even a well-prepared cavity; a dense well-malleted foil can be lost through an incorrect line of force.

The line of force is determined principally by the axis of the shaft or handle of the condenser. For example, with a monangle condenser in a class 3 restoration, that monangle is used to wrap around the approximating tooth. If the angle is wrapped around the labial margin of the cavity, the axis of the condenser is not directed into the axiogingival angle but is mistakenly directed out of the cavity. The result then is to tip the foil and loosen it. It should be stressed that if movement is ever seen in a foil during its compaction no attempt should be made to relock it; it just will not reseal the wall. If there is movement, the foil should be removed and the insertion started again.

It is usually best for the operator to use a holding instrument to stabilize the first pellets of gold while he is condensing and until he locks the gold into the second convenience point or against the opposite wall of the cavity. There are some operators who are able to start with one pellet and so control the line of force that they do not need to worry about the slipping or buckling of the foil, and they do not use a stabilizing instrument, but they are few and far between. It is the better part of valor to use the holding instrument.

Operating Position

So far we have considered the material, the means of preparing it for compaction, the highly important contribution by the assistant, and factors to be controlled by the operator. A word might be said about the operator's stance at the chair. The past masters in gold foil procedures advocated the direct approach to the cavity with the gold. Rather than use a palm and thumb grasp on the condenser and work in a mirror, it is preferable to use the pen grasp, stabilized with a finger rest with the other hand, and look directly into the cavity, and thus control the line of force more readily. While the current trend is for the operator to sit constantly and never bend, and to use a mirror routinely, if one is having any problem with the placing of gold he might give consideration to resuming the proven, advantageous method of working directly into the cavity.

As an example, when a right-handed operator is restoring a gingival third lesion on the left side, he should not try to work over the patient and upside down. He will be thrown off balance and is not properly oriented. He should turn the patient toward him and work from the right front position so he can see directly into the cavity. In the same way, even though it is a little more uncomfortable for the patient, when adding foil from the lingual in a class 3, it is better to have the patient's head back, and chin sufficiently raised from the chest, so the operator can look directly into the lingual and be sure of the line of force.

Quality Control

The uniformity of compaction of the foil is important. Each pellet must be condensed thoroughly before proceeding to the next pellet. Hodson (1961) showed that the usual compacting force is not conveyed through a thickness of gold greater than 0.2 mm. If we hurry over the compacting of one pellet and leave any void, and then add another pellet over the void, it is unlikely that the initial void will be eliminated with the succeeding pellet, unless the thickness of the second pellet is less than 0.2 mm. So it is important to develop a good rhythmic sequence of passing the condenser back and forth over the pellet, compacting as we go, producing a uniformly smooth, mat surface, then adding the next pellet and keeping control of the contour. It is essential, too, that margins be completely covered, yet not damaged by striking with the condenser. A valuable instrument to check marginal coverage is a very sharp explorer, passed lightly from the gold to the tooth. If there is a catch, the margin is not covered completely and another pellet can be added.

With class 3s, care must be taken in several areas to avoid defective compaction. The first is the linguogingival angle where it is easy to cut off one's access by building the foil labial to that area too rapidly. Secondly, the central area, where, if compaction is not confirmed during the building of central bulk with an oblique-faced condenser or with a foot condenser, there is danger of having poorly compacted gold in the contact area, or just gingival to the contact. The third problem area is the linguoincisal cavosurface. Inadequate compaction in this location can be avoided if the cavity has a definite incisal wall as advocated by Ferrier (1936) and if the operator will be sure, as he "makes the turn," that the compacting force is directed from the gingival to the incisal so the gold is definitely condensed. It is usually unsatisfactory to attempt to add foil from the lingual in that location. The gold may appear to be dense for awhile, but soon it will exhibit a pitted surface, or the added foil will be displaced. It is most important to be careful with the compacting of the foil in these three areas. One of the most useful instruments for ensuring density in these locations is an oblique-faced monangled condenser. It will reach directly into the linguogingival angle and into the central area after the bulk has been compacted with the regular condenser, and it will also cover the linguoincisal cavosurface margin without damaging the enamel rods.

Finishing and Polishing

After the restoration has been built to contour with a slight excess to allow for finishing, the surplus is reduced, and the restoration is contoured, carved, and polished. The general procedure is to confirm the compaction of the gold by so-called after-condensation, which is a matter of going over the surface with a finely serrated condenser, usually foot-shaped. This flattens out the serrations resulting from the original condenser point. It also detects any dips in contour where a little additional foil might be needed.

When satisfied that there is sufficient foil and all margins are covered, the operator should lightly burnish the surface. This is not so much to work-harden the surface, but rather to confirm uniformity of density and to ensure that there is no dip in contour below the final one desired. If such a dip is evident, the surface can be reserrated and another pellet or so added.

After the light burnishing, the restoration is finished by alternating between the use of hand instruments and rotary abrasives. Both must be used properly, because either the hand instrument, the rotary instrument, or the polishing abrasive can damage not only the restoration but also the tooth. It is preferable generally to favor the use of hand instruments rather than rotary tools. Excessive bulk can be reduced with a disc or with a coarser strip; otherwise, finishing is begun with the push-cut and pull-cut files. These should be sharp. The sharpness can be assured by discarding the instruments promptly when they are dull, or by learning how to resharpen them with a suitable Swiss file. Gold is worked from the mass of metal to the margin. If it is dressed in the other direction the bite of the file may loosen or dislodge the foil.

In a class 5 restoration the push-cut file is used on the gingival and approximal portions and the pull-cut file is used on the occlusal portion. The file should be kept flat on the surface of the gold rather than to cut with just the end, because, particularly when reducing excess from the gingival, if just the end of the file is on the gold it is easy to gouge the cementum. It is important, too, when filing, to keep control of the instrument by having a short grip on the file and maintaining a supporting finger rest. It is unfortunate, and a mark of careless operating, for the soft tissues to be bruised and mutilated when a foil is finished.

After the preliminary dressing with the files, contouring is continued with a disc of extra-fine garnet, ⅜ inch in diameter, mounted on a miniature snap-on mandrel, such as the Sproule type, if available, rather than on a screw-head mandrel, running at slow speed and with a constant stream of cool air on it, and with a very slight film of vaseline on the surface of the gold. The reason for using the tiny ⅜-inch or even ¼-inch disc is that it will reach into the embrasures more readily, and the cutting is controlled more easily. The reason for the disc mandrel rather than the screw-head mandrel is that the operator can revolve it from gold to tooth, and reverse it readily, whereas with the screw-head type the head simply unscrews in reverse; it is a definite handicap if the disc revolves only one way. The reasons for the vaseline are that it lubricates, the cutting is less harsh, and the disc will convey some of the lubricant to the dam so the rubber is not torn.

By alternating back and forth from files to discs and back to files, then changing discs from fine garnet disc to a coarse cuttle disc, then filing again, then using a medium or cuttle disc, and finally a fine cuttle disc, the excess is systematically reduced to the desired contour, the scratches of the coarser instruments are eliminated, and the foil is brought to a satin finish. The filing and discing may drag gold over the margins; if so, these little tags are removed with the file or with the back of a sharp gold knife. The knife is kept keenly sharp, sharpening from the front edge of the blade all the way to the back so there will be three cutting edges on the blade, and a light push cut will flick off the excess.

In a class 3 restoration discs are used only rarely. The abrasive medium used is a linen strip, 18 inches long, carrying various abrasives, either cuttle or garnet. After the preliminary burnishing and filing, contouring is accomplished with the very sharp gold knife, then with controlled use of strips. Whenever strips or discs are used cool air must be kept on that tooth so the gold will not be overheated with resultant damage to the pulp. Draw the strip across the surface of the gold, not too quickly, and do not seesaw as though polishing shoes. Again, the sequence is to progress from the coarser to the finer strips.

In class 3s separation is needed. If the separator has not been placed during compaction, one is placed before finishing procedures are instituted; or, if a separator has been on during compaction, a little extra tension is provided to increase separation during the preliminary burnishing and carving with the knife. A strip of steel matrix metal is passed through the contact area to facilitate passage of strips and to work-harden the foil in the contact zone. When some contour has been developed with a knife and files, an extra-fine cuttle linen strip is passed over the gold a few times; it is then laid aside to be used again later in the operation. More contouring is done with the knife and occasionally with the files. If there is considerable excess a coarser strip, such as a medium cuttle of medium or wide width is used. The wide strip is preferred if there is a prominence to be reduced, for it will stay on the peak or hump rather than slip off to one side or the other. Very occasionally a garnet strip may be used, but one's objective should be to control the amount of excess of gold during compaction to avoid the need for such a coarse abrasive. As finishing progresses, the sequence is to reduce the abrasiveness of the strips. Go from medium to fine, then to extra-fine, and finally to the partly worn-out extra-fine strip that was used at first. If a class 3 foil extends further on to the lingual surface than usual, a small mounted stone may be required to develop the desired lingual contour. Occasionally a ⅜-inch disc may be needed, but usually there is not much use for discs on class 3s, unless they are of the lingual approach design.

After the foil is brought to the best possible finish with the strip or disc and instruments, the final finish is developed. While some operators use a wet slurry of abrasive or polish when finishing a class 5 so as to minimize the danger of thermal irritation to the pulp, the slurry tends to obstruct the vision of the operator. This permits the rubber cup to go beyond the gingival margin on to the cementum, and the cementum is ditched. It is safer to use the polishing powder dry and keep cool air on the field rather than to use a paste or slurry. While rougher finishing can be done with a coarse abrasive such as flour pumice, a nicer preliminary surface is produced by lap emery, which is designed as No 303 lap emery by the manufacturer. Some use a fine silex powder, but it can cut tooth structure readily.

The next step in the finishing procedure is the final polishing. One highly satisfactory product for this is the White Polishing Compound No 309, which is used by optical glass laboratories; alternatives are tin oxide or one of the proprietary high-gloss polishing materials. Some time ago the department of dental materials of one of the dental schools conducted tests and compared the results obtained with tin oxide, one of the proprietary agents, and the No 309. The finest polish, with the least effort, was that obtained with the No 309. A powder named Tru-Polish, manufactured by the Dentists Supply Company, also creates an excellent surface. However, it is slightly more abrasive, so is apt to ditch tooth structure unless very carefully controlled. Class 5s in the maxillary arch or those that may be visible when the patient smiles or talks are usually not carried beyond the stage of the satin finish produced by lap emery. The mandibular teeth or those that are not conspicuous are given the high gloss.

