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REVIEW

Microleakage: A Measure of the Performance of Direct Filling Materials

JANET G BAUER • JOHN L HENSON

INTRODUCTION

Microleakage—the passage of bacteria, fluids, chemical substances, molecules, and ions between the tooth and its restoration—is an intrinsic problem of direct filling gold, amalgam, resin, and cast restorations and is clinically undetectable.[1-3] Microleakage is used as a measure by which clinicians and researchers can predict the performance of restorative materials in the oral environment. The importance placed on this measure is based on the premise that no available restorative material is perfectly adaptive or adhesive to the tooth.

The purpose of this paper is to review microleakage and its use in evaluating the marginal integrity of restorative materials.

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FACTORS CONTRIBUTING TO MICROLEAKAGE

Factors contributing to microleakage include the interfacial space, inadequate physical properties of the restorative material, and improper restorative technique or procedures.

Interfacial Space

An ever-present space, the interfacial space, exists between the tooth structure and the restorative material, base, or liner. However, it is the size of this space and the bacterial activity occurring within that contributes to microleakage, which can lead to recurrent caries.

Although the size of an offending bacterium is two micrometers (μm), a space ranging

EDITORIAL

Further Study Is Needed

A disappointing experience for the reader of a scientific article, when he reaches the end, is to find the statement that, "Further study is needed." His reaction may understandably be, "Well, get on with it; do not toy with us; give us some information we can use." Sometimes, the early publication of important information discovered part way through an investigation may be warranted, but too often the haste to rush into print would appear to be based more on obtaining credit for a publication than on disseminating useful information. Taking the time to do what is needed to clarify the issues that require further study would be a boon to readers of scientific journals.

Equally frustrating for the reader is to find that studies of the comparative efficacy of materials or techniques may include only a relatively small number of those available, or those of only one manufacturer, or may test for only one or two properties so that reliable conclusions about the relative merits of the materials or techniques cannot be ascertained. Research is difficult enough without increasing the number of variables in experiments, but when the experimental protocol has been established and the equipment is ready for use, the extra time and effort required to strive for comprehensiveness are more than compensated by the greater usefulness of the results obtained.

The reader can also be intimidated by statistics. The need to analyze data statistically is beyond dispute but authors would help the reader immensely if they would translate statistical jargon into terms more readily understood by those not so familiar with statistics. A difference between samples that is statistically significant, for example, may be too small to be of clinical significance. It would be salutary if investigators, studying comparative properties of materials or techniques, would decide in advance of the experiment how large a difference would be accepted as being clinically significant (Feinstein, 1977). Too often an impeccable statistical analysis is applied to data that have been obtained from experiments of faulty design, thus giving misleading information; statistics cannot compensate for unsound scientific method.

Completeness of the study, comprehensiveness of the variables studied, and scrupulous attention to experimental design would do much to improve the quality of our research—especially of research with clinical relevance.

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Reference

FEINSTEIN, A R (1977) *Clinical Biostatistics.* Pp 285–334. St Louis: C V Mosby Co.

from 2 to 20 μm is necessary for penetration of the bacteria and deposition of a bacterial film. The incidence of caries requires a space of not less than 50 μm.[4-9] Fortunately, a space of 50 μm is detectable with a dental instrument. Unfortunately, this space is at the lower limit of visual acuity and is difficult for the dentist to evaluate clinically.[4,9]

Physical Properties of Restorative Materials

The failure of a restorative material to adapt to the cavity wall of a prepared tooth has generally been ascribed to the solubility of the material and its coefficient of thermal expansion.

SOLUBILITY

The solubility of a material is affected by adherent foods, inadequate oral hygiene, and the amount and frequency of carbohydrate ingestion.[5,10-12] These conditions can promote rapid disintegration of areas of the restorative material especially in the cervical areas which are not readily washed by saliva, and in areas where food debris and plaque accumulate.[10]

COEFFICIENT OF THERMAL EXPANSION

The coefficient of thermal expansion also plays an important role in microleakage. The tooth, which is in a dynamic exchange with the oral fluids, has a specific coefficient of thermal expansion as does each restorative material.[1,4,8,9,11,13,14] If the values for tooth and restorative material were similar, microleakage would be lessened. Unfortunately, this is not the case with present restorative materials.

The tooth has a coefficient of thermal expansion of $11 \times 10^{-6} \cdot {}^{\circ}C^{-1}$. Of the available direct filling restorative materials, direct filling gold has the closest value at $14 \times 10^{-6} \cdot {}^{\circ}C^{-1}$, then amalgam at $22–28 \times 10^{-6} \cdot {}^{\circ}C^{-1}$, followed by composite resin at $26–40 \times 10^{-6} \cdot {}^{\circ}C^{-1}$, and lastly unfilled resin at $81–92 \times 10^{-6} \cdot {}^{\circ}C^{-1}$ or seven times that of tooth structure.[15]

Whichever material is present as the restoration, the coefficient of thermal expansion contributes to approximately 90% of the exchange of fluid during contraction and expansion with varying temperatures. The remaining exchange is caused by the differential thermal expansion of the oral fluid itself.[1,4,9] Setting or curing shrinkage and expansion, porosity, and fracture of the material are additional contributing factors.[4,5,8,12-16]

Restorative Technique

Improper operative techniques can result in inadequate adaptation of the restorative material and in reduced physical properties. The restorative material is sensitive to manipulation especially during placement and condensation.

Improper procedures can affect the tooth as well. The tooth is sensitive to cavity preparation, the use of dentate burs, and restorative techniques. For example, thinner cervical enamel can be damaged by the acid applied in the etching technique used for composite restorations. This damage can also contribute to inadequate adaptation of the material.[8,9,11,17]

CLINICAL EFFECTS OF MICROLEAKAGE

Clinically, microleakage can increase the breakdown, dissolution, and discoloration of certain materials. These clinical effects can often lead to postoperative hypersensitivity of the tooth as well as to bacterial penetration of the interfacial space. Bacterial penetration can contribute to recurrent caries, which may lead to pulpal damage.[3,6,11,12,16,18-20] Further, it has been reported that manifested pulpal irritation and pathosis are related more to the diffusion of bacterial toxins into the pulp than to toxicity from the restorative material itself.[6]

CONTROL OF MICROLEAKAGE

Fortunately, microleakage can be controlled, thus limiting its damaging effects. In the tooth, natural barriers limiting microleakage are created by the decomposition of mineral salts of low solubility, chemical changes in the character of the dentin brought about by the leaching of tin, mercury, or fluoride from particular restorative materials, and by calcification of calculus-like debris.[11] The character of the dentin can also limit microleakage. For example, sclerotic or reparative dentin can act as a barrier and reduce microleakage.[21]

With direct filling materials, the use of the rubber dam can reduce the possibility of moisture contamination of the restorative material thereby diminishing the potential for inadequate physical properties in the restoration.[22]

Other steps to reduce microleakage include the use of techniques that help ensure smooth cavity walls and sound designs of preparation. Rough walls produced by dentate burs can be corrected by the use of hand instruments, thus obtaining improved adaptation.[23]

With cavities prepared for restorations of amalgam and resin, rounded line angles and smooth walls will promote condensation into these areas and improve adaptation, thus minimizing microleakage and secondary caries.[23]

Liners are used to seal the dentinal tubules and reduce the penetration of bacteria and soluble ions. Studies have shown that bonding agents, Dycal (L D Caulk Co Ltd, Milford, DE 19963, USA) and Copalite (Teledyne Getz, Elk Grove Village, IL 60007, USA), adapt well to the cavity walls and are effective in reducing microleakage.[19,20,24-28] These advantages of liners are transient, however, due to inferior physical and chemical properties which promote their dissolution, breakdown, and eventual loss.[23]

METHODS OF INVESTIGATION

Microleakage has been examined by various methods as a function of diffusion of liquids, capillary penetration, marginal percolation, micromarginal leakage, dialysis, changes in hydraulic or gas pressure, and exchange of fluid or ions between the pulp and oral environment.[4,8,9]

The methods used to study these functions with direct filling materials have made use of visualization, diffusers or tracers, and caries.

Visualization

Described in 1895, the oldest of the experimental methods used to study microleakage is direct visualization.[2] Other methods of visualization include detection of surface profile, microscopic examination, and scanning electron microscopy.[1,5,9,29,30]

The use of scanning electron microscopy provides good direct visual observation because of its high magnification and depth of focus.[3,8,9,30,31] The method has been criticized for its potential to introduce errors and artifacts related to drying, cracking, distortion, and sectioning.[5,9,31] The method of scanning electron microscopy can be improved by the use of replicas, thereby avoiding shrinkage and other problems related to artifacts.[5,22,31]

In addition, adaptation and modified relief studies are used to visualize and evaluate the adaptation of dental materials at the cavity walls and margins.[7,24,32,33]

Diffusers

Evaluation of air under pressure, dyes, isotopes, and bacteria as diffusers between the tooth and restoration has been used extensively to study microleakage. Among other methods are marginal percolation, the study of the extrusion of moisture at the margins, and conductimetric studies, the study of the changes in the dimensions between the cavity wall and restoration with the use of an electrochemical cell.[1,3,8,9,11,12,19,22,24,33]

Air

Studies using air pressure, first described in 1912 by Harper,[34] demonstrated the presence of air bubbles at the cavosurface margin and indicated the amount of pressure needed to break the marginal seal.[21,31,35] The technique enabled quantification of data. However, critics complained that the technique required elaborate equipment, was difficult, time consuming, and unsuitable for clinical studies.[11,12] The technique has been modified and refined by the use of compressed air.[12,29]

Dyes

Dyes are the most frequently used diffusers for the study of microleakage.[11,31] Organic dyes, used as early as 1933 by Fish,[36] had numerous disadvantages, toxicity to tissue being the most serious.[3,9,12] It was with the introduction of fluorescent dyes that the popularity of the technique increased. Among the numerous advantages of fluorescent dyes are ease of technique, lack of toxicity, reproducible results, and cost.[11,12,37] However, critics cite that fluorescent dyes show less microleakage in laboratory than in clinical studies. Lack of quantification with this method and the use of zinc oxide and eugenol cement were also mentioned as disadvantages.[1,11,31] Zinc oxide and eugenol cement, being oil-based, will chemically quench the dye, saturating it within the material and preventing its use in detecting microleakage.[12]

Isotopes

Isotopes, introduced by Armstrong and Simon in 1951,[38] and the technique of neutron activation were used because of their distinct advantages over dyes. The isotopes or tracers penetrated more deeply, thus their use permitted detection of minute amounts of leakage, provided greater versatility and recorded data that could be quantified and verified.[1,3,9,29,31,33] The tracers used are ^{22}Na, ^{55}Mn, ^{131}I, ^{35}S, Dysprosium, and ^{45}Ca. Calcium was the most popular because it was a low-energy beta emitter and did not readily penetrate enamel.[1,9,21,37,39] The reasons cited as advantages of isotopes over dyes soon became the reasons by which investigators criticized them. The methods were considered too sensitive in detecting marginal leakage to the point that a nonleaking system could not be found.[9,22,40] Penetration of tracers was too pronounced in dentin and quantification was reduced by specific variables.[1,3,9,24] Among these variables were limitations due to the molecular size, ion exchange, and chemical affinity of the tracer for the restorative material and tooth structure.[1,40] The systems also demonstrated less leakage in laboratory than in clinical studies and were unsuitable for monitoring over a long period of time.[3,31,40] Other disadvantages include the expense and complexity of the procedure, and the need for specialized equipment and personnel.[3,9,12,22]

In response to the disadvantages of using isotopes, radiochemical diffusion was introduced as a procedure that was quantitative and capable of monitoring leakage over a long period of time. Radiochemical diffusion makes use of metal ions as tracers, ^{14}sucrose being considered as a future tracer.[3]

Bacteria

The action of bacteria has also been used as a diffuser of sorts. Bacterial penetration, introduced by Fraser in 1929,[41] related the carious process and recurrent caries to microleakage.[1,8,11,12,19,21,24,31,33,35,39] This method too was criticized for its lack of quantification, limitations due to the size of bacteria when compared with other tracers, and its unsuitability for monitoring marginal leakage over a long period of time.[1,3,11,31] The method was also considered tedious and unreliable due to the many variables experienced.[3,12]

Caries

The method of simulating caries, introduced by Brown[42] in 1962, improved upon the Fraser method. Brown's method could be used in laboratory and clinical studies with little difference between the results obtained. Quantification of the depth of the lesion was also possible. However, inability to quantify the degree of demineralization promoted the use of the acidified gelatine gel technique, a modification introduced by Silverstone[43] in 1967 and representing a system controlled by diffusion.[2,31] The in vitro caries produced was indistinguishable from natural caries. However, the long exposure times required to create even small caries-like lesions has limited the use of this technique.[2]

Thermal Cycling

Most of the methods reviewed utilized thermal cycling in the experimental method with the exception of neutron activation and procedures simulating caries.[3,4,13,31]

Thermal cycling is believed to be necessary in studies of microleakage because it exposes the restorations to simulated clinical situations that normally stress the marginal seal. This is particularly important when the coefficient of thermal expansion of the restorative material is different from that of tooth structure.[5,13,31]

