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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

What Happened to Freedom?

Dental restorations that continue to serve after 40 years, as illustrated in the article by Gerald D Stibbs in this issue of *Operative Dentistry,* provide adequate evidence that we have the materials and techniques to produce restorations that will endure for long periods of time and, in many instances, for the life of the patient. A statistical analysis of the longevity of restorations that have been placed in a practice extending over 40 years would present a formidable challenge, but those that know Gerry Stibbs would testify that these successful restorations are not rare exceptions but routine operations for a dentist dedicated to exact and conscientious operating. Other examples of the long-term success of restorations are also available (Markley, 1984). Furthermore, many of us know of restorations that have served for at least several decades. These successes are all the more commendable because they were produced by techniques and with materials that were available many years ago. Also it should be noted that the economic environment when these restorations were placed was free of interference from third parties, the contract for treatment being made freely between the patient and the dentist.

Materials are now better and techniques have been refined, so it is disturbing to see so many references to the relatively short life of today's restorations, particularly those of amalgam, which is one material that has been improved substantially over the last 20 years. It is equally distressing to note that some insurance companies honor claims for replacing restorations that have failed after periods as brief as two years for amalgam and five years for castings (Maryniuk, 1985). This rapid rate of replacement of restorations is bound to contribute to the increasing cost of dental treatment.

A major cause for the decline in the quality of restorative dentistry is the failure of too many dental schools to develop an adequate level of competence in their students. Disparities in the competence of graduates of the various schools have not received much attention but have not gone unnoticed (Blutig, 1985). We have the techniques for the long-term restoration of teeth and we know how to teach these techniques to students, so why not ensure that the graduates of our dental schools are well prepared for their profession?

In addition to restoring excellence to dental education we need to examine the effect of third parties on the quality of restorative dentistry. Interesting as that information might be, however, a much more fundamental issue is at stake.

The relation between cause and effect is often difficult to trace; nevertheless, the use of fringe benefits instead of cash to pay wages and salaries has led to the development of a large industry engaged in managing the funds that have been generated in the form of prepayment for dental treatment. These organizations are thus given the opportunity to make large sums of money through interest earned by the investment of these funds, interest that properly should belong to individual subscribers were they not coerced into accepting part of their pay in dental benefits for which payment must be made in advance. This loss of income to consumers is offset to some extent by the fact that dental benefits are not taxed as income. On the other hand the lag in paying claims can enrich the insurance company at the expense of the dentist. But quite apart from the effect on the quantity and quality of dentistry, an even more insidious consequence of dental insurance, or prepaid dentistry, is the diminution of freedom — freedom of consumers to spend their money as they see fit, to patronize the dentist of their choice, and to buy the kind of dental treatment for which they are able and willing to pay, and freedom of dentists to treat patients in the most beneficial manner and without the interference of third parties. Those dentists that may believe the system of third-party payment to be a boon to their practices should reflect on David Hume's admonition — "Seldom is liberty of any kind lost all at once."

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MARYNIUK, G A (1985) Clinicians' perceptions of restoration longevity *Journal of Dental Education* **49** 769–772.

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ORIGINAL ARTICLE

Cavity Design and Mathematics: Their Effect on Gaps at the Margins of Cast Restorations

Contrary to common belief, steep bevels are likely to magnify rather than diminish the discrepancy of the fit of a cast restoration after it has been cemented

LYLE E OSTLUND

Summary

In the one hundred years since Carroll (1885) reported making restorations of cast gold, albeit primitive in form and fit, the segment of dentistry concerned with the repair and restoration of teeth using the cast restoration has sought to improve the fit of castings. This search has led to improvements of materials and their manipulation, as well as clinical considerations in the preparation of teeth. This article is a departure from the currently accepted design of the cervical wall bevel whose angulation approaches parallelity with the axis of the plane of the insertion of the casting. Inasmuch as the luting medium has a finite thickness and ultimately controls the margin fit, the author poses some thought-provoking questions about the advisability of bevels of cervical walls steeply angled in the vertical axis of the preparation.

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Introduction

Ever since Taggart's adaptation of the lost-wax method to dentistry (Taggart, 1907a,b) there has been a historic search for improvements in the accuracy of gold alloy castings, both internally and at their margins. This search has resulted in empirical techniques, breakthroughs as a result of scientific investigation, and theories of fit based on mathematical concepts (Lewis & Owen, 1959). These advancements have led to the possibility of an accuracy of fit of margins that is beyond our clinical ability to perceive, by either our tactile or visual senses, no matter how simple or complex the design of the cavity or preparation. This accuracy, however, is predicated on the necessity for controlled compensations in all steps in the construction of a casting. But alas! the ultimate in fit after cementation continues to elude the profession.

As will be shown herein, based on the science of the relationship between the sides and angles of the right-angled triangle (Hooper, 1942), attaining acceptability of fit at the cervical margin also requires an understanding of certain mechanical principles in the design of tooth preparation. This author challenges a long-held belief, based on the principle of the sliding-joint, that the closer the bevel on the cervical wall approaches the axis of insertion of the cast piece, the better the fit of the finished restoration at that site will be.

Importance of Fit at the Margin

The preoccupation that most dentists have in adapting restorative materials to the walls of prepared teeth to effect closure of the margins is understandable inasmuch as closure of the margins is believed to be an important determinant of longevity with all types of restorative media and of the health of the teeth (Krug & Markley, 1969; Brännström, 1981, p 47; Wu & others, 1983; Maryniuk, 1984; Hamilton, 1984; Stibbs, 1985; Assif & others, 1985; Mjör, 1985; Belser, MacEntee & Richter, 1985). Even though there were crude methods for making dental castings of gold long before Taggart's demonstration of a practical method (Carroll, 1885; Reese, 1894; Martin, 1897), since 1907 to the present time whenever tooth repair necessitates some kind of intracoronal or extracoronal casting, whether of metal or ceramic material, the fit of the restoration at the margins becomes an intense preoccupation above other features of fit (Price, 1911; Christensen, 1966; Ostlund, 1974; Moore & others, 1985). Reason tells us that the narrower the gap, or space, between the casting and the tooth before cementation of the casting, the better the fit will be after cementation. However, a frequently heard complaint against all types of cast restorations is that after the restoration is cemented it does not fit with the same accuracy as it fit in its uncemented state. And when the gap at the margin exceeds a certain dimension, particularly at subgingival margins (Jørgensen & Wakumoto, 1966), these openings can create problems ranging from shortened life of the restoration to impaired pulpal health and longevity of the tooth (Rosenstiel, 1964). It is generally believed that these same open gaps can impair the health of the surrounding periodontium as well (Löe, 1967, 1968; Kashani, Khera & Gulker, 1981; Mjör, 1985).

Scientific Search for Improved Fit at the Margins

Turning from the early concept of grinding the internal surfaces of castings to make them fit (Hinman, 1908; Black, 1924) to the idea of casting for accuracy of fit required that the effort move from empiricism to science. Up to this time, investments for dental inlays were proprietary mixtures of plaster of paris, often secret, without a scientific basis for their formulations (Ward, 1909). It was generally agreed that these investments were in large measure responsible for the poor fit of castings inasmuch as the investments failed to adequately compensate for the shrinkage inherent in the casting procedure. Trying to find ways to increase the expansion of the invested wax pattern, technicians that had knowledge of the chemistry of gypsum added small amounts of substances as additives (Harder, 1926; Shell, 1962). Some of these additives improved the performance of the investment, but inadequately.

Concurrent and timely with this research by experimentation, the National Bureau of Standards, in cooperation with Weinstein Laboratories and under the stimulus of the American Dental Association, set up standards for testing and criteria for products, giving the search for improvement much needed direction (Coleman, 1926; Souder & Sweeney, 1930; Taylor, Paffenbarger & Sweeney, 1930). Among other things, the necessary breakthrough came with the discoveries of cristobalite and the principle of hygroscopic expansion (Taylor & others, 1930; Scheu, 1932; Shell, 1960a). Clinicians were now presented with a calcium-bonded investment that was controllable and predictably accurate (Scheu, 1935; Phillips, 1935; Smyd, 1948; Landgren & Peyton, 1950; Asgars, Mahler & Peyton, 1955; Skinner, 1957; Docking, 1957; Shell, 1960a,b; Hollenback, 1964; Rosenstiel, 1975a).

At the same time and for a period thereafter, interest was shown in the instability of dental inlay wax (Lasater, 1940). Despite the fact that it had been discovered that the dimensional stability of the wax pattern was in question, especially for those complex types of inlays wherein the effect of unequal expansion of the investment upon wax patterns during the setting period made detrimental dimensional changes of a minor nature within the casting mold (Suffert & Mahler, 1955; Mumford & Phillips, 1958; Palmer, Roydhouse & Skinner, 1961; Barnes, 1974; Asgar, 1977; Eames, 1981a; Darveniza, 1983), casting accuracy could be considered as approaching the ultimate limits* of fit at the margins (Hollenback, 1964; Barnes, 1974; O'Brien, 1977).

With results in casting technology now consistently accurate, it followed that attention focused on impression materials from which accurate likenesses of prepared teeth could be reproduced as models. Although the search continues for better materials for impressions and dies, the materials now at hand, when properly handled, are sufficiently accurate to allow the clinician the capabilities for sophistication of restorative treatment heretofore unknown (Eames, 1981b; Williams, Jackson & Bergman, 1984; Johnson & Craig, 1985). Disappointingly, despite these improvements, castings do not fit their counterparts after cementation in the same way they did before cementation (Eames, O'Neal & Miller, 1974). This discrepancy of fit cannot be the result of poor accuracy of casting or failure in replication. It must lie elsewhere.

*After initial procedures for adapting margins, the closure of margins at the border of tooth and casting results in open gaps at the margin that are beyond the limits of the unaided eye to perceive and the tactile perception to discern under clinical conditions. (Author's opinion)

Clinical Search for Improved Fit at the Margins

That luting cements have some adverse influence on the fit of the margins has been recognized by many investigators (Barnes, 1974; Donovan & Prince, 1985). They explain this adversity as a result of the size of the particles of cement, the thickness of the film of cement, and related problems in cementing procedures (Jørgensen, 1960a; Kaufman, Coelho & Colin, 1961; Fusayama & others, 1963; Walton, 1980). Clinicians recognizing poor fit after cementation have suggested that some of these problems in cementation can be effectively minimized by relief of internal components of intracoronal castings (walls and floors) with aqua regia (John T Ryan, 1916 unpublished; Hollenback, 1928; Krug & Markley, 1969) or a nonferrous metal etchant allowing for escape of cement around retaining vertical walls (Ostlund, 1974; Cherberg & Nicholls, 1979; Baum, Phillips & Lund, 1981, p 512; 1985, pp 530–531). Other clinicians have achieved similar results using electrochemical stripping for both complete cast crowns and intracoronal restorations (Bassett & Stauts, 1966; Parkins, 1969; Bassett & Smith, 1971), whereas a die relief consisting of multiple layers of butyl acetate applied to the surface of the stone die, particularly for crown dies, has its adherents (Arthur G Shultz, 1950, unpublished; Eames & others, 1978, 1981a,b; Campagni, 1982).

In the instance of the extracoronal restoration specifically, perforating the crown on the occlusal to allow the escape of entrapped cement to effect better fit of the margin was advocated by Lange (1955) and Jørgensen (1960a). Escape channels for outflow of cement, instrumented into the surfaces of the prepared tooth just before cementation, or channels cut into the internal walls of the wax pattern or the crown casting, have also been reported as successful in closing the gap at the margin (Tjan & Sarkissian, 1984; Tjan, Miller & Sarkissian, 1985). Recently Pascoe (1978), using mathematics and experimentation, has advocated the use of an oversized casting.

Other authors have turned to the geometry of the design of the cervical wall. They state that increasing the angulation of the bevel of the finished wall will improve the fit of the margin, not only in the fabrication of the wax pattern and the fitting of the restoration, but in the cementing phase also (Eames & Little, 1967; McLean & Wilson, 1980; Kuwata, 1980; Gavelis & others, 1981).

Principle of the Sliding-Joint

When the cervical margin of any type of cast restoration — class 2 inlay, partial or complete crown — is instrumented, the relationship of the plane of the finished wall to its adjacent counterpart on the casting favors a beveled wall, based on the principle of the sliding-joint (Cooper, 1946, unpublished; Gilmore & others, 1977; Baum, Phillips & Lund, 1981, p 401; 1985, p 419). In applying this principle to the insertion of a cast restoration of any design of class 2 or any type of crown it can be shown mathematically as well as by demonstration models that as the casting moves toward the bevel of the cervical wall, the space between walls in the vertical axis, which is in the plane of the path of insertion, is smaller than the space between walls at right angles to the path of insertion (the horizontal plane). Of course, in the perfect casting (admittedly there are none) at maximal closure the space between the prepared tooth and the casting would be zero. Thus pulpal and cervical floors (horizontal components) have larger gaps than have axial walls and bevels on cervical walls (vertical components). This is shown graphically in Figure 1.

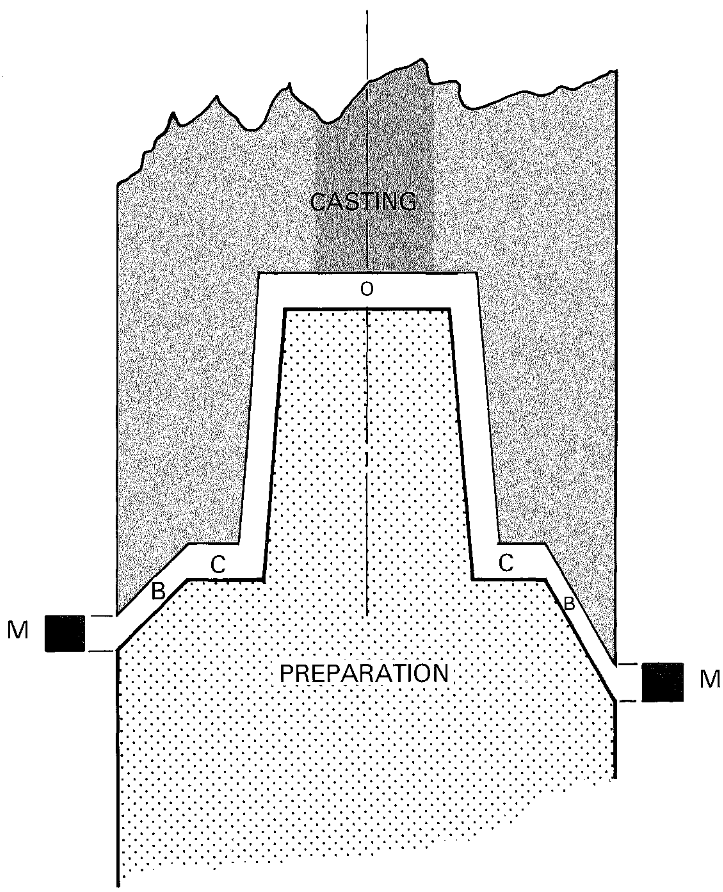
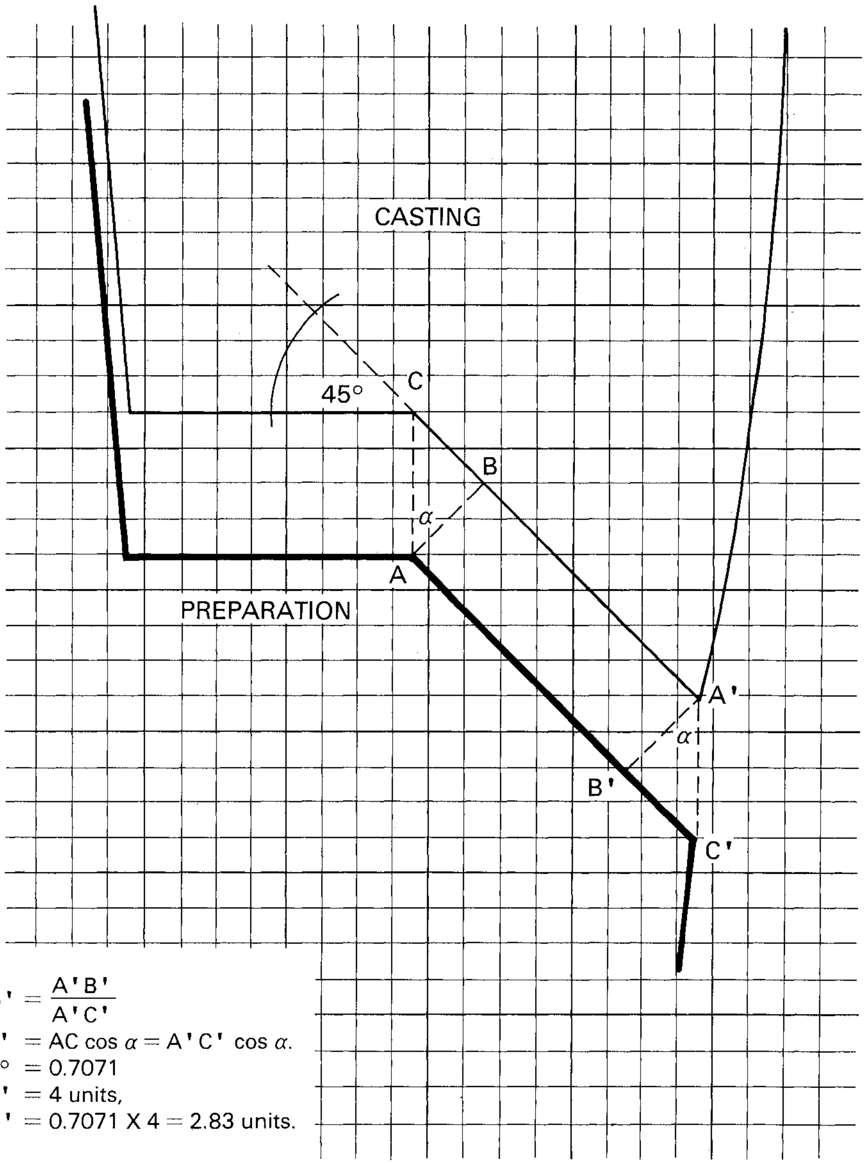


FIG 1. *The mechanical principle of the sliding-joint, dependent on the uncemented state, is shown above. As the casting slides toward its preparation, components lying in occlusal plane* (O) *and cervical wall* (C) *are equidistant from the preparation. However, the distance between cervical bevel* (B) *and the casting is smaller; the steeper the bevel the closer the casting approaches the preparation. The gap* (M) *at the margin is the same dimension as* (O) *and* (C)*, and is the same on right and left.*

Thus, in the uncemented state, the steeper the bevel of the cervical wall the smaller proportionately the gap at the other parts of the preparation. This is explained mechanically as a function of the trigonometry of the acute angles of a right triangle in Equation 1 (Fig 2) (Rosner, 1963). As can be proven from this equation by the use of the cosine rule, the closer the hypotenuse of the right triangle approaches the adjacent leg of the triangle the smaller the gap between the bevel of the wall of the cavity (adjacent leg) and the casting (hypotenuse) will be. Clinically, this is easily demonstrated by placing the casting on its die or by fitting the casting to its prepared tooth. The principle is correct, but only in the uncemented state when



EQUATION 1.

$$\text{Cosine } \alpha = A'B' = \frac{A'B'}{A'C'}$$

or $AB = A'B' = AC \cos \alpha = A'C' \cos \alpha$.

Since cosine 45° $= 0.7071$

and if $AC = A'C' = 4$ units,

then $AB = A'B' = 0.7071 \times 4 = 2.83$ units.