For class 3s, the finish generally advocated is that produced by a worn-out extra-fine cuttle strip. This is the reason for saving the strip that was used first in passing the contact. The long strip is carried over and over the surface and the scratches from the coarser strips are eliminated. Be sure to hold the strip at the same end always, or nip off the final inch of the strip. Otherwise, if it is picked up end for end you can be polishing with the first 17 inches of the 18-inch strip and scratching with the unused final inch, negating the polishing effect. Unfortunately, it has become almost impossible to secure the former "extra-fine" grit on strips, in spite of the packages being so labeled. Manufacturers at present tend to turn a deaf ear to requests for some high quality products. Therefore it is necessary to dull one of the so-called extra-fine strips by running it across the roughened surface such as the handle of an instrument before performing the final stripping. The satin finish obtained with the worn-out strip minimizes the reflection of light from the gold. Some operators like to bring the lingual to a higher polish, although the shine will not last very long. For a clinic or display, however, the high shine is appropriate.

The finishing of class 2s is perhaps the most difficult step in that class of foil restoration. The 'after-condensation' of the noncohesive foil in the approximal portion is highly important. For a class 2 involving the distal surface, a back-action, noncohesive foil condenser is required; for a mesial surface, the finely serrated gooseneck condensers with the long thin nibs are used. They will reach into the interproximal space and complete the compaction of the noncohesive foil. Then the burnisher is used.

The occlusal of class 2s is usually dressed down first. The separator is not placed yet. The excess is removed with a suitable 12-bladed carbide bur or a plain-cut straight fissure bur. Care must be taken to not cut into the occlusal tooth structure. If the bur is applied so part of its head lies on the occlusal surface, it is easier to restore the occlusal anatomy in the gold. The straight fissure bur does an excellent job of reforming cusp ridges, central grooves, developmental grooves, and spillways. The anatomical form can be further refined with a sharpened cleoid. After the occlusal anatomy is developed, the buccal, occlusal, and lingual embrasures are established with a disc, followed by the use of gold knife and files. When preliminary work on the approximal surface is completed, a separator is placed and stabilized with modeling compound. Next a strip of matrix steel is worked through the contact area, followed by a fine linen abrasive strip, and then a coarser strip to finish the contouring of the approximal surface. The surface finish is refined and completed with progressively finer strips. Finally, the separator is removed and the polishing is accomplished with the No 303 and No 309 powders.

After the finishing and polishing are completed, all remaining debris must be removed. Particularly in class 5s, the cuttings from the files tend to be pushed under the cupped rubber dam. They can work their way into the gingival sulcus and the soft tissues, become lodged there, and be almost impossible to remove. So a required step after the retractor or separator, and dam, are removed is to irrigate the tissues and massage them gently. A transilluminating light and some air are helpful to be sure that the gingival sulcus is clear of all polish and debris. It takes only a few seconds, but lessens postoperative pain, reduces the danger of leaving extraneous material in the sulcus, and of gold filings being embedded permanently in the soft tissues. Next it is advisable to apply a soothing antiseptic to the operated area, because it is probable that some degree of trauma has occurred.

Finally it is highly desirable to instruct the patient. Inform him that after the anesthesia wears off there will probably be some degree of reaction to thermal change for a brief period and that, in the case of class 5 restorations, the retracted gingival tissues may be tender for a few days. If the patient knows this beforehand he is not alarmed if such reactions do occur. He should be advised to divert foods or liquids that are extremely hot or cold away from the new restoration for a little while. Sometimes class 5s are quite comfortable for a week or two and then may become sensitive for a period of time. Operators and patients alike should be aware of this possibility. Usually the temporary sensitivity to thermal change will fade away very soon. However, when you warn patients that such a reaction may occur, you should also advise them that if the tenderness should increase, they must let you know promptly so steps can be taken to protect the pulp with a periodontal pack, or varnish, or other suitable means.

If the cavity was of proper depth, neither too shallow nor too deep, and if the compacting force was not excessive, and if retraction or separation was performed with due care, and if finishing was atraumatic — that is, with a constant air coolant while discing, stripping, or polishing — rarely are the teeth uncomfortable. In a class 5 the application of cavity varnish to the axial wall before placement of the gold is an additional help; it does not seem to be necessary in class 3s.

The patient should also be instructed in the correct care of the tooth and the new restoration. The goal of the operator should be that when he removes the retractor or separator, and the dam, only an impression or indentation from the pressure of the retractor or separator should be evident. There should be no tearing or bruising of the gingivae. The patient should be guided to relieve any tenderness by irrigating the site with warm saline mouthwash or one of the proprietary mouthwashes comfortably warmed, two or three times a day. In class 5s he should be cautioned not to brush too vigorously for the first few days. With a class 2 restoration, occlusion should be checked. This will be necessary also in class 3 restorations that extend to functioning areas on the lingual surface.

Conclusion

In summary — aside from a correct cavity preparation in a moisture-free field — fabricating a lifetime restoration of gold foil demands the following:

- Balanced, skilled teamwork by the operator and the assistant
- An adequate assortment of sizes and forms of foil, correctly annealed
- Unwavering attention to compaction of the foil in respect to line of force, amount of force, and compaction pattern
- Building the gold to seal the cavity walls and cover the cavosurface margin; dressing the restoration to correct contour; restoring function; and completing the finishing and polishing procedures
- Consideration for the health of the dental and supporting tissues
- Instruction to the patient

(Accepted 31 July 1978)

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Pin-retained Base in Conjunction with Complex Pin-and-Amalgam Restoration

Solid retention of the cement base for protection of the pulp and support of the amalgam should be considered during restoration of severely mutilated teeth.

ROBERT R MURRAY

Summary

The use of pins to provide stability for a base of cement in a tooth that has little resistance or retention form is a technique that allows the base to be trimmed to proper form without danger of dislodgment.

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Introduction

Since the introduction of cemented retentive pins for amalgam restorations, it has become accepted practice to rebuild teeth into service rather than to resort to the dentally crippling practice of extraction. Rebuilding teeth is not undertaken without technical complications, however, for the grossly carious tooth, especially a molar, leaves an inadequately retentive surface for a cement base once the caries has been removed. The resulting "shiny" dentin, traditionally covered with calcium hydroxide, produces a glazed surface that will not adequately retain the subsequently applied thermally protective base. The purpose of this presentation is to provide a rebuilding technique for the clinician faced with the problem of securing a protective cement base that will withstand the procedures of repreparing the tooth and of treating that hard base as if it were sound dentin. This technique allows the operator to instrument the cement confidently.

Materials and Methods

Two teeth requiring extensive restoration are shown in Figure 1.

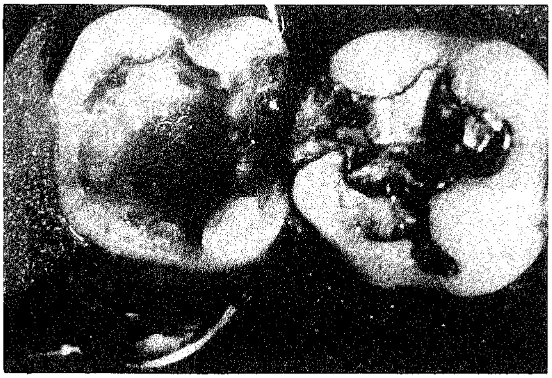

FIG 1. *Two teeth requiring extensive restoration*

The classic initial layer used for protecting the pulp is calcium hydroxide (Fig 2). To provide

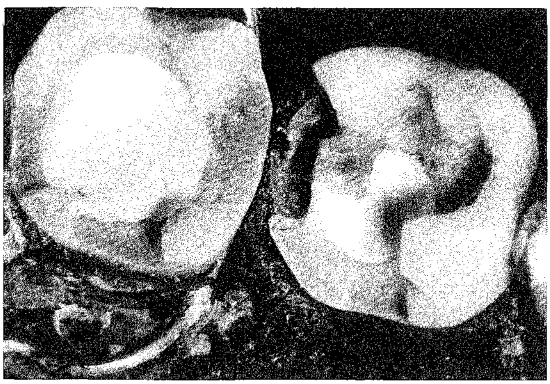

FIG 2. *Caries removed and a base of calcium hydroxide applied*

retention for the second layer, of cement, one or more TMS 0.013 self-threading pins, with their long axes angled toward the periphery of the tooth to avoid the pulp, are placed in the remaining dentin at the periphery of the excavated area (Fig 3). (The smaller pin, 0.013,

FIG 3. *Retentive 0.013 self-threading pins placed in remaining peripheral dentin. Note direction of placement to keep pins within subsequent cement base.*

is preferred because of its minimal lateral stresses.) Prior to seating in the pin channel, the tip of each pin is dipped in calcium hydroxide; this procedure both lubricates the pin while seating and acts as a sealant at both the cavosurface of the pin channel and at sites of crazing, should they develop. Finally, a heavy putty-like consistency of zinc phosphate cement is condensed over the calcium hydroxide and accompanying pins to serve as the thermally protective base.

Once this second layer achieves a hard set texture, it is instrumented with burs at high and low speed and then with hand instruments to provide proper dimensions and resistance and retention form (Fig 4). From this point on, the

FIG 4. *Cement base placed and trimmed*

standard pin-retained amalgam restoration is carried out by properly placing the required pins within the missing tooth structure to provide the amalgam with additional retention (Fig 5).

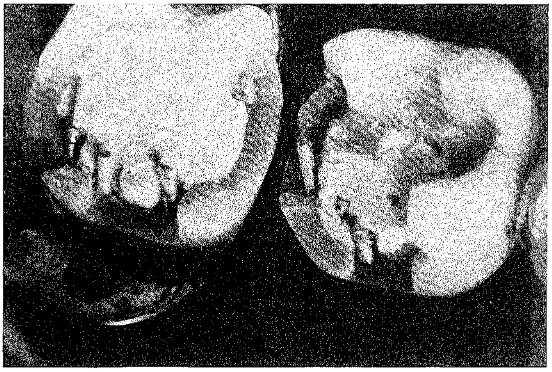

FIG 5. *Peripheral retentive pins prior to placement of amalgam*

This rebuilt pin-and-amalgam restoration can be polished to stand as a restoration with no further manipulation, or be prepared later as a strong foundation for a crown (Fig 6).