The range of temperature used in techniques of thermal cycling, with the upper limit being 45-60 °C and its lower limit 4-15 °C. These ranges are based on changes in temperature that are within normal extremes in the oral cavity and that induce an opening and closing between the tooth and restoration.[4,31,39] Reliable results are obtained if short exposures to extreme temperatures are used with an adequate intervening period for the specimen to return to body temperature.[14] The problems encountered with the procedure include increased crazing of the enamel initiated during cavity preparation and increased leakage when numerous immersions are made.[14,31]

PERFORMANCE OF RESTORATIVE MATERIALS

All restorations show some degree of microleakage, which indirectly may be more responsible for pulpal irritation and potential pulpal pathosis than the possible chemical irritation from the restorative material itself.[6,21]

Direct Filling Gold

Direct filling gold is still considered and advocated as a superior restorative material over all other proprietary direct filling materials, especially in the class 5 area. Among the advantages of direct filling golds are permanence, good marginal adaptation, and a smooth surface finish, which lessens the attraction of plaque and promotes compatibility with the adjacent tissue.[4,25,39,44] Unfortunately, many operators consider the manipulation of the material too demanding and difficult to master. Secondarily they also cite esthetics, chair time, and expense as additional disadvantages.[44,45]

Composite

Composite restorative material is considered the weakest of the direct filling restorative materials because of its lower strength and high coefficient of thermal expansion.[4,5,19]

With the introduction of the procedure of etching with acid, beveling enamel margins, and subsequently, the use of a bonding agent or primer, studies have demonstrated improved marginal seal mainly due to the formation of micropores in enamel within which the resin forms a mechanically retentive seal.[5,16,19,24,26,27,33,44,46-48] However, in preparations whose dimensions are larger than 1.5 mm, other studies have demonstrated the ineffectiveness of the primer to reduce microleakage.[4,5,25,49]

When an improved seal has been demonstrated, it has been shown to be effective only initially, then to degrade precipitously as the etched composite restoration ages.[2,50] However, even with the breakdown and increased microleakage, composite resins are better than restorations of unfilled resin.[6,10,11,20,22,26,27,44,46,47]

Typically, the cervical margins of class 5 restorations are not located in enamel. Located in cementum, the margins of these preparations are not conducive to etching with acid and bonding and thus do not benefit from improved marginal seal.[5,14,16,21,25]

In addition, the interface gap at the cervical margin can contribute to microleakage. This is due to the tendency of the operator to drag the composite material away from the gingival wall toward the cervical convexity of the tooth during placement of the material. In the class 5 preparation, cervical convexity may also have some directional influence on the pattern of polymerization shrinkage resulting in inadequate adaptation of the composite material to the gingival wall.[5,8]

Amalgam

The most common evidence of deterioration in amalgam restorations is microleakage.[17] While the use of high-copper amalgams has demonstrated a greater resistance to marginal deterioration and corrosion, amalgam restorations continue to exhibit an initial interfacial gap great enough to permit microleakage.[4,27,22,44,51] The pattern of leakage can be minimized by the use of a cavity liner, which has been shown to be an effective initial barrier to microleakage.[4,8,12,19,24,31,33,51,52]

In contrast to the sealing characteristics of the other direct filling materials, studies have shown the initial seal of amalgam restorations to be poor. With age, however, the marginal seal demonstrates improvement due to corrosion products which are deposited between the tooth and amalgam and which provide a bacteriostatic effect.[1,2,4,11,24,31,33,35,44,51]

CONCLUSION

The occurrence of microleakage is used to evaluate the success of restorative materials and procedures; however, they themselves continue to be determinative factors. Properties of dental materials such as porosity, solubility, and thermal expansion and contraction are problems limiting clinical performance. While restorative materials and techniques have improved, manipulation of the material continues to affect the success of restorations.

Numerous investigations have used a variety of research tools to evaluate the extent of microleakage and the marginal integrity of restorations. Visualization techniques including scanning electron microscopy and the use of diffusers are among the most commonly used methods. A comparison of results of recent microleakage investigations indicates direct filling gold to be superior to composite and amalgam in resisting microleakage.

As a measure, microleakage can provide much useful information regarding the performance of restorative materials and procedures, but as a clinical occurrence it remains a primary source of restorative failure.

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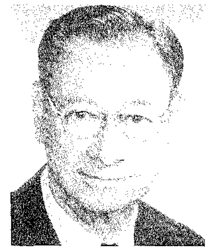
LEGENDS OF OPERATIVE DENTISTRY

MILES R MARKLEY

Silver Amalgam



INTRODUCTION

No place could be more appropriate for a two-day review of the "Legends of Operative Dentistry" than Northwestern University, where the "Legend of G V Black" lives on. Black entered the dental profession amid chaos and controversy. Many operators were then opinionated craftsmen, with guarded professional secrets. The same was true of manufacturers of dental supplies. Black studied dental practice, past and present, and brought order to chaos by his publications.

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TRIBUTE TO G V BLACK

Giving full credit to other contributors, Black founded new and revolutionary restorative techniques upon anatomy, logic, and physiology. He systematized cavity preparation based on the principle of "extension for prevention" of recurrent decay. His *Operative Dentistry,* in two volumes, eventually became the standard for restorative dentists worldwide. The sixth and final edition (1924) has been my personal bible in dentistry. The present condition of the book (Fig 1) indicates

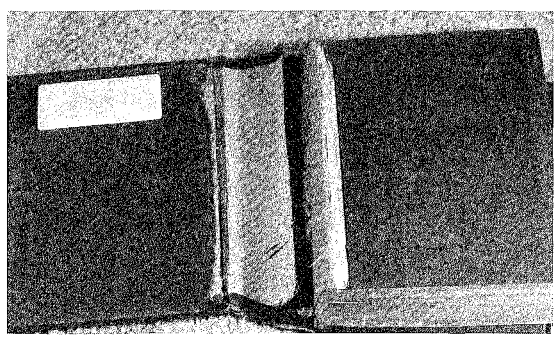

FIG 1. *The author's copy of G V Black's* Operative Dentistry, *volume II, showing much use*

how much it has been used in my lifetime—along with many newer texts.

Black knew that the retention of food and filth caused both caries and periodontal disease. Sugar concentrates had not yet been associated with plaque activity, nor had the trace element, fluoride. He sensed that prevention was prerequisite to restorative dentistry, so he prescribed brushing and extended cavity margins to semi-immune areas. Dental disease is now largely preventable. Otherwise we dentists treat symptoms and ignore the disease.

Black studied and perfected dental materials, creating the instruments needed for his research. In *Dental Cosmos* of 1896 (which later became the *Journal of the American Dental Association*) Black publicized the fact that there was not a single dependable filling alloy on the market. Then he proceeded to compound one and presented a balanced silver amalgam alloy to the profession. In his *Operative Dentistry,* volume II, edition of 1916, he recognized that the addition of 5% copper would almost double the strength of amalgam. He was ahead of his time in that!

Except for the weeding out of inferior amalgam alloys by the US Bureau of Standards in the 1920s when establishing the American Dental Association certification of dental materials, little more was done for amalgam alloys until the 1960s. In 1963, Innes and Youdelis added spherical particles of a silver-copper eutectic, 39% copper to 61% silver, to particles of lathe-cut low-copper alloy. This was the first major change for dental amalgam since Black. Ten more years proved the superiority of the high-copper alloys, which reduce creep and corrosion by eliminating the weak γ_2 phase of setting amalgams. Marginal strength has been enhanced.

PREPARATION OF THE CLASS 2 CAVITY

Design

It is not surprising that Black's cavity preparation has been upgraded since his last text came off the press 59 years ago. Over the years several modifications have been made, mainly to conserve tooth structure.

After one year of apprenticeship as a machinist, followed by a year in the Engineering Department at the University of Nebraska, I studied dentistry. This background taught me that sharp internal angles, in any structure, create weakness to stress. In the pattern-making laboratory of a foundry I learned to round the internal angles of patterns designed to produce commercial castings.

In dental school I was taught from Black's *Operative Dentistry,* volume II, to cut sharp internal angles in teeth, in violation of my engineering concept. Preparations were to be ideally one-third the width of the tooth. Our instruments were designed to cut such preparations (Fig 2) and we were graded accordingly.

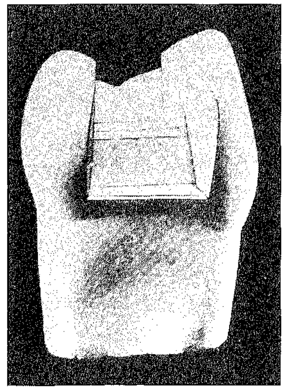

FIG 2. *Textbook amalgam cavities one-third the width of a tooth and with sharp internal angles are a prime cause of fractured teeth in middle age. (From* A Textbook of Operative Dentistry, *4th ed, 1956, McGehee, WHO, True, HA & Inskipp, EF. Permission McGraw-Hill Book Co Inc, Blackiston Division, New York)*

Graduated, I began to observe cracked teeth in my practice, and in that of my father with whom I practiced (Fig 3). So I narrowed

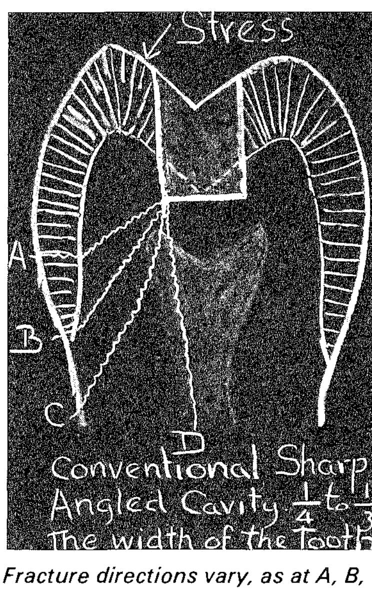

FIG 3. *Fracture directions vary, as at A, B, C, or D.*

my cavities. Then a scourge of class 2 amalgam failures resulted from fractures across the isthmus of my restorations. This influenced me to become an inlay enthusiast, and I spent countless hours perfecting and teaching their techniques. Amalgam was regarded as an inferior restorative.

In 1931, Bronner taught us to retain conservative class 2 amalgams by proximal locks, instead of the occlusal step. This and other refinements revolutionized my practice, because during those years of the Great Depression many patients could not afford gold inlays. It was rewarding to have increasing success with an alternate restorative.

Genesis of the Pear-Shaped Amalgam Bur

The principle and practice of sharp internal angles continued to bother me. They were clinically necessary for the condensation of gold foil only. With the courage of conviction I attempted to induce Kerr Manufacturing Co (Romulus, MI 48174, USA) to make inverted cone burs with round corners. Such an idea was heresy.

World War II stopped the manufacture of dental burs and they went off the market. Steel burs dull quickly and my supply became exhausted. An Iowa firm came to the rescue by resharpening burs. As a bonus, they were returned with the rounded corners we had longed for. Wonderful! Now cavities with rounded internal angles could be prepared. Fewer teeth cracked. Margin failures such as those shown in Figure 4 were almost eliminated by the right-angle cavosurface margins that early diagnosis and conservative preparation made possible.

FIG 4. *Amalgam cavities with parallel walls produce restorations with fragile acute-angle margins that chip. These had been in service five years.*

In 1956 I met George Beavers of Beavers Dental Products Ltd in Morrisburg, Ontario, Canada. We became warm friends. He offered to make a tungsten carbide bur for amalgam if I would supply a mock-up (Fig 5). He made

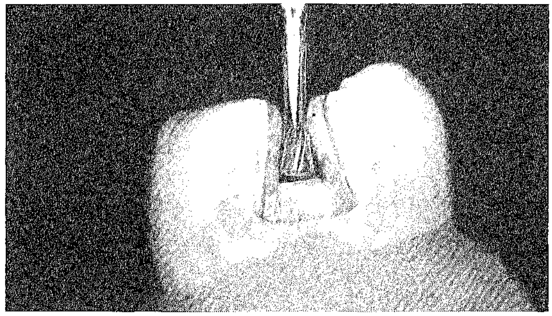

FIG 5. *A mock-up of the pear-shaped bur was copied by Beavers Dental Products Ltd into the 329–330 bur series.*

several sizes for trial. The No 330 was ideal for preparing conservative cavities in molar teeth. A still smaller bur was needed for premolars, but it proved to be too frail. Two years later, Beavers started making his own tungsten carbide. It was so superior that he could now produce the smaller, No 329, pear-shaped bur for premolars. Midwest American, then the United States distributor for Beavers' burs, bought Beavers' factory just before Mr Beavers died. Midwest (Ritter-Midwest, Div of Sybron Corp, Des Plaines, IL 60018, USA) continues to make pear-shaped burs to the original specifications. Only three burs, one from each pair shown in Figure 6, are needed for a conservative preparation.