FIG 2. *By setting our trigonometry on a graph, using a right triangle and cosine, a picture can be gained of how a cervical bevel of 45° demonstrates the principle of the sliding-joint at work. We see that the dimension of* (AB) *is less than* (AC); (AB) *and* (A'B') *are equidistant. Thus, the greater the apical angle of the bevel is toward the vertical axis, the closer the casting approaches the beveled cervical wall. The cavomargin opening* (A'C') *is the same as the internal space* (AC).

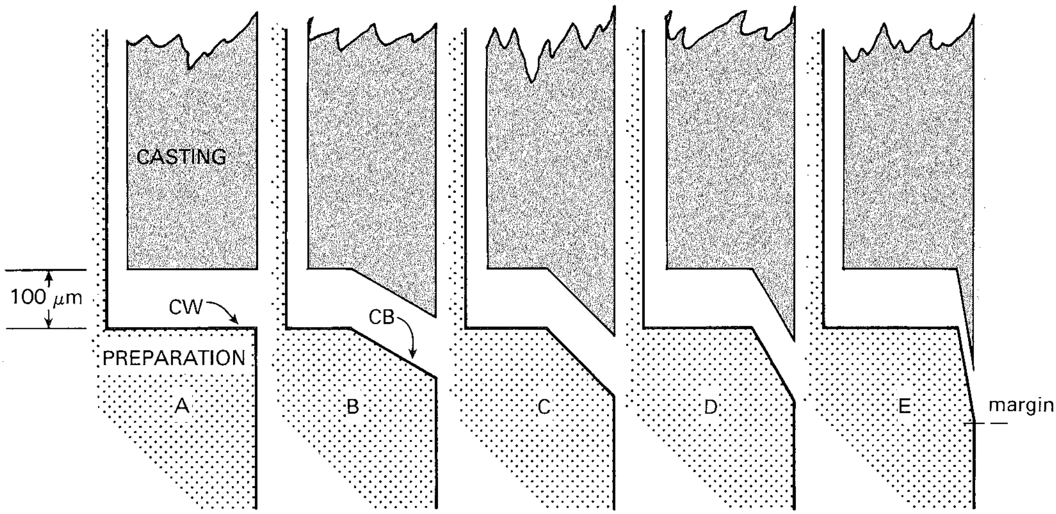


FIG 3. *Each of the five drawings above illustrates a different conformation of cervical wall,* (CW), *demonstrating the effect of the shape of the cervical wall of the preparation on the cervical fit of the casting in the uncemented state. For comparison, the horizontal space is standardized at 100 μm. By applying the cosine ratio to the principle of the sliding-joint, it can be seen that the opening of the shoulder preparation remains stable and the relationship of the casting to the prepared tooth remains on the same horizontal plane.* (A) *represents a wall without a bevel that lies at 90° to the long axis of the tooth. The openings between the cervical bevel,* (CB), *and the castings are: for a 30° bevel,* (B), *87 μm; for a 45° bevel,* (C), *70 μm; for a 60° bevel,* (D), *50 μm; and for an 85° bevel,* (E), *9 μm.*

the casting and prepared tooth have no intermediary except air (Fig 3).

Influence of the Cementing Medium

When a cementing medium is introduced, the application of the cosine rule no longer applies since the control of fit is a direct function of the film thickness of the cement used. Therefore, the closer the angulation of the bevel approaches the plane of the path of insertion of the casting, the greater the cement-filled gap between the margin of the casting and the finish line of the prepared tooth (Fig 4). This must be so inasmuch as all dental luting cements have a finite film thickness, whatever it is. This is provable by the trigonometry of the sine function of the right triangle. Now, instead of using the cosine of the acute angle opposite

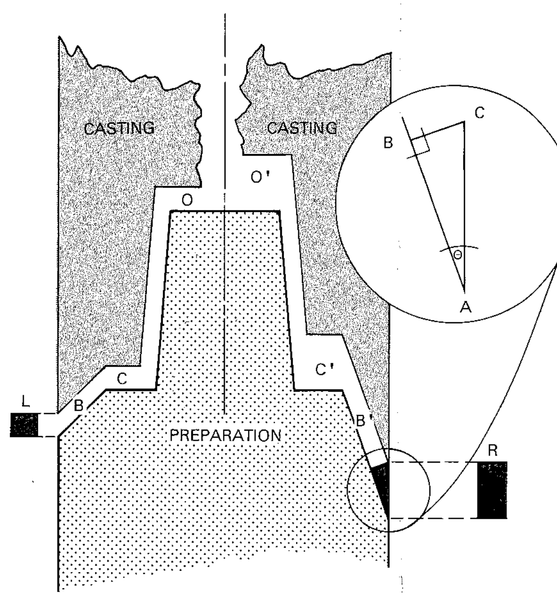
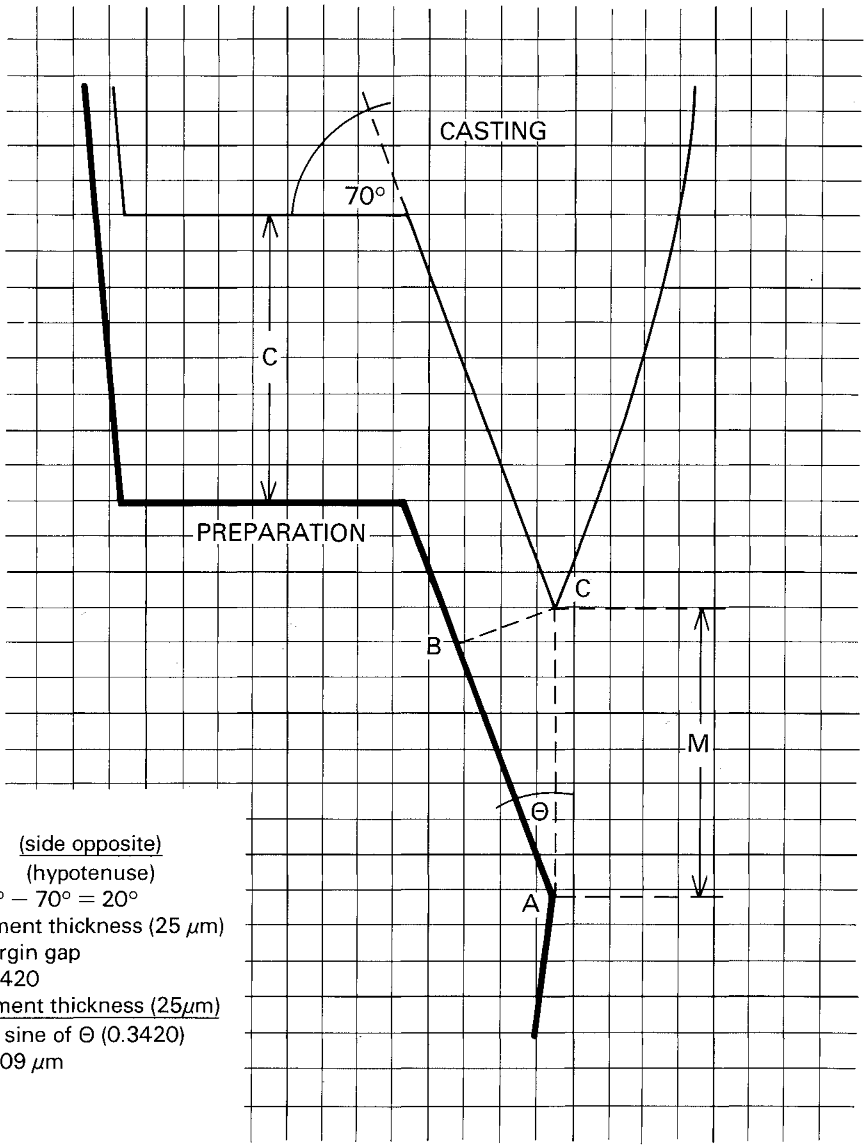


FIG 4. *A prepared tooth is depicted showing two choices of cervical wall bevels: left* (L) *at 45° and right* (R) *at 70°. All luting substances have a finite thickness beyond which they cannot be compressed* (B & B'). *This thickness becomes the limiting factor in seating a casting during cementation. This is clearly shown in the horizontal discrepancy in fit on the occlusal* (O), *the cervical wall* (C), *and at the gap at the margin* (L) *as well compared with* (O'), (C'), *and* (R). *The gap at* (R) *corresponds to line* (AC) *in the encircled enlargement.*

the perpendicular erected to one of its sides, the sine of the same angle is applied as in Equation 2 (Fig 5). In this function, the sine of the angle equals the side opposite the angle over the hypotenuse. In this formula the thickness of the cement film becomes the limiting factor.

Although numerous investigators report various thicknesses of cement film between castings and their counterparts of the prepared teeth, this paper is using the maximum film thickness of 25 micrometers (μm) for class I luting cements as specified by the American Dental Association (1976). Using the illustra-



EQUATION 2.

$$\text{Sine of } \Theta = \frac{BC}{AC} \quad \frac{\text{(side opposite)}}{\text{(hypotenuse)}}$$

$$\Theta = 90° - 70° = 20°$$

Line BC = cement thickness (25 μm)

Line AC = margin gap

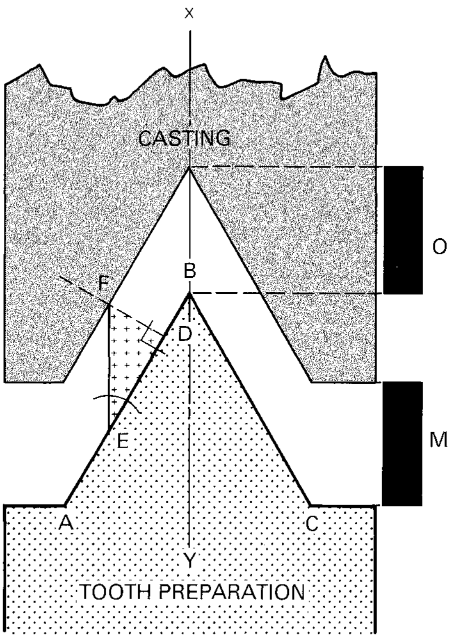
Sine of 20° = 0.3420

$$\text{Margin gap} = \frac{\text{cement thickness } (25\mu m)}{\text{sine of } \Theta \ (0.3420)}$$

Margin gap = 73.09 μm

FIG 5. *In right triangles the sine ratio states that the side* (BC) *opposite an acute angle* (Θ) *has a certain relationship to the hypotenuse* (AC). *This illustration has a 70° bevel, as has Figure 4 at* (R). *As the steepness of the angle of the bevel approaches parallelity with the axis of the path of insertion of the casting, the opening of the margin* (M) *becomes highly magnified inasmuch as the thickness of the cement film* (BC) *remains unchanged. This has the effect of creating the same cement space at* (C) *as at* (M), *causing an extrusion of the casting in an occlusal direction.*

tion of an equilateral triangle as representing a prepared crown with a 60° convergence of its axial walls, it is seen in Equation 3 (Fig 6) that the finite thickness of cement holds the casting away from the wall of the preparation by a distance of 25 μm, creating an opening at the cervical cavomargin of 50 μm. As shown in the illustration, there is also an equal space of 50 μm over the occlusal of the preparation (apex of the triangle). The mathematical formula for the sine of an acute angle of a right triangle, as given in Equation 3, proves this width of opening. By the use of a system of right triangles, the acute angle opposite the right angle can be shown to be 30°. The table of trigonometric functions lists the sine of 30° as 0.5000 (Griffin, 1936). Substituting 0.5000 for the sine of 30° in Equation 3, and using 25 μm as the thickness of cement, it is shown mathematically that the gap at the margin is 50 μm. According to this principle, as the acute angle gets smaller in Equation 3 and approaches zero, the opening at the cervical line, due to the finite thickness of cement film, enlarges. It has just the opposite effect upon fit after cementation as the principle of the sliding-joint has upon fit before cementation.



EQUATION 3.

Since the sine of angle DEF $= \frac{\text{DF (cement thickness)}}{\text{EF (margin gap)}}$

and angle DEF = 30°

and sine 30° = 0.5000

and cement thickness = 25 μm

then margin gap $= \frac{25\ \mu m}{0.5000} = 50\ \mu m$

FIG 6. *This illustration demonstrates the effect that walls in the vertical axis of a tooth preparation have upon cementation. The space* (DF) *between the casting and its preparation is perpendicular to* (AB). *The distance, 25 μm, represents the limiting thickness of the film of cement. The long axis of the tooth* (XY), *passing through the apex of the triangle* (ABC) *at* (B) *and bisecting it, is perpendicular to an imaginary line* (AC) *whose extension forms the cervical shoulder of the preparation and creates a right angle whose angle at* (B) *is now 30°. Since alternate angles of parallel lines are equal, the line* (EF), *parallel to the long axis of the tooth* (XY), *created a triangle* (DEF) *of 30, 60, and 90°, whose angle* (DEF) *is 30°. The length of* (DF) *remains the same, since a film of cement cannot be compressed beyond its limit. As the angle of convergence of the axial walls approaches parallelism, the line* (EF) *lengthens and is equal to the gap at* (M). *It is also the same dimension as the cement space at* (O), *that is, 50 μm.*

Translating this from triangles to prepared teeth, and using the complete crown as an example, it is possible to partly (and theoretically) explain why castings fit so poorly after cementation when they fit so well before the cementing step (Dedmon, 1985). This phenomenon is especially evident in those castings not adequately and uniformly relieved on their internal surfaces.

Effect of Internal Relief Versus No Relief Upon Fit of Crowns and Inlays

Basic requirements for success in cast restorations are accurate fit at the margin and good retention (Rosenstiel, 1964). Good retention is gained by long opposing walls that have minimal taper with each other. The shorter the walls, the closer the opposing walls should approach parallelism. Unfortunately, unless there is adequate space to accommodate the cement between the casting and the walls of the preparation, the closer to parallelism those walls are, the greater the gap between the casting and the margins of the tooth will be. As will be shown, it is a problem that can be solved only by uniformly relieving the internal of the casting. Authors of standard texts and papers on the subject of retention, mindful of Ward's text (1926) and Jørgensen's work (1955; Jørgensen & Esbensen, 1968), advocate taper between 2° and 8° (Johnston, Phillips & Dykema, 1965; Tylman, 1970; Gilmore & others, 1977; Charbeneau & others, 1981; Rosenstiel, 1975b). In this paper an axial wall convergence of 10° (5° each wall) is being used to illustrate the effect that cement thickness has upon castings whose opposing walls have minimum taper (it is assumed that the internal of the casting is an accurate negative replication of the tooth preparation, which it is not). As the cement-coated casting moves toward its preparation and approaches the finite thickness of the film of cement, the gap at the cervical margin of the preparation becomes of an intolerable clinical magnitude of 286.69 μm (sine of 5° = 0.0872). Unless the casting is uniformly relieved, meaning an internal relief of 25 μm, but preferably 35 μm (Fusayama & Iwamoto, 1961), venting at the occlusal of the casting, or any other type of channel escapement for cement, is not totally effective as a means of letting the restoration go to place to its maximal closure of the margin of the cervical wall. Venting will allow seating of the casting only to the limits imposed by the thickness of the film of cement.

If the casting is adequately relieved except for the surrounding collar, which represents the bevel of the cervical wall, then the closer the angulation of the plane of the bevel on the cervical wall approaches parallelity to the plane of the axis of insertion, the greater the gap at the margin will be. Therefore, the bevel at the cervical should more nearly approach the horizontal plane than the vertical plane. The bevel should be angled apically only enough to be certain that the cleavage planes of the enamel prisms are adequately instrumented. With internal relief and masking out of the cervical margin so that no relief is evident at the cervical finish line of the casting, a 90° shoulder will, at least theoretically, approach the smallest limit possible — a margin gap of 25 μm as shown at A in Figure 7.

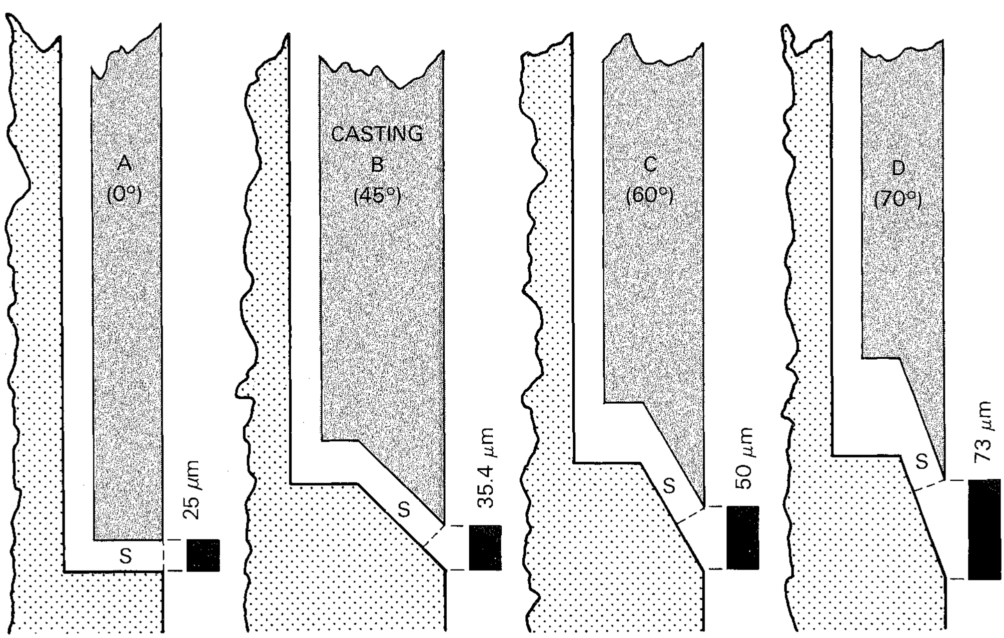


FIG 7. *The drawings above illustrate the effect that the thickness of the film of cement and the conformation of the cervical wall have upon open margins at the cervical cavomargin. The broken line at* (S) *represents the thickness of the film of cement, 25 µm, and is always perpendicular to both the unbeveled wall at* (A) *or the beveled walls at* (B), (C), *and* (D). *The shoulder preparation* (A) *should have the least opening of 25 µm. As steepness of bevel increases, the opening increases. Bevels of the cervical wall are indicated to correct for weak or loose enamel prisms.*

Castings of intracoronal design (inlays, onlays, and partial crowns) have the same problems of gaps at the margins after cementation as complete crowns have, only more dramatically because some margins are visible. This might explain, in part, why dentists favor the complete crown. Inlays, with their intricacy of design of interlocking boxes, channels, grooves, and pins, as well as beveled planes that slope in the axis of insertion of the casting, pose problems that result in magnified gaps at the margins.