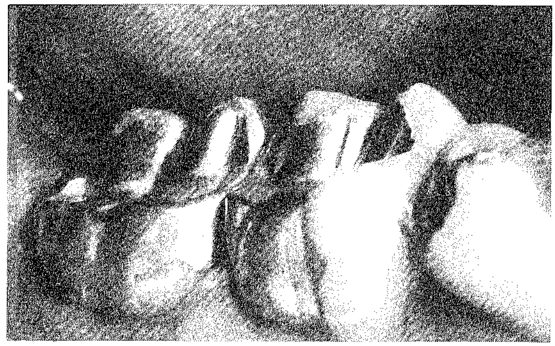

FIG 6. *Final pin-and-amalgam restoration*

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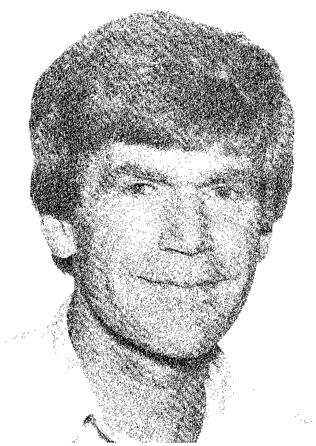
BUONOCORE MEMORIAL LECTURE

Clinical Relevance of Physical, Chemical, and Bonding Properties of Composite Resins

ERIK ASMUSSEN



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Presented on 18 February 1985 at the annual meeting of the Academy of Operative Dentistry in Chicago.

INTRODUCTION

Modern restorative resins originated with the invention of the Bowen monomer and with the introduction of composite materials. Obviously, the clinical performance of composite resins in restorations is influenced by the properties of the resin, the problem being, however, to determine which of the many properties are clinically relevant and which are interesting only from the point of view of the pure science of materials. Clinical data have formed the basis for the identification of many relevant properties and, concomitantly with clinical research, new resins have emerged. Today's materials exhibit various properties and handling characteristics superior to those in the first generation of composite resins but still somewhat short of perfection.

The development of the bonding properties of restorative resins goes back to the pioneering work of Michael Buonocore. Buonocore discovered that adhesion to enamel could be increased substantially if the enamel were pretreated with phosphoric acid (Buonocore, 1955). The technique of etching with acid has subsequently been studied in great detail and is now a generally accepted technique in restorative therapy.

Michael Buonocore also pioneered work on adhesion to dentine (Buonocore, Wileman &

Brudevold, 1956). Buonocore's idea resulted in a bonding agent to be used as an intermediary between dentine and restorative resin. The strengths of bond obtained, however, were comparatively low but, later, more effective systems of bonding based on the original idea of Buonocore have appeared. Agents for bonding to dentine have not been used widely until now but in the years to come will undoubtedly be recognized as necessary supplements in therapy with restorative resins.

My aim is to focus on the relationship between the clinical performance and the properties of composite resins. I intend to demonstrate that some properties can be used to advantage in restorative therapy, whereas, for best result, other properties should be suppressed. I shall divide my presentation into two main sections, the first of which will be devoted to physical and chemical properties, the second to various aspects of bonding to the hard dental tissues.

PHYSICAL AND CHEMICAL PROPERTIES

The mechanical properties most often measured are compressive strength and tensile strength.

Compressive Strength

Macrofilled composites have less compressive strength than microfilled composites (Fig 1). Compressive strength, however, has no

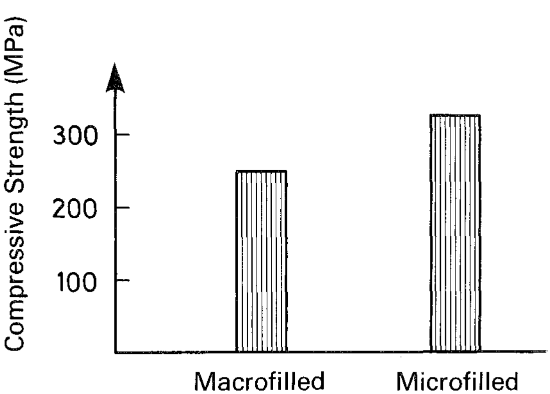

FIG 1. *Compressive strength of typical macrofilled composite (left) and microfilled composite (right)*

documented clinical significance. Even in stress-bearing areas of occlusal surfaces restorative resins are not crushed or broken, implying that compressive strength is sufficiently high and should not be used to classify proprietary resins.

Tensile Strength

Microfilled composites have lower tensile strength than macrofilled composites (Fig 2).

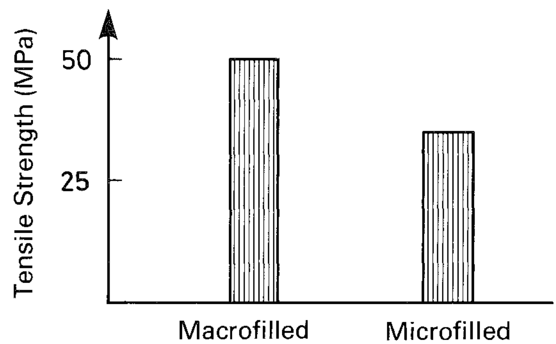

FIG 2. *Tensile strength of typical macrofilled composite (left) and microfilled composite (right)*

The difference in tensile strength, however, has not been reflected in clinical studies and may therefore be regarded as irrelevant from a clinical point of view. I shall return later to the relationship between tensile strength and the strength of the bond to etched enamel.

Now, which are the shortcomings that **have** been demonstrated in clinical studies? Restorative resins have been shown to fail mainly in areas pertaining to 1) abrasion, 2) stability of color, and 3) marginal leakage.

Resistance to Abrasion

In the mouth abrasion occurs in different ways, depending on the type of restoration. Class 3 and class 5 restorations are abraded predominantly by brushing with toothpaste. Laboratory tests show that macrofilled composites wear much less than microfilled composites, the large particles of filler in the macrofilled resin protecting against the abrading particles in the toothpaste. Clinically, however, this difference is not displayed since in most cases abrasion by toothpaste, even on microfilled materials, results in negligible loss of the surface.

Abrasion by toothpaste can also affect the smoothness of the surface. Microfilled composites remain smooth because of uniform abrasion but the wear of macrofilled composites is characterized by an attack on the polymer between the particles of filler, resulting in increased roughness of the surface. Although never shown directly in clinical experiments, increased roughness probably predisposes to retention of plaque and staining of the surface.

On occlusal surfaces a different kind of wear is observed. Class 1 and class 2 restorations are abraded mainly by food being compressed between restoration and antagonist during biting and chewing. The resistance of composites to occlusal wear has been assessed in a study in which the materials were inserted into class 1 cavities in porcelain teeth in complete dentures (Jørgensen & Asmussen, 1978). The restorations of macrofilled resin showed the characteristic mode of abrasion where the occlusal surface is displaced parallel to the original surface. The magnitude of the abrasion could be gauged from the depth to which the walls of the cavity had been exposed and amounted to about 30 μm per year. With the microfilled restorations, however, abrasion did not expose the walls of the cavities. This study was performed in patients with dentures; in the natural dentition more intensive abrasion will occur. The results from five studies in which the occlusal abrasion of composite resins was measured in natural dentitions are summarized in Figure 3

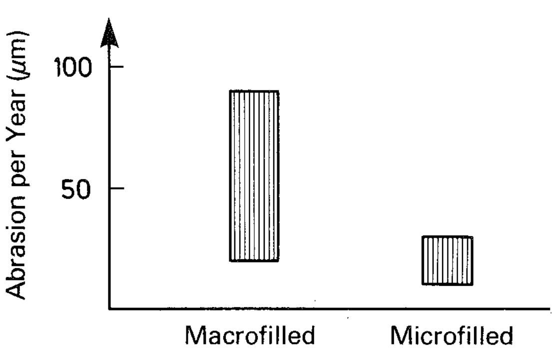

FIG 3. *Range of occlusal abrasion for macrofilled composites (left) and microfilled composites (right) in natural dentitions*

(Jørgensen & others, 1979; Knudsen & Jørgensen, 1983; Lambrecht & others, 1984; Meier & Lutz, 1978; Roulet, Mettler & Friedrich, 1980). In general the microfilled composites show less occlusal wear than the macrofilled composites, but some relatively fine-grained, macrofilled composites also show good resistance to wear.

To improve further the resistance of restorative resins to wear we need to understand the process of wear. Jørgensen (1980) has offered the following explanation: During biting and chewing, minute hard particles in the food are pressed into the surface of the restoration and thereafter moved along the surface, the resulting fine scratches causing the abrasion. Studies with a microscope have shown that when macrofilled composites are abraded by food, only the polymer matrix between the particles of filler is attacked; the particles themselves are not abraded, but fall out with time as they lose their grip in the surrounding polymer. Microfilled composites, on the other hand, are abraded uniformly, that is, polymer and particles of filler are lost concomitantly in the process of wear.

As a consequence of this explanation of the mechanism of wear, resistance to abrasion should increase the better the abraded material resists the penetration of the hard particles of food. Resistance to penetration may be assessed as follows: A Vickers diamond is subjected to a given force, after which the depth of indentation can be determined. For a Bowen polymer the depth of indentation is approximately 22 μm, whereas the depth of indentation of a microfilled material may be as low as 14 μm. The measured amount of occlusal abrasion by food, 80 μm for macrofilled composite and 30 μm for microfilled composite, corroborates the above theory about the mechanism of wear (Jørgensen, 1980).