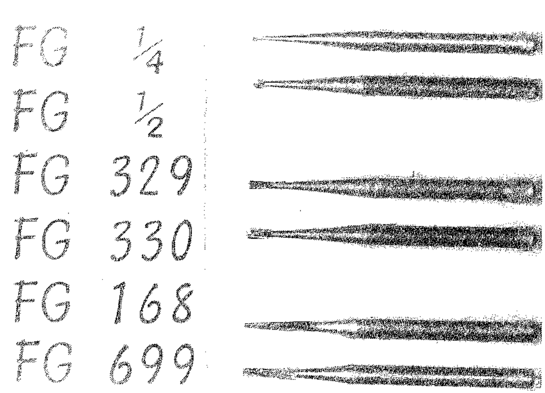

FIG 6. *Only one of each pair of burs shown is used in a conservative class 2 preparation for amalgam: the larger Nos ½, 330, and 699 are used for molars.*

Instrumentation

Wedges are placed to retract and protect interdental tissue so that gingival margins can be extended into the wedges, just past the contact areas.

Cavities are opened with tiny round burs, No ¼, in a turbine, cutting under water and air. The bur penetrates the dentin just **inside** the enamel from a narrow occlusal opening to the broader gingival, estimated as just past the contact area. The proximals are then notched with the No ¼ bur and fractured out with an instrument (Figs 7 & 8). This con-

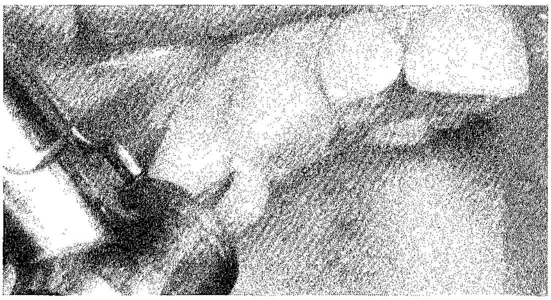

FIG 7. *Opening the cavity with a No ¼ bur and notching the proximal enamel*

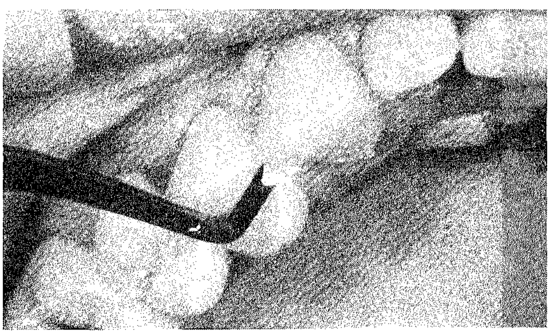

FIG 8. *Fracturing out the enamel with an instrument*

cludes the use of the turbine for a conservative preparation. To continue at high speed beyond this stage would overcut the preparation and risk damage of the contacting tooth (Fig 9). The gingival walls are now extended with the No 329 bur at low speed under a continuous flow of air. The shank of the pear-shaped bur is leaned against the adjacent tooth to protect it from injury. Proximals are opened with a thin hand instrument to allow dental tape to pass freely. Then extra-heavy

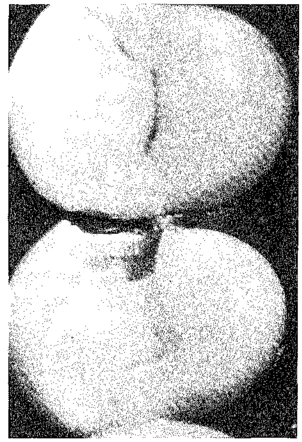

FIG 9. *An overcut cavity and damage to the adjacent tooth as a result of continuing with the use of the bur at high speed*

rubber dam is placed about all teeth included in the field for the remainder of the operation (Fig 10).

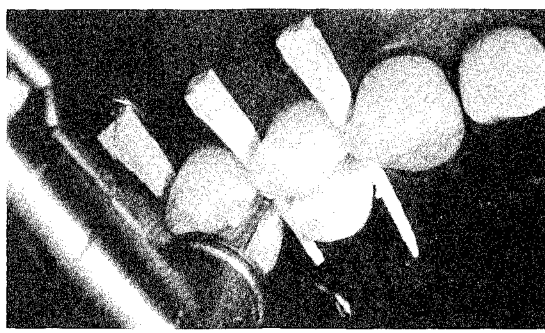

FIG 10. *Rubber dam applied, wedges reinserted, and the gingival walls being extended just into the wedges*

Black did not call it pellicle but he was fully aware that saliva contains a lubricating contaminant that could not be washed off a cavity preparation. From his *Operative Dentistry,* volume II, you will find this rule: "No moisture of any kind whatever should enter a cavity after the last of the cutting is done, and if, by any accident, a portion of the cavity should become wet, it should be dried thoroughly and then the portion that has been damp should be freshened by cutting away the surface," and you also find this statement: "The rubber dam should be in place for all amalgam fillings, the same as for gold, before the enamel walls were finished." Research by

Jendresen (1980) proves Black's observation. In teaching participating classes, it is my observation that dentists that lack training in gold foil simply do not know how to establish a dry field.

With the rubber dam in place, wedges are reinserted and the gingival walls prepared just into them. Finishing the occlusal with a pear-shaped bur at slow speed (up to 30 000 rev min^{-1}) under a continuous flow of air will perfect a cavity so conservative that the bur head will not pull through the occlusal step (Fig 11). Only by having the occlusal step narrow, where one is necessary, can cracked teeth in later life be avoided. The pear-shaped burs finish the occlusal step with right-angled margins, and create round internal angles.

FIG 11. *When a conservative class 2 premolar cavity is opened with a No ¼ bur in a turbine under high speed and water, then is perfected with a No 329, but at low speed, the bur will be ideally retained by the constricted occlusal opening.*

Scientific proof often lags behind clinical observation. In 1970 DeStefanis of Oregon, appearing before the American Academy of Restorative Dentistry, used ultraviolet light to demonstrate occlusal stresses in a cavity having one round and one square internal angle between pulpal floor and cusps (Fig 12). He showed the characteristic fractures of restored teeth which confirmed our clinical experience (Fig 13).

Locks for premolars are cut in sound dentin with the tiny No 168 fissure bur, leaving the enamel with ample dentin support between the lock and the dentinoenamel junction (Figs 14 & 15). **All** locks are **proven** to have retain-

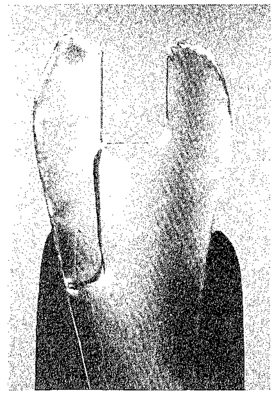

FIG 12. *Cavity prepared in a plastic tooth with a sharp pulpal angle on the left and a rounded angle on the right. Note the evidence of stress accumulated around the sharp angle.*

FIG 13. *A load placed upon the plastic tooth causes it to break in the region of the sharp angle.*

Photos courtesy of Mario P DeStefanis

FIG 14. *Proximal locks in a premolar are cut at slow speed under continuous air with the tiny No 168 fissure bur, leaving ample dentin to support the enamel. Locks should* ***not*** *notch the enamel as is shown here.*

FIG 15. *The retentive lock is deepened with the point of the bur as it is tilted and drawn occlusally. The lock would weaken the enamel if extended* ***through*** *it.*

ing ledges from A to B against a mesial or distal pull (Fig 16). Then a sweep from one lock to the other, with the same fissure bur,

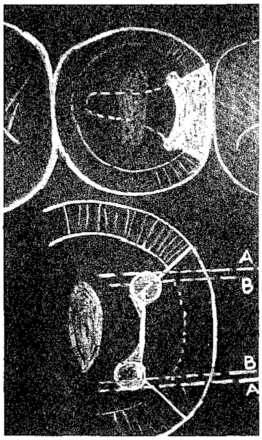

FIG 16. *Every lock should be proved by the bur that made it. With a pull directly forward (for a mesial cavity), the bur must be held securely by a ledge from A to B on both buccal and lingual, then the axial is rounded from buccal to lingual to strengthen the locking fingers.*

rounds the axial wall from buccal to lingual and removes some dentin to strengthen the fingers of amalgam in the locks. At the same time the axiogingival angle is squared with the end of the bur, as the **only** sharp internal angle. This is to provide vertical resistance to occlusal stress; this angle carries no fracture hazard. Three thin, sharp, carbon-steel instruments—hatchet, hoe, and Wedelstaedt chisel—held parallel to the enamel prisms then perfect the proximal and gingival margins. Blades, 0.013 - 0.015 in (0.33 - 0.38 mm) thick, extend conservative buccal and lingual margins out to where the operator can finish, and the patient can care for, them. The gingival is scraped with an enamel hatchet held with the side of the blade contacting the adjacent tooth to remove weak enamel prisms at the margin (Fig 17).

FIG 17. *Gingival walls are scraped to remove weak enamel prisms—the hatchet blade held against the contacting tooth.*

Varnish

Amalgam is our only self-sealing restorative. But sealing takes weeks or months. Percolation induces corrosion to eventually seal restorations. Meanwhile discoloration and temporary sensitivity result. Routinely, several applications of Copalite cavity varnish (Bosworth Co, Skokie, IL 60076, USA) will block, from the day of insertion, these undesirable effects of percolation.

MATRIX

A matrix is a form, or mold, into which a restorative is condensed. A proper matrix will resist moving under condensing pressure and will create an anatomical restoration that needs little finishing of inaccessible areas. The matrix shown in Figure 18, resulting in the restoration shown in Figure 19, is the only one I know that qualifies.

FIG 18. *A supported and contoured two-hole matrix*

FIG 19. *The finished restoration, condensed in the matrix shown in Fig 16, retained by L-shaped pins which cross-splint a weak tooth into a strong one.*

This matrix has a noble ancestry. It was originated by Black and detailed in his *Operative Dentistry,* volume II (Fig 20). Black de-

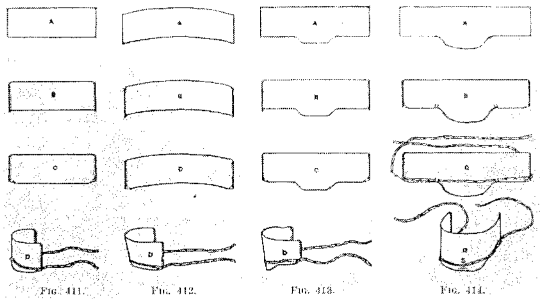

FIG 20. *G V Black's matrix—from his text (courtesy of Medico-Dental Publishing Co, Chicago)*

signed and taught the use of an improved matrix for amalgam that has developed into the rigid, anatomical matrix of today. Hollenback improved it by adding modeling compound for rigidity. Black's and Hollenback's matrices were hard and thick and thus resisted contouring, the lack of which is shown by the result illustrated in Figure 21.

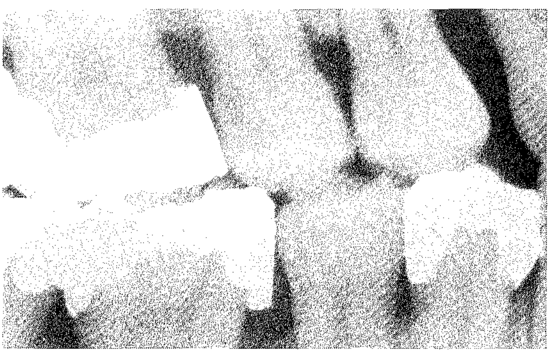

FIG 21. *Radiograph of restorations condensed into inadequately contoured matrices*

Easton, reporting in 1941 on the causes of 415 amalgam failures, noted that 89% of them **also** had faulty contours from application of a compromise matrix.

The technique of making and applying the matrix was published in the August 1951 number of the *Journal of the American Dental Association.* Hundreds of lectures since then have influenced many dentists and some dental schools to use this matrix. Lambert, who now heads the Department of Operative Dentistry at the University of Colorado, describes the matrix in his chapter on amalgam in Baum's *Advanced Restorative Dentistry,* and teaches the technique at the school of dentistry. But why has its use not become universal?

First, its benefits are not fully appreciated. Second, patented, highly advertised, ready-made commercial matrices seem quicker and easier to use. They are, but only if their compromise results are ignored. From them patients suffer iatrogenic consequences, a few horrible examples of which are shown in Figures 22 and 23.

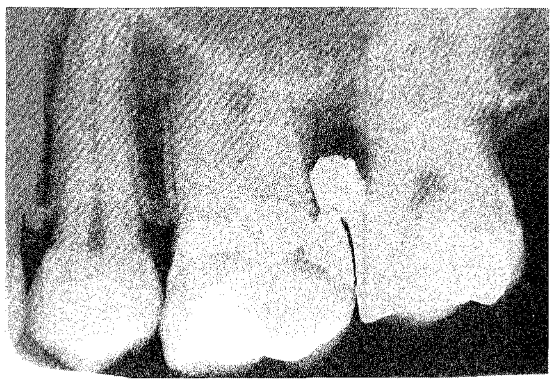

FIG 22. *Iatrogenic result from faulty matrix*

FIG 23. *Recurrent caries resulted from food impaction. Nonanatomical matrix was the cause.*

Amalgam contours can equal those of any restoration built outside the mouth. The inaccessible proximals perfected by the custom matrix need no carving, no contouring, nor even polishing. The custom matrix is really a time saver if end results are considered.