Unless the internal relief of the casting is adequate, probably the ultimate gap at the margin would be in pin-retained inlays. When a tapered fissure bur with a 2.5° taper to each side of the bur is used to instrument recesses for the pins the theoretical gap should be over 573 μm, as illustrated by the hyperbolic curve in the graph in Figure 8. In the technique for

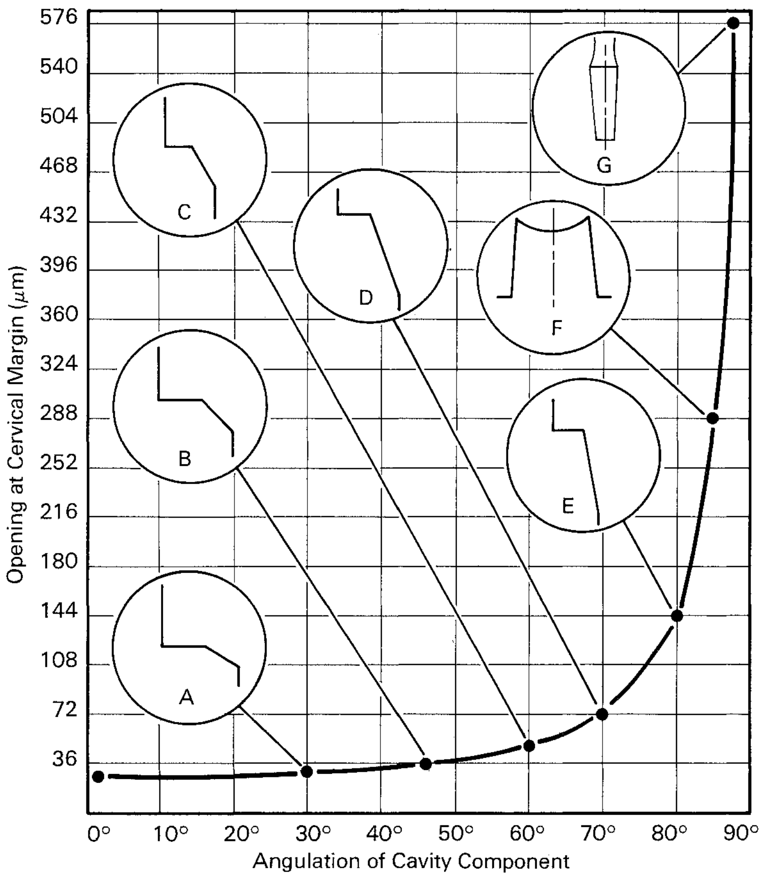


FIG 8. *To illustrate the effect that varying angulations away from the horizontal plane have upon the opening at the cervical margin after cementation, the opening is plotted against the angulation of the encircled detail of the conformation of cavities, preparations, and burs. It is assumed that the castings fit their prepared cavities intimately and that no relief to accommodate the 25 μm thickness of the film of zinc phosphate cement has been made. At 0°, meaning a preparation with a shoulder wall and no bevel, theoretically the casting should approach the cervical shoulder as closely as the limiting thickness of the film of cement will allow, namely, 25 μm. Cervical bevels of 30° and 45°* (A & B) *would have open margins of cement of 27 and 35 μm, respectively. As the angulation of the bevel increases* (C & D), *the cement-filled opening increases dramatically, and at a bevel of 80°* (E) *the opening would be more than 0.1 mm. A complete crown preparation* (F) *with converging walls of 5° each would be elevated above its cervical seat almost 0.3 mm, and a pin-retained inlay using pins with a 2.5° taper* (G) *would be held away from its cavomargin finish line almost 0.6 mm.*

pin-retained inlays in which nylon bristles with parallel sides are used as patterns for the pins, the castings, theoretically, could not be cemented at all. However, the pins of smaller diameter that are used in the waxup phase result in cast pins that readily compensate for the thickness of the film of cement.

Some Interesting Conclusions — Are They Theory or Fact?

A cast restoration, unless relieved fully to accommodate the finite thickness of cement, whatever that thickness is, is a restoration that cannot be optimally set. At least from a theoretical standpoint, that fact, as shown mathematically, has some interesting implications gnathologically, periodontally, endodontically, and economically for the recipient of these restorations.

From the time of the inception of the cast restoration, clinicians have had the experience that visible cement-filled discrepancies between supragingival margins of castings and prepared teeth are unacceptable because they prematurely fail (Schwartz & others, 1970). Information from a third-party source, an insurer of restorative dental procedures (Washington Dental Service Corporation, R Fenno, director), indicates that complete cast crowns account for 25.4% of its claims. When claims for replacement or repair for reasons of failed margins are submitted after only five years, it represents a sizable economic drain on the system.

When open margins that are filled with cement are in apposition to soft tissues, these clefts are believed by some investigators to be detrimental (Silness & Hegdahl, 1970; Roberts, 1970). Although recent papers question the role of faulty restorative dentistry in periodontal disease (Than, Duguid & McKendrick, 1982; Grasso & others, 1985), that zinc phosphate cement causes severe inflammation of some soft tissues cannot be questioned (Waerhaug, 1956). Even though there is not good clinical data on what constitutes a maximal allowable opening for subgingival margins of cast restorations, a study by Jørgensen and Wakumoto (1966) implies that an opening of something less than 50 μm might be acceptable. Reason tells us that when there are obvious cement-filled margins, the wider they are the greater the potential is for adverse effect on the investing periodontium.

From the evidence shown mathematically herein, and from observations made clinically, castings, after cementation, are often extruded from their precemented position. If the clinician is not aware of the resulting occlusal disharmony, the dismissed patient will suffer discomfort once the anesthesia has dissipated. This results in odontalgia (Seltzer, 1971). Whether this tooth discomfort results in an irreversible pulpitis is controversial (Seltzer & others, 1967). In a long-term study on animals, teeth in occlusion that were overfilled with dental amalgam resulted in short-term pulpal inflammation (Landay, Nazimov & Seltzer, 1970). Evidently, the wear of the amalgam, with a hardness somewhere between enamel and dentin (Peyton, 1964), allowed for "self-equilibration." In a longer study, with occluding surfaces filled with harder materials, the resulting pulpal changes were dramatic and damaging (Landay & Seltzer, 1971; Seltzer & Bender, 1984). Whether or not inferences can be made and conclusions drawn in relation to this study is yet undetermined, but it gives cause for thought and concern. Although not provable, persistent and subtle occlusal interferences are thought to be damaging to the pulp (Brännström, 1981, p 67) as well as to the periodontium (Stahl, Miller & Goldsmith, 1958). There also seems to be a correlation between extensive restorative treatment and the temporomandibular apparatus in the form of mandibular dysfunction, all of which might implicate the "too high" crown (Kampe, Hannerz & Ström, 1983).

Lastly, when the gnathostomatic system is pathologically involved (Glickman, Stein & Smulow, 1961), clinicians are taught to analyze the occlusion (Glickman, 1964, 1965) for "occlusal interferences (and) heavy parafunctional activity" (Ingraham, 1972). If the occlusion is suspected as a contributory causative element and the patient has multiple poorly restored teeth with questionable function, a part of treatment might consist of waxing a new occlusal relationship on a precision articulator that is highly adjustable and using the preciseness of gnathological principles (Guichet, 1976a,b). Despite the precision in this phase, unfortunately the restorative treatment, after cementation, will still leave the patient with occlusion-related disharmony unless compensations are made for the disharmony resulting from the effect of the finite thickness of the film of cement upon the cemented casting.

Precision in every step involved in making a cast restoration is essential. For castings that are well retained, most postrestoration difficulties are caused by discrepancies in the fit of margins, which is detrimental to tooth-related systems in one way or another. Not all, but certainly many, of the foregoing problems can be avoided when the clinician has a thorough understanding of the importance of engineering the components of the tooth preparation. In addition, it is important that the dentist realizes the need to adequately and uniformly relieve the internal of all castings, especially walls in the plane of the path of insertion, in order to accommodate for the space required for cement. If this relief is adequate, the casting, during the cementing phase of the fitting procedure, should seat until the surface plane of cavomargin bevels is approached. The angulation of this bevel then becomes the factor that limits the extent to which the casting can be seated. "To bevel or not to bevel?" (Rosenstiel, 1975a) is not the question. Rather, the question should be, "Where should bevels be placed, and how much angulation should be given those bevels?" Bevels at the cervical, when angled too closely to the path of insertion, invite failure through a widened cement margin, which, through dissolution and poor sealing properties, becomes the weak link (Norman, Swartz & Phillips, 1957, 1963; Jørgensen, 1960b; Mesu & Reedijk, 1983).

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LEGENDS OF OPERATIVE DENTISTRY

GERALD D STIBBS

Individual Intracoronal Cast Restorations

INTRODUCTION

Cast restorations constitute a very large segment in the field of operative dentistry. Countless essays have been given on the subject. Many, many hours have been devoted to the development and refining of technics for the fabrication of dental castings. Clinics on cast restorations have been given, ad infinitum, at dental meetings. Why then should another paper be added?

Several considerations justify further study of the single, intracoronal dental cast restoration. First of all, some of the more recent dental graduates have received somewhat perfunctory training in the technic. The undergraduate curriculum has become so crowded that some of the time formerly allotted to operative procedures, particularly those involving laboratory sequences, has been reallocated. Manual training tends to be de-emphasized in some of our dental schools. As a result, some students graduate with little or no experience in the actual production of an accurate dental casting, and a dental laboratory is foreign territory to them.

Second, even in practices devoted to rebuilding or reconstructing dentitions by the quadrant, there are usually subsequent indications for the occasional single, simpler restoration. In practices given over largely to amalgam and composite restorations there are occasional demands for an inlay. Knowledge of, and competency with, a good workable inlay technic are sound insurance.

Third, and by no means least, there are periods in some practices at present when the appointment book is not completely filled for

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weeks in advance. It is economically feasible at such times to be able to fill in some of the gaps with the pleasure and satisfaction of performing the laboratory procedures to produce some fine cast inlays.

In striving to improve a practice and to deliver higher quality service, we can be reminded that (a) producing **excellent** inlays is anything but easy, (b) much care and expertise are required when operating on teeth, and (c) the physical properties of the materials we use require study.

Many changes and developments have come about since the casting process was introduced to the profession by Dr Taggart in 1907. Empirical methods have yielded to sound research. A really good inlay technic is not acquired simply by a "laying on of hands." When we look at the inlays in most mouths we realize that the **perfect** inlay is a rare bird indeed. Recently I came upon a statement in one of my earliest papers, written many years ago. It is apropos even today. "A technic that is satisfactory for one operator may be entirely unsuited to the ability of another. Consequently, it is necessary for each person to test the various methods to prove their merits, rather than to accept, unquestioningly, the claims made by the sponsors. It is only by so experimenting and comparing results that the profession may develop the science of producing **inlays that fit**" (Stibbs, 1931).

As we develop our own technic we can learn much from others. When we have a procedure that produces the best results we can achieve, then we should be slow to change. A sound inlay technic consists of a multitude of minutiae. If just one step is altered, it may throw the entire procedure out of balance. The old admonition of Alexander Pope (1711) holds true here: "Be not the first by whom the new are tried, nor yet the last to lay the old aside." Certainly failure will meet anyone who decides that an accurate, properly fitting inlay can be produced by reading a text once or by watching one good table clinic. It requires many "repeats," and attention to each detail to achieve competence that produces even **near** perfection.

In acquiring or refining a suitable inlay technic we must keep several factors in mind:

1. There must be a properly prepared cavity that will:
   (a) permit removal of an impression without distortion and insertion of a casting;
   (b) meet the demands of protection of the pulp, the cusps, and other remaining tooth structure;
   (c) satisfy the requisites of esthetics and function.
2. Remember that gold shrinks a definite amount as it passes from the molten to the solid state in the mold, so that the mold, at the instant of receiving the gold, must be proportionately larger than the original pattern, so the casting will fit the cavity. This necessitates balancing the shrinkage of inlay wax and the setting and thermal expansion of the investment against the shrinkage of the gold.
3. Then, of course, the usual requisites of operating painlessly, of completely removing defective tooth structure, and of having a clean, dry cavity in which to seat the casting must be met.
4. Contouring for function and periodontal health, and final finishing cannot be ignored.

A procedure that has given acceptable results for many years has been evolved from the contributions of many fine teachers and clinicians. I wish each one could be acknowledged, but though that is impossible, I am eternally grateful for the patience and inspirational demonstration of details by so many in the journey through a dentally oriented life. While details would be overly burdensome here, the steps, in general, are set forth. The substance of this paper is offered to remind readers of things they have learned already but may have put on the "back burner" recently, and to whet your appetite to improve the quality of the inlay service you render, regardless of the present degree of your expertise. Remember that consideration is being restricted here to the single, intracoronal inlay.

PREPARATION OF THE CAVITY

The usual prerequisites of treatment plan, preparation of the general field, securing adequate anesthesia, and establishing a clean operating field are met. Almost invariably local anesthetic is administered and a rubber dam is applied.

The cutting of the cavity is accomplished largely with high-speed rotary instruments, then completed by a planing of walls with sharp hand instruments and the finishing of cavo-surface margins with a slow-running disc on proximal outlines and a 12-bladed bur on occlusal margins. The gingival bevel is made with either a suitable hand instrument or a flame-shaped 12-bladed bur.

Undermined enamel is removed. All enamel walls should be supported by sound dentin. Leaving the remains of defective grooves, or saving unsupported enamel in the interest of esthetics, will usually end in failure of the restoration. A decision must be made as to the required extent of inclusion of functioning cusps, and the most esthetic manner of minimizing the display of gold.

Then, since we are considering a case in which the operator will be performing the laboratory work, it may be feasible not to remove all of the carious dentin until the impression of the cavity has been taken. This saves the time of removing caries, rebuilding the central portion of the cavity with core or buildup material to facilitate impression taking, then removing the buildup before seating the casting.

IMPRESSION AND REGISTRATION OF OCCLUSAL PATHS

For the single restoration, the pattern may be made either directly or indirectly. If the indirect procedure is followed, a simple impression in a small mesh tray wrapped with wax, and with a wax stop at either end and adhesive painted on the inner surface, is usually the method of choice (Fig 1). If preferred, a split-tray impression can be made. It, of course, entails more extensive and time-consuming laboratory procedures.

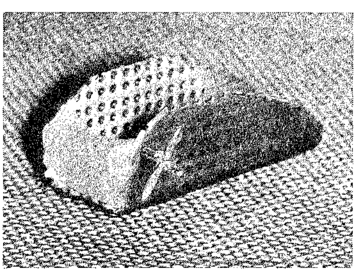


FIG 1. *Impression tray. Brass mesh, 24 gauge, wrapped loosely with sheet casting wax, 30 gauge. Utility wax 'stop' at each end.*

If the prepared cavity is entirely clear of the rubber dam and dam retractors, the impression can be taken with the dam in place (Fig 2).

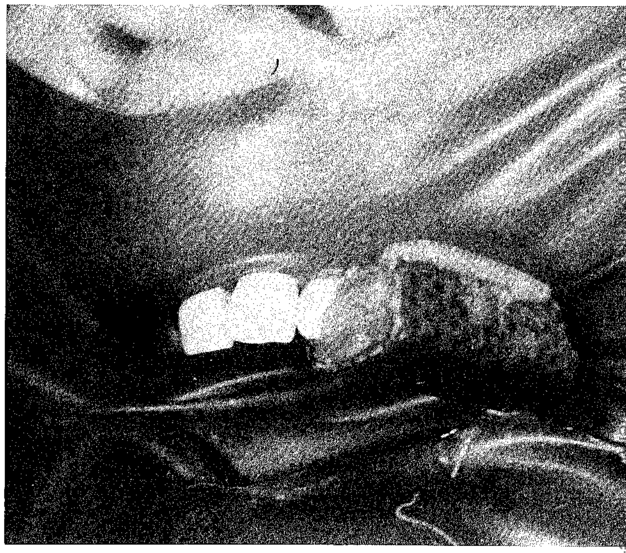


FIG 2. *Taking impression. Whenever possible, it is taken with the rubber dam in place, to retract the gingival tissues.*

However, if gingival margins are too close to the dam, it is better to remove the dam, isolate the field with cotton rolls, and apply suitable retraction cord to achieve a dry, clean cavity.

The impression can be made with whatever material gives the operator the most accurate results. This author for a number of years has used one of the silicone-based impression materials. They retain their accurate registration for a considerable time, they are cleaner and more odor-free than are some of the other materials. Their accuracy is excellent. Other operators prefer the reversible colloids, or one of the other irreversible materials. The important requirement is that the prepared cavity be recorded completely and precisely, so an accurate die can be secured from it.

The next step is to obtain a wax registration of the occlusion on the tooth, and an indication of the contacts by approximating teeth. With a cotton roll in place and excess saliva cleared away, a small amount of softened inlay wax is introduced into the cavity (Fig 3). Complete

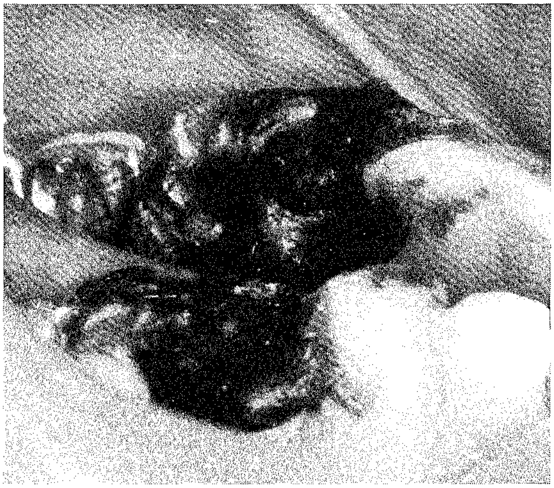


FIG 3. *Wax bite registration. It becomes the pattern when carried to die, voids filled in, and desired carving to form is completed.*

adaptation to the details of the preparation is not required. The patient is immediately asked to close tightly in centric relation, then to open. A small stream of hot air is played over the surface of the wax. Some dental units have this highly desirable accessory; if yours does not, another means of softening the surface of the wax must be secured. A small piece of rubber dam, approximately one inch square, mounted on an articulating paper holder or held with cotton pliers, is placed over the surface of the melted wax. The patient is again asked to close in centric and then make lateral excursions, then open. Again the wax surface is softened and again the rubber is interposed and the patient closes and performs the usual lateral and protrusive motions. The wax is then removed and set aside. It will become the foundation for the final wax pattern.

INTERIM PROTECTION

The prepared tooth is protected with a suitable temporary material. Each of these materials has its advantages and disadvantages. In general, the cavity is well protected with a thin layer of baseplate gutta-percha (as advocated by Richard V Tucker) or periodontal pack in the gingival portion, and the balance of the void filled with increments of a durable, flexible, self-cure resin, applied with a brush. The occlusion is determined by having the patient close into the hardening resin, with an interposed layer of lubricated rubber dam. Excess bulk is trimmed away with a sharp-bladed instrument. In some cases the preferred interim protection is temporary cement confined within a trimmed, contoured band; or it could be a temporary inlay of rigid, cured resin cemented with temporary cement.

LABORATORY PROCEDURES

Die

A properly proportioned small amount of die stone (110 g) is mixed with 1.5 ml of water in a small rubber bowl. Then very small increments of the mix are carried to the side of the impression of the prepared tooth on the end of a wood toothpick, and vibrated into the mold, being careful not to trap air in any of the sharp angles of the impression. When the coronal portion of the impression is filled, a suitable amount of the remainder of the mix is formed into a cylinder or roll, dried slightly in a paper tissue, then attached by slight vibration to the first part of the pour to form a handle and to absorb some of the water in the coronal part of the die (Fig 4).

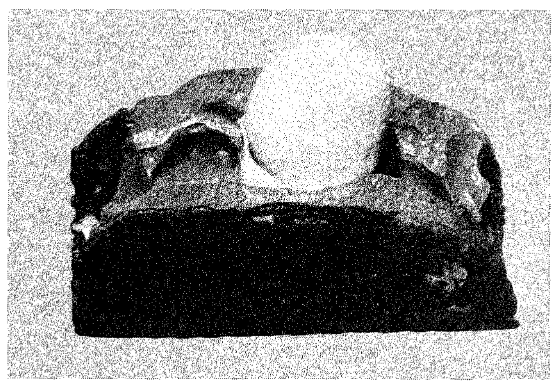


FIG 4. *Master die and die handle, poured in die stone*

It is left to set for at least one hour. When separated, the die is dressed to the margins of the preparation and the handle portion is trimmed suitably. The surface of the die is treated with a separating medium.