Thus, it would seem that an avenue to increased resistance to wear involves polymers of high hardness. Most dental polymers originate from mixtures of the Bowen monomer — the so-called bis-GMA — and a thinner, diluting monomer (Asmussen, 1975a). The extent of polymerization depends on the ratio of bis-GMA to diluting monomer (Fig 4) — the more

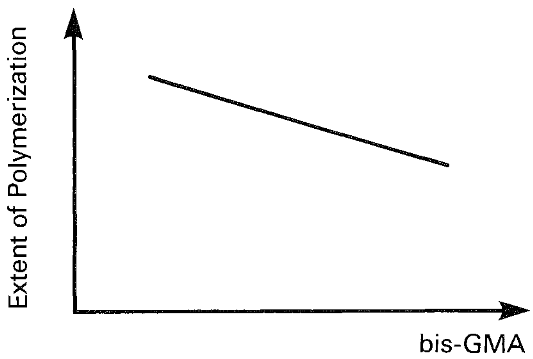

FIG 4. *Extent of polymerization in relation to the content of bis-GMA in the monomer — the more bis-GMA the less the extent of polymerization*

bis-GMA in the monomer the less the extent of polymerization (Asmussen, 1982b). Strangely enough, however, this variation in the extent of polymerization is not reflected in the hardness of the polymers, which all show the same depth of indentation (Asmussen, 1982a). But when the resins are placed in a softening solution like alcohol, for example, differences in the extent of polymerization become apparent (Asmussen, 1984). With a high content of bis-GMA — and therefore a small extent of polymerization — the polymer is especially susceptible to softening (Fig 5). Food contains numerous substan-

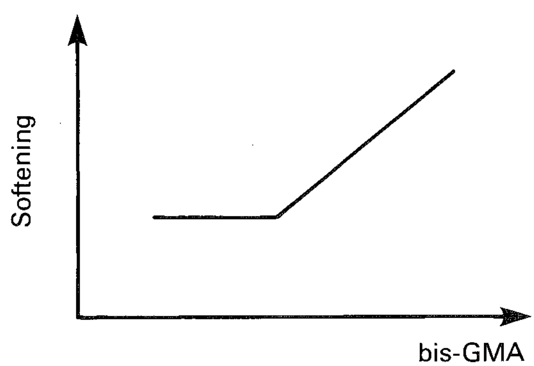

FIG 5. *Softening of polymers in relation to the content of bis-GMA in the monomer — the more bis-GMA the greater the softening*

ces having a molecular size and polarity that will cause softening. Furthermore, propionic acid and acetic acid — most effective plasticizers — are produced in the bacterial plaque (Asmussen, 1984). Consequently, the surface of a composite resin covered by plaque will be softer than the surface of a clean resin and therefore more susceptible to abrasion. Microfilled composites contain relatively little bis-GMA compared with the average macrofilled composite, thus the polymer of the microfilled materials is quite resistant to softening at the surface. This may contribute to the relatively good resistance to abrasion by food that this type of material exhibits. Fine-grained and highly loaded macrofilled composites also contain relatively little bis-GMA and exhibit good resistance to wear (Fig 3).

Stability of Color

A substantial amount of clinical data and number of observations have shown that the color of composite restorations is not stable but tends to change to various shades of yellow and brown. The discoloration may be of several types, one being the so-called internal discoloration.

INTERNAL DISCOLORATION

We have searched for the causes of internal discoloration by a method consisting of prolonged storage of the materials in water at 37 °C, whereby an internal change of color is provoked (Asmussen, 1981a). Much laboratory work has pointed to the role of aromatic tertiary amines in the process of discoloration. Such amines are present in the catalytic system of chemically cured restorative resins. The change in color is brought about by oxidation of excess amine in the cured polymer.

We have investigated several factors that are involved in internal discoloration induced by amine (Asmussen, 1983). First, the type of amine plays a role. The amine used in the first generation of composite resins has been replaced by amines with more stable color.

The amount of amine in relation to benzoylperoxide also plays a role. The amount varies greatly between brands of composite resin. The higher the ratio of amine to peroxide, the more intensive is the internal discoloration (Fig 6). A practical consequence of the excess of

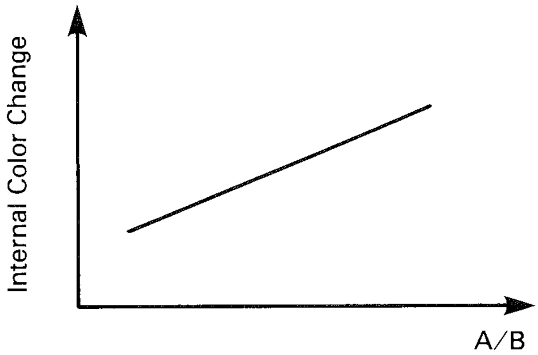

FIG 6. *Internal discoloration of chemically cured composite resins in relation to ratio between amine* (A) *and benzoylperoxide* (B) — *the higher the ratio of amine to peroxide the greater the internal discoloration*

unconsumed amine present in the resin after polymerization is an increase in the chromogenic potential of resins stored too long at temperatures too high. The benzoylperoxide will decompose under such conditions, causing an increase in the ratio of amine to peroxide, which leads to increased internal discoloration.

A third factor influencing discoloration induced by amine is the amount of bis-GMA in the monomer; the higher the content of bis-GMA in the mixture the less the discoloration of the polymerized material (Fig 7). This relationship does not favor the microfilled composites, which contain relatively little bis-GMA. On the other hand, microfilled composites have little propensity to discoloration of the surface compared with macrofilled composites.

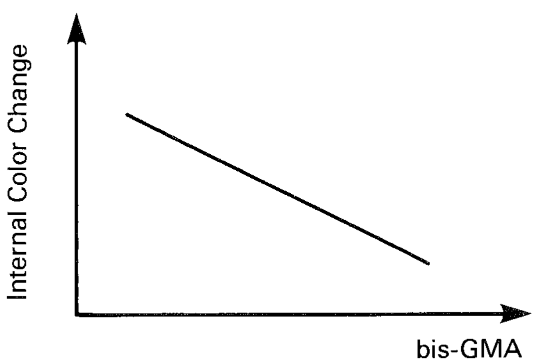

FIG 7. *Internal discoloration of chemically cured composite resins in relation to the content of bis-GMA in the monomer — the more bis-GMA the less the discoloration*

The color of restorations of chemically cured composites is considerably less stable than that of restorations cured by ultraviolet light (Wilder, May & Leinfelder, 1983). This is readily explained by the absence of amines in composites cured by ultraviolet light. Data on the clinical performance of composite resins cured by visible light are scarce. Probably some brands are cured without the aid of amines. Other brands contain amines to enhance the effect of the light-sensitive catalyst. The amine may be aromatic or aliphatic, the aliphatic being less chromogenic. In general, the quantity of amine in the light-cured composite is less than in the chemically cured composite. We have used the water immersion test to assess the stability of the color of several proprietary composites cured by visible light. It appears that the color of these composites is on the average more stable than that of chemically cured composites (Fig 8).

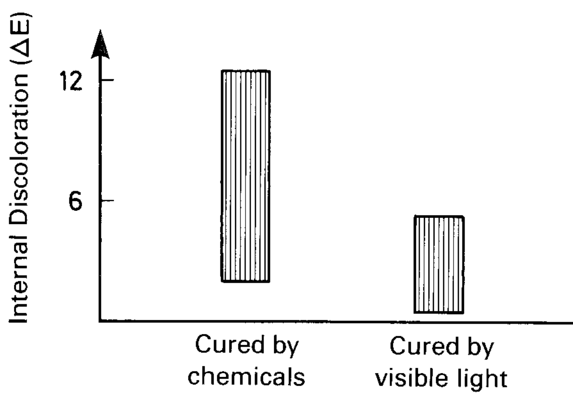

FIG 8. *Range of internal discoloration in chemically cured composites (left) and composites cured by visible light (right), the color of those cured by visible light being more stable*

SURFACE STAINING

Apart from internal discoloration, restorations of composite are liable to discolor from staining of the surface. Microfilled materials, owing to their smoother surface, may be expected to be less susceptible to surface staining. Also the possibility of softening of the surface of the restoration should be considered. A softened polymer has a looser structure into which dyestuff may diffuse. We have investigated the effect of softening of the surface on its staining, using propionic acid as a plasticizer, and have found enhanced propensity to discoloration of the surface in specimens with softened surfaces. Propionic acid and acetic acid are formed in bacterial plaque, and the surfaces of restorations of composite resin covered by plaque are subjected to softening by these acids and thus are more susceptible to staining. In this manner we may explain the clinical observation that poor oral hygiene is frequently associated with pronounced discoloration of restorations of composite resin.

Since the tendency to softening of the surface depends on the amount of bis-GMA in the resin monomer — the higher the content the greater the tendency to softening — so discoloration of the surface depends on the content of bis-GMA (Fig 9).

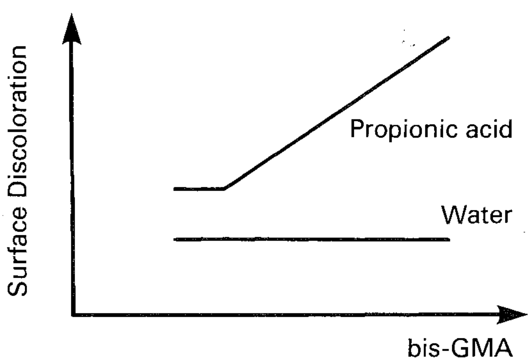

FIG 9. *Surface discoloration of polymers in relation to the content of bis-GMA in the monomer. The dye was dissolved in either water (below) or the plasticizing compound propionic acid (above) — the more bis-GMA the greater the softening in propionic acid.*

Marginal Leakage

A third major shortcoming of composite resin as a restorative material is the susceptibility to marginal leakage. Marginal leakage implies penetration of bacteria and coloring matter from which secondary caries, damage to the pulp, and marginal discoloration may arise. Marginal leakage is associated with marginal gaps, which may occur for several reasons. First, contraction of the composite resin during polymerization predisposes the formation of gaps. If a gap is formed and the filling then polished, a stress is applied to the unsupported margins of enamel causing them to fracture (Asmussen & Jørgensen, 1972). The width and extent of the gaps are determined mainly by the amount of bis-GMA in the monomer of the composite resin — the more bis-GMA the less the contraction and the smaller the gap (Fig 10)

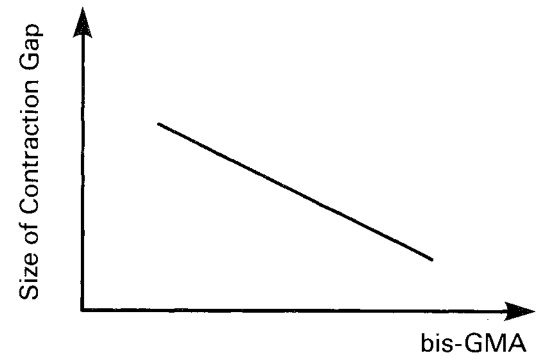

FIG 10. *Size of contraction gap from polymerization of composite resins in relation to content of bis-GMA in the monomer — the more bis-GMA the smaller the gap*

(Asmussen, 1975b). This relationship favors the average macrofilled composite over microfilled composites.