Figure 24 shows five types of matrix, each

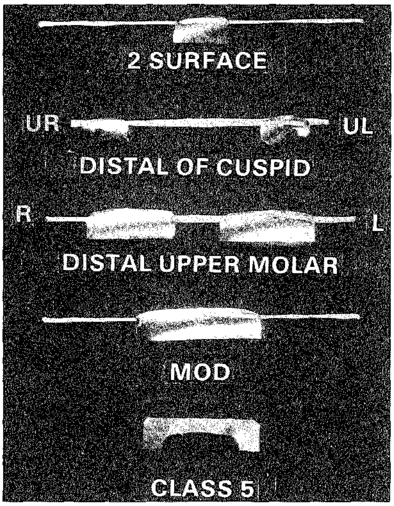

FIG 24. *Each of the five types of matrix is made in various sizes.*

in several sizes. All have rounded gingival edges and corners. A two-hole matrix serves for a two-surface class 2 cavity. A special, in rights and lefts, is made for a class 3 cavity, usually for the distal of cuspids. A three-hole matrix serves for the distal of upper molars where the distolingual groove or cusp, or both, are involved. These matrices are made in rights and lefts. A four-hole matrix is needed for an MOD and mesiodistal combinations. Modified, the matrix serves for broken-down teeth where only one cusp may remain (Fig 25). When all cusps are missing,

FIG 25. *The four-hole matrix can be used wherever some part of a cusp remains. This one is ready for wedges and compound support.*

a copper-band matrix is used (Fig 26). Class 5 matrices supply rigid support for thorough

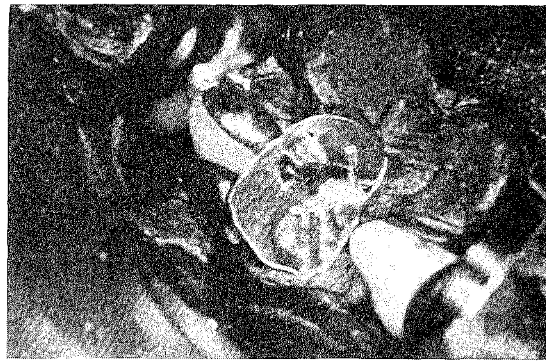

FIG 26. *When the coronal portion is gone, a contoured copper-band matrix is used. This one allowed building a repair abutment about a lug cut from the former retainer. Copalite protected the gold from the amalgam. The repair continues in service after 14 years.*

condensing. They are not anatomical. Class 3 (distal of the cuspid) and class 5 matrices are usually made at the chair since their shapes and lengths are critical. Otherwise, a stock of matrices is made in leisure moments by the staff to be ready for selection.

Technique for Making and Using Matrices

We coaxed the Crescent Dental Manufacturing Company (Lyons, IL 60534, USA) into making a three-quarter hard, stainless steel strip 0.0015 in (38 μm) thick that can be burnished to an anatomical contour (Fig 27).

FIG 27. *Specifications for the matrix material*

A Detroit pedodontist, McBride, had suggested punching holes along the gingival edge of the matrix (Fig 28) to hold the dental

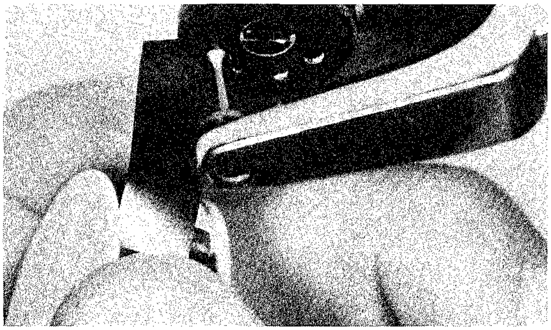

FIG 28. *The smallest hole of a sharp rubber dam punch is used to cut the holes with a shearing action.*

tape better than did Black's notches, making it possible to hold a thinner matrix. Holes are made along the gingival edge of the strip with the smallest hole of a sharp rubber dam punch. Revolving the strip about the punch while holding tight will shear most of the burr; metal debris left in the punch should be removed occasionally with an explorer. Any burr left in the strip is erased by burnishing with a large, egg-shaped burnisher (No 28) against a hard surface. A bulge is then started in the center by burnishing the strip against a soft pad of scratch paper. The holes are strung with the strongest waxed dental tape available. Large tape can be threaded through the small hole easily if the tape is first rolled between finger and thumb, then against a towel to the center of the strand. The tape is pulled through one hole at a time to the center of the strand (Fig 29). A three-hole matrix

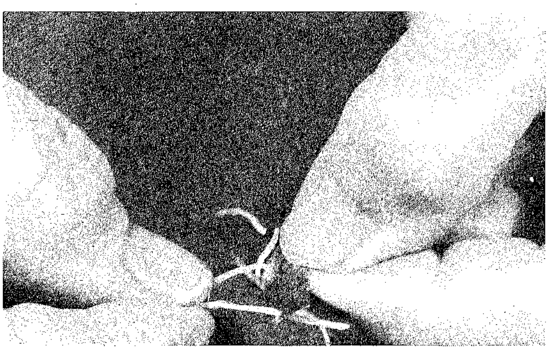

FIG 29. *Threading dental tape through a three-hole matrix*

for the distal of upper molars involving the distolingual cusp or groove has a blanket stitch about the center hole to keep the tape outside the strip (Fig 30).

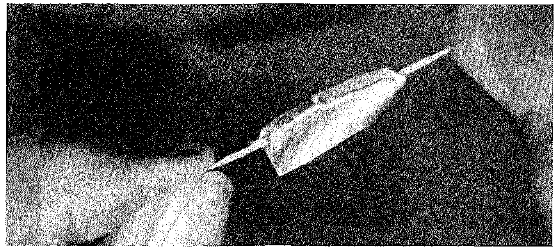

FIG 30. *A blanket stitch keeps the dental tape on the outside.*

The occlusal side of the matrix selected is cut with a concave curve to the proper height by the operator. All sharp corners are removed. For a two-surface cavity the dental tape is passed through the contact (Fig 31);

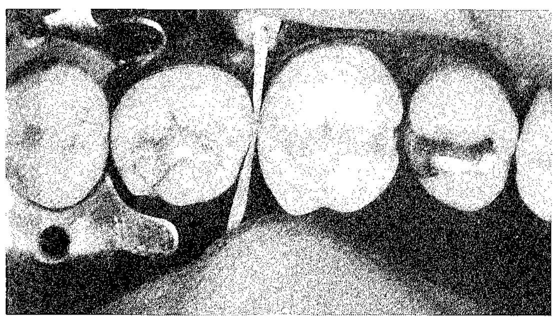

FIG 31. *Dental tape is passed through the contact.*

the other end is passed through the same contact in the reverse direction (Fig 32). While the operator pulls both ends of the

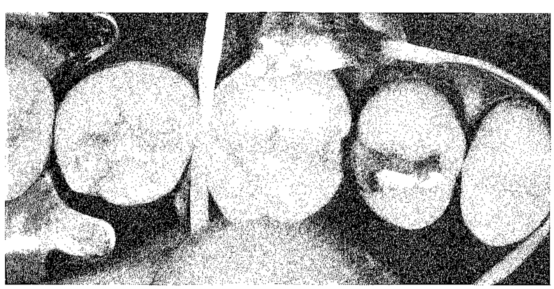

FIG 32. *The other end of the tape is passed through the contact in the other direction, then both ends of the tape are pulled while the assistant guides the matrix.*

tape, the assistant guides the tape into the embrasure. The tape is pulled tight. For an adult the tape is passed around the tooth a second time and is tied with a surgeon's knot.

If the gingival margin is deep, the tape and matrix, before tying, are forced to the depth of the gingival sulcus with an instrument, then tied. All sharp corners should be trimmed before placing the matrix. This prevents cutting the operator's finger or the patient's lip.

WEDGING THE MATRIX

With a compound support for the matrix, Hollenback considered a wedge unnecessary. We have found a wedge to be important for three reasons: first, to hold the matrix to the tooth, else a crevice may open while the matrix is contoured from within; second, to separate the teeth enough to compensate for the thickness of the matrix; and third, to create enough tension so that the tooth will not move away from the matrix under the force of condensing. We carved wedges from round toothpicks until Premier Dental Products Co (Norristown, PA 19401, USA) marketed a superior wedge, now color coded (Fig 33). The four smallest sizes serve all but situations with drifted teeth, which may require a custom wedge.

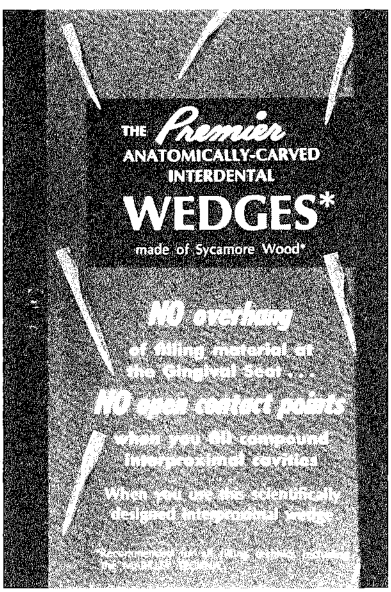

FIG 33. *Suitable commercial wedges*

The wedge is inserted firmly with hemostat forceps (Fig 34). The absence of a wedge allows overhangs when the teeth move away

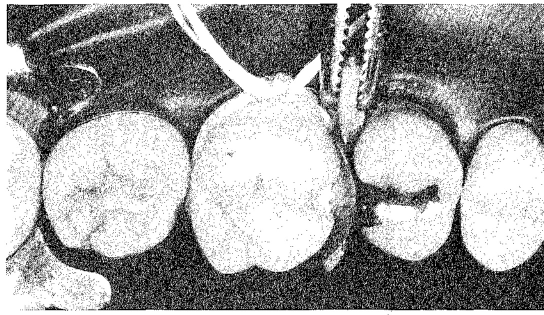

FIG 34. *The compound buttered wedge is forced into the embrasure with forceps.*

from the matrix (Fig 35). A wedge should never distort the matrix, as illustrated in Figure 36, so the wedge should have the shape of an equilateral triangle.

FIG 35. *Marginal overhangs result from a matrix that is not wedged.*

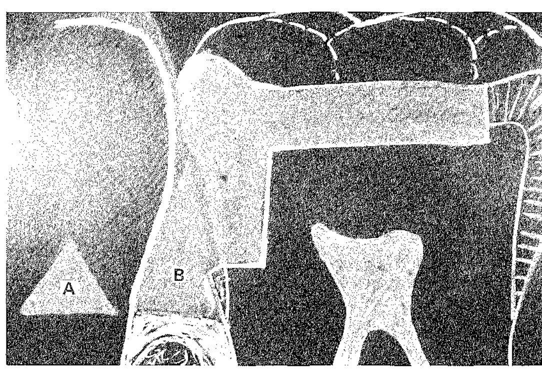

FIG 36. *An isosceles triangle wedge* (A) *is least apt to distort a matrix. The taller wedge* (B) *encroaches on the contour of the restoration.*

If the gingival margin is so deep that the interdental tissue displaces the wedge, the wedge is buttered with green stick compound. The tip of a Hollenback carver will first have been placed between the matrix and the tooth, the blade being held by the assistant to contact the adjacent tooth (Fig 37). The instrument guides the wedge so that it cannot distort the matrix. The fluid compound lubricates the wedge to slide freely across the rubber dam. This works so well that we adopted the compound-on-wedge technique for routine procedure. The entire matrix is stabilized with compound. The Hollenback carver leaves a crevice causing a slight gingival overhang, which is removed after the matrix has been discarded.

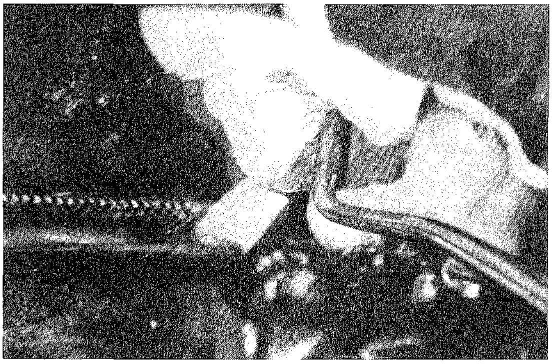

FIG 37. *Where the gingival margin is deep, a Hollenback carver between the matrix and tooth will guide a buttered wedge to place without distorting the matrix.*

Matrices are reinforced and secured to the teeth with cones of green stick compound. Compound cones are created in one of two ways.

First method: The stick is held at an angle of 60 degrees to a flame, which heats the end considerably and the sides slightly as the stick is twirled. Blades of crown shears are made to enter the compound until stopped by the hard core. Thumb and finger are brought over the blades with pressure enough to crack the hard core, leaving the compound cone held between thumb and finger by the cool end. The cone is inserted over the head of the wedge and another cone is quickly made to be forced over the point. With a thumb or finger placed to keep compound out of the cavity, the pair of cones is pinched to force compound completely through the embrasure. This reinforces the entire interproximal portion.

Second method: Several sizes of cone-shaped molds are carved into a block of dental stone. A stock of compound cones is obtained by forming them into the wetted stone molds (Fig 38). Heating the flat side of the cone when it is used will make the compound stick to a finger tip. The cone is then flamed and inserted by that finger.