A second pour of die stone is made into the impression of the prepared tooth and at least one tooth on each side of that (Fig 5). Regular

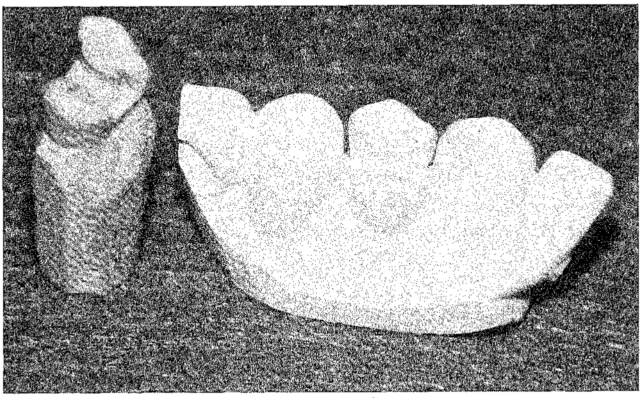
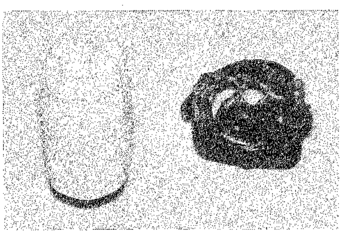


FIG 5. *Second pour, in dental stone, to check contacts and occlusal form*

stone may be used for this second die, which is used as a check for proximal contacts and tooth form while carving the pattern.

Pattern

The functional registration in wax that was taken in the mouth is now placed firmly into the lubricated die (Fig 6). Voids are filled in with



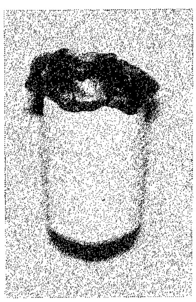


FIG 6. a *Trimmed die and functional wax bite*

b *Wax occlusion registration seated on the die, ready for fill-in of voids and for preliminary carving, prior to warm-water swaging*

inlay wax melted into place with a heated, small wax-carving instrument. Care is taken not to obliterate the registration of the excursions of the opposing tooth and the contacts of the approximating teeth. As each segment of wax cools it is compressed to place with a finger. To achieve uniform compression of the wax and a close adaptation of the wax to the die, and to relieve stresses in the wax, the pattern is subjected to controlled hydraulic pressure in a warm water swage (Star Brass Works, 5813 Airport Way South, Seattle, WA 98108, USA) (Fig 7). Many operators will forego

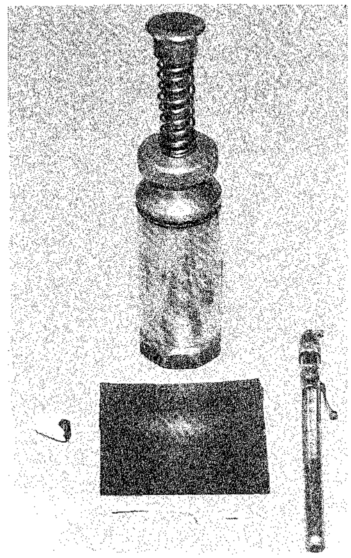
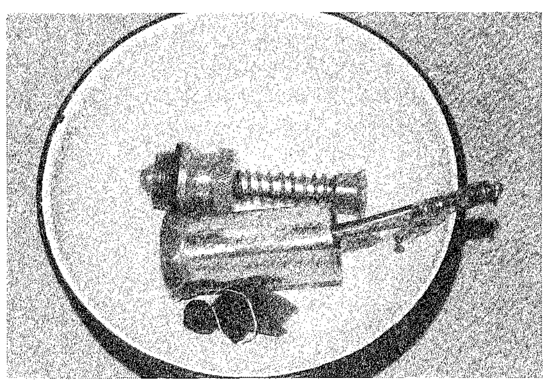


FIG 7. a *Swaging setup. Hot water swage; die with grossly carved pattern; rubber dam and floss with which to wrap die and pattern during swaging; thermometer to accurately control temperature of water during the three-minute conditioning period. Temperature of water varies with brand and batch of wax used; for Maves No 2 green stiff wax the temperature is 117 ± 1 °F (47 ± 1 °C). Also required is a source of swaging force, e g, 4 lb (1.8 kg) hammer. The resultant hydraulic pressure forces the wax into contact with all portions of the die, and establishes fit to cavity* ***walls****, rather than just to cavity* ***margins****.*



b *The swage and wrapped pattern in the water bath, at a temperature suitable for the wax used.*

this step as being a nuisance and too time consuming, but careful testing by many clinicians and researchers including Fleetwood (1940), Lasater (1940), Stibbs (1948), Christensen (1965), and Krug and Markley (1969) has shown it to be a valuable step in producing a fine pattern.

Tooth form is carved as completely as the operator's skill permits. Reproduction of occlusal embrasures, grooves, spillways, and buccal and lingual embrasures is particularly important. Finally the occlusal surface of the pattern is smoothed with the bristles of a stubby camel-hair brush and the other surfaces are polished with a piece of silk. A minute addition of wax is flowed over the contact areas to allow for the loss of contour when polishing.

The pattern is sprued in a bulky portion in such a way that the molten gold will flow smoothly into the mold. The sprue may be plastic, brass, or hollow stainless steel. If the latter, it is well to add a film of wax to the outer wall of the sprue so the warmed sprue may be removed more readily from the invested case. An important consideration is that the sprue must be of proper diameter and length. The sprued pattern is mounted on a crucible former. It is usually unnecessary to wash the pattern.

In the case of a bulky pattern, the internal bulk may be reduced with either a wax-cutting bur running at slow speed (Fig 8), or with a very sharp spoon excavator. (A wax-cutting bur is made from a No 35 inverted cone bur by removing alternate blades with a knife-edged stone.) Care is taken not to remove wax that forms part of the retention form of the pattern.

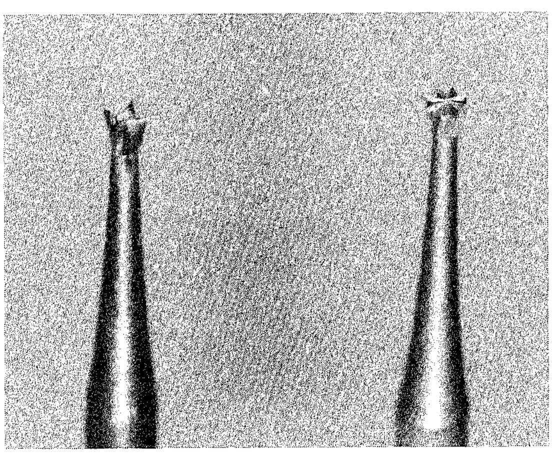


FIG 8. *Wax-cutting bur (left) made from a 35 inverted cone bur (right) by grinding out alternate blades. This open form permits removal of unwanted wax from the interior of the pattern, without heating the pattern or clogging the bur blades.*

Investing and Burnout

Investing is done with a gypsum-bonded, hygroscopic investment. Accurate proportioning of powder and water is important, to control the amount of expansion. The investment is mixed under vacuum and the pattern is invested under vacuum and with careful vibration. The case is permitted to set in a water bath at 100 °F (38 °C) for a minimum of 30 minutes, to achieve a controlled amount of expansion of the wax and mold; it is then removed to bench-set for another 30 minutes. If considerable time must elapse between setting time and burnout, the invested ring is kept in a closed humidor.

Any one of many burnout technics may be followed. The objective is to produce a clean mold expanded to an extent that will compensate for the shrinkage of the gold as it passes from a liquid to a solid state. Hollenback and Skinner (1946) showed that this shrinkage varies in amount, depending on the alloy used.

The casting is made by pressure or by vacuum, with either controlled electric heat or with a gas and air torch or with a gas and oxygen torch. After the redness is out of the button, the ring is quenched in water, the case retrieved, and brushed free of as much investment as possible. Cleansing of the casting is completed in an ultrasonic cleaning unit. It is then pickled in hydrochloric acid or in a proprietary pickling solution, neutralized in a solution of sodium bicarbonate, washed, and blown dry for inspection.

Preliminary Finishing

The casting and sprue are separated. The internal surface of the casting is studied carefully under magnification for any minute imperfections or nodules. Provision of relief of the casting to allow complete seating, and to create room for insulation between the gold and the deeper portions of the preparation, is accomplished in one of several ways:

(a) the axial and pulpal wall areas are ground and relieved with a mounted carborundum disc;
(b) the internal surface can be etched by immersing the casting in fresh aqua regia after the margins, peripheral walls, and outer surface are coated with a film of wax; or
(c) the internal surface can be stripped (electrochemically milled) in a heated cyanide solution (Bassett, Ingraham & Koser, 1964).

Preliminary smoothing and finishing can be done in the laboratory. Unless the operator is particularly adept, it is best not to attempt to polish the margins until the casting is tried in the cavity.

FITTING AND FINISHING

At the second appointment the tooth is usually anesthetized. The interim restoration is removed, fragments and any debris are flushed out, and the casting is tried in for fit, proper contact, and noninterfering occlusal contact. Finish of the occlusal margins is accomplished with 12-bladed carbide burs of suitable shape or with fine, mounted carborundum points. Proximal margins are dressed flush by means of medium and fine sand or cuttle discs, rotating from gold to tooth. Gingival margins are dressed with gold files, then fine garnet and medium sandpaper discs, with the casting held in the operator's hand, being extremely careful not to lose required marginal coverage. All but final polishing is completed with rubber wheels and points impregnated with abrasive.

CEMENTATION AND POLISHING

The casting is now cleaned with soap and water and a brush, then dried. The internal surface is cleaned further with a solvent, such as chloroform, carbon tetrachloride, or Cavidry (Parkell Co, Farmingdale, NY 11735, USA). The contact areas are lubricated lightly with a film of vaseline, being careful not to contaminate the margins. The casting is set to one side.

The cavity is now prepared for cementation by isolating it with a rubber dam. It is cleansed of debris and any remaining particles of temporary cement. It is carefully checked for removal of all residual carious dentin. The internal surface is treated as desired. One sequence that has proven to be satisfactory is to wash the cavity with a cotton pellet saturated with a fresh mix of hydrogen peroxide and ammonia to neutralize any acidic condition resulting from the interval between appointments, and to assist in dislodging residual debris. The cavity is then rinsed with warm water and dried with warm air, without dehydrating the dentinal surface. Any oily debris that may remain is removed with a pledget dampened with a solvent, such as Cavidry (not chloroform or alcohol). All of the internal form except the peripheral walls, and any particularly deep portion that is to be protected with an insulating cement, is now given an application of a thin cavity varnish. The deep protective dressing of choice is applied, staying clear of margins.

The cementing medium is mixed to the desired consistency. The addition of a minute drop of Dentalone (Parke, Davis & Co, Detroit, MI 48232, USA) in the liquid prior to mixing, helps to eliminate postoperative sensitivity. The cement is applied first to the cavity side of the casting, then to the cavity, being sure not to skip any part of that surface. The casting is carried to place and seated firmly.

As the cement begins to take its initial set, an instrument is used to reburnish the margins to the cavosurface margins of the tooth, and a fine sand or cuttle disc is moved lightly over the proximal margins. When the cement has set completely (2 or 3 minutes), the excess is flicked off with an explorer or carving instrument. Dental floss is passed through contact areas to remove particles of cement. A fine strip is fed through the interproximal space and drawn over the gingival margin.

Polishing is completed with a high polish. The tooth is kept cool with air or water. The field is flushed clean of debris and dried. The dam is removed and the mouth irrigated with warm mouthwash. A final check of the occlusion is made. The patient is instructed in home care and dismissed.

CONCLUSION

Familiarity and competence with a really good technic for the fabrication of individual intracoronal cast restorations is definitely required at present because of inadequate training in this field, and because there **are** indications for some of these restorations in any general practice, and also because there can be blanks occasionally in any appointment book that could be made profitable by knowing how to do one's own laboratory work.

These are operations that should give a lifetime of service. Examples of some cases that are **beginning** to meet that goal are shown in Figure 9. Further, when beautiful inlays with fine tooth form and excellent marginal integrity are produced, the operator can not help but have a sense of pride in having delivered a superlative treatment. Our inlays may never be perfect, but the more we do, and the more attention we give to detail and function, esthetics, and health of supporting tissues, the nearer the goal of perfection will be.

An outline of the requirements of such a technic has been given, in the hope of stimulating more of us to produce even better inlays than we are now achieving.

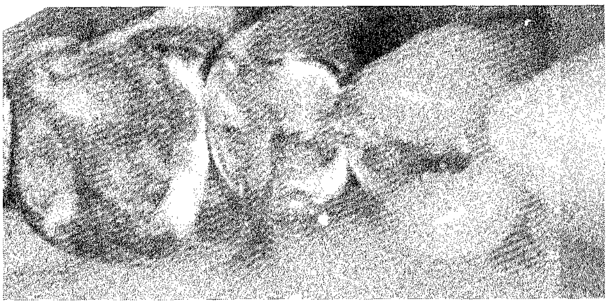
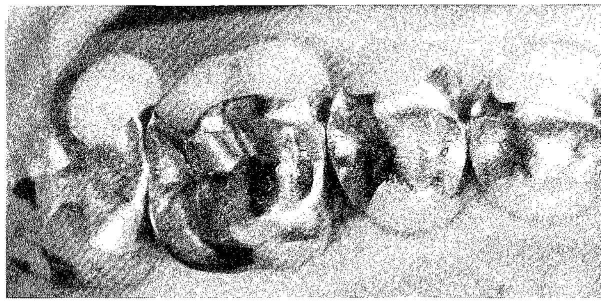
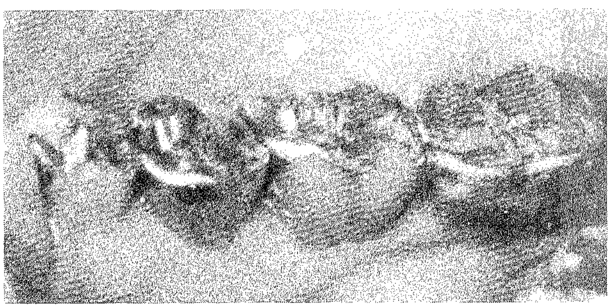


FIG 9. a *Onlay, maxillary right second bicuspid; 39 years of service*

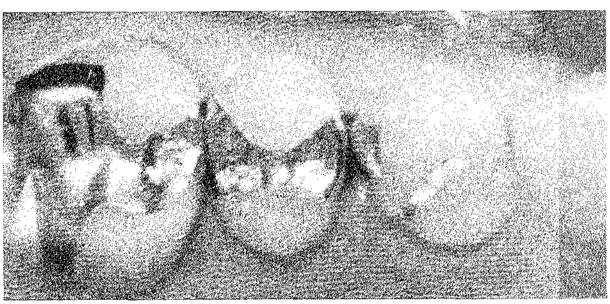


b *Onlays in maxillary right bicuspids and molars, placed 42 years ago; still in service*



c *Onlays in mandibular left molars and bicuspids; 43 years service, and still continuing*

d *Onlays, mandibular bicuspids, still serving; placed 43 years ago. Buccal restorations are gold foil.*



e *Long-lived cast restorations — molar, 35 years old; second bicuspid — 28 years. Restorations in first bicuspid and mesial surface of the first molar are gold foils.*

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POINT OF VIEW

New Restorative Methods: Another Problem for a Crowded Curriculum

JAMES W O'HARA, JR

Over the last few years, several new restorative procedures, based mainly on the bonding of composite resins to etched enamel, have been introduced to the dental profession. These new procedures are exemplified by pit and fissure sealants, laminate veneers, resin-bonded bridges, dentin adhesives, posterior composite restorations, direct-bonded resins for improved esthetics (cosmetic dentistry), and preventive resin restorations. Some of these procedures may prove only transient but others may prove to be superior methods of treatment. Some are already widely used and have stimulated much research.

THE PROBLEM

A challenge faces the restorative faculty of dental schools in deciding which of the new methods, many with only abbreviated clinical trials, should be taught to dental students and how to introduce these new methods into the existing curriculum. The new procedures and materials are seductive. Many require little or no preparation of the tooth and their immediate appearance is pleasing. Often laboratory studies are minimal and reasonable clinical trials are nonexistent. It is here that the faculty will be tested. They must be able to recognize and reject the fads, but also they must be able to identify those procedures that have merit.

Dental school faculties are understandably cautious about embracing new materials or techniques. Over the years the profession has listened to a number of promises that have never been fulfilled. Old journals are replete with scientific articles and advertisements that promised quantum leaps for dentistry. The handpiece of the 1950s that was to prepare cavities painlessly by an abrasive under air pressure and the ultrasonic instrument of the same decade are only a couple of examples of events that were long anticipated, but never arrived.

In addition to identifying the procedures that have merit, dental educators must decide at what stage in the educational program they should be introduced and where in the curriculum they should be taught. The extreme crowding of the dental curriculum is well known.

For a long time the methods for restoring teeth to form and function have remained basi-

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cally unchanged, and adjustments in response to innovations could be made within the traditional curriculum. In the case of the amalgam restoration it was a matter of substituting the conservative cavity for the cavity of G V Black and substituting high-copper alloy for low-copper alloy. Adjustments like this were not disruptive to the curriculum. With one exception — direct gold — no modern restorative faculty has had to make major judgments on the value of traditional restorative procedures. In the case of direct gold, many schools have eliminated or de-emphasized the teaching of gold foil, much to the regret of the operative dentistry faculty. Other traditional restorative methods, however, are still used routinely in practice, so there is nothing further to eliminate or de-emphasize, but now new procedures beg admittance to the curriculum. A new concept in a theoretical course may be added to an existing lecture by condensing another concept but with a new clinical procedure there must be time for teaching not only the theory, but also time for preclinical and clinical instruction. Besides the time for teaching, advanced planning and expense in procuring new materials are involved. There is an additional concern about new restorative procedures; many faculties are extremely territorial, and jurisdictional disputes may arise.

CURRENT APPROACH

Some of these procedures that show promise are being taught now in whatever time is available. Some are sandwiched in preclinical courses on operative dentistry and materials, some are taught in senior catchall courses, and some are taught as electives. Certainly none are given the same treatment as traditional restorative procedures. The real crunch will come when some of these procedures become completely respectable as a result of sound research and universal clinical acceptance.

How are dental schools dealing with these new procedures at this time? The departments of operative dentistry of 10 dental schools were asked to comment on their approach to teaching five newer conservative procedures that are currently used in dental practice. The procedures and a summary of the comments follow.

Sealants

Sealants are taught at all schools in lecture, laboratory, and clinic. Often the departments of preventive dentistry or pedodontics teach or share the teaching responsibility for teaching with the department of operative dentistry. This is a simple procedure and by sharing the responsibility for teaching, there is little effect on the curriculum time. It will be interesting to see if this development translates to future practice, since sealants have been slow to gain popularity in private practice.

Direct Composite Veneers (Cosmetic)

In its more sophisticated form this is the newest concept in conservative restorative dentistry. It is taught in every school varying from freshman lecture to senior elective or in selected clinical cases. Although all of the schools teach this in clinical practice, only two schools offer a preclinical laboratory exercise. This procedure best illustrates the dilemma caused by these procedures. The schools recognize a widely used method of treatment, but are unwilling to embrace an unproven procedure.

