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

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EDITORIAL

Conserving Scarce Materials

The problem of increasing scarcity of metals and materials used in manufacturing is addressed in the article by Robert P Kusy in this issue of the journal. He alerts us to the fact that the United States is more dependent on foreign sources for 12 important metals than it is for oil. What is even more distressing is that the large reserves of some of these metals are in countries that may not be friendly to the United States and thus in times of trouble our supply might be interrupted. Another source, the Dental Health Committee of the British Dental Association, has estimated that the entire supply of mercury will be exhausted in 20 years (*Australian Dental Journal,* 1981).

Increasing scarcity of materials and increasing demand for them lead to increases in their prices. The effect of this principle of economics on the prices of noble metals, silver, and mercury has been felt by dentists, who have reacted to the higher prices by turning to alloys with less noble metal and to alloys entirely of base metals. Also the development of substitutes, such as composite resins, proceeds apace. So far, however, the substitutes are not as satisfactory as the metals they are intended to replace.

Another solution to the problem is conservation — an effective remedy in the case of oil. How can we apply the principles of conservation to dentistry? Conservation of teeth has always been our aim; but we can do more — we can conserve restorations. Unfortunately, a large part of a dentist's time is spent in replacing restorations that have failed. Some of the materials from these failed restorations, such as those of gold, may be salvaged and returned to the refinery to be used in making new alloy; but restorations of silver amalgam are usually removed by grinding to dust and thus the metals are lost. Apart from the loss or recovery of materials, however, there is the enormous loss of effort and time used in replacing restorations that have failed. In the circumstances, we should do our utmost to avoid the need for replacing restorations and in this way ease the demand for scarce materials. More attention to details while we are preparing cavities and placing restorations would add to their longevity, thus not only saving materials but also benefiting patients.

Eliminating dental caries, of course, would provide a much more satisfying solution, and the effects of fluoride and oral hygiene are taking us in that direction. Nevertheless, *Streptococcus mutans* is not yet on the list of endangered species, so for the foreseeable future there will be carious teeth to be restored. In view of the precariousness of the supply of our restorative materials let us strive to enhance the durability of our restorations, even if it means extending their lives for only a year or so, and thus help to forestall a crisis in dental materials.

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OPERATIVE DENTISTRY, 1982, 7, 2-6.

ORIGINAL ARTICLE

Adhesiveness of Glass-ionomer Cement to Enamel and Dentin: A Laboratory Study

ASPA was found to adhere more strongly to enamel than to dentin.

THOMAS L COURY • FRANK J MIRANDA
RICHARD D WILLER • ROBERT T PROBST

Summary

The mean force needed to shear glass-ionomer cement (aluminasilicate polyacrylate) from the enamel and dentin of extracted teeth and from a surface composed partly of each was 548 lbf · in^{-2} (3.8 MPa), 354 lbf · in^{-2} (2.4 MPa), and 359 lbf · in^{-2} (2.5 MPa), respectively. The difference between the force required for dentin and that for the combination of dentin and enamel was not significant.

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Introduction

To date, the most common and most successful method of restoring class 5 lesions has involved mechanical preparation of the teeth to receive a restorative material. These materials are normally retained in the prepared cavity by mechanical retention. However, such preparation has been shown at times to render teeth sensitive.

Where teeth are not cariously involved, yet demonstrate significant cervical abrasion or erosion, it would be beneficial if they could be restored with a minimum of mechanical preparation. The technique of etching with acid, pioneered by Buonocore (1955), aids the retention of certain restorative materials (Laswell, Welk & Regenos, 1971; Short, Hembree & McKnight, 1976); however, application of etchants to dentin may not be beneficial and may, in fact, damage the tooth (Brännström & Nordenvall, 1977).

Aluminasilicate polyacrylate cement, a glass-ionomer cement of the type first developed by Wilson & Kent (1972), is currently being recommended as suitable for the restoration of such noncarious lesions as abrasion and erosion without the need for preparing a cavity. The manufacturer of the cement under study in this investigation states in the literature accompanying the product that this material "chemically adheres to both enamel and dentin without mechanical undercutting or phosphoric acid-etching" (L D Caulk Co, 1977). This statement is further supported by Hotz & others (1977), who verified that adhesion of glass-ionomer cement to tooth structure was the result of molecular interactions that are polar or ionic rather than mechanical.