In contrast, as seen in Figure 11, contraction

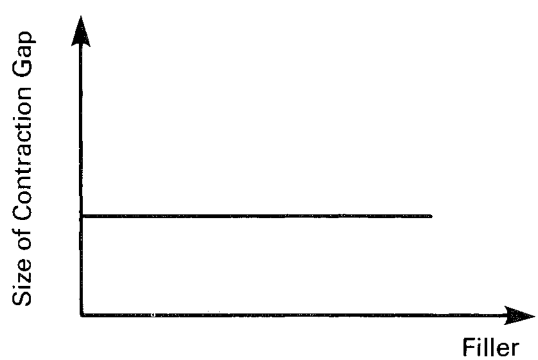

FIG 11. *Size of contraction gap from polymerization of composite resins in relation to content of filler, the size of the gap being independent of the content of filler*

gaps are independent of the content of filler in the composite resin. This is surprising because a filler reduces the volumetric contraction of the composite. The explanation is that the viscosity, or stiffness, of the material increases with the content of filler and inhibits the flow of material from the free surface of the restoration, thus allowing less compensation for shrinkage.

HYGROSCOPIC EXPANSION

One method of preventing the formation of marginal gaps is to make use of the hygroscopic expansion of the restorative material (Asmussen & Jørgensen, 1972). Restorations of composite resin absorb water from saliva, and thereby expand. If the initial contraction gap is relatively small, and if the hygroscopic expansion of the composite is large enough, the marginal gap will close as a consequence of this expansion. Fractures of enamel are now avoided because the expanded filling supports the enamel margins. The closure of the gap, however, is conditional upon the margins of the filling not being polished immediately after initial set, but only after several days, depending on the brand of composite. If the margins are polished immediately after setting, debris from polishing will be forced into the open gap and prevent the subsequent closure.

Obviously, hygroscopic expansion of a certain magnitude is a desirable property in a composite resin. The expansion differs significantly from brand to brand and depends on the content of filler and the composition of the monomer — the greater the content of filler, the less the hygroscopic expansion. Microfilled composites contain less filler than macrofilled composites and hence have more hygroscopic expansion. The greater tendency of the microfilled restorations to form gaps is thus counterbalanced by a correspondingly greater hygroscopic expansion. As to the composition of the monomer (Asmussen, 1975a), some proprietary composite resins contain monomers that are not based on bis-GMA and give polymers that have very low absorption of water. These composites will not be able to close contraction gaps by hygroscopic expansion.

BONDING

Another method for preventing the formation of gaps relies on bonding the composite resin to the walls of the cavity. Bonding to enamel may be obtained by etching the enamel with acid, and to dentine by means of an effective bonding agent. I shall subsequently consider in greater detail these methods for bonding and here restrict myself to the situation where the cavity is entirely surrounded by enamel. Effective etching of a cavity involves etching the walls and, preferably, 1 mm of unprepared peripheral enamel. Upon application of the restorative resin a bond is formed. With brands having little tendency to form contraction gaps, the bond is of such strength that marginal gaps are not formed (Asmussen, 1977a). With brands of composite resin having large tendencies to form gaps, the forces of contraction are so strong that gaps result. When observed in the microscope, it is interesting to note that the contraction gaps — as well as the accompanying defects of polishing — are located not at the interface of composite and enamel, but several micrometers inside the enamel. Obviously, the bond between restorative material and enamel is stronger than interprismatic cohesion. Also when the etching technique is used, postponed polishing of the margins of the restoration will allow hygroscopic expansion, thus reducing the risk of marginal gaps (Asmussen, 1977a).

THERMAL CONTRACTION

In addition to the contraction of polymerization, a lowering of the temperature of a restoration of composite may cause marginal gaps. This is a consequence of the difference in the coefficient of thermal expansion between composite and tooth, the composite having the larger coefficient. Accordingly, a composite restoration will tend to shrink more upon cooling than the surrounding tooth structure, whereby gaps may be formed. However, the tendency of a restoration to withdraw from the walls of the cavity is reduced by two main factors. Firstly, the bond to the walls of the cavity established through etching the enamel or through the use of an effective dentinal adhesive will prevent — as far as the strength of bond allows — the formation of gaps. Secondly, and perhaps more important, the hygroscopic expansion of the restoration compresses it against the walls of the cavity. The tendency to form marginal gaps upon cooling is therefore counteracted by the elastic recovery of the filling, which is towards the walls of the cavity (Asmussen, 1974).

We have found with many proprietary composite resins that, after absorbing water for a couple of days, restorations in etched cavities can be cooled to less than 15 °C without marginal gaps being formed. This applies to macrofilled as well as microfilled composites. This demonstrates that thermal percolation may not be of clinical significance and, furthermore, that the somewhat higher coefficient of thermal expansion of the microfilled materials does not necessarily imply greater marginal leakage.

Bonding Properties

BONDING TO ENAMEL

Etching enamel with phosphoric acid of suitable concentration results in a highly irregular surface. The enamel prisms become preferentially etched, whereby the so-called etch pattern is formed. When a restorative resin is applied to such a surface, the monomer of the material is drawn by capillary attraction into the irregularities of the surface, where polymerization takes place. In this manner the resin becomes mechanically attached to the enamel.

A controversial question has been whether the composite material can be applied directly to the etched enamel or whether an intermediary unfilled resin of low viscosity is beneficial. The influence of the intermediary layer has been investigated in several different ways. Some investigations have focused on the degree of adaptation to etched enamel that may be obtained by the two types of resins. Jørgensen (1975) has made use of the fact that contralateral teeth have identical patterns of etching. Consequently the two types of resins may be investigated and compared as follows (Jørgensen & Shimokobe, 1975): One tooth of an etched pair of contralateral teeth is covered by an unfilled resin of low viscosity, whereas the other tooth of the pair is covered by the highly viscous paste of a composite resin. After the materials have set, the teeth are dissolved in hydrochloric acid. The resinous materials are then placed with their fitting surface upwards and inspected in a scanning electron microscope. This inspection demonstrates that the two replicas are indistinguishable, showing no difference in adaptability between a highly viscous composite and an unfilled resin of low viscosity.

Another way of assessing the relevance of the intermediary layer is to study the length of so-called tags originating from composite and unfilled resins. With macrofilled composites, only the monomer — never the particles of filler — penetrates into the pores of the surface of etched enamel. The penetration is governed by the viscosity, surface tension, and contact angle on enamel of the penetrating monomer (Asmussen, 1977b). These factors have been measured for several resins of high and low viscosity and it has been calculated that penetration to a depth of about 50 μm may be obtained with composite as well as unfilled resins (Asmussen, 1977c). The calculations have been verified experimentally, and we have concluded that there is no disparity in the ability of macrofilled composites and unfilled resins to penetrate the pores of etched enamel.

As regards the microfilled composites, the particles of filler are so fine that they participate in the penetration and impede the process. The tags have been found to be about 30 μm long, which, though less than those of macrofilled composites, is sufficient, as it has been shown that the tags are not pulled out of the enamel surface but remain embedded when the bulk of the resinous material is separated from the enamel in measurements of strength of bond (Zidan, Asmussen & Jørgensen, 1982).

As regards the strength of the bond between the restorative resins and etched enamel, Figure 12 shows the results of Zidan (1979), who

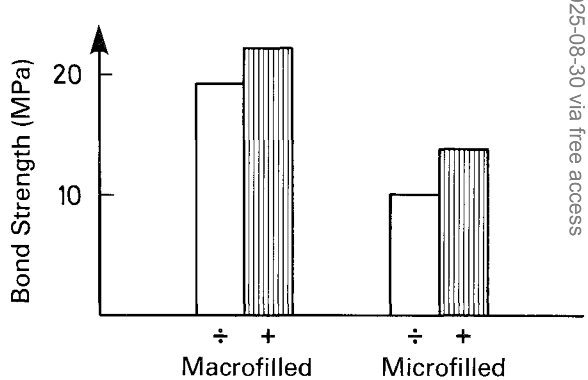

FIG 12. *Strength of bond to etched enamel of typical macrofilled composite (left) and microfilled composite (right). The use of an intermediary resin of low viscosity is indicated by +.*

investigated macrofilled and microfilled composites with or without the use of an intermediary bonding agent. The finding that the bond of microfilled composites to etched enamel is weaker than that of macrofilled composites will be considered subsequently. The finding that the use of an intermediary resin increased the strength of bond is not readily explained since, as we have seen, the length of the tags penetrating the surface of the etched enamel does not increase with the use of an intermediary resin of low viscosity.

An analysis of fractured surfaces, however, shows that when the composite material is applied directly to the surface of enamel, a considerable number of air bubbles are caught at the interface (Zidan & others, 1982). Furthermore, in the clinical siutation, owing to the stiffness of the composite, it may be difficult to exert enough pressure on the material to obtain contact with the enamel, a contact that is a prerequisite for capillary attraction. This is illustrated in Figure 13 where it can be seen that

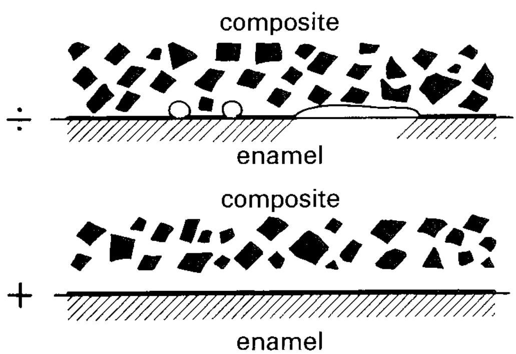

FIG 13. *Diagrammatic representation of a composite resin applied to a surface of etched enamel. Above (÷), without an intermediary resin of low viscosity; below (+), with an intermediary resin.*

without the intermediary, interfacial bubbles of air are present as well as an area showing lack of contact between composite and enamel.

A clinical benefit accruing from the use of an intermediary bonding agent of low viscosity is that the frequency of marginal discoloration is reduced from 31% to 17% when the resin intermediary is used (Hansen & others, 1984).