Laminate Veneers

Four of the schools responding do not teach this procedure at all. Where it is taught, it is only mentioned in lecture or in elective courses. No preclinical exercise is required.

Resin-bonded Bridges (Maryland or Rochet)

This is taught in junior or senior lectures, in a senior elective, or in selected cases in the clinic. Again no preclinical experience is offered.

Posterior Composites

The responses from the schools were most guarded on this procedure. All recognized that it is unproven in both laboratory and clinic. Five of the schools do not teach this procedure. The other schools teach it only in lecture, senior elective, or as needed in the clinic.

Although this is a small sample it gives some insight into the way dental schools are attempting to handle new unproved but widely accepted restorative procedures. Sealants and direct-bonded resins seem to have gained greater acceptance than the other procedures, and are taught in lecture, clinic, and preclinical laboratory. The other procedures are in ascending or waning stages of acceptance.

SOLUTION TO THE PROBLEM

As a solution to the problem of introducing new procedures into existing curricula, a three-tier approach is suggested. This would carry a new procedure from familiarization through inclusion in the core curriculum. When a procedure is worthy only of the students' notice, inclusion in the junior or senior lectures is the best approach. This way the lectures can be adjusted without affecting curriculum time.

Once a procedure becomes more respectable from favorable results of tests and is successfully used in dental practice, then it should be more thoroughly taught — lecture, preclinical technique, and clinical experience. It is at this point that a junior or senior elective course in the procedure would be most beneficial. This elective should include both theory and laboratory experience, and should be followed by clinical experience on selected cases. This step would require some commitment of resources but does allow flexibility and is amenable to change when required.

The final step is inclusion in the core curriculum. Each of these stages requires judgment by the faculty, but this last stage would be the most serious and the most disruptive to the curriculum. Curriculum committees of dental schools must be made aware of these problems so the need for time to teach new procedures will be anticipated.

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PRODUCT REPORTS

Maillefer and TMS Pins Compared for Retention and Penetration

Maillefer pins with either a handle for insertion with fingers
or a mandrel for use in a contra-angle handpiece
have been found to be less retentive than TMS pins

J P VAN NIEUWENHUYSEN • J VREVEN

Summary

When Maillefer pins, both those incorporating a handle for insertion with the fingers and those with a mandrel for insertion with a contra-angle handpiece, were compared with TMS pins for retention and penetration into a prepared channel in dentine, the TMS pins were found to be more retentive, and the extent to which all pins completely penetrated the prepared channel varied between 80 and 90%.

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INTRODUCTION

In the past 25 years, the evolution of pins in restorative dentistry has been marked by progress in retention. Retention of pins in dentine has been found to be lowest with cemented pins, intermediate with friction-locked pins, and highest with self-threading pins (Dilts, Welk & Stovall, 1968; Moffa, Razzano & Doyle, 1969; Welk & Dilts, 1969). Consequently, self-threading pins have been widely accepted for use in restorative dentistry.

A few years ago (1974), a pin incorporating a handle for inserting the pin with fingers was introduced by Maillefer (CH-1338 Ballaigues, Switzerland). This consituted the first advance, in the convenience of inserting pins, over TMS pins (Whaledent International, New York, NY 10001, USA), which are inserted with a hand wrench. Another advance has been the use of mechanical means for inserting the pins, namely, the Auto-Klutch contra-angle handpiece (Whaledent) incorporating a 10 to 1 reduction in speed, and pins with mandrels that fit the contra-angle handpiece.

The optimum depth of embedment of pins in dentine has been established at 2 mm for maximum retention and minimum risk of perforating the pulp (Moffa, Razzano & Doyle, 1969). Most investigations to determine the depth of seating of self-shearing pins have shown that shearing occurred before the pin reached full depth (Perez, Schoeneck & Yanahara, 1971; Barkmeier, Frost & Cooley, 1978; Barkmeier & Cooley, 1979; Eames & Solly, 1980; Garman & others, 1980; Currens, Korostoff & Von Fraunhofer, 1980; Schaefer & Reisbick, 1981, 1983; Kelsey, Blankenau & Cavel, 1983; Van Nieuwenhuysen & Vreven, 1985). This lack of complete insertion does not necessarily seem to be a problem if we consider, on the one hand, the stress studies of Standlee, Collard and Caputo (1970; 1971) and, on the other hand, the difficulty in determining the optimum retention of the pin to ensure the longevity of the restoration. However, to resolve this problem of incomplete insertion of the pin, some modifications in the design of self-shearing pins have been proposed (Chan, 1978; Baum, 1978; Butchart & Page, 1983). These modifications should combine superior penetration with increased retention.

The principal advantage of Maillefer pins should reside in the thread of the pin, which acts as a tap thus averting destructive stress within the dentine. The purpose of this laboratory study was to determine the retention and the depth of seating of Maillefer pins with mandrels and pins with handles and to compare them with TMS Regular and Minikin pins. A recent study showed that Whaledent pins, in all sizes, were the most retentive (Eames & Solly, 1980).

MATERIAL AND METHODS

Twenty freshly extracted molars, free of caries, were stored in tap water until used and were kept wet during the entire experiment. The teeth were imbedded in cubes of resin and the crowns removed, with a diamond disk under a constant flow of water, 1 or 2 mm coronally to the cementoenamel junction to produce a flat surface of dentine. Each cube of resin was mounted in a vise during the preparation of the channels and the tests.

Two types of Maillefer self-shearing pin in two diameters (0.5 mm and 0.7 mm) were tested: a pin with a mandrel for use in a contra-angle handpiece and a pin with a handle (Fig 1). The TMS Regular (0.7 mm) and Minikin (0.5 mm) self-shearing pins were used for comparison (Fig 2).

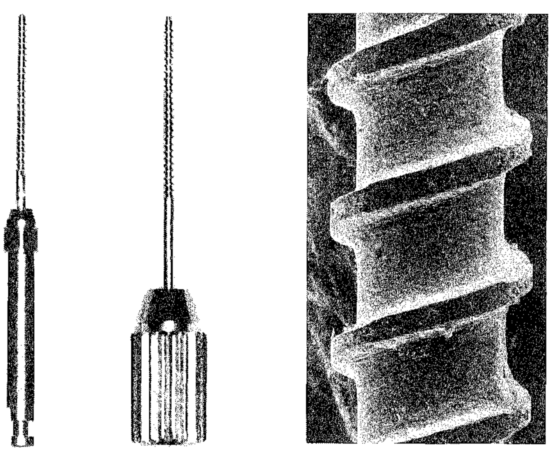

FIG 1. *Maillefer pins:* left, *with mandrel for contra-angle 10 to 1;* center, *with handle;* right, *scanning electron micrograph of threads. X26*

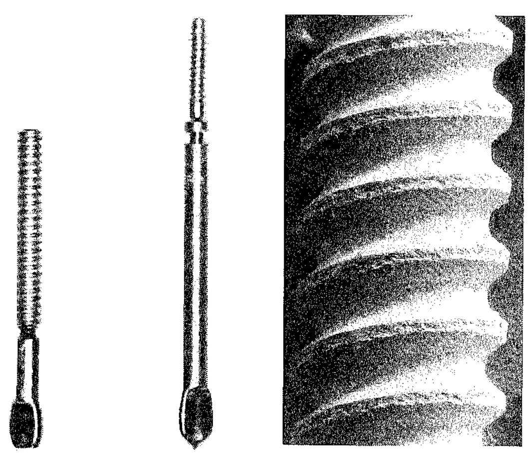

FIG 2. *TMS pins:* left, *Regular;* center, *Minikin;* right, *scanning electron micrograph of threads. X26*

Each tooth received six pins. Starting points, 0.5 mm from the dentinoenamel junction, were made in the dentine of each tooth with a No ½ round bur at slow speed in a contra-angle handpiece. The six channels were located equidistant from each other to ensure the maximum amount of dentine around the pins. The holes were drilled with a self-limiting twist drill of appropriate size as supplied by the manufacturer. The holes were drilled at 90° to the surface of the dentine with a handpiece mounted in a parallelometer (Fig 3). The channels were made with a double-

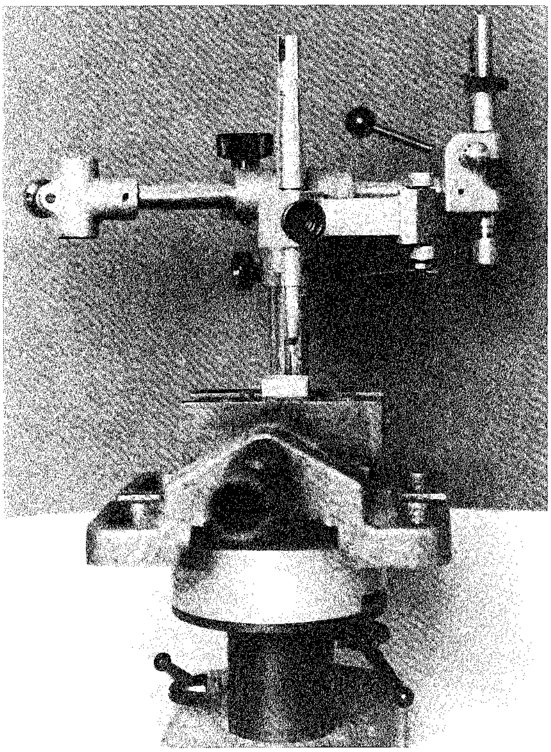

FIG 3. *Parallelometer and handpiece used for the drilling of the holes*

thrust motion, the first thrust being to one-half the length of the cutting tip, the second to fully seat the drill to the shoulder stop. The dentine chips were removed from the hole by a blast of air before the pin was inserted. To avoid dentinal crazing each drill was discarded after drilling 20 holes. The pins were inserted until the scored point sheared.

All channels were drilled and all pins inserted by one investigator. To reduce variability further, this same investigator also measured the twist drills and pins with a vernier caliper measuring to 0.05 mm. The drills were measured from the shoulder stop to the outside edge of the cutting bevel, excluding the length of the bevel. Also measured were the length of the pins with a mandrel and the length of the mandrel portion after shearing, and the length of the pins with a handle and the length of the handle portion after shearing. The length of the protruding part of each pin was measured with a comparator and the depth of the penetration of the pin in the hole was calculated by subtracting this measurement from the length of the pin. The outside diameter of the pins and the diameter of the twist drills were measured with a micrometer and the mismatches between pins and channels were calculated by subtraction.

Each pin was held in a lathe chuck (Fig 4) and subjected to an axial load on a mechanical testing machine at a loading rate of 1 mm min^{-1} (Van Nieuwenhuysen & Vreven, 1983) until complete withdrawal of the pin (Fig 5). The peak load for dislodgment of each pin from dentine was recorded. Twenty tests for each category of pin were performed and the results compared for statistical significance by means of Student's *t* test.

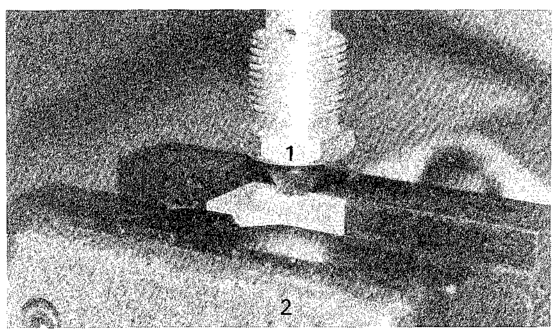

FIG 4. *Tooth embedded in acrylic resin.* 1 - *modified lathe chuck;* 2 - *vise*

Forces Required to Remove Various Stainless Steel Pins from Dentine and Depth of Insertion of Pins

Type of Pin	Technique of Insertion	Force kg Mean ± SD	Depth of Pin in Dentine mm Mean ± SD	Length of Twist Drill mm	Penetration into Prepared Holes % Mean ± SD
TMS Regular self-shearing	Hand wrench	29.14 ± 4.28	1.767 ± 0.255	2.2	80.34 ± 11.62
TMS Minikin	Hand wrench	15.76 ± 3.50	1.608 ± 0.237	1.8	89.33 ± 13.20
Maillefer 0.7	Pin with mandrel	21.22 ± 3.41	2.149 ± 0.224	2.4	89.56 ± 9.36
Maillefer 0.5	Pin with mandrel	11.22 ± 1.37	1.424 ± 0.129	1.6	89.03 ± 8.06
Maillefer 0.7	Pin with handle	16.25 ± 2.32	1.612 ± 0.075	2.0	80.6 ± 3.75
Maillefer 0.5	Pin with handle	10.63 ± 2.00	1.380 ± 0.149	1.6	86.28 ± 9.30

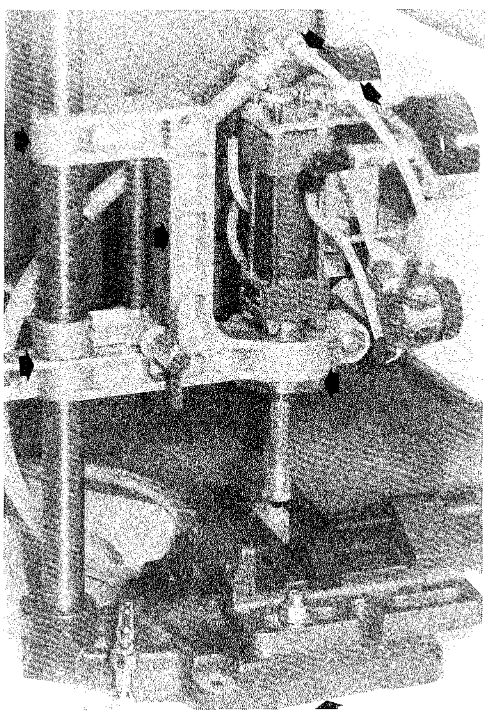

FIG 5. *Testing device for evaluating retention of pin in dentine*

RESULTS

The mean forces required to remove the pins from the channels and the depth of penetration of the pins in dentine are shown in the table.

Retention

For the two diameters of pin (0.7 mm and 0.5 mm), the Whaledent TMS pins demonstrated the greater potential for retention compared with the Maillefer pins. The differences were statistically highly significant ($P \leq 0.001$). No statistically significant difference was found between the smaller diameter Maillefer pin with a mandrel and the Maillefer pin with a handle, ($P = 0.28039$), whereas, on the other hand, the difference in retention between the larger diameter Maillefer pins was statistically highly significant ($P \leq 0.001$).

Depth of Seating

The length of the cutting blade of the different twist drills varied considerably.

No statistically significant difference was found between the depth in dentine of the Maillefer pin with a mandrel and the Maillefer pin with a handle in the smaller diameter ($P = 0.32411$). On the other hand, for the larger diameter (0.7 mm), the difference between the mandrel pin and the handle pin was statistically very highly significant ($P \leq 0.001$).

Mismatch of Pin and Channel

The mismatch of pin and channel calculated for each type of pin was 0.06 mm for TMS Regular self-shearing and TMS Minikin pins; 0.14 mm for Maillefer pins of the larger diameter; and 0.07 mm for the pins of smaller diameter.

DISCUSSION

In testing the quality of the retention of the different pins, it would seem that the mismatch of pin and channel is very important in comparison with the mechanism of shear and the depth of insertion at the moment when shearing occurs. A laboratory analysis of self-shearing retentive pins (Collard & others, 1981) has shown that the degree of retention is increased by a smaller mismatch of pin and channel. Moreover, smaller lateral stresses will be induced and dentinal crazing will be reduced. The TMS Regular self-shearing and Minikin pins present a mismatch of pin and channel more favorable than the Maillefer pins of corresponding diameters. The difference in degree of retention between the Maillefer pins of larger diameter can be explained by the deeper seating achieved by the pin with a mandrel. A large proportion of the pins shear off before reaching the fundus of the hole: this agrees with the observations of most authors on the self-shearing pins. This discrepancy in seating will leave an excessive length of pin projecting from the cavity. For clinical use, it will be sometimes necessary to trim the excess length of pin so that it will be completely embedded in the restorative material.

The mean percentage of penetration achieved by the TMS Regular self-shearing pins (80.34% ± 11.615) inserted with a hand wrench is in agreement with the results of Barkmeier and Cooley (1979) in their laboratory evaluation of penetration before shearing of the same kind of pin but inserted with an Auto-Klutch handpiece (81.75% ± 18.42). It is also in agreement with the study of Newitter and Schlissel (1980) who have shown that neither the retention of self-threading pins nor their depth of insertion were affected by the means used to insert the pins. The dentist must be aware of the possibility of a lack of standardization between the pin and the twist drill of the Maillefer system. Another problem is the fragility of the twist drill (0.5 mm) for the Maillefer pins. On the other hand, in this laboratory study, the shearing point of the Maillefer pins is very constant. In clinical use, however, this is not always true.

For the clinical application of the results, the problem is that the mechanical properties of the dentine might be slightly modified by the cariologic process and thus might not be favorable for activating the self-shearing mechanism of the Maillefer pins and, for the most part, of the self-aligning pins. It is also difficult to establish that the best pin is necessarily the most retentive, as we have no notion of the optimal retention needed to ensure the durability of the restoration in the oral cavity. The facility of manipulation and the security of use of self-shearing pins with mandrels recommend them.

CONCLUSIONS

For the two diameters of pin the better retention is achieved by the TMS pins. For all the pins, the mean percentages of penetration of pins into channels before shearing varied between 80 and 90%.

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Pulp Capping with a New Visible-Light-Curing Calcium Hydroxide Composition (Prisma VLC Dycal)

HAROLD R STANLEY • CORNELIS H PAMEIJER

Summary

The visible-light-curing calcium hydroxide product (Prisma VLC Dycal) has the potential of inducing a dentinal bridge over a pulp exposure without creating the chemical cautery (mummification) that occurs with most calcium hydroxide products. Sixty-three class 5 cavities were prepared in three *Cynomolgus fascicularis* monkeys. The cavities were deepened until an exposure occurred as evidenced by the presence of blood. The exposures were capped with the VLC calcium hydroxide and then restored with amalgam or composite resin. After sacrifice at 4, 62, and 64 days the tissues were processed for routine histological evaluation. Pulpal response after four days was essentially uneventful. No chemical mummification was found. In the long-term specimens, dentinal bridge formation was graded excellent to good in all the specimens but one. Reactions of significance were related to the embolization and impaction of particles of calcium hydroxide or to the lifting of the capping agent.

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INTRODUCTION

During the last 200 years there have been many changes in the rationale governing the treatment of exposed dental pulps. Many schools of thought have arisen to prominence only to be cast aside as newer and more promising methods were suggested (Berman, 1958; Stanley, 1985).

Hermann's (1930) introduction of calcium hydroxide started a new epoch in the treatment of the dental pulp (Kalnins, 1957). Hermann demonstrated that a living pulp amputated and covered with a calcium mixture called Calxyl would repair itself by bridging across the cut surfaces of the pulp with reparative dentin beneath the capping agent. Since that time, mixtures of calcium hydroxide have been used with much success not only in capping pulps, but also in pulpotomies, amputations, and apexifications (Coolidge, 1960). Calcium hydroxide also serves as a protective barrier for pulp tissue not only by blocking patent dentinal tubules but also by neutralizing the attack of inorganic acids and leached products from certain cements and restorative materials.