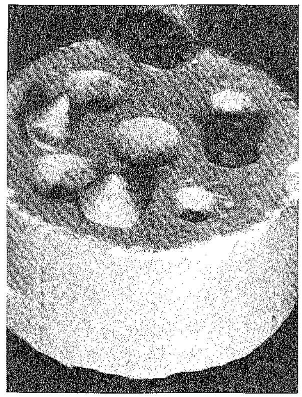

FIG 38. *Compound cones can be made in a dampened mold of dental stone.*

Forcing the compound into the embrasure will distort the matrix, which is then contoured from within by a warmed SSW FP 2A instrument (Fig 39). No other tool will do it so well. This instrument was designed to place "Filling Porcelain," the SSW trade name for silicate cement, therefore FP. Burnishing in-

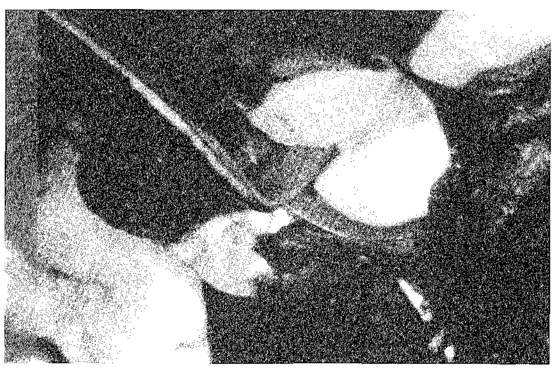

FIG 39. *Compound support is warmed by the SSW FP 2A instrument, then contoured to anatomical form.*

side the matrix with the warmed FP 2A will establish a true anatomical contour every bit as good as the best cast restoration (Fig 40).

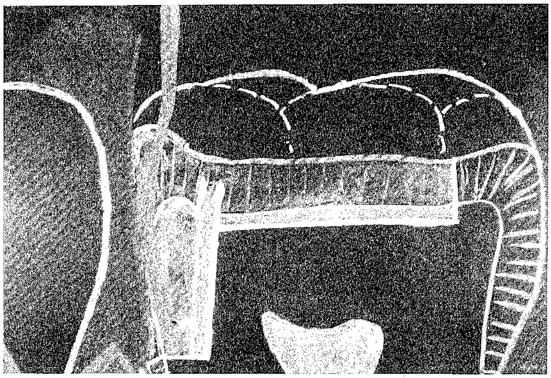

FIG 40. *The matrix is contoured from the buccal to the lingual margin and from the gingival occlusally past the contact.*

The contact area can be the exact shape and in the position desired. To ensure condensing a complete margin, a tiny crevice or gap that can be felt with the tip of a Hollenback one-half carver should be established around the entire periphery. The tiny marginal flash created will be trimmed with a No 5 gold knife at the finishing appointment, **after** the amalgam is completely set.

This matrix is anatomical from the buccal to the lingual and from the gingival up through the contact area. To provide access for condensing the amalgam, the matrix and compound are contoured back over the marginal ridge of the contacting tooth. The occlusal embrasure therefore is open for access and is not anatomical. It must be carved as also must be the occlusal.

This matrix, inspired by Black, is one important step toward building an amalgam restoration having a proven lifetime potential rivaled only by direct gold foil.

CLASS 5 MATRIX

For larger class 5 cavities, the matrix shown in Figure 41 invites condensation every bit as good as does the matrix for the class 2; otherwise landslides occur during condensation. This matrix is not anatomical, but is rigid to support the overpack so necessary to achieve optimum quality of the amalgam, that is, low

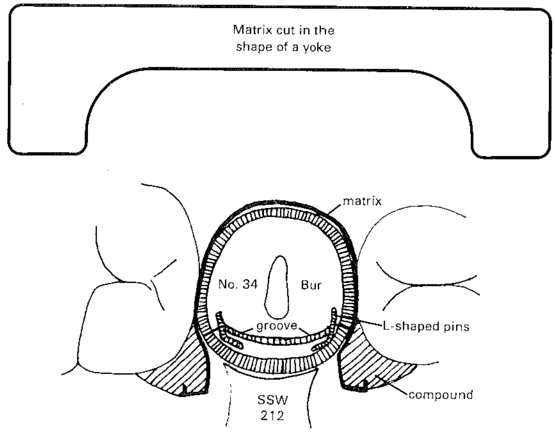

FIG 41. *Class 5 rigid matrix*

mercury at the surface and margins of the restorations.

A yoke shape is cut from matrix stock to a length that encircles the tooth. The broad wings follow the cervical contour, extending ideally to the jaw of the rubber dam clamp (retainer). With the cavity covered momentarily by the matrix wings, a cone of compound is forced in turn between the matrix and each adjacent tooth well into the embrasures. Before the compound is completely set, each wing is opened just enough to allow access for condensation. The end of each wing is then bent back with hot cotton pliers to embed the edge securely in compound.

Once the amalgam has set enough to resist carving, the excess is carved to locate the occlusal and gingival margins (Fig 42). From these landmarks the contour is carved, leaving some excess for subsequent finishing.

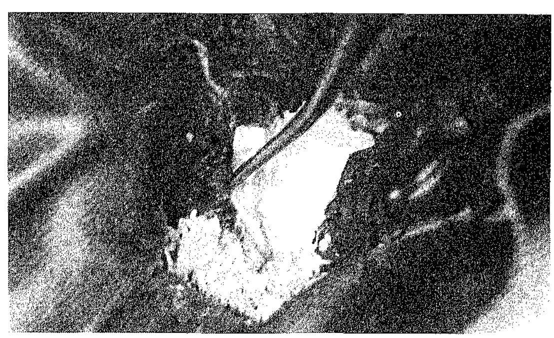

FIG 42. *Carving the amalgam within the extended wings of the matrix*

The matrix is opened for more carving, then removed with forceps (Fig 43).

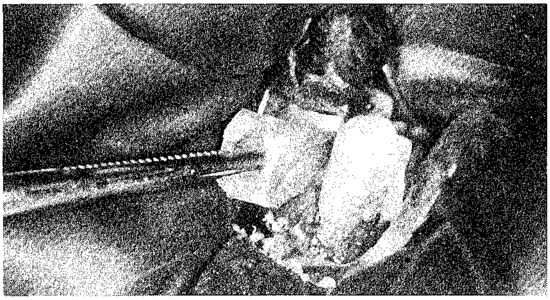

FIG 43. *Removing the matrix by pulling it with forceps*

A class 5 amalgam restoration of this size needs L-shaped threaded pins for retention in addition to grooves prepared with a No 34 bur in the axiogingival and axio-occlusal angles (Markley, 1967). Amalgam has a coefficient of expansion 2.6 times that of the tooth. Grooves will not dependably retain a filling wider than 1.25 mm occlusogingivally. Grooves plus a pin in the mesial and another in the distal will dependably retain an amalgam up to 3 mm in width occlusogingivally. Larger cavities need a pin in each of the four corners.

Observe in Figure 44 that the margins of

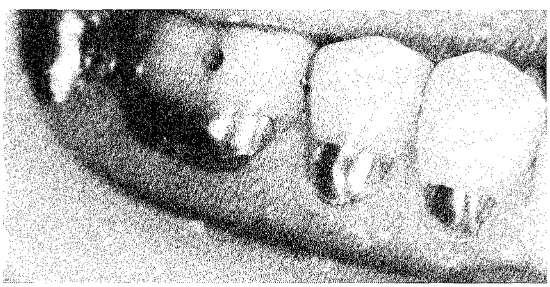

FIG 44. *Amalgam restorations in the first molar and second premolar after 25 years with margins as good as those of the gold foil, also 25 years old, in the first premolar*

the 25-year-old amalgams in the first molar and second premolar are as good as those of the gold foil of the same age in the first premolar. This is typical of pin-retained class 5 amalgams, which are retained against the disparity of coefficient of expansion and the flexure of the tooth under stress.

CONDENSING AMALGAM

Mahler finds, in his work with study groups, that most dentists do not condense amalgam well enough to eliminate voids, to reduce mercury content to optimum final strength, and to assure an intimate fit (Mahler & Nelson, 1984). To help achieve well-condensed amalgam in conservative preparations and around pins, a Markley auxiliary set of six hand condensers is made by the Hu-Friedy Manufacturing Company, Inc (Chicago, IL 60618, USA). Also, Teledyne Densco (Denver, CO 80207, USA) makes conservative points for the Condensaire.

Surface mercury of the deliberately overbuilt occlusal is blotted with unvulcanized rubber (Fig 45). Denture vulcanite is no longer

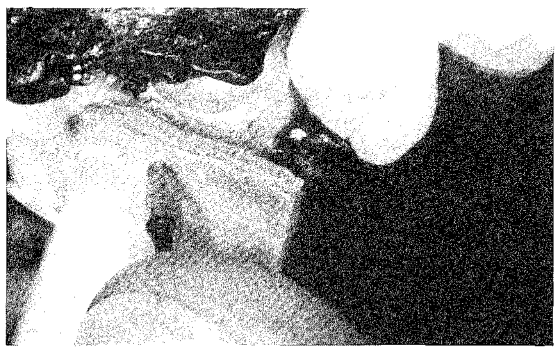

FIG 45. *Condensing the overpack through a pad of unvulcanized rubber removes excess mercury near the surface.*

available, so cushion-stock rubber, from a tire retread factory, is substituted (Fig 46).

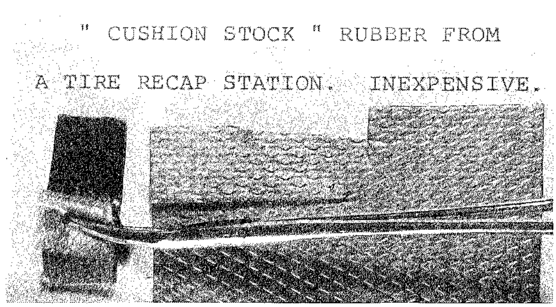

FIG 46. *Cushion-stock rubber from a friendly tire recap factory has replaced the denture vulcanite no longer available.*

Carving is deferred until resistance to a sharp instrument develops. The time will depend upon residual mercury and choice of alloy. A slow-setting amalgam allows thorough condensing. Leave a slight excess everywhere for finishing later, because carving fresh amalgam to a margin leaves a rough, overcut surface. A No 5 gold knife (Suter Dental Manufacturing Company, Chico, CA 95926, USA) best contours the embrasure from the height of the marginal ridge to the contact area inside the matrix.

The compound is **wedged** away from the teeth—it clings tenaciously to dry teeth. The tape is cut and the expendable matrix removed with hemostat forceps; but not until the occlusal embrasure has been carved completely (Fig 47).

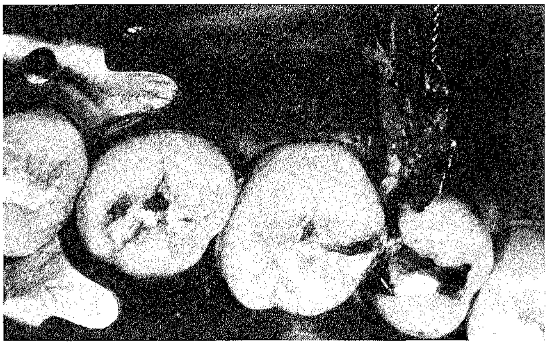

FIG 47. *Hemostat forceps remove the expendable matrix* ***after*** *the embrasure is fully carved.*

Tape is passed through the contact immediately to remove any inherent crumbs of amalgam. After the occlusal anatomy has been perfected, a future appointment is made for finishing and polishing.

FINISHING AMALGAM RESTORATIONS

At the finishing appointment, marginal flash can be cut flush with the margin, so smooth that it need not be polished on inaccessible gingival margins. Contours are perfected with burs at slow speed under a stream of air, then polished.

Conservative amalgam restorations made according to these principles (even with SSW True Dentalloy having 2% creep) are giving remarkable service. The four conservative amalgams in premolars, placed in 1937 and 1938 (shown in Figures 48 and 49) appear to be good for indefinite continued service.

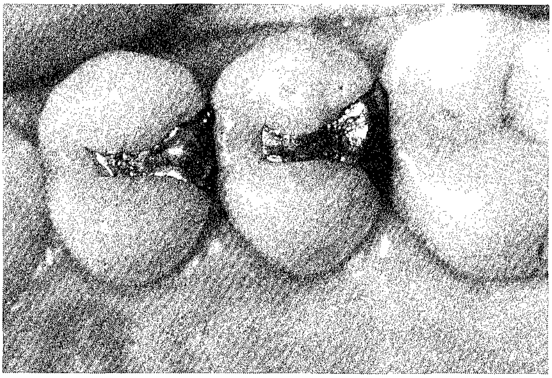

FIG 48. *Photographs taken in 1982 of conservative amalgam restorations of True Dentalloy in service since 1937—45 years*

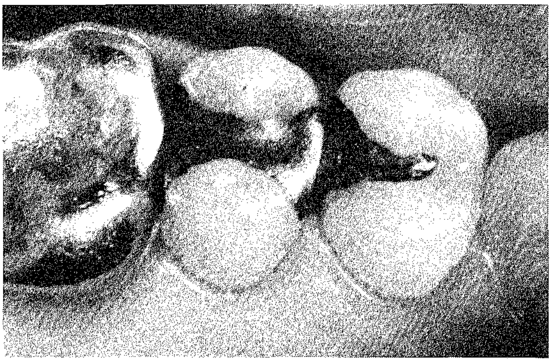

FIG 49. *Conservative amalgams of True Dentalloy in service since 1938*

PROBLEMS WITH CEMENTED RESTORATIONS

By contrast, biodegradable cement limits the life of all cemented restorations. I need not go outside myself for an illustration.