The reason the strength of the bond of microfilled composites is only about half that of macrofilled composites is that the tensile strength of microfilled composites is less (Zidan, Asmussen & Jørgensen, 1980). It should be emphasized, however, that there are no clinical data to show that the strength of the bond of microfilled composites to enamel, when used with a bonding agent, is inadequate in situations where macrofilled composites have proved sufficient.

Among the many factors pertaining to the technique of etching with acid we have studied the efficacy of an acid gel compared with liquid acid (Asmussen, 1981b). The area to be etched is controlled more easily with an acid gel than with liquid acid. Whether the detail of the pattern of etching produced by an acid gel is as rich as that produced by a liquid acid has been questioned, but by means of the technique of using contralateral teeth it has been found that the patterns of etching are identical, which implies that sufficient etching can be obtained with a gel. Consequently no difference in the strength of bond would be expected, which has been found to be true.

Of other factors in the technique of etching — strength of acid, time of etching, and time of washing, to name a few — it has been shown that even fairly large deviations from the generally recommended procedure of etching are not critical for obtaining good bonding. Summing up, the technique of etching with acid has proved to be a highly potent, versatile means of bonding restorative resins to enamel.

BONDING TO DENTINE

Bonding to dentine has been more elusive. One obstacle is that the surfaces of cut dentine are always covered with the so-called smear layer. This layer is a loosely bonded labile layer of organic and inorganic debris from cutting. For an adhesive to be effective, either the adhesive must strengthen this layer or the layer must be removed before application of the adhesive. The smear layer may be removed by etching with acid or by means of ethylenediaminetetracetic acid (EDTA), but at the same time the dentinal tubules are opened. If a low viscosity monomer is applied to such a surface, the monomer will penetrate into the tubules where polymerization will take place, not unlike the process of bonding to etched enamel. A large number of tags are formed and it is surprising that the bonding obtained in this manner is very low, almost nonexistent. A tentative explanation for the low strength of bond is that the tags are incompletely polymerized because of oxygen present on the surface of the dentine and in the liquid of the tubules. Thus the tags alone do not constitute bonding; a dentine adhesive is necessary.

Except in a few instances, all attempts at bonding restorative resins to dentine have been carried out according to the same basic principle originally devised by Buonocore (Buonocore & others, 1956). This principle involves the application of a bifunctional molecule of the type shown in Figure 14. The adhesive molecules all contain a methacrylate group. The various dentinal bonding agents vary, however, with respect to the spacer and the functional group. The functional group is designed so that it may react with the surface of the dentine to create a bond. The establishment of this bond leaves the dentine covered with a layer of adhering methacrylate groups. By subsequent application of a polymerizable restorative resin the double bonds of the methacrylate groups may react by copolymerizing with the restorative resin. In this manner the restorative resin will bond to the dentine via the adhesive molecule. The problem is to devise active groups that will in fact react with the surface of the dentine and, further, to use spacers of suitable length and polarity to make the methacrylate groups of the adhesive accessible to the restorative resin.

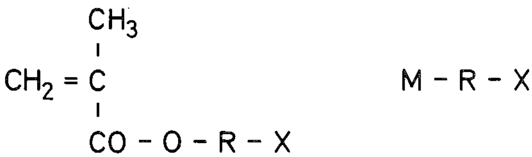

FIG 14. *Principle of adhesive molecule:* M — *methacrylate group;* R — *spacer;* X — *functional group designed to react with dentine*

Dentine adhesives may react with dentinal surfaces to form a chemical bond according to two main modes of operation. Bonding may be to either the inorganic or the organic constituents.

The adhesive molecule of Buonocore and others (1956) was designed to bond to the calcium ions of the dentine through a phosphate group as the active group. The possible mechanism of bonding is illustrated in Figure 15. However, the strength of bond obtained with this adhesive was relatively weak, of the order of 2-3 MPa. The first real breakthrough in bonding to dentine was achieved by Bowen and coworkers a few years ago (Bowen, Cobb & Rapson, 1982). By means of two intermediary adhesive agents that presumably also bond to the inorganic part of the dentine, strengths of bond of about 13 MPa were obtained. This compares well with the strengths of the bond to etched enamel.

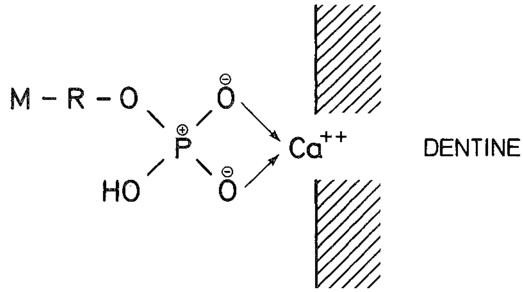

FIG 15. *Principle of bonding between phosphate-based adhesive and calcium ions of the dentine*

In Copenhagen, my colleague Munksgaard and I have followed other avenues to bonding by investigating the possibilities of bonding to the organic part of dentine. This part, being mainly collagen, contains several groups that may be attacked by a reactive group.

Since water is always present on the surface of dentine, an adhesive that would operate in an aqueous environment would be interesting. Aldehydes may react with collagen under moist conditions. Our approach to bonding with aldehydes was to couple the monomer to the product of the reaction between dentine and aldehyde. The suggested mechanism for a reaction of this type is seen in Figure 16. The pendant amino group of a collagen molecule is attacked by the aldehyde. In the presence of a monomer containing active hydrogen, such as the hydrogen of the hydroxy group, water is split off and the monomer bonded chemically to the collagen. In this manner the surface of the dentine is

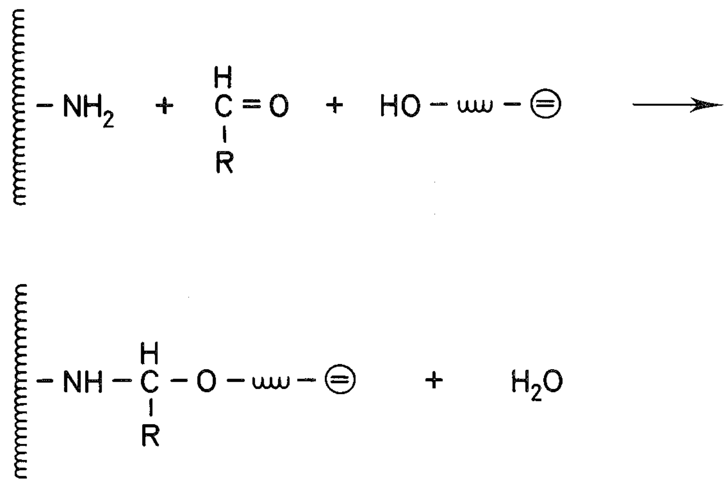

FIG 16. *Principle of bonding between aldehyde/HEMA-based adhesive and collagen of the dentine*

covered by a polymerizable layer of double bonds and after the application of a restorative resin the double bonds will react by copolymerizing with the resin.

We have investigated a variety of aldehydes and monomers carrying active hydrogen (Asmussen & Munksgaard, 1985; Munksgaard & Asmussen, 1984). Among aldehydes, glutaraldehyde is especially effective, and the so-called HEMA (hydroxy-ethyl-methacrylate) monomer is suitable. The aqueous mixture of glutaraldehyde and HEMA has been termed GLUMA. Through the use of GLUMA, a strength of bond to dentine of about 18 MPa was obtained, which is very close to the approximately 20 MPa obtained to etched enamel. The effectiveness of the GLUMA system was such that in about half the cases the dentine itself, not the bond, was ruptured in the experiment.

For an adhesive to dentine to be effective, it is paramount not only that a bond of high strength be developed but also that the bond be established rapidly. Ideally, bonding should occur so fast that no contraction gaps are formed during polymerization of the restorative resin. The GLUMA adhesive was tested in this respect in cylindrical cavities with butt joints prepared in dentine and a composite resin polymerized by light (Hansen & Asmussen, 1985a). Ten minutes after polymerization the restorations were polished and inspected in the microscope for marginal gaps. The maximum width of gap was expressed as a percentage of the diameter of the cavity, and it was found that without adhesive the mean width of gap was 0.4%, corresponding to gaps of the size of 10-15 μm. When the GLUMA adhesive was used, the mean width of gap was 0.04%, that is, 10 times smaller. In some instances the strength of the adhesive bond developed so rapidly that no contraction gap was formed. After the restoration had absorbed water for a day hygroscopic expansion had closed the remaining contraction gaps completely (Hansen & Asmussen, 1985a). The effectiveness of the GLUMA system is unparalleled by proprietary adhesives for dentine tested by us.

We have investigated the impact of bonding to dentine on the preferable shape of cavities (Hansen & Asmussen, 1985b). The types of cavity investigated had cavosurface angles of 90°, 110°, 135°, and 160°, respectively. The depth of the cavities from the cavosurface angle was 1.5 mm or less and the diameter varied. For a given adhesive the width of the contraction gap was found to increase with the diameter of the cavity. This means that the larger the diameter of the cavity the greater is the demand for the effectiveness of the adhesive. Furthermore, the main determinant of the size of the contraction gaps was found to be the ratio of the volume of the restoration to the area of the walls of the cavity — the higher the ratio the larger the contraction gap.

From a clinical point of view this means that after excavation of a carious lesion on a root, one should **not** prepare it further if the retention of the restorative resin can be ensured with an effective adhesive. Changing a rather flat cavity into one with a butt joint will increase the ratio of volume to area giving larger contraction gaps for a given adhesive. Trimming the marginal area of an excavated cavity to improve esthetics will also impair marginal adaptation, though less than with the cavity with a butt joint. The same principle presumably applies also to cavities involving enamel.

A prerequisite for the described principle for preparing cavities is that the retention of the restoration is secured without the aid of undercuts. For this purpose it is necessary to have an adhesive that mediates a bond to dentine comparable to that to etched enamel. Such adhesives will undoubtedly be available to the dental profession in the very near future. An effective bonding agent to dentine will — in conjunction with etching enamel — prevent the formation of marginal gaps and eliminate the need for retentive undercuts. The results will be smaller restorations of increased longevity.