With some of the new hard-setting formulations, bridging at the calcium hydroxide/pulp interface without inducing a visible intermediate necrotic layer has been reported, indicating an initial chemical injury less extensive than that produced by calcium hydroxide and water. These differences in tissue response to various cements containing calcium hydroxide are related to such factors as lower pH and varying rates of release of hydroxyl and calcium ions. The release of calcium hydroxide will depend on the composition of the material and its solubility in water (Schröder, 1985). However, this is not a consistent finding, and the presence of a very minimal necrotic zone was reported with one of the newer calcium hydroxide agents, Life (Kerr Division of Sybron Corp, Romulus, MI 48174, USA) (Jerell, Courts & Stanley, 1984).

A correlation between the inflammatory response and the barrier formation has been noted: the slighter the inflammation, the higher the frequency of bridging. This indicates that less tissue damage is occurring with the newer formulas compared with that caused by calcium hydroxide and water, but that sufficient irritation occurs, nevertheless, to stimulate healing of the pulp wound.

Based on our current knowledge, it may be concluded that there must be a certain degree of stimulation to induce deposition of minerals in a barrier, at least in human pulp tissue. A firm necrosis exerts such a stimulatory action by attracting minerals from the tissue fluids (Schröder, 1985).

The formula of each brand has been varied to improve its ease of manipulation and application and to provide certain biologic and therapeutic benefits. A clinician's preference is determined by his degree of apparent clinical success with the various brands. It should be remembered, however, that microbial contamination, dentin debris, lack of proper peripheral seal, and the operator's inability to perform the proper surgical procedure, rather than the inadequacy of the medicament employed, can lead to failure in a procedure on vital pulp. A great effort is being made to find a formula that will stimulate the formation of reparative dentin without sacrificing any of the remaining pulp tissue by chemical cauterization as occurs with most calcium hydroxide products.

The object of the present study is to evaluate a new calcium hydroxide pulp-capping material cured with visible light, Prisma VLC Dycal (L D Caulk Co, Milford, DE 19963, USA).

The main clinical advantage for using a photoactivated product is the control the clinician has over the working time. Products activated with visible light usually contain diketone initiators such as camphoroquinone and a reducing agent such as a tertiary amine. The controlled irradiation by the visible light produces ion radicals that initiate polymerization (Phillips, 1982; American Dental Association, 1985). The camphoroquinone initiator is activated by wavelengths of light in the range of 400-500 nm (the blue region of the visible spectrum).

MATERIAL AND METHODS

Prisma VCL Dycal consists of calcium hydroxide and fillers of barium sulfate dispersed in a specially formulated urethane dimethacrylate resin containing initiators and accelerators activated by visible light. The material polymerizes on exposure to any typical dental unit used for curing with visible light. This composition favorably passed all the recommended initial and secondary tests for biocompatibility.

Table 1 compares the physical properties of Prisma VLC Dycal with Advanced Formula II Dycal (L D Caulk Co). Some of the advantages of this new product include dramatically improved strength, essentially no solubility in acid, and minimal solubility in water. Resistance to dissolution by acid during etching procedures is a great improvement. Additionally, since this product is a one-component, light-cured mate-

Table 1. Physical Properties of Prisma VLC Dycal and Advanced Formula II Dycal

Property	Prisma VLC Dycal	Advanced Formula II Dycal
Solubility		
Phosphoric acid 35% for 60 s	$< 0.18\%$	2.0–2.5%
Water for 24 h	$< 0.5\%$	1–2%
Compressive strength	12 000–15 000 lbf in^{-2} (83–104 MPa)	3700–4700 lbf in^{-2} (26–32 MPa)
pH at 24 h	9–10	9–10
Depth of cure - 20 s	1 mm	—
Radiopaque	yes	yes

rial, no mixing is necessary. Also, the material sets on command with the use of the visible-light-curing unit. Therefore, the setting and working times are not sensitive to humidity or moisture, and the material develops its maximum physical properties almost immediately. The fact that this material is based on polymeric resins allows for intimate bonding between the base material and the overlaying polymerizable restorative material, producing a more uniform, stronger restoration.

Three male monkeys *(Cynomolgus fascicularis)* weighing approximately 4 kg were used. The animals were anesthetized by means of Ketamine and Acepromazine (80 ml Ketamine + 0.35 ml Acepromazine per 3.17 kg body weight), and atropine (1 ml per 9.07 kg body weight) was injected intramuscularly to control salivary secretion. Approximately 4-5 days prior to the experiment all teeth were scaled and given a prophylaxis.

A total of 63 class 5 cavities were prepared in incisors, premolars, and molars. The cavities were prepared with a high-speed turbine handpiece at 250 000-300 000 rev min^{-1} with abundant air-water spray. The cavity outline was established with a 330 carbide bur and finished with a 33 inverted cone. The cavity was placed in the cervical area of the tooth and extended wherever possible to both approximal areas. After preparation, the cavities were washed and then dried with a short blast of air at room temperature. Gradual deepening of the cavity in its center with a 2 round bur created an exposure ranging from 0.1 to 0.5 mm in size. In all instances, however, the presence of blood was established as an indication that a true exposure had been made. Sixty-three teeth received the calcium hydroxide cured by visible light (Prisma VLC Dycal). Care was exercised to prevent the protective agent from impacting upon the pulp tissue in the exposure site during application of the material. The Prisma VLC Dycal was cured for 20-30 seconds. The enamel of the teeth was then etched with 50% phosphoric acid for 60 seconds. After washing with copious amounts of water for 30 seconds the cavities were dried and further treated by means of a bonding agent, Prisma Bond (L D Caulk Co), and a visible-light-cured composite resin, Prisma-Fil, light shade (L D Caulk Co); or the cavity was painted with a cavity varnish, Cavaline (L D Caulk Co), and restored with amalgam, Valiant (L D Caulk Co).

Period of Evaluation

The three primates were sacrificed at 4, 62, and 64 days. In view of the material investigated, the decision was made to study two animals for the long term and to forgo the intermediate interval of time. Prior to sacrifice all restorations were clinically examined and deficiencies noted. Each quadrant was photographed and recorded on Kodachrome film. Sacrifice was carried out with T-61 (0.3 ml kg^{-1}) after initial anesthesia with Ketamine, following which the mandible and maxilla were cleaned from soft tissues and removed from the head with a Stryker saw. With a high-speed 331 carbide bur the pulp was exposed by cutting a groove through the cortical bone and root at one-third the apical height, thus promoting better fixation of pulpal tissues. Fixation was carried out in 10% buffered formalin for seven days. All samples were then demineralized in 5% formic acid and processed for standard histologic evaluation. Sections were stained with hematoxylin and eosin for general cellular evaluation, with adjacent sections being stained according to the Brown and Brenn method for recognition of bacteria. The severity of the responses were evaluated according to criteria specified by Document No 41 of the American National Standards Institute/American Dental Association (1979).

The following histopathologic features were recorded:

a. Firm necrosis (mummifications) (+,—)
b. Dentinal chips (+,—)
c. Congestion (0–3°)
d. Hemorrhage (+,—)
e. Cellular response and displacement (0–3°)
f. Quality of bridge (barriers)
   0 – no bridge or matrix
   Good – a bridge, but porous and irregular
   Excellent – a solid, intact, relatively non-porous bridge
g. A double bridge – due to embedding of dentinal chips or deep impact of $Ca(OH)_2$ (+,—)
h. Impaction or embolization of $Ca(OH)_2$ particles
i. Phagocytosis of $Ca(OH)_2$ particles
j. Matrix growing out into the prepared cavity, either due to lifting of capping agent or organization of a protruding excessive blood clot.

RESULTS

Microscopic Findings

Of the 63 teeth clinically exposed, 14 were eliminated because, microscopically, an exposure site was not revealed in the serial sections. One tooth was obviously nonvital prior to instrumentation and the others were lost due to technical difficulties. Because no differences were seen between the categories restored with the composite resin and the amalgam restorations, the data from the histological evaluations were combined.

At the four-day postoperative interval, of 16 specimens with exposures 12 revealed no inflammatory cellular reaction, four showed a minimal cellular inflammatory response of 1° or less, two showed an increased vascularity, one of which demonstrated focal hemorrhage. No bridges were found at this time interval, as expected, and no evidence of chemical cautery (mummification or firm necrosis) was observed (Fig 1a,b). Dentinal chips were observed in seven specimens.

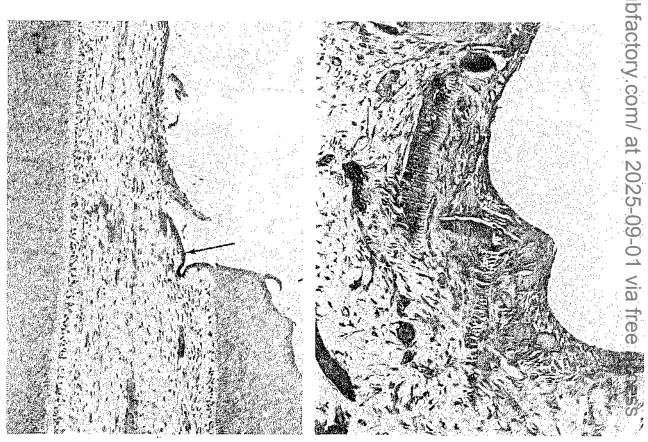


FIG 1a *Some disruption of pulp tissue at the calcium hydroxide/pulp interface, but no evidence of coagulation necrosis. A thin sliver of predentin left at apical margin (arrow). X60 (4 d—Prisma VLC Dycal 20 s; etched, Prisma Bond & Prisma-Fil)*

b *Three dental chips impacted into deeper pulp tissue but no coagulation necrosis. Little cellular response but dilated and congested vessels about chips. X75 (4 d—Prisma VLC Dycal 30 s; Cavaline & Valiant)*

At the 62- and 64-day postoperative intervals, of 33 specimens 20 presented a bridge graded as excellent (Fig 2a,b), 10 graded as good, two as porous (Fig 3a), and one with no observable attempt at bridging. This specimen revealed a large chunk of calcium hydroxide impacted deep into the pulp tissue (Fig 3b,c). Of the two specimens with porous bridges, one revealed a bridge extending out into the prepared cavity and the other revealed a very small exposure so that the calcium hydroxide was generally unable to induce its healing effect.

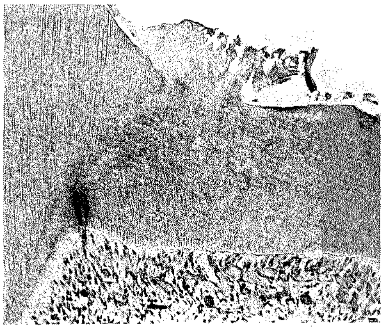


FIG 2.a *An excellent bridge, showing maturation of odontoblastic layer now producing tubular dentin. Earlier formed matrix has inclusions and some matrix around clusters of calcium hydroxide. X41 (64 d—Prisma VLC Dycal 20 s; etched, Prisma Bond & Prisma-Fil)*

b *An excellent bridge with a completely regenerated odontoblastic layer now producing tubular dentin. X82 (64 d—Prisma VLC Dycal 20 s; etched, Prisma Bond & Prisma-Fil)*

No inflammatory cell responses were recorded in 18 of 33 specimens. Fifteen specimens demonstrated some degree of response, 10 of which exceeded 1°. Of these 10, four were related to the impaction of particles of calcium hydroxide into the pulp tissue, two to the extension of the bridges out into the prepared cavity (Figs 4; 5a,b; 6a,b), and one was

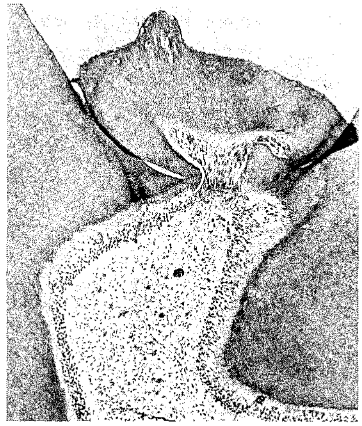
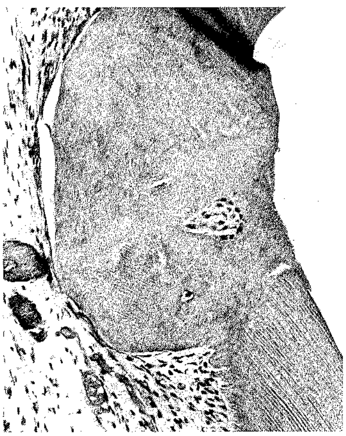


FIG 4. *An excellent bridge, but completely above the level of exposure, projecting into the prepared cavity but already producing tubular dentin. X50*



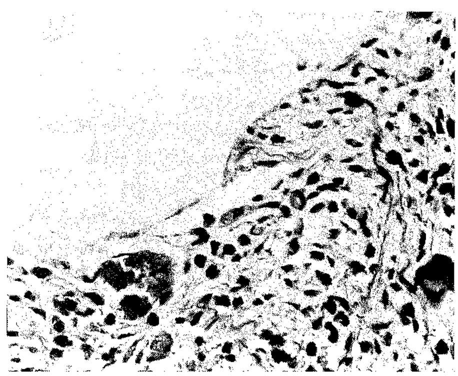


FIG 3. a *An excellent bridge with multiple chips incorporated within it. Also an island of soft tissue (cellular inclusion). X100 (62 d—Prisma VLC Dycal 20 s; etched, Prisma Bond & Prisma-Fil)*

b *No attempt at bridge formation. A 2° chronic response. A large chunk of calcium hydroxide impacted deep into pulp tissue below level of exposure. X100 (64 d—Prisma VLC Dycal 20 s; Cavaline & Valiant)*

c *A higher magnification of Fig 3b showing the complete lack of matrix formation in the presence of a moderate chronic inflammatory cell infiltrate. The spent calcium hydroxide, having lost its generating power, now acts as a chronic irritant. X240*

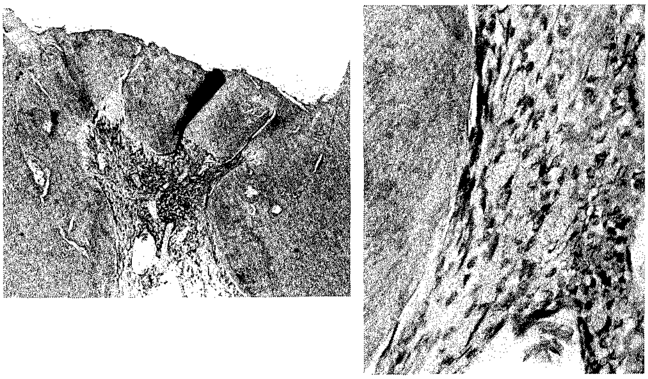


FIG 5. a *A massive bridge protruding into the prepared cavity, showing intense chronic infiltrate around emboli of calcium hydroxide in numerous blood vessels deep to proper level of calcium hydroxide/pulp interface. X40 (64 d—Prisma VLC Dycal 20 s; etched, Prisma Bond & Prisma-Fil)*

b *A higher magnification of Fig 5a, revealing deep penetration of granules of calcium hydroxide far removed from appropriate surface. X192*

related to a large focus of entrapped hemorrhage (Fig 7a).

The incorporation of dental chips into the bridges was a common finding (eight specimens); a few pulp stones (Fig 6a,b) appeared to be initiated by the deep impaction of particles of calcium hydroxide. A multinucleated giant cell reaction occurred in the specimen with entrapped hemorrhage (Fig 7b). Hemorrhage, dilatation, and congestion were minor features, however, being mentioned in only three of the 33 specimens. Table 2 summarizes the histopathological findings.

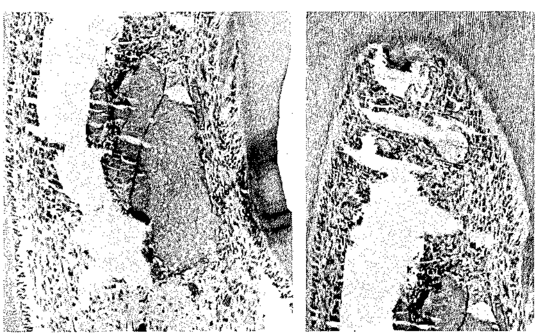


FIG 7. a *A good bridge with chips incorporated but with hemorrhage entrapped beneath and a 2° chronic inflammatory response. X80 (64 d—Prisma VLC Dycal 20 s; Cavaline & Valiant)*

b *A more coronal view of Fig 7a just above the entrapped hemorrhage where the chronic cellular infiltrate is widespread and a multinucleated giant cell is seen. X192*

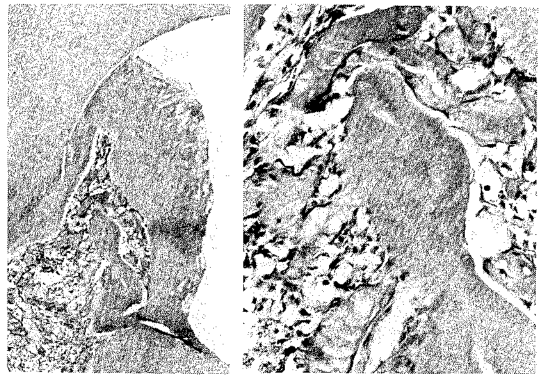


FIG 6. a *A massive bridge protruding into the prepared cavity. A 2° response. Pulp stones formed from particles of calcium hydroxide. Macrophages in deeper layer containing spent particles of calcium hydroxide. Extreme dilatation and congestion. X80 (64 d—Prisma VLC Dycal 20 s; etched, Prisma Bond & Prisma-Fil)*

b *A higher magnification of Fig 6a demonstrating the original implanted foci of particles of calcium hydroxide that generated pulp-stone-like formations. X160*

DISCUSSION

Regular Dycal, as described in the literature review (Stanley & Lundy, 1972), caused a thickness of mummification (chemical cautery) of 0.3–0.7 mm following application. No evidence of mummification occurred with Prisma VLC Dycal. There is evidence that a calcium hydroxide formula with a lower pH, with decreased solubility, and reduced capacity for concentrating hydroxyl ions may have a positive effect on the living tissue by preventing overt denaturization of pulp protein in adjacent viable cells and by increasing the alkaline phosphatase activity, which is highest at pH 10.2 (Gordon, Ranly & Boyan, 1985).

Inflammation was of no consequence unless something occurred clinically that was unexpected or not properly accomplished (usually not observed or appreciated clinically) such as

Table 2. Histopathological Findings

Number of Specimens	Firm Necrosis (Mummification) +/−	Inflammatory Cellular Response (0–3°)	Bridge Formation +/−	Dentinal Chips +/−	Hemorrhage +/−	Dilatation and Congestion +/−
Time Interval — 4 days						
16	0	4(0.5–1°)	0	7	1	2
Time Interval — 62 and 64 days						
33	0	15 (10 exceeded 1°)	32 (20 excellent 10 good 2 porous)	8 (all incorporated in bridge)	1 (severe)	2

deep impaction of particles of calcium hydroxide or dentinal chips or lifting of the capping agent.

Features that are elicited because of technical difficulties are double bridges (Fig 8) where dentinal chips are forced into the deeper pulp tissue and stimulate a deeper aborted bridge, lifting of the capping agent due to intrapulpal edema, which permits serum to get into the prepared cavity, and a conversion of the excessive blood clot into organizing connective tissue (Fig 4 & 5a). These features can occur with any calcium hydroxide product and have been seen in other studies. To minimize the possibility of these events happening will require diligence on the part of the clinician to prevent the bayonetting of chips into the pulp and to make certain that the capping agent cannot be pushed out of the pulp.