In 1962, 20 of my bruxed teeth were restored (Fig 50), the rehabilitation requiring

FIG 50. *Twenty onlays restored Dr Markley's teeth in 1962.*

20 half-day appointments. My dentist built beautiful margins on silver electroformed dies. A sophisticated gnathological technique assured occlusal harmony. He used the rubber dam; but all were built over cement bases; also he used hard, unburnishable gold. I continued bruxing for 17 more years. Some occlusals wore through the gold. With burnishable gold of a Brinell hardness under 85, having an intimate overall fit to the tooth, the gold might have adapted as it wore, or over amalgam bases the worn gold onlays would have maintained a seal.

The onset of a toothache led to the discovery that caries had consumed the cement base of an upper molar, destroyed much dentin, and involved the pulp! The lingual cusps were lost (Fig 51). I was amazed! This could

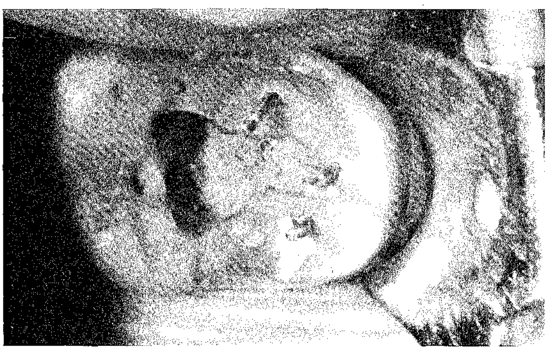

FIG 51. *After 17 more years of my bruxing, a toothache signaled trouble in 1979. Caries into the pulp had followed deteriorating cement bases.*

not happen to me. The molar was treated endodontically and a pin-amalgam foundation placed (Fig 52). With this shocking expe-

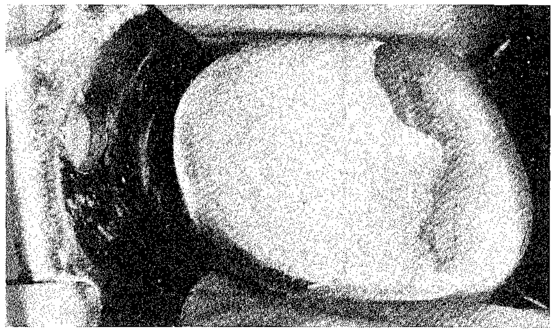

FIG 52. *A pin-amalgam foundation will resist future caries under a new cast restoration.*

rience, the worn **first** molar became suspect and was scheduled for replacement. The first molar was operated upon (Fig 53). It too lost

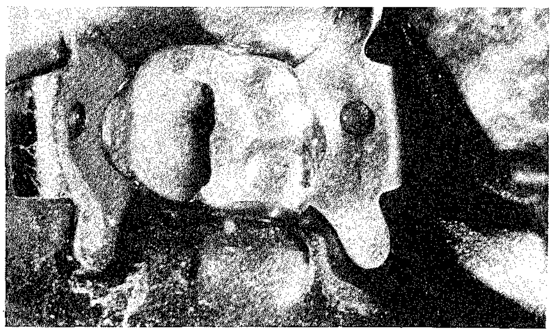

FIG 53. *Serious defects necessitating pin-amalgam repairs were found under comparably restored upper molars.*

its entire lingual, with caries close to the pulp. It has a huge pin-amalgam repair now, as do both molars on the other side, which failed likewise. Caries had consumed the entire linguals of all four upper molars by way of cement bases.

In December 1983, after 21 ½ years in service, a lower molar onlay came out. Cement had disintegrated, and dentin caries was removed. The onlay was reset experimentally with glass-ionomer cement—some chelation is possible under optimal conditions, and the fluoride content will, we hope, resist future caries.

When a restoration fails, it can be seen that

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DENTAL EDUCATION

Teaching Gold Castings in North American Dental Schools

NEREYDA P CLARK • GREGORY E SMITH

Summary

A survey of dental schools in the United States and Canada has revealed that all schools teach intracoronally retained cast gold restorations, although inlays without coverage of cusps are given minimal emphasis.

Most schools routinely bevel occlusal cavosurface margins for inlays, and create sharply defined internal line angles. Cervical cavosurfaces are commonly finished with margin trimmers, whereas diamonds are preferred for occlusal and the remaining approximal margins.

Most schools prefer bevels to chamfers for onlays, and create bevels of 0.5 - 0.7 mm in width with tapered diamonds. Most schools prefer a shoulder and bevel rather than a chamfer for centric holding cusps with 1.0 - 1.5 mm of occlusal reduction. A reverse bevel is preferred by most when treating noncentric holding cusps but schools are equally divided between 0.5 - 1.0 mm and 1.0 - 1.5 mm of occlusal reduction for these cusps. Most schools create a divergence of internal walls of 5 - 10°. Most schools adapt margins and polish castings before cementation. Only 38% of the responding schools apply the rubber dam before cementation of castings.

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Presented at the annual meeting of the American Academy of Gold Foil Operators, 30 September 1983, in Los Angeles

INTRODUCTION

The longevity of cast gold restorations depends, in part, on the design of the cavity (Krug & Markley, 1969) and, in part, on the quality of the final cemented restoration. This paper reports the results of a recent survey of philosophies and techniques advocated for the teaching of gold inlays and onlays in schools of dentistry.

even more damage results, therefore every effort should be made to build permanence into a restoration.

CONCLUSION

From these experiences five lessons can be cited:

1. Any cemented restoration should fit the tooth intimately overall. I worry about excessive die-spacing. We have used Hollenback's aqua regia for a dependable 25 μm relief since 1940. Amalgam has that intimate fit.

2. If a cemented restoration needs a base, the base should be amalgam. Well-condensed amalgam restorations become the most dependably sealed of **all** restoratives.

3. If a cavity is so deep as to need thermal insulation, it can be provided by a combination of a thin cement base, completely covered and protected from percolation by amalgam.

4. Use a burnishable gold alloy with a Brinell hardness below 85 whenever possible.

5. Class 2 inlays, with their mandatory occlusal steps, weaken teeth more than do conservative amalgams.

Since even the best restoration is but a repair, the need is ideally prevented by early care. Experience lends conviction to my conclusion: Good **conservative** amalgams, in lesions diagnosed early, have the best chance for preserving natural teeth for lifetime service.

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METHODS

A questionnaire was mailed to 65 schools of dentistry in the United States and Canada during the 1982-83 academic year. Forty-eight (74%) responded. Questions were asked about the following aspects of intracoronally retained castings: indications; design of cavity; type of gold; and methods of adapting the gold to the margins and of polishing and cementing the castings.

RESULTS

All 48 responding schools teach intracoronally retained castings for individual teeth. Of these, 44 schools (92%) teach both inlays and onlays and 4 schools (8%) teach only onlays.

Inlays

INDICATIONS

Thirty-three schools (75%) believe that MOD inlays are indicated if the occlusal isthmus is narrow. The remaining 11 schools (25%) teach inlays only for two-surface class 2 restorations, believing that all MOD lesions should be restored with amalgam or onlays.

Twenty-seven schools (61%) believe that inlays are superior to restorations of amalgam because inlays offer the dentist excellent control of approximal contour, placement of contact, and polish. Only 20 schools (45%) believe inlays last longer than restorations of amalgam.

DESIGN OF CAVITY

Bevel of margins: Schools were asked to indicate when occlusal cavosurface margins should be beveled in preparations for inlays. Twenty schools (45%) always bevel occlusal margins, 21 schools (48%) bevel occlusal margins only in teeth with steep cuspal inclines, and three schools (7%) bevel in teeth that have flat occlusal anatomic form. Occlusal bevels are placed with tapered diamonds by more than 50% of responding schools. Tapered fissure burs, green stones, or tapered finishing burs are preferred by the remaining schools. These same burs and diamonds are used for the placement of bevels on approximal margins; however, such bevels are also placed with hand instruments (margin trimmers, chisels, or angle formers) in 27 schools, or with disks in six schools (Table 1).

Table 1. Instrumentation for Placing Bevels (44 schools)

Instrument	Number of Schools: Occlusal Bevels	Number of Schools: Approximal Bevels
Tapered diamond	26	20
Tapered fissure bur	11	3
Hand instrument	5	27
Tapered finishing bur	10	20
Green stone	4	0
Disk	0	6

Internal line angles: Twenty-eight schools (64%) teach placement of sharp faciopulpal and linguopulpal line angles in preparations for inlays; 16 schools (36%) permit slightly rounded angles; 24 schools (56%) teach sharp, slightly obtuse facioaxial and linguoaxial line angles; and the remainder of the schools are evenly divided between rounded line angles and sharp 90° angles. The axiogingival line angle is created as a 90° angle at 21 schools (48%), whereas 17 schools (38%) create an acute angle in the gingival wall, and six schools (14%) round the angle.

TYPE OF GOLD

Most of the responding schools teaching inlay technique use Type II gold alloy to fabricate their restorations (Table 2).

Table 2. Casting Alloy Used for Inlay Restorations (43 schools)

Type of Alloy	Schools: Number	Schools: Percent
I	3	7
II	31	72
III	2	5
Semiprecious	6	14
Nonprecious	1	2

Onlays

INDICATIONS

Forty-seven responding schools teach cast gold onlays. There is general agreement that onlays are indicated when treating teeth with weakened facial or lingual cusps, when restoring endodontically treated teeth, and when correcting the plane of occlusion in teeth needing conservative restorations.

DESIGN OF CAVITY

Bevel of margins: Thirty-six schools (82%) teach that bevels of the cavosurface margin should be 0.5 – 0.7 mm in width. Seven schools (16%) believe that bevels should be greater than 0.7 mm, and one school prefers bevels of less than 0.5 mm. Cavosurface bevels are placed with tapered diamonds, finishing burs, hand instruments, and disks in decreasing order of preference. Twenty-seven schools (61%) believe centric holding cusps should be finished with a shoulder and bevel. Sixteen of the schools (36%) indicated they prefer a chamfer finish line around the centric holding cusp and two schools (3%) prefer a long bevel or knife-edge margin.

Schools also vary in their treatment of the facial cusp in maxillary premolars. Twenty-seven schools (61%) place a reverse bevel slightly onto the facial surface along the entire mesiodistal length of the cusp ridge, nine schools (20%) place a regular rather than a reverse bevel just to the height of the cusp ridge, six schools (14%) establish a regular bevel on the mesial ridge of the cusp and a reverse bevel distal to the cusp tip, and two schools (5%) place a chamfer finish line.

Occlusal reduction: Schools were asked to indicate the amount of occlusal reduction needed to provide an adequate thickness of gold. Most chose 1.0 – 1.5 mm reduction for centric holding cusps, but they were divided evenly between 0.5 – 1.0 mm and 1.0 – 1.5 mm reduction for noncentric holding cusps. Two-thirds of the respondents teach that centric holding cusps should be reduced 0.5 mm more than noncentric holding cusps (Table 3).

Table 3. Preferred Amount of Occlusal Reduction (48 schools)

Reduction	Schools Number	Schools Percent
Centric Holding Cusp		
mm		
1.0 – 1.5	37	77
1.5 – 2.0	11	23
Noncentric Holding Cusp		
0.5 – 1.0	26	54
1.0 – 1.5	22	46

Internal line angles: In the internal portion of the preparation for an onlay, 33 schools (70%) establish a 90° axiogingival angle while seven schools (15%) prefer an acute angle and seven schools (15%) round this angle; 42 schools (89%) bevel the axiopulpal line angles and five schools (11%) teach a sharp angle of 270°. Many schools prefer hand instruments to establish the correct form of the axiopulpal line angle; others, however, use a combination of hand instruments or the side of a bur (Table 4).

Table 4. Instrumentation for the Axiopulpal Line Angle (47 schools)

Instrument	Schools Number	Schools Percent
Hand instrument	22	47
Side of bur	8	17
Both hand and rotary	17	36

Divergence of walls: Forty-five schools (94%) create a divergence of 5 – 10° for internal walls, with 6° being the most common. Two schools (4%) create no divergence of walls at all while one school creates a divergence greater than 10°. Internal walls are prepared with a variety of rotary instruments (Table 5).

Table 5. Choice of Rotary Instrument for Preparing the Internal Walls of Onlays (47 schools)

Instrument	Schools Number	Schools Percent
Tapered plane fissure bur	32	68
Tapered crosscut fissure bur	10	21
Straight plane fissure bur	3	7
Tapered diamond	2	4

TYPE OF GOLD

Type II gold is preferred for onlays by 17 schools (37%), whereas it is preferred for inlays by 31 schools (72%). Both Type III gold and semiprecious alloys are also frequently used (Table 6).