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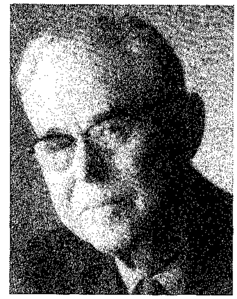
Hollenback Prize for 1985



The Hollenback Memorial Research Prize for 1985 has been awarded to José E Medina, who is currently professor of clinical dentistry at The University of Florida in Gainesville. This prize is given annually by the Academy of Operative Dentistry to recognize excellence in research and dedication to the advancement of operative dentistry.

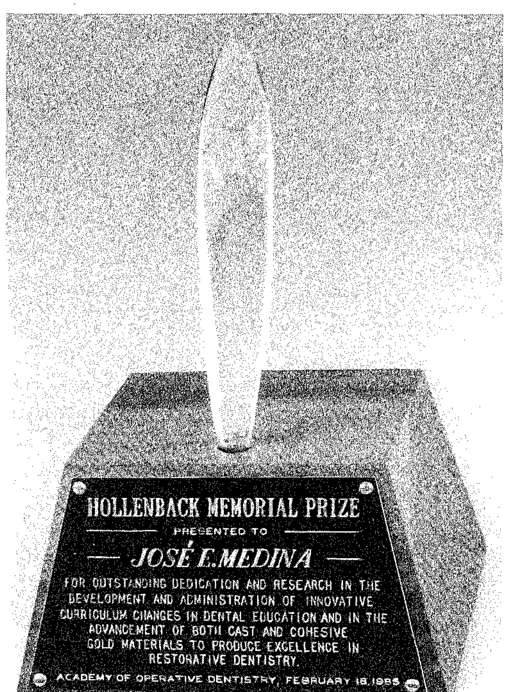
In the official description of this prize, Dr Hollenback is credited with a lifetime of applied research that had a beneficial effect on the quality of dental practice. The winner of the prize this year has shown such characteristics in an extensive academic career devoted to the application of research methodology to improve dental science and education.

Dr Medina is a native of Puerto Rico, where he received his early education. From there, he traveled to Maryland and obtained predental training at The Johns Hopkins University. He received a DDS degree from the Baltimore College of Dental Surgery, School of Dentistry, University of Maryland, in 1948. From that point on, his involvement in education has been a continuous process of both learning and teaching in a variety of postgraduate courses related to restorative dentistry.

Immediately after graduation, Dr Medina began an academic career as an instructor in the Department of Operative Dentistry at his alma mater, The University of Maryland. He was promoted quickly to assistant professor, then associate professor, and finally to professor of dentistry in 1957. In 1961, he was made chairman of the department of operative dentistry and in 1964 he began an administrative career as an assistant dean at the same school.

His capabilities as an administrator were soon recognized by those who were founding a new dental school in the state of Florida. In 1967, Dr Medina moved to Gainesville to participate in the development of a new concept in dental education as an associate dean at the University of Florida. Two years later Dr Medina succeeded Dr Edmund Ackell as dean of the dental school, and from that time has had a profound influence on dental education. In further recognition of his abilities in planning and implementing the teaching concepts in which he believed, he was promoted, in 1976, to his current position as assistant vice president for facilities, planning, and operations at the J Hillis Miller Health Center of The University of Florida.

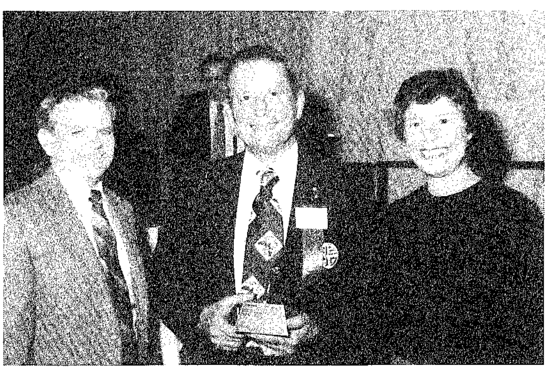
Dr Medina investigated epoxy resin die materials and elastomeric impression materials with specific interest in improving the quality of cast gold restorations. His deep interest in both cast



and cohesive gold as permanent restorative materials is evidenced by his publications related to their qualities and handling characteristics. Another area of study involved instrumentation for both rotary and hand cutting of tooth structure, involving efficiency, design, and spray contamination. Perhaps the most significant contribution Dr Medina has made to dentistry has been in the field of education with the design of a modular curriculum to educate the dental student in an environment of learning that will accommodate a changing profession. The success of the "Florida story" in dental education and the demand that was created for Dr Medina's expertise is evidenced by the many committees that he has chaired at both the university and the national level.

Dr Medina has given liberally of his time as a major consultant to the Army at Walter Reed, the Navy at Bethesda, the Public Health Service at Baltimore, the Veterans Administration, the American Dental Association, the National Institute of Dental Research, and the Fund for Dental Health. He is currently a member of some 12 scientific and professional societies, including the American Academy of Gold Foil Operators, of which he is a past-president and the George M Hollenback Operative Dentistry Seminar, which he has directed since 1961. He is a Fellow of both the American College of Dentists and the International College of Dentists and has also been active in many educational, fraternal, and honorary organizations.

His service to our own Academy of Operative Dentistry is unsurpassed, as he is a charter member and was a councilor during the formative years of 1976 to 1979. Since 1980, Dr



Above: Joseph B Dennison, José E Medina, and Mrs Medina

José Medina

Medina has been the president of The American Board of Operative Dentistry, and as such he has been both the chief operating officer and the motivating force to make this effort a reality. Those whom we have honored at this meeting as the first to be "Board Certified" in operative dentistry are a fulfillment of the dreams, hard work, and perseverance of Dr Medina and those men of similar character who have stood by him to bring this distinction to operative dentistry.

We honor Dr José Medina today for these many contributions that he has made to us and to our profession. As a clinician, he has been most gracious and liberal in passing on his knowledge in presentations throughout this country and in Central and South America. As an educator, he has contributed significantly to the bank of knowledge known as dental science and has marked out a pathway for its dissemination. As a citizen, he has dedicated much of his life to helping others in both church and civic organizations. As a colleague, his personality and spirit shine as a beacon that has crossed the path of each of us in the Academy and marked indelibly an example to be followed.

JOSEPH B DENNISON

DEPARTMENTS

Book Review

CHANGE YOUR SMILE
Ronald Goldstein, DDS

With contributions by Louis Belinfante, DDS, and John R Lewis, MD

Published by Quintessence Publishing Co, Inc, Chicago, 1984. 300 pages, illustrated. $23.95

This is a welcome addition to the dental literature on cosmetic restorative dentistry. Dr Goldstein has prepared a beautifully illustrated book that reviews a wide variety of cosmetic dental problems and provides discussions of various modes of treatment including time, cost, and life expectancy of treatment, maintenance required by the patient, and advantages (or disadvantages) when compared to alternative modes of treatment.

The book is written primarily for the dental consumer, but is equally informative for both the practicing general dentist and the dental specialist who may not routinely offer cosmetic services, but who wish to have basic information on the emerging disciplines of cosmetic dentistry.

Dr Goldstein has organized the book according to dental problems as perceived by most patients. These include (but are not limited to) stained teeth, fractured teeth, diastemae, rotated and malposed teeth, malocclusions, periodontal disease, effects of aging, and maxillofacial malformation. Such an approach necessarily invites duplication of some modes of treatment throughout the book, but this style of organization allows the readers to easily identify their specific problem and quickly explore possible alternative treatments. Methods of dental treatment that are illustrated and discussed include bleaching, crowns, bridges, bonded restorations, orthodontic realignment, cosmetic contouring, dentures, and maxillofacial surgery. The final chapter of the book extends cosmetic dentistry beyond tooth repair, and discusses correction of destructive habits, the use of facial makeup, alternative hair styling, and dietary and adjunctive therapy to achieve total facial cosmetics. This comprehensive approach to dental esthetics is a welcome addition to the dental literature.

The "before" and "after" pictures are excellent, both in the quality of dentistry illustrated and in the reproduction of the color photographs by the publisher. The book is written in nontechnical language which is easily understood by both the professional and lay reader. This book belongs in the waiting room of every practice that delivers cosmetic dental services.

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Letters

Advantages and Disadvantages of Direct Gold Restorations

I wish to applaud Dr Larry Clark's article, "Advantages and Disadvantages of Direct Gold Restorations," which appeared in the Winter 1985 journal. His is a candid perception that "ourselves" may be the biggest disadvantage to the use of direct gold as a viable restorative consideration by the majority of the profession.

Like Dr Clark, I stood in abject fear of direct gold in school, and it wasn't until my residency under the tutelage of Dr Ralph Lambert and his nonthreatening encouragement — followed by the same attitude at the Naval Dental School foil study club — that I would even consider direct gold. I still get knots in my stomach on foil study club days. But thanks to concerned men who patiently shared their love for an excellent restorative material in spite of my inability to handle it as they could, I too have the privilege now of encouraging the residents with whom I work to use direct gold.

So much can be learned about the discipline of operative dentistry through the use of direct gold that we dare not allow it to become a historical curiosity piece reserved only for the master operator.

ROBERT D COWAN, USAF
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Shalimar, Florida 32579

Supplement on the Smear Layer

The smear layer phenomenon described in Supplement 3 of *Operative Dentistry* has always been intriguing. The symposium did much to clarify the matter. Its causes, significance, and influence on clinical dentistry are thought-provoking. Sponsors of this publication are to be congratulated and thanked by us all.

ROBERT B WOLCOTT, DDS, MS
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Wit and Wisdom

With the ever-changing face of dentistry today, it is essential to keep up with all of the latest terminology found in the literature. It is also certainly necessary to have a working knowledge of effective buzz words to impress colleagues at cocktail parties and other professional meetings.

The well-worn, but reliable, classics have always been available for use when the need arose. Gnotobiotic, iatrogenic, thixotropic, and serendipity are a few of the words that would have always raised an eyebrow in years gone by. But those days are gone forever and the average practitioner faces a real dilemma. There is precious little time not only to read all the latest journals, but locate and commit to memory such authoritative vocabulary.

To offer a solution to this problem, the most recent edition of *Ireland's Crown and Unabridged Dictionary* was thoroughly combed. Included herewith are some little-known but definitely intimidating words guaranteed to impress everyone at your next function.