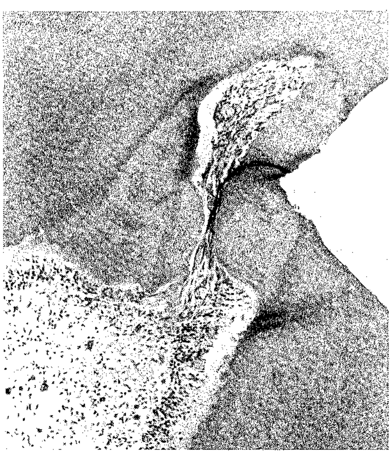


FIG 8. *Dentinal chip deep in pulp, causing formation of a deeper second bridge. The two bridges could eventually join and curtail blood supply. X68 (64 d—Prisma VLC Dycal 20 s; Cavaline & Valiant)*

Because the working time of Prisma VLC Dycal is controlled by the clinician, several of the technical problems resulting from improper application described above can be minimized.

Histopathologically, other than the absence of firm necrosis, the calcium hydroxide product cured by visible light maintains all the characteristics of healing and bridge formation equivalent to the original Dycal. In conclusion, it can be stated that this formula (Prisma VLC Dycal) has met acceptable biocompatibility standards in nonhuman primates.

Acknowledgment

The authors wish to acknowledge the assistance of Dr R Gilpatrick during the clinical phase of this project.

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DEPARTMENTS

Letters

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

I have more than a few quibbles with Robert R Murray's article in the Spring 1985 journal.

Covering all shiny dentin on the cavity floor with calcium hydroxide may be "traditional," as the author asserts, but it is an unwarranted practice unsupported by the literature. No useful purpose is served by an underbase of this type, unless the excavation is so deep as to make a microscopic, subclinical pulp exposure likely. Many teeth with a past history of deep amalgams may require no base at all; their relatively thick layer of secondary dentin provides adequate thermal insulation to the pulp (Going, 1984). Farah, Hood and Craig (1975) demonstrated that a weak base such as calcium hydroxide or unfilled ZOE compounds may jeopardize the strength of the amalgam restoration. A thin layer of calcium hydroxide is not thermally protective (Phillips, 1973). In fact, calcium hydroxide has little to recommend it as a base material except that it is the most reliable pulp-capping medicament available.

Perhaps Dr Murray feels the need for an extensive application of calcium hydroxide because of his use of zinc phosphate cement as a base. Zinc phosphate is acidic and for at least 30 years has been shown to be pulpally irritating. Why would anyone, in this exciting age of polymers, still want to use this old-fashioned material?

There are two excellent polymeric cements available for basing which are adherent to dentin, obviating all need for mechanical retention. One is polycarboxylate which, although acidic, is nonirritating to the pulp due to its large molecular size (Eames, Hendrix & Mohler, 1979). The new fast-set glass ionomers (e.g., Ketac-Bond, Premier Dental Products Co, 1710 Romano Dr, Norristown, PA 19404, USA) not only provide excellent adhesion and high strength, but also, by high concentrations of leachable fluoride ion, inhibit recurrent decay.

Were Dr Murray to use either of these adhesive base materials, his plethora of self-threading pins into sound dentin would be largely eliminated. The practice of placing two pins per missing cusp had, I thought, gone out with the 1960s!

With an adherent base, retentive 33½ slots, and a **maximum** of two pins placed diagonally across the cavity floor, an operator may restore any vital posterior tooth with amalgam, no matter how few cusps are left. Just why the author believes such a proliferation of pins is necessary is a mystery to this clinician!

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EAMES, W B, HENDRIX, K & MOHLER, H C (1979) Pulpal response in rhesus monkeys to cementation agents and cleaners *Journal of the American Dental Association* **98** 40–45.

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AUTHOR'S REPLY

Dr Henry's statement, "In fact, calcium hydroxide has little to recommend it as a base material except that it is the most reliable pulp-capping medicament available," seems to say it all. Whereas I concede to the good indications of the glass ionomers, there are increased indications and reports of unfavorable pulpal sensitivities.

Having treated literally hundreds of teeth by these procedures — teeth with their pulps insulted by the trauma of open caries or by deep portions of the tooth having fractured away — it is rewarding to me to observe a relatively low incidence of pulpal pathosis requiring root canal therapy. And these are often, if not usually, teeth that, in recent years past, would have been extracted.

I would hope that Dr Henry would not confuse the use of 0.013 pins to retain the base materials and then pins to provide additional retention for the amalgam as being "two pins for each missing cusp." That concept is neither expressed nor implied.

The journals are full of "exciting" new dental products that have proven themselves "on the bench." But the true testing grounds are in the human mouth. We are witnessing all sorts of claims by manufacturers and their fieldmen who keep the bandwagons parading by. Many lecturers are enjoying the tide of popularity as the dentists flock in for the great cure-all to save them from the tedium of properly placed amalgams, onlays, and the rarest of them all, gold foil.

I prefer to learn dentistry from dentists, not from salesmen, and I'll sit here on the bench of proven procedures and materials with the "old timers" and let the excitement pass me by.

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

I have just received my latest copy of *Operative Dentistry* (Spring 1985) and of course turned first to your editorial. You are quite right — there is a serious dearth of articles with obvious relevance to clinical practice. I agree with your rationalization of the reasons for this lack and you are probably correct when you suggest that practitioners "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." Your final sentence is a clarion call to every one of us — "there is no easy way, practitioners must think!"

Ready to do battle, I turned the page to the first article, "Marginal Seal of a Composite Resin, Clearfil: A Laboratory Study," with keen anticipation, as it is an area of considerable interest to me. When I found the glass-ionomer cements were involved in the study, I was even more interested. However, by the second page I was beginning to suffer indigestion and having read the entire article, it took me several days to get my mental digestion sufficiently reorganized to write logically to you. "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." This article is not a new discovery and neither is it relevant. It performs a tremendous disservice to a material which is battling for survival and it gives an unwarranted boost to a material which has a very limited place in clinical practice.

My criticism begins with the fact that the cavities on the extracted teeth were prepared entirely in enamel. It is a well-known fact that composite resins will attach adequately to enamel following etching, at least for the time being. It is also a well-known fact that not all cavity margins are in enamel and in fact in the average class 5 cavity 50% or more of the margin is normally in dentine. Therein lies the clinical problem which is not addressed by this article.

There is a serious lack of description in the method of handling of both the Clearfil and the Chemfil and it is not clear whether it was the original Chemfil that was used or Chemfil II which was used in this case. The difference is material.

There is a complete lack of description of how the Chemfil was handled. There is not even a notation to the effect that the manufacturer's directions were followed. It is well known to those who read the literature that the manufacturers' directions are inadequate, but there have been instructions published in your own journal to assist the practitioner in obtaining adequate results. Assuming the results as published are an adequate reflection of the experiment, it is obvious that the glass-ionomer cement was not adequately sealed at the time of placement to give it the opportunity to mature and develop its adhesion.

One is forced to wonder about the authors' knowledge and understanding of the material they are using when the latest article they can refer to is dated 1978. Certainly there is not a wealth of material available on the glass-ionomer cements, but this is at least in part because of articles like this which denigrate the material quite unjustifiably.

The length of time involved in this experiment is quite irrelevant. I am far more interested in the results at 90 weeks or 90 months rather than 90 days, and there is accumulating evidence now which suggests that the adhesion of the resins, particularly to dentine, is very much at risk over time.

The big difference between the written article and the presented lecture complete with colored slides and 10 projectors is that one is entirely transitory and caters to the mood of the day, while the other is there written indelibly for the rest of history. This means that journals have a heavy responsibility to ensure that there is at least a modicum of validity in the articles they publish. Such an article as this has done no good for Clearfil, has denigrated a perfectly sound material (Chemfil), and sullied the reputation of an otherwise excellent journal.

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AUTHOR'S REPLY

First of all I would like to thank Dr Mount, whom I hold in high esteem, for his comments. I am well aware of his interests in glass ionomers, and I use his paper (Mount, 1981) both for teaching dental students on the subject and in seminar presentations to practicing dentists. It should, however, be obvious from our paper that upset Dr Mount so much that Chemfil was used as a basis of comparison because it is known to perform well, and not because of any intention on our part to "denigrate" it. We believe that both our experimental procedures and our materials were described clearly in our paper — and our conclusions certainly refer to specific types of cavity and specific periods of time. The clinical problem of class 5 cavities that reach the dentine is certainly an important one and it must be dealt with in future research.

If Chemfil II had been used it would have been mentioned in our paper, and the same holds true for any deviations from the procedures of application suggested by the respective manufacturers. If the composite resin or the glass ionomer perform differently under different circumstances and after 90 weeks or even 90 months in various types of cavity, this is, in our view, something that can be shown by long-term clinical studies, which reveal, quite often, different behavior of the materials studied. We assure Dr Mount that we would be most happy if such studies concerning these and other materials were published in the best interests of dental practice and regardless of the battle of survival of this or the other product.

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MOUNT, G J (1981) Restoration with glass-ionomer cement: requirements for success *Operative Dentistry* **6** 59–65.

Approximal Retentive Grooves in Cavities Prepared for Amalgam: A Historical and Current Assessment

Recently, we read Dr James Childers' paper (*Operative Dentistry,* Summer 1985). The cited in vitro works of Mondelli and others (1974) and Crockett and others (1975) were repetitious of our earlier in vitro research in which we, too, found that the proximal portions of two-surface silver amalgam restorations placed in preparations with proximal retention grooves and subjected to isthmus loading showed the highest loads before angular fractures that left part of the restoration locked in position. However, our in vivo research proved that the additional resistance to fracture demonstrated in laboratory tests is not necessary to prevent fracture of the proximal portion of the restoration as long as modern alloys are used in properly designed cavities. Proximal retention grooves should not be used to compensate for poorly prepared cavities.

Despite the work of Mondelli and others (1974) and Crockett and others (1975) and the opinions of superb clinicians like Miles Markley, there has yet to be published any findings based on **clinical** research data that refute our conclusion about proximal retention grooves in standard class 2 cavities prepared for silver amalgam.

We believe that cavity preparations should be as conservative as possible **inside** as well as **outside**, and until clinical research findings prove otherwise, the use of proximal retention grooves clearly is not justified on any substantive basis. We have many years of clinical evidence to support our conclusion about proximal retention grooves.

Unfortunately, Dr Childers' paper offered the readers a choice between using proximal retention grooves and not using them, with the choice to be based on the published works that he cited. This implies that the cited publications are equally substantive. How can this be true when only our papers provide the **clinical** data necessary for making such a choice?

If the survey of North American dental schools mentioned by Dr Childers is correct, it is surprising to us that many schools still advocate the use of proximal retention grooves despite the clinical evidence to the contrary.

Between Dr Childers' conclusion and the results of the school survey, it is no wonder that empiricism in clinical dentistry still reigns supreme!

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CROCKETT, W D, SHEPARD, F E, MOON, P C & CREAL, A F (1975) The influence of proximal retention grooves on the retention and resistance of Class II preparations for amalgams *Journal of the American Dental Association* **91** 1053–1056.

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AUTHOR'S REPLY

The response of Drs Terkla and Mahler to my literature review regarding approximal retentive grooves in cavities prepared for dental amalgam provides an opportunity for me to declare publicly that I am in complete accord with the conclusion resulting from their clinical research. Personally, I do not favor the inclusion of retentive grooves in the standard class 2 cavity for dental amalgam and do not feel that this feature should be taught universally.

Since my article was a review of literature, I felt that it was more appropriate for me to present the various opinions and studies as objectively as possible, and allow the individual reader to make his or her own assessment. I did not feel it appropriate to possibly bias the article with my personal opinions, which would have been empirical in themselves, having resulted only from my years in practice and teaching.

As reported in the article, 51 dental schools currently teach the inclusion of retentive grooves. This would seem, as Terkla and Mahler point out, to be in contradiction to the observations obtained in their clinical studies. This would seem to substantiate at least two facts. One fact is that there are those who feel that results of laboratory tests are conclusive, and who will not desert those results when clinical testing supports a different conclusion. The other fact is that philosophical consensus is often arrived at by "hard instinct." Empirical statements can be made by revered individuals, accepted by impressionable enthusiasts, and sometimes converted into teaching principles.

In conclusion, I am reminded, and I think we should all be reminded, of the motto for the *Clinical Research Associates Newsletter:* "Clinical Success Is the Final Test."

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Book Reviews

THE STOMATOGNATHIC SYSTEM: FUNCTION, DYSFUNCTION AND REHABILITATION

Franco Mongini, MD, DDS, FICD

Published by Quintessence Publishing Co, Inc, Chicago, 1985. 375 pages, indexed. $68.00

The author's qualifications are already known to those who have read his earlier articles and lectures: Seven on condylar remodeling in relation to occlusion, two on TMJ radiography, two on pantographic tracing of the TMJ, and three on therapeutic positioning of the condyle, all of which are cited in his book.

The author's purposes are revealed in his introduction: (1) to describe the function and dysfunction of the stomatognathic system as interactions between its three components — the temporomandibular joint, the masticatory muscles, and the dental-periodontal complex; (2) to show how proper treatment for this system depends on the initial status of these three components and on a knowledge of the methods and techniques used to restore correct function and form.

Both the author and publisher have made this book a model for quality. It is instantly recognizable as a Quintessence product by its glossy paper, clean, strong type, and the high resolution and full-tone scale of its photographs, which include beautiful intraoral pictures in color. On these pages the author has written a chapter for each of the following topics:

Part I: Function and Dysfunction
- The Articular Heads of the Temporomandibular Joint (57 references)
- The Articular Disc (32 references)
- The Temporomandibular Joint as a Load-Bearing Joint (39 references)
- The Neuro-Muscular Factor (161 references)
- The Movements of the Mandible (59 references)
- The Occlusal Factor (27 references)
- Dysfunction of the Stomatognathic System (27 references)

Part II: Diagnosis
- Mandibular Position in ICP (2 references)
- Examination of the Patient (24 references)
- Radiographic Examination of the TMJ (48 references)
- Registration Techniques (14 references)
- The Final Diagnosis (no references)

Part III: Rehabilitation
- Treatment Planning (no references)
- Temporary Occlusal Treatment (4 references)
- Definitive Occlusal Therapy: Orthodontic Treatment (3 references)
- Definitive Occlusal Treatment: Selective Grinding (no references)
- Definitive Occlusal Therapy: Prosthodontic Treatment (no references)
- Occlusal and Articular Surgery (7 references)
- Collateral Treatment: Biofeedback Therapy (27 references)
- Other Types of Collateral Treatment (18 references)
- Clinical Examples (no references)

These chapters are concise distillations of relevant research findings and specific clinical procedures for diagnosis and treatment. The book is a well-organized, very readable compilation of useful, important information. It meets the needs of dentists for an integrated approach to occlusal dysfunction and therapy. The final chapter (41 pages) provides clinical examples of how the author has used his approach to the diagnosis and treatment of five patients ranging in age from 13 to 43 years.

The author is a disciplined writer and thinker who chooses his anatomical terms carefully and has a correct understanding of remodeling and degeneration. However, several of the people cited or acknowledged will hope to see their names spelled consistently and correctly in the next edition. The book's subtitle might deliver the author's message more effectively if it were Form, Function, Dyscrasia, and Rehabilitation. You will be glad to have this work in your library.

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OPERATIVE DENTISTRY: MODERN THEORY AND PRACTICE

M A Marzouk, A L Simonton, and R D Gross

Published by Ishiyaku EuroAmerica, Inc, St Louis, 1985. 477 pages, 842 illustrations, indexed, softcover. $47.50

Dr Marzouk initiated this fine textbook at the urging of his former students. His extensive clinical knowledge, and that of Drs Simonton and Gross, is at once apparent. While basic procedures, terminology, instruments, and materials are well presented, the authors also offer detailed insight into virtually every clinical challenge in operative dentistry. The 28th and final chapter is entitled "Principles for Restoration of Badly Broken Down Teeth" and includes information regarding minor tooth movement and root extrusion. This progression from introductory principles to their application in complex situations beautifully achieves the authors' goal.

The book is instructional as well as informative and is generally written in a manual/syllabus format, containing numerous lists and sublists. Some readers will not be comfortable with this style. Comparatively little space is devoted to background information in preventive dentistry, dental caries, biology, and basic sciences. Accordingly, the book is primarily clinical in nature and in that regard may well be the most exhaustive publication in the field. The chapter on dental amalgams contains eight designs for class 1 cavities prepared for amalgam. Five designs for class 3 cavities for direct tooth-colored materials are offered and 17 potential restorative problems are addressed for badly broken teeth that have been periodontally treated.

The scanning electron micrographs are impressive, but like many of the 842 detailed illustrations, are not self-explanatory. Consequently, the reader must refer to the narrative for elaboration. Among the many highlights of this book is the contribution by Dr A H El-Kafrawy. His discussions of the pulp, dentin, and periodontium are outstanding.

This textbook should be of much value to the teacher as a ready reference, particularly for the specifics of cavity preparations. Students will find it an excellent resource both initially and later, as they meet more challenging clinical situations.

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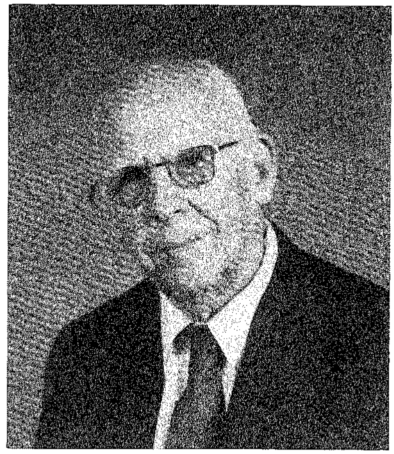
Wit and Wisdom

No passion in the world is equal to the passion to alter someone else's draft.

H G WELLS

Announcements

Ralph Boelsche Honored by Baylor College of Dentistry



Ralph A Boelsche, secretary-treasurer of the American Academy of Gold Foil Operators, was inducted into the Hall of Fame of Baylor College of Dentistry on 18 October 1985 at the annual Homecoming Banquet. Induction into the Hall of Fame recognizes the inductee's "outstanding services and devotion to the Science and Art of Dentistry at Baylor College of Dentistry." Ralph Boelsche has maintained a lifelong interest in furthering professional education — not only in clinical dentistry but in dental research. His enthusiastic study and research with Bernhard Gottlieb at Baylor College of Dentistry during the 1940s is reflected in his endowment of research in histopathology at the College in memory of Dr Gottlieb.

Dr Boelsche, a graduate of the University of Texas Dental Branch at Houston, practiced general dentistry at the same location for 52 years. He is a past president of the Houston District Dental Society, the American Academy of Gold Foil Operators (charter member), the Southwestern Academy of Oral Medicine (charter member), the American Academy of Restorative Dentistry, and the Southwestern Academy of Restorative Dentistry. He is a member of the Houston Gold Foil Study Club (charter member), the Academy of Dentistry International, the Pierre Fauchard Academy, and the American Academy of Endodontists. A Fellow of the American College of Dentists, he served on the Board of Regents and as vice chairman of the Texas Section. He was also a reporter of research and new endeavors in dentistry for the Texas Dental Association.

His special honors and awards include: Cooley Trophy (1969), Distinguished Member Award of the American Academy of Gold Foil Operators (1979), William John Gies Award (1981), Award of Honorary Alumnus of Baylor College of Dentistry (1982), and Omicron Kappa Upsilon. Dr Boelsche has been active in the United Methodist Church of Industry as a lay leader and has endowed an internship for ministers at Southern Methodist University. He is a member of the Masonic and Elk Lodges in Houston.

All of Ralph's many friends will rejoice to learn that his dedicated efforts to advance the art and science of dentistry have been acknowledged.