Table 6. Casting Alloy Used for Onlay Restorations (46 schools)

Type of Alloy	Schools Number	Schools Percent
I	1	2
II	17	37
III	13	28
Semiprecious	9	20
Nonprecious	1	2
Semiprecious or III	5	11

Finishing, Polishing, and Cementing

Answers to questions about techniques used in finishing, polishing, and cementing revealed considerable diversity among the 47 responding schools. Thirty-one (65%) use hand-held burnishers for initial finishing of margins on the tooth and 35 schools (75%) may also use rotary instruments to improve marginal adaptation. Some combination of green stones, Shofu Rubber Points (Shofu Dental Company, Menlo Park, CA 94025, USA), and garnet disks are preferred for adapting the margins. Thirty-three schools (70%) polish to the margins with cuttle disks, rubber wheels, or polishing abrasives before cementation. Two schools do not adjust the occlusion on a casting before cementation and only 18 (38%) advocate placing the rubber dam.

Forty-five responding schools (98%) usually use zinc phosphate cement to cement inlays and onlays. One school reported a preference for glass-ionomer cement. Twenty-three schools (49%) adjust the occlusion after cementation and 20 schools (43%) apply hand-burnishing instruments to margins. Eleven schools (23%) apply rotary stones or Shofu points to margins after cementation and 33 schools (72%) polish with cuttle disks, rubber wheels, or abrasives.

DISCUSSION

Inlays

INDICATIONS

There is general agreement that gold inlays provide excellent control of approximal contour and contact. A few schools teach the inlay technique primarily because state boards of dentistry require candidates to demonstrate proficiency with this restorative material.

One-fourth of responding schools teach that MOD inlays are contraindicated, preferring onlays whenever three-surface castings are placed. These schools treat all conservative MOD lesions with silver amalgam. Research has shown that stress created in teeth with inlays can be controlled (Farah, Dennison & Powers, 1977) if width of isthmus and taper of walls are minimized. The decision to use amalgam or inlays to restore teeth with lesions should be made from an analysis of size of lesion, occlusion, and the existence of other restorations in the mouth rather than to rule out MOD inlays just because poorly fitted castings may place undesirable wedging forces on teeth.

BEVELS

Forty-five percent of respondents always bevel the occlusal cavosurface margin of inlay preparations in addition to the internal divergence of facial and lingual walls; 48% of schools bevel only those teeth with steep cusps; and 7% of schools bevel only those teeth with flat occlusal surfaces. To bevel in all cases risks unnecessary overextension of the occlusal outline and increases the concentration of stress at the margin as the bevel approaches areas of occlusal contact. Bevels on teeth with steep cusps may create finish lines that are exceptionally difficult to locate. Bevels are most desirable in teeth with a flat occlusal surface to provide a thin margin of gold for finishing. Research has identified the optimal bevel to be 30 – 45° at cavosurface margins (Rosenstiel, 1964). Functional wear on gold is significant on beveled edges of less than 30°, and marginal finishing techniques are less effective on beveled edges greater than 45°.

INTERNAL ANGLES

Debate continues on the subject of the design of internal line angles. Photoelastic studies have demonstrated concentration of stress at sharp line angles (Fisher & others, 1975); however, 64% of responding schools teach creation of sharp faciopulpal and linguopulpal angles, while 36% of schools advocate slightly rounded angles. Given sufficient length of wall and parallelism, the slightly rounded form may provide for sufficient retention, resistance of the tooth to fracture, and minimize concentration of stress.

Considerable difference of opinion on the correct form of the axiogingival angle is revealed. Two-thirds of the schools that create acute axiogingival line angles in inlay preparations create 90° axiogingival line angles in onlay preparations. The rationale for the change is not clear from this survey, though it may be that some of the respondents create the sharp acute axiogingival angle for two surface inlays to gain additional length of wall or to prevent the gingival portion of the inlay from being forced out of the cavity during cementation, and feel it is not needed for the MOD onlay preparation. Eleven percent of the schools teach a sharp 90° axiopulpal line angle for reasons that were not identified.

Onlays

INDICATIONS

Schools seem in general agreement on the value of the onlay restoration (Shillingburg & Fisher, 1970) and the need for careful attention to all cavosurface bevels.

BEVELS

There is general agreement that cavosurface bevels should be optimally 0.5 – 0.7 mm in length. Considerable diversity of opinion was obtained for treatment of facial cusps on maxillary posterior teeth requiring onlays. Sixty-one percent of schools prefer the routine use of a reverse bevel, which can have poor esthetic results although it affords maximum protection of cusps. A regular bevel is preferred by only 20% of the respondents and, although it provides minimal protection of cusps, it does have an esthetic advantage. A combination of the two may offer a good solution and studies of the resulting resistance form would be helpful.

Finishing, Polishing, and Cementing

A multitude of finishing techniques is taught. Many are acceptable; none, however, is optimal if care to waxing and casting procedures is overlooked. Several techniques are advocated in the literature and warrant careful study (Christensen, 1966). Studies with the scanning electron microscope of marginal finishing indicate that flame-shaped 12-bladed finishing burs applied with slow speed create optimal gingival bevels and 40-bladed finishing burs applied with high speed create finer occlusal bevels that diamonds or hand instruments (Barnes, 1974). Some abrasives, such as green stones and white stones, have recently been shown to be particularly damaging to enamel and should be used judiciously if at all (Sarrett, Richeson & Smith, 1983). When these abrasives must be used, an application of fluoride after cementation would be appropriate (Osborn, 1982).

CONCLUSION

Intracoronally retained gold castings have historically proven themselves to be a valuable therapeutic mode available to dentists. Most schools currently place greater emphasis on the fabrication and placement of onlays than they do on inlays. Many variations in design of preparation and instrumentation are taught throughout North American schools of dentistry. Research findings have been implemented to varying degrees in school curricula and this survey indicates additional need for research and study.

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PRODUCT REPORT

Effectiveness of Three Cavity Varnishes in Reducing Leakage of a High-copper Amalgam

Copalite is effective in preventing leakage around restorations of Tytin for at least a year in the laboratory

W DAN SNEED • JOHN H HEMBREE, JR • EDWARD L WELSH

Summary

When Cavi-Line, Copalite, and S S White Cavity Varnish were applied to the walls of prepared cavities before placing Tytin, tests with ^{45}Ca and autoradiography showed that at six months both Cavi-Line and Copalite were effective in preventing leakage from reaching the axial wall of the cavity but at one year only Copalite was still sealing.

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Introduction

Cavity varnishes are used with amalgam restorations to minimize early microleakage. Contraction of dental amalgam on setting promotes microleakage, and in the absence of an effective varnish, contributes to microleakage and tooth sensitivity (Going, 1972; Yates, Murray & Hembree, 1980). The lack of significant expansion during hardening by high-copper alloys could further aggravate the problem.

The purpose of this study was to examine the effectiveness of three commercially available varnishes to reduce early microleakage of a high-copper alloy.

Materials and Methods

Eighty class 5 cavities were prepared in sound, extracted human molars that had been stored in tap water. The teeth were then divided into four groups of 20 teeth. Three groups were treated with three different cavity varnishes, and one group received only amalgam to serve as a control.

Two layers of each of the varnishes listed in Table 1 were applied to each of the three experimental groups of prepared cavities. All internal walls, including the cavosurface angle, of the preparations were well covered.

Table 1. Varnishes Tested

Copalite	H T Bosworth Skokie, IL 60076 USA
Cavi-Line	L D Caulk Company Milford, DE 19963, USA
S S White Cavity Varnish	S S White Philadelphia, PA 19102, USA

After the varnishes had been applied, each tooth was restored with silver amalgam alloy (Tytin, S S White, Philadelphia, PA 19102, USA), and the specimens were stored in tap water at 37 °C before testing. The size of the sample allowed for 20 specimens with each varnish and 20 specimens for control. One autoradiograph of the group with S S White Varnish was lost and, therefore, only 19 specimens are reported. Each group of 20 specimens was further divided into four subgroups of five. One subgroup from each type of varnish was then tested for leakage at intervals of either one week, three months, six months, or one year. Before testing, each specimen was cycled thermally by dipping alternately in water at 4 °C and 58 °C, one minute each, for 100 cycles.

Marginal leakage was determined by the presence of a radioactive isotope, ^{45}Ca, between tooth and restoration as shown on an autoradiograph. Each specimen was soaked for two hours in a solution of $[^{45}Ca]Cl_2$ (concentration 0.1 mCi · ml^{-1}, pH 7). After removal from the isotope, the teeth were brushed with a detergent, mounted in a block of autopolymerizing resin and then sectioned longitudinally through the restorations by grinding wet on a wheel of aluminum oxide. The sectioned teeth were again brushed with a detergent, and the sectioned surface of the tooth was placed on an ultraspeed, periapical x-ray film for 17 hours to produce an autoradiograph. The films were processed in an automatic machine (Swartz & Phillips, 1961). Leakage was evaluated on the following scale.

0 - No evidence of the isotope between tooth and restorative material
1 - Evidence of penetration of isotope between tooth and restorative material at the cavosurface angle
2 - Evidence of isotope along the cervical and incisal walls but no penetration to the axial wall
3 - Evidence of penetration of isotope to the axial wall

Results

The results are shown in Table 2. The specimens with no varnish (control) demonstrated gross leakage after one week with every sample showing penetration of isotope to the axial wall. S S White Cavity Varnish produced the poorest results of the three materials tested. After one week, all 15

Table 2. Degree of Penetration of Isotope

		0	1	2	3
No varnish (control)	1 week			2	3
	3 months				5
	6 months				5
	1 year				5
Copalite	1 week	4	1		
	3 months	2	2	1	
	6 months		4	1	
	1 year		3	2	
Cavi-Line	1 week	3	2		
	3 months	4		1	
	6 months		2	3	
	1 year				5
S S White Cavity Varnish	1 week		1	3	
	3 months				5
	6 months				5
	1 year				5

samples showed maximum leakage through one year, similar to that seen when no varnish is used. Cavi-Line provided a seal up through six months but the five samples tested after one year showed gross leakage. Only Copalite demonstrated prolonged sealing up to one year.

Discussion

This laboratory study indicates that S S White Cavity Varnish does not prevent microleakage when used under the high-copper amalgam, Tytin. This varnish appears to lack the viscosity of the other two products examined, and this may contribute to its poor performance. Cavi-Line appears to be thicker than either Copalite or S S White Cavity Varnish and up through six months demonstrated good sealing. After six months, however, leakage increased dramatically. It is possible that sealing occurred until the varnish was lost by dissolution. The space left between amalgam and tooth structure may then have been too large for Tytin to seal itself as several investigators have shown can occur (Andrews & Hembree, 1975, 1978; and Boyer & Torney, 1979).

Conclusion

When no varnish is used, leakage can be expected to be immediate and long standing. S S White Cavity Varnish allowed for patterns of leakage similar to those seen when no varnish is used. Both Copalite and Cavi-Line sealed the amalgam margins well until six months had passed. After one year Cavi-Line demonstrated severe leakage whereas Copalite continued to seal.

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POINT OF VIEW

Contributions always welcome

Microfilled Resin Bonding Techniques in Today's Practice

JERRY M BROWN

The telephone rang on a windy Sunday afternoon last February. "Dr Brown, your telephone service is calling. You have an emergency call." My caller, Dan, said he was in a touch football game and had been accidentally hit in the mouth by the opposing team's tackle, fracturing six incisor teeth.

The next day I examined Dan and his fractured teeth. The maxillary central incisors were chipped in a mesioincisodistal manner. The four mandibular incisors were fractured horizontally between their incisal and middle thirds. A year ago I would have immediately begun preparations for crowns, but I now felt adhesive dentistry was a more desirable restorative choice. Dan did not have a bruxing habit, his overbite was normal, he did not smoke, nor drink large amounts of tea or coffee, and the traumatized teeth exhibited an adequate area of enamel for bonding.

I was able to achieve an excellent result thanks to the latest refinements in the technique of bonding with microresins. The contour, color, and highly polished surface of the microfilled resin harmonized with the natural tooth structure.

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JERRY M BROWN, DDS, assistant clinical professor of dental materials at New York University College of Dentistry

A short time thereafter I described this story to an older colleague. Even though I lent him the necessary instruments and composite materials, I could not persuade him to try these techniques in his practice. The thought of postponing the placement of crowns for as long as possible was not as important a consideration in his mind as it was in mine.

As for my own patient, I wanted him to know that the treatment had limitations. The resin is not very resistant to wear; chipping may result; and the resin technique is more "technique sensitive." Yet I now felt obliged to attempt a procedure that has a proven scientific basis and has been repeatedly documented to remain intact, depending on the individual's habits of chewing, while preserving the remaining natural tooth structure.

Throughout Dan's treatment I reminded him that the placement of crowns may be needed should the microfilled resin not withstand the test of time. I also reminded him of the time-honored, important preventive and home care measures that promote good dental health. I have found in Dan's case that he has mentioned me to his fellow employees, resulting in additional new patients to the practice. I strongly believe that the up-to-date practitioner should include microfilled resin bonding procedures in his or her restorative armamentarium.