Cyclocottonation — a state of sudden alarm caused by a cotton roll becoming entwined in a rapidly moving bur

Aerodynamiclandestinability — the uncanny ability of gold casting to fly out of your grip during polishing, land in some aberrant location, eluding discovery for hours

Juxtalutinization — the act of coating a small gold casting with cement and invariably placing it onto the tooth backwards

Schnuckbargle — a patient who just ate a garlic sandwich for lunch and says that he hopes you don't mind

Neophytic Reflectoplasty — the experience dental students have when they work on the upper arch for the first time and they accidentally drill into their mirror

Dinglebit — the carefully wrapped but useless piece of fractured cusp that well-meaning patients always bring in with them

Ballistic Dysclampsia — the act of a rubber dam clamp flying off a tooth and bouncing from the adjacent wall

Schizophrenephrine — an adrenal hormone released in you, the dentist, as a response to the cracking sound a patient makes when he bites down on a new MODFL amalgam and you know before you look that you can kiss off the marginal ridge

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Announcements

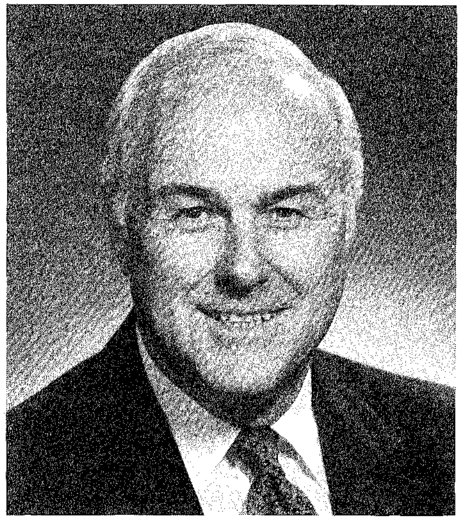
Wilmer Eames Wins Souder Award

On 21 March 1985 Wilmer B Eames received the prestigious Souder Award from the International Association for Dental Research. The Souder Award is intended to confer the highest honor for research in dental materials upon those scientists whose research has brought about outstanding advances in dental health. Dr Eames was recognized for his research on amalgam, cements, composite resins, and instrumentation, and especially for his development of the technique of mixing amalgam at a low ratio of mercury to alloy. He has also provided dental practitioners with significant contributions on the performance of dental products and has done much to encourage dental students to participate in dental research.

Dr Eames has received many honors including the Hollenback Memorial Prize, the Hinman Distinguished Service Medallion, the Albert L Borish Award, the Jerome and Dorothy Schweitzer Research Award, and Alumnus of the Year (University of Missouri-Kansas City).

Dr Eames is now professor emeritus of Emory University. Though retired from formal teaching and living in Colorado he continues to serve as a consultant in dental materials and, as an associate editor, provides valued counsel to *Operative Dentistry*.

Gilmore Appointed Dean at Indiana



A familiar figure in operative dentistry circles, Dr H William Gilmore, 1977 president of the Academy of Operative Dentistry and past secretary-treasurer of the American Academy of Gold Foil Operators, has been named to succeed Dr Ralph E McDonald as dean of the Indiana University School of Dentistry.

Dr Gilmore is a well-known author, lecturer, and clinician in the area of operative dentistry. He received his DDS degree from Indiana University in 1958 and his MSD in 1961. He is a professor of operative dentistry and was the chairman of the department from 1964 to 1970. He was responsible for the training of many graduate students in operative dentistry.

Among his numerous publications, Dr Gilmore's textbook, *Operative Dentistry,* is in its fourth edition. He has been a visiting professor to several universities in the United States and Latin America, and has presented many programs, nationally and internationally.

Dr Gilmore has served as the editor of the *Journal of the Indiana Dental Association* since 1974, and in 1980 was president of the American Association of Dental Editors.

His awards include the Hinman Medallion (two awards), the 1980 Pierre Fauchard Academy Award, and in 1977 the Alumnus of the Year Award from Indiana University School of Dentistry.

Currently, Dr Gilmore is serving as trustee of the American Dental Association for the Seventh District.

New Journals

In February of 1985 two new journals, *Dental Materials* and *Endodontics & Dental Traumatology* began publication.

Dental Materials, the official publication of the Academy of Dental Materials and edited by Franklin A Young of the Medical University of South Carolina, is to be published bimonthly. The purpose of this journal is "to promote rapid communication of scientific information between academia, industry, and the dental practitioner" through the publication of original articles "on clinical and laboratory research of both basic and applied character in which the focus of the effort is on the properties or performance of dental materials or the reaction of host tissues to materials"; manuscripts about the "technology of the application of dental materials in clinical dentistry or dental laboratory technology are also appropriate." The first number, consisting of 40 pages, contains articles with the following titles: The Academy of Dental Materials; Physical properties of an experimental periodontal dressing material; Microleakage of posterior composite restorations; Correlation between hardness and degree of conversion during the setting reaction of unfilled dental restorative resins; Influence of abrasive particle size and contact stress on the wear rate of dental restorative materials; Resistence to mercury embrittlement of some alloys for amalgam; Measurement of change in surface contour by computer graphics; Human enamel-dental amalgam pin on disc wear.

The journal is published by Munksgaard International Publishers Ltd at a subscription of $78.00, with a special introductory rate of $60.00 valid until 1 July 1985. Orders may be sent to the publisher at either: 35, Nörre Sögade, DK-1370 Copenhagen K, Denmark or to 200 Meacham Avenue, Elmont, New York 11003, USA.

Endodontics & Dental Traumatology, also published by Munksgaard, is a bimonthly journal edited by Leif Tronstad of the University of Pennsylvania.

The journal is independent with an international scope and aims "to convey scientific and clinical progress in the areas of dental biology, endodontics, pediatric endodontics, and dental traumatology, and to promote communications among clinicians, educators, researchers, and administrators interested in the relevant fields." The first number, consisting of 48 pages, contains articles with the following titles: The radiopaque lesion: a diagnostic consideration; Effect of masticatory stimulation of dentoalveolar ankylosis after experimental tooth replantation; Periapical tissue responses to dentin and vitreous carbon plugs in apical perforations of dogs' teeth; Endodontic treatment of experimental root perforations in dog teeth; A retrospective study of direct pulp capping with calcium hydroxide compounds; Long-term calcium hydroxide treatment of a tooth with iatrogenic root perforation and lateral periodontitis; Paget's disease of the mandible — a review and report of a case.

The subscription is $80.00 and orders may be sent to Munksgaard at the addresses given above.

NEWS OF THE ACADEMIES

Academy of Operative Dentistry

The fourteenth annual meeting of the Academy of Operative Dentistry was held 18 and 19 February 1985 in Chicago at the Westin Hotel. The program comprised essays, table clinics, and limited attendance clinics. The fourth M G Buonocore Memorial Lecture was delivered by Erik Asmussen.

At lunch on the first day the Hollenback Memorial Prize was presented to José E Medina and the Student Achievement Award to Jill Bedrick of the University of Minnesota.

Officers elected for 1985 are: president, Lawrence L Clark; immediate past-president, William N Gagnon; president-elect, Frank K Eggleston; secretary-treasurer, Ralph J Werner; assistant secretary, Gregory E Smith; and councillors, Allan G Osborn, Richard B McCoy, Glenn H Birkitt, Eugene S Merchant, Baxter B Sapp, and Judson Klooster.

Student Achievement Award

The Outstanding Student Achievement Award of the Academy of Operative Dentistry was presented this year to Jill Bedrick, a junior dental student at the University of Minnesota. Jill has a degree in dental hygiene from the same university and has received numerous

awards and fellowships for outstanding efforts in research. She dedicated several summers to the development and execution of basic research projects on the inflammatory response associated with periodontal disease. Her award-winning clinic summarized this research in relation to early detection and was titled: "Clinical Diagnosis of Periodontal Disease Using Chemical Measurements of Crevicular Fluid."

Certification in Operative Dentistry

On 17 February 1985 in Chicago at the annual meeting of the Academy of Operative Dentistry, the American Board of Operative Dentistry received into membership Dr Donald H Downs (Colorado Springs, Colorado), Dr Daniel Frederickson (Libby, Montana), Dr James V Gourley (Silverdale, Washington), Dr William T Pike (New London, New Hampshire), and Dr

Left to right: J W Reinhardt; W T Pike; J V Gourley; D Frederickson; D H Downs

John W Reinhardt (Iowa City, Iowa) and presented them with a Certificate of Proficiency in Operative Dentistry. This distinction was earned by the recipients after an examination extending over two years and involving three phases: a written examination, an oral examination based upon the submission of cases for which restorative services were provided, and a clinical examination that required the performance of clinical procedures during a concentrated three-day session.

This Certification Program, which designates the successful candidates as Board Certified in Operative Dentistry, is sponsored by the Academy of Operative Dentistry, an organization devoted to the promotion of excellence in the practice, education, and research in operative dentistry. These five board members named above became the first group of dentists to achieve this distinction and recognition.

Membership in the Academies

Information on membership in the academies may be obtained from the respective secretary.

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Houston, TX 77030
(713) 664-3537

Academy of Operative Dentistry
Dr Ralph J Werner
Box 177
Menomonie, WI 54751
(715) 235-7566

NOTICE OF MEETINGS

American Academy of Gold Foil Operators

Annual Meeting: 31 October and 1 November 1985
University of California
San Francisco, California

Academy of Operative Dentistry

Annual Meeting: 13 and 14 February 1986
Westin Hotel
Chicago, Illinois

INSTRUCTIONS TO CONTRIBUTORS

Correspondence

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

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,* 5th ed, 1983; the terms 'canine', 'premolar', and 'facial' are preferred but 'cuspid', 'bicuspid', and 'labial' and 'buccal' are acceptable. SI (Système International) units are preferred for scientific measurement but traditional units are acceptable. Proprietary names of equipment, instruments, and materials should be followed in parentheses by the name and address of the source or manufacturer. The editor reserves the right to make literary corrections.

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 size of figure 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 number of the figure. Type legends on a separate sheet. Where relevant, state staining techniques and the magnification of prints. Obtain written consent from holders of copyright to republish any illustrations published elsewhere.

References

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

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Reprints can be supplied of any article, report, or letter. Requests should be submitted at the time the manuscript is accepted.

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EDITORIAL

Writing and Thinking 41 A IAN HAMILTON

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