Ralph A Boelsche receiving the award of Baylor College of Dentistry's Hall of Fame from Richard A Bradley, president and dean of the College

Correction

Dr R L Martina was graduated from the University of Utrecht in Holland, not from the University of Nijmegen as was previously reported in the list of the recipients of the 1985 Student Achievement Awards, Academy of Operative Dentistry (*Operative Dentistry*, Summer issue).

Movie on Rubber Dam Available on Video Tape Cassettes

The movie, "Practical Rubber Dam Application" (G D Stibbs and Bruce B Smith), made on a grant from the Hygenic Dental Manufacturing Company, has been duplicated into video tape cassettes (VHS, Beta 2, 3/4 inch). These are available from The Hygenic Rubber Dam Company, 1245 Home Avenue, Akron, OH 44310-2575 ($50.00) or on loan from the audiovisual library of the American Dental Association.

NOTICE OF MEETINGS

Academy of Operative Dentistry

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

American Academy of Gold Foil Operators

Annual Meeting: 15-17 October 1986
University of Puerto Rico
San Juan, Puerto Rico

Membership in the Academies

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

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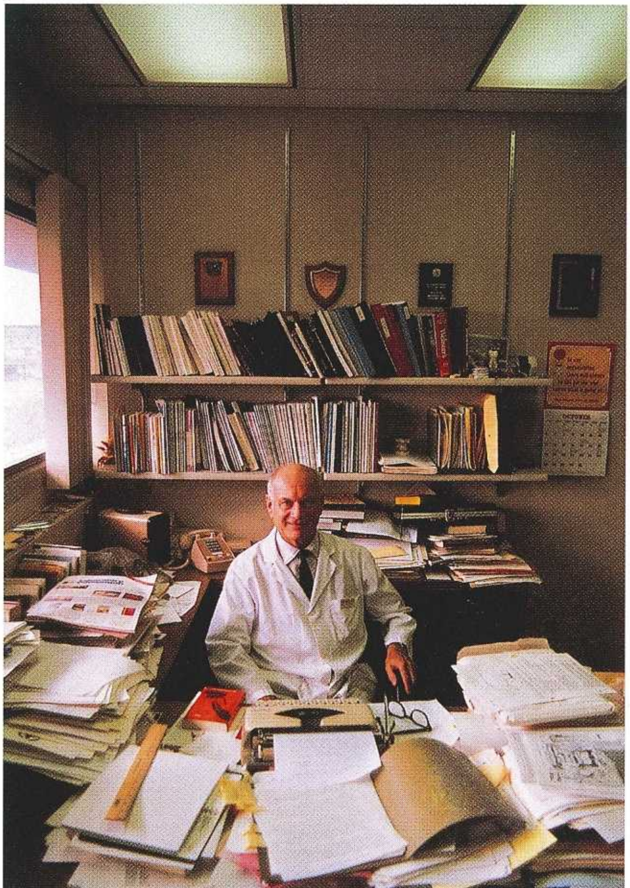
A Tribute of Appreciation to Our Editor



A Ian Hamilton
Editor — 1975 - 1985

Our Sincere Thanks, Mr Editor

With this issue of *Operative Dentistry,* the individual who has given the major portion of his waking hours to nurture our Journal concludes his 12-year appointment as editor-in-chief.

The Academies have been most fortunate in having the services of one so highly qualified. Dr Hamilton is an idealist who enjoys the written word and proper sentence construction; he knows the rules of grammar and writing; he has practiced general dentistry on a very high plane, in both civilian and military life; he has been an outstanding participating member of gold foil study clubs that stress discipline and quality in restorative dentistry. Besides, he is an avid student, having earned a bachelor's and a master's degree in economics, and a PhD in anatomy in England since entering the academic world of dentistry in 1949 as an instructor of operative dentistry at the University of Washington. At present he is professor of restorative dentistry and lecturer in biological structure at the same institution. He has taught undergraduates and graduate students, the topics ranging from technic courses in operative dentistry and fixed partial dentures and clinical instruction in the same fields to conducting courses in gold foil procedures and to teaching various phases of biological structure. His research on cell population studies of oral mucous membrane led to additional research, as well as providing food for his PhD thesis.

Through it all, Ian maintains an intense desire to see the quality of ethical dental service elevated. His editorials through the 40-some issues of *Operative Dentistry* bear witness to his critical attitude toward sham and mediocrity. Fortunately his keen sense of humor makes his barbs against dental education's weaknesses quite palatable.

We readers of *Operative Dentistry* should feel a sense of gratitude to those in the two academies who had the foresight to select Ian as the editor of their journal after the resignation of the former editor, Dr Robert Wolcott. Ian has been most patient in requiring rewriting and editing of manuscripts, much of which he has done himself at home, at nights and on weekends; he carefully checks references given in manuscripts. He is distressed when an infrequent printing error slips by, so we have been privileged to have a journal that is recognized by other editorial peers as being a superior publication, as evidenced by the awards *Operative Dentistry* has received from them.* Through the years we have had a balanced number of articles on clinical procedures and restorative research, and space has been available to those who had a point of view to express.

You have done a fine job, mate. You leave a highly enviable legacy to your successor, to our two academies, and to the general readership who look to *Operative Dentistry* for worthwhile restorative information. Our sincere thanks for your unselfish, productive service, and Godspeed as you continue to serve the great profession of dentistry.

Gerald D Stibbs
Associate Editor

*Special Citation to *Operative Dentistry,* Dr A I Hamilton, Editor, 1977 Journalism Awards Competition, International College of Dentists.

The Successful Editor

Before the idea of starting a journal for operative dentists became fact, my concept of an editor was that of a person who sat in obstruction between the author and the printer. As an author, I had an image early on of the editor as a person whose concerns were essentially directed toward syntax, grammar, and the like. How naive I was! Little did I know that with the birth of *Operative Dentistry* there would be also born a first-hand opportunity for me to watch not only the development and success of an editor but the effects upon the man who had achieved that success. Needless to say, my early concepts were totally in error. Now I understand that a successful editor, aside from knowing the principles of writing and grammar, must in addition have a deep appreciation and understanding for the subject toward which his publication is directed—and more.

When that publication is a scientific journal, and its readers are of like mind, it is essential that the man in charge be knowledgeable in a variety of disciplines, the more diverse the better. For starters, being in an academic circumstance helps, but when that academician's interests have motivated him to achieve the goal of advanced degrees in areas of such diversity as economics and anatomy, the base of knowledge and consequent understanding of systems is broadened beyond that of many, but extremely useful to the man in the editor's chair—Ian's chair.

Many branches of learning that require a professional degree in order to practice one's endeavor, however, are not strictly academic nor totally scientific. The field of dentistry is a good example. Within that example, the clinical practice of that branch called operative dentistry is specific. To be sure, those who practice operative dentistry well are guided by principles found in textbooks. These same clinicians, however, practice with a disciplined degree of pragmatism bounded by the textbook.

The editor of a journal committed to clinical dentistry should have that same philosophical latitude. To an outside observer, the editor of *Operative Dentistry* might appear to be a person whose only outlook is academic. In many areas of dentistry, that may be so. But in matters of "what works best" in operative dentistry, he takes his direction more from successful practitioners than textbooks. And to his credit, he has kept his skills intact and his ideals alive through study club membership, not as an observer but as a clinical participant.

So here we have, we readers of journals and specifically *Operative Dentistry,* a rare bird—an editor who has looked out over the dental scene from a high perch and from many viewpoints. In his ten years, he has established and guided a fledgling and given it wings. To his credit, it has become an award-winning journal whose editorials have appeared in high places. He has given it a certain detail, tone, color, purity, and life.

As you step aside in retirement, Ian, I hope you will feel a deep sense of satisfaction in your accomplishments in journalism for dentistry. Rather that than the memory of deadening tiredness as a result of long hours with a blue pencil and relentless deadlines to which editors are subject. I wish for you a rewarding retirement.

As for me, it has been a privilege to be a closer observer, colleague, associate and friend, experiencing a new journal's birth and watching its successful development. Ian, I thank you for the education.

Lyle E Ostlund
Assistant Managing Editor

A Personal Tribute

I feel honored to have the opportunity of helping to pay tribute to my good friend and colleague, A Ian Hamilton, on the occasion of his retirement as editor of *Operative Dentistry.*

Originally, Ian began his editorship with *The Journal of the American Academy of Gold Foil Operators,* following on the heels of Dr Robert Wolcott. As the Academy of Operative Dentistry grew, it became clear that a new journal should evolve and Ian Hamilton accepted responsibility as the editor. The decision was made that this journal should be a purely scholarly publication, free of advertising and ultimately able to support itself through subscription alone. Initially, it was subsidized through the two academies, but quickly developed into a high-quality publication under Ian's able leadership, and today stands as one of the truly prestigious journals of the dental profession.

No one will ever truly appreciate the time, effort, and dedication which Ian Hamilton has expended in making *Operative Dentistry* a great journal. Throughout these years, he received no monetary reward for his efforts but only the personal satisfaction of a monumental contribution made and a job very well done.

I applaud you, Ian Hamilton, for your selfless dedication, your leadership, and continued friendship. May you feel great satisfaction in the realization that you have honored yourself and the profession you serve; you have inspired many, and truly touched the hearts of those of us who have had the privilege of working closely with you in your many years of service to dentistry.

Clifford H Miller
(Associate Editor)
Northwestern University Dental School
Associate Dean, Administrative Affairs

A Tribute to Ian

Ian Hamilton personifies through his editorship of the journal of *Operative Dentistry* his many examples of excellence.

He has been my friend, confidant, and mentor long before he assumed the editorship. My friend, through his many personal kindnesses over a long period of time; confidant, through his advice over trying problems in the early development of the Academy of Operative Dentistry; mentor, through his classical clinical demonstrations before the American Academy of Gold Foil Operators, that is, his miniaturization of hand instruments to achieve finer conservative cavity preparations.

May our friendship long endure and his service to the academies never cease.

Ralph J Werner
(Assistant Managing Editor)
Secretary-Treasurer
Academy of Operative Dentistry

Tribute to Dr Hamilton

I never have thought that Ian Hamilton ever got paid what he was worth. (His associate editors certainly got paid what *they* were worth —for whatever *that* is worth.)

Fact is that no one could pay Ian enough, because in spite of the pain of being kind to the rejectees, and "turning out" a readable journal of excellence, and its being a "thankless job," Ian immensely enjoyed his work. And that is a highly enviable position to be in.

Ian wrote editorials that are classics: always clinically oriented, idealistic, just philosophical enough, and always good basic stuff for the readers.

Ian really started something that he can finish, with pride.

Wilmer B Eames, DDS
(Associate Editor)

In Appreciation

A Ian Hamilton retires as editor of *Operative Dentistry* with the completion of Volume 10. His reorganization of *The Journal of the American Academy of Gold Foil Operators* brought a new format and a new composition to dental literature. The new journal became unique — an international publication for articles exclusively devoted to the science and practice of operative dentistry. The first editor of *Operative Dentistry* leaves more than a distinguished standard of fastidious supervision and direction. In his editorial pieces and his other writings he set the tone and created the spirit of *Operative Dentistry.* He left his mark on every page of every number. Properly conducted research coupled with a simple, legible account of that research was oxygen in his lungs. His critical analyses of research proprieties, and that of his associate editors and referees have been invaluable to the readers. Unworthy manuscripts simply were not published. Many writers learned from him a respect for craft and discipline in the language. Though his editorials were often bashing, he was remarkably keen and quick in the defense of personal liberty and purity of expression.

To appraise the editor is to appraise the value, significance, and magnitude of his work. Ten volumes of *Operative Dentistry* have provided the readers with considerable information. A Ian Hamilton's estimation of qualities, merits and flaws, has made the reading of *Operative Dentistry* immensely nourishing. He will always be our benefactor.

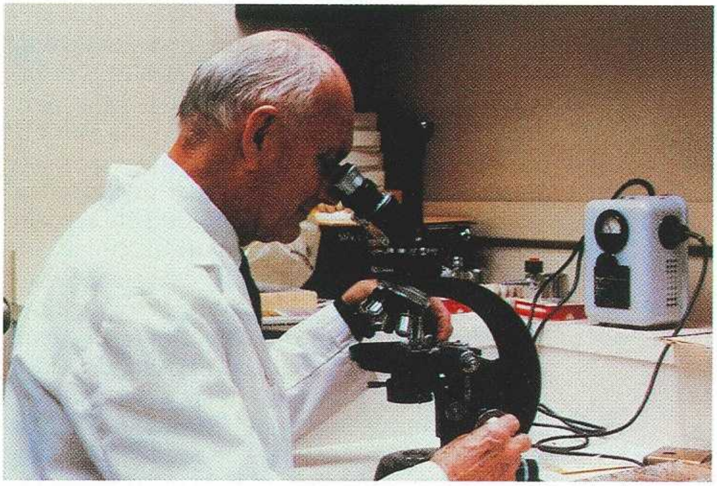
J Martin Anderson
Managing Editor

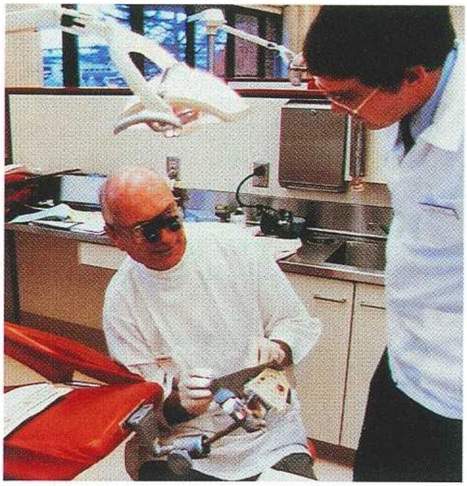
From the Editorial Production Staff

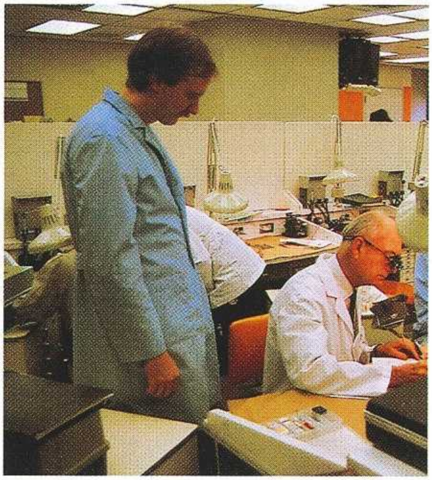
To work for 10 years (or one) on the various elements required to make a quarterly journal approach excellence *each time* is, under an editor like Dr Hamilton, a truly valuable experience in exercising the many aspects of editorial involvement. His enthusiasm for resolving editorial problems and learning from them engendered the same response from his staff. He made the process not only interesting but enjoyable.

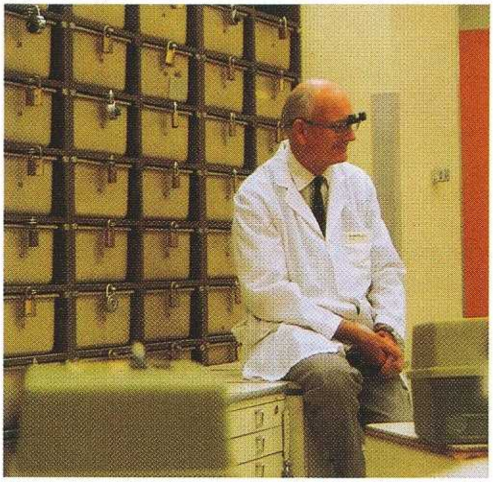
Constantly in motion with his own professional matters as well, Dr Hamilton was never too busy to answer questions or listen to an idea. Our editorial abilities have had no choice but to blossom in the company of such a natural teacher and consummate editor.

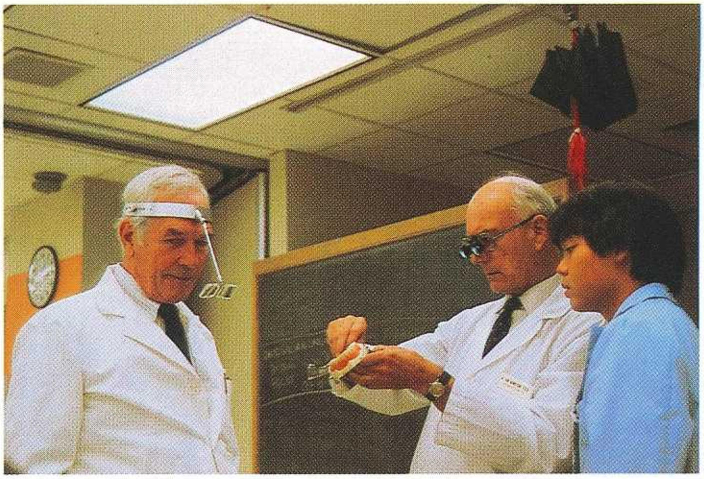
Joan Manzer, Editorial Associate
Nancy Neyens, Editorial Assistant

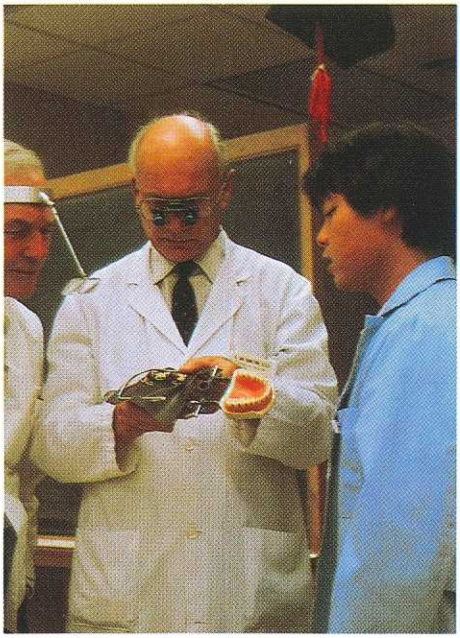


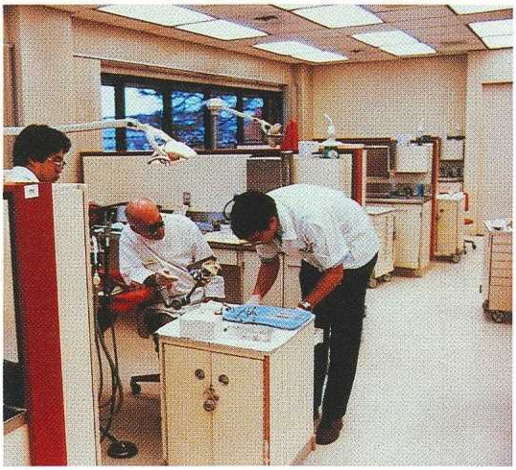


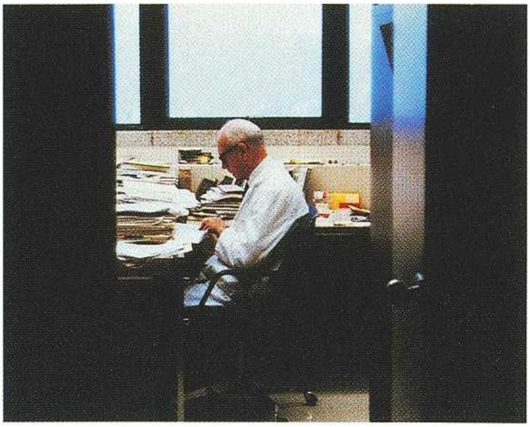












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ACADEMY OF OPERATIVE DENTISTRY

volume 10
1985

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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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INSTRUCTIONS TO CONTRIBUTORS

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