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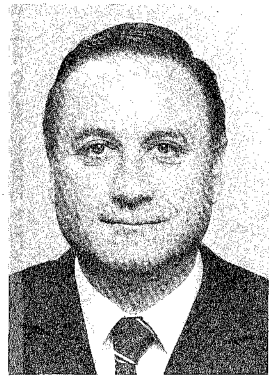
Letter from Europe

ADAM J SPANAUF



In order to align the European dental degrees within the European Common Market Community, important changes have been introduced into dental education in Italy. At present there are 25 dental schools or dental faculties in Italy. The total number of students for the 25 dental faculties is:

1st year — 792 students
2nd year — 663 students
3rd year — 452 students

Up until now the Faculty of Medicine and Surgery granted a degree in medicine and surgery (Laurea in Medicina e Chirurgia) as well as a degree in dentistry and prosthodontics (Laurea in Odontoiatria e Prostesi Dentaria).

Since 1980 a new curriculum has been introduced whereby only a dental degree will be given, that is, a degree in dentistry and prosthodontics (Laurea in Odontoiatria e Prostesi Dentaria). The duration of the dental course is five years and is divided into a first part of two years and a second part of three years. The curriculum consists of core subjects. The subjects are as follows:

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PART I

First Year:

1) General biology for medical studies
2) Chemistry and foundations of biochemistry
3) Medical physics
4) Normal human anatomy with special reference to the mouth
5) General histology and embryology (including cytology)
6) Dental materials

Second Year:

1) General anesthetics and sedation in dentistry (half year)
2) Pharmacology (semester)
3) General human physiology and physiology of the mouth
4) Pathological anatomy and histology
5) Microbiology (semester)
6) Conservative dentistry (first year)
7) Biochemistry
8) Hygiene, preventive dentistry, community dentistry, and epidemiology (semester)
9) General pathology

PART II

Third Year:

1) Special oral surgery (first year)
2) Conservative dentistry (second year)
3) Special surgical pathology and foundations of clinical practice
4) Special medical pathology and clinical methodology
5) Special oral pathology
6) Prosthodontics (first year)
7) General radiology and dental radiology (semester)

Fourth Year:

1) Special oral surgery (second year)
2) Clinical practice (first year)
3) Neuropathology and psychopathology (semester)
4) Conservative dentistry (third year)
5) Orthodontics and function of the jaw (first year)
6) Periodontics (first year)
7) Prosthodontics (second year)

Fifth Year:

1) Clinical practice (second year)
2) Forensic and insurance medicine and ethics of dental practice (semester)
3) Orthodontics and function of the jaw (second year)
4) Periodontics
5) Pedodontics (semester)
6) Prosthodontics (third year)

Supplementary Subjects (two to be chosen by student):
1) Maxillofacial surgery
2) Dermatology and venereology (semester)
3) Otorhinolaryngology (semester)
4) Health statistics

Attendance is compulsory for all the students enrolling in the course. Any student failing to maintain a satisfactory record of attendance will be excluded from the examination. At the end of their five-year course, students are obliged to write a thesis and pass the final examinations. Students may not proceed to Part II unless they have obtained satisfactory marks in the examinations in 12 of the 14 foundation courses set during Part I. Students failing to meet this requirement are allowed a period of grace of one year only. If at the end of this time they still have not passed the requisite number of examinations in foundation courses, students will be expelled from the course.

Graduates of medicine and surgery will also be entitled to register as dental practitioners provided they hold the specialist's qualification in stomatology (Diploma di Specialista in Stomatologica), to obtain which they must study for three years at a school of postgraduate studies (Scuola di Specializziane), pass appropriate examinations, and defend a thesis.

With regard to the state examination for authorization to practice dentistry, arrangements organized on the basis of two groups of subjects have been proposed:

Group One — Clinical Dentistry

Related subjects: special medical pathology; special surgical pathology; general and dental radiology; hygiene and preventive dentistry

Group Two — Dental Surgery

Related subjects: conservative (operative) dentistry; periodontology; orthodontics and function of the jaw

In conclusion it may be stated that dental practice will therefore become the exclusive province of graduates of dentistry and prosthodontics. The field of activity covered by future graduates of dentistry and prosthodontics will conform to the European Community Directive, that is, to "pursue activities involving the prevention, diagnosis, and treatment of anomalies and diseases of the teeth, mouth, jaws, and associated tissues."

Acknowledgments

I acknowledge the help of Dr H W Dippel, a member of the European Commission for Dental Affairs, for letting me have access to his personal files.

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DEPARTMENTS

Book Reviews

ESTHETIC GUIDELINES FOR RESTORATIVE DENTISTRY

Edited by Peter Schärer and Ludwig A Rinn, with 15 contributors including Lloyd L Miller and Jack D Preston

Published by Quintessence Publishing Co, Inc, Chicago, 1982. 236 pages; 241 illustrations, 232 in color. $72.00

According to the foreword, the guidelines presented in this text are for promoting, by the practicing dentist, dental technician, and student, an understanding of the clinical problems of esthetic dentistry in relation to their practical consequences. The editor presumes that the reader's awareness of these guidelines will result in the improvement of his esthetic accomplishments in daily practice and his efficiency in communicating the associated problems. The subject matter is presented by contributions from all the members of the graduate training program in the department of crown and bridge (fixed) prosthodontics, Dental School of Zurich, Switzerland; plus the contributions of Miller, Preston, and Rinn.

This text, like many others that have multiple contributors, has a tendency to lack cohesion. It is artfully produced with legible print, paper of high quality, and a careful binding. The illustrations, mostly in color, are numerous, well described, and clarify the principles and problems presented. Each legend is adjacent to the illustration and appropriately positioned relative to the descriptive text. The reproduction and presentation of the color illustrations are a credit to the publisher. The writing style, although acceptable, varies with each chapter and its contributor. Some chapters present brief descriptive texts in the form of checklists or outlines. With some modification to their length, the esthetic checklists, providing evaluation and identification of potential problem areas, could be adapted to the practical situation.

The chapter on tooth morphology, which utilizes the FDI numbering system, draws heavily on established textbooks in its description of the individual teeth. Partial coronal prostheses are described as compromises to dental esthetics in another chapter, which does not address the resin-bonded retainer. The last three chapters—10, 11, and 12—present the esthetic differences and the principles in the design of complete and partial removable prostheses. Discussion and comparison of these clinical problems with fixed prostheses seem to broaden the meaning of restorative dentistry. The task of teaching clinical esthetic dentistry is principally fulfilled in the chapters on color, framework design, and technical manipulation. Miller comprehensively describes the marriage of the metallurgical and ceramic systems in porcelain fused to metal veneers. He should also be acknowledged for the careful translation of the entire text from its original German. Rinn details a cookbook presentation of the technical manipulation of these materials that should provide ample information to those developing and enhancing their technique. Preston summarily addresses the science of color, which he has also presented more comprehensively in his own text on the subject.

Although interesting and readable, this is not a detailed text presenting the many problems associated with dental esthetics. The periodontal and orthodontic considerations in the restorative dentist's approach to this area could have been addressed. When a text is intended to teach a large audience—dentists, technicians, and students—its impact is compromised by its attention to their varying areas of interest. Techniques, information, tips on handling problem areas and scientific references are provided for these readers. It is difficult to suggest a single audience that would benefit most from this book. *Esthetic Guidelines for Restorative Dentistry* can serve as an additional reference to the library of individuals interested in this fascinating and demanding area of dentistry.

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MODERN GNATHOLOGICAL CONCEPTS — UPDATED

Victor O Lucia, DDS, FACD

Published by Quintessence Publishing Co, Chicago, 1983. 440 pages, 865 illustrations (most in color). $160.00

This textbook, first published in 1961, is a complete work on all aspects of gnathology, from the basic sciences through speculation on the future, by an author with more than forty years of experience as a clinician and teacher. The book is well illustrated and contains many practical clinical and laboratory suggestions. A chapter on practical hints includes a section on "advice I would like to have had in my early career."

Two chapters are devoted to anatomy and physiology and five chapters deal with instrumentation, including the use of the Stuart and Denar articulators. Specific materials and manufacturers are listed throughout the book. The illustrations are effective in relating anatomical determinants of occlusion to articulator settings and movements. An entire chapter on the hinge axis discusses the technique of location as well as the "proof positive" that it is locatable and consistently usable.

A cautiousness that comes from experience is reflected in the chapters on diagnosis and treatment planning. The author encourages the use of the expertise of other dental and nondental professionals in creating an optimal environment for restorative procedures. A later chapter defines a philosophy and protocol for occlusal adjustment. It is well integrated with earlier material on the development of an articulation in wax.

Chapters on precision partial dentures and ceramic veneer restorations are thorough, though an entire book on each subject would be necessary to cover both of these subjects completely. Dr R Brian Ullman contributed the chapter on ceramic veneers. His thesis, in 1972, at the University of Indiana was on the evaluation of the collarless veneer crown.

Five chapters deal specifically with the details of full mouth rehabilitation. Preparations, temporaries, impression techniques (hydrocolloid, rubber base, silicone), die making and waxing, and articulation are covered thoroughly, as well as remounting, cementation, and case follow up. Investing and casting techniques for restorations are not included but a chapter is devoted to the fabrication of aluminum clutches.

Twenty individual cases are presented demonstrating examples of particular rehabilitative problems. The presentation of each case includes two to three photographs, in most cases, and a very limited description. The presentations could have had much more teaching value if they had been presented with more individual data, both pre- and postoperatively.

A very important chapter in the book deals with the role of the anterior teeth in occlusion, a subject frequently given inadequate attention. Reference is made to the work of Dr William H McHorris, published in 1979, and to publications by the late Dr Charles E Stuart, in 1976.

While the book is not exhaustive in its coverage of the subject matter, it is a good resource of practical information and gives a thorough overview of the author's concepts of how gnathology should be practiced.

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NOTICE OF MEETINGS

American Academy of Gold Foil Operators

Annual Meeting: 18 and 19 October 1984
Emory University
Atlanta, Georgia

Academy of Operative Dentistry

Annual Meeting: 18 and 19 March 1985
Westin Hotel
Chicago, Illinois

The following name and affiliation were erroneously presented in the list of recipients of the 1983 Student Achievement Awards for the American Academy of Gold Foil Operators:

Temple University—Richard L Schnarrenberger

Letters

What Happened to Slide Rules?

I will preface this letter by saying that I would have responded earlier to your well-expressed editorial in the summer issue if I had received it sooner. It arrived yesterday—two days after the autumn issue. I don't know if the post office is to blame or the weatherman, who has been throwing curves to you on the West Coast recently. Maybe he mixed up your journal's seasons also.

Inasmuch as none of us now alive will be able to know if H G Wells was as prescient about dentists' future as he obviously was in regard to military matters, I think it would be more helpful if your editorials were to focus on our turbulent present.

As you said: "For the past twenty years or so subsidies by the government have resulted in a large increase in the supply of dentists . . ." But it is not enough for you to be a mere reporter of such events, you and our other editorialists should be vigorously pointing out to us dentists and to our legislators that there has not been the expected concomitant large increase in the supply of patients and that a rational government would now take the necessary steps to achieve that end, which presumably was its reason for increasing the supply of dentists in the first place.

At the very least, it is the responsibility of Congress, not the American Dental Association, which plans to do it, to underwrite the proposed expensive public information campaign needed to inform the people that these dentists are now available to serve them. However, in your editorial you hit upon a more fertile approach, which I feel the profession could pursue most reasonably.

"Paying employees in fringe benefits" as you put it was in reality, as we all know, a tax break for relatively few—usually union members. Therefore Congress has an obligation to equalize its treatment by granting a similar tax break to the far greater number of non-union members who did not receive any such favors from their government.

Justice demands this, and such help would also do a lot to aid those dentists that Congress created and who now are "more likely to treat some conditions they formerly referred to specialists" (and undoubtedly help their patients and dentistry even more—take "conscious sedation," for example).

Our editorialists should, I feel, not stand silently by and let the government inadvertently destroy the profession in an attempt to promote dental care. Our focus must be on our immediate future—not 2106.

JAMES T O'CONNOR, DDS
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Which Is Best?

I must hasten to congratulate you on your editorial "Which Is Best?" that appeared in the Autumn 1983 issue of *Operative Dentistry.* It addresses a matter of increasing importance in the profession, particularly in restorative dentistry.

The practicing dentist is daily faced with the dilemma of making rational decisions on the host of new materials and evolving, sometimes revolutionary, concepts of usage. He must sift through the claims of clinicians and manufacturers and then hopefully separate fact from fiction. In many instances the newer systems have no proven criteria for evaluation and their track record is often short lived.

You properly emphasize that although laboratory data prove a valuable mode for screening these materials, the final test remains well-conducted clinical investigations—coupled, of course, with sound biocompatibility tests. Until such data are available the dentist should assume a critical posture, as you well state.

It is an exciting era and one which challenges the minds of the scientist and the ultimate users—the dentist and his auxiliaries.

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INSTRUCTIONS TO CONTRIBUTORS

Correspondence

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

Exclusive Publication

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

Manuscripts

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

Tables

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

Illustrations

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

References

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