The purpose of this investigation was to measure the magnitude of adhesion of a glass-ionomer cement (ASPA, L D Caulk Co, Milford, DE 19963, USA) to enamel and dentin.

Materials and Methods

Thirty recently extracted teeth that were relatively free of caries were obtained for this study. Each tooth was cleansed with flour of pumice and then stored in an isotonic saline solution at 37 °C for a week. The teeth were then randomly assigned to one of three groups, each group consisting of 10 teeth. The teeth in each group were prepared as follows:

Group 1: The facial surface of each tooth was ground on a model trimmer just enough to provide a flat surface of enamel.

Group 2: The facial surface of each tooth was ground sufficiently to provide access to the dentinoenamel junction.

Group 3: The teeth were ground as for Group 2; however, focus in this group was on a flat surface of dentin.

All prepared surfaces were then smoothed with emery cloth and water to simulate the surface of clinically abraded or eroded teeth. To achieve relative standardization, all teeth were prepared by the same operator.

Just before testing, and as recommended by the manufacturer, each tooth was cleansed with Zircate prophy paste (L D Caulk Co) and Prelim, a 50% solution of citric acid (L D Caulk Co), then washed with water and thoroughly dried.

ASPA cement in the precapsulated form was the brand of glass-ionomer cement used in this study. The cement was activated and triturated according to manufacturer's directions with a Vari-Mix II triturator (L D Caulk Co). The cement was placed in a cylindrical matrix of gelatin, 4.6 mm diameter, and applied to the prepared surface of each tooth (Fig 1). The cement was

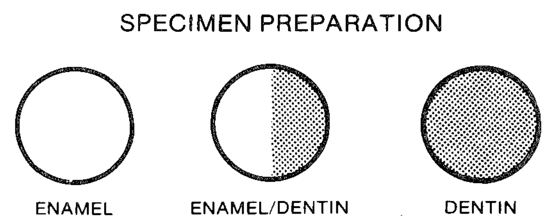

FIG 1. ***Schematic illustration of surfaces to which cement specimens were applied***

held in place with an ASPA cervical matrix (L D Caulk Co) and finger pressure until the initial set (6 min). After initial set, the gelatin matrix was removed and the coating solution supplied with the ASPA kit applied to each specimen. All specimens were then stored in 100% humidity for a week.

At the end of the week, all burrs and sharp edges on the cement were removed with a scalpel. Each specimen was then positioned in an acrylic base and aligned by a dental prosthetic surveyor so that the direction of applied force during testing for adhesion would be at right angles to the specimen. The specimens were subjected to random testing with the Instron Universal Testing Instrument (Instron Corp, Quincy, MA 02021, USA) to determine the amount of force necessary to dislodge the specimen from the tooth structure (Fig 2).

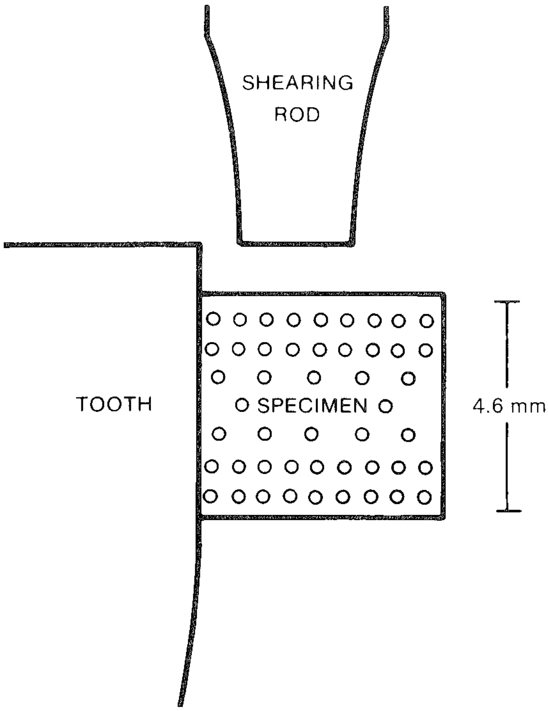

FIG 2. *Shearing rod (displacement force) directed at right angles to specimen attached to the surface of a tooth*

The applied force was converted to pounds per square inch ($lbf \cdot in^{-2}$) by means of the following formula:

$$S = \frac{4F}{\pi d^2}$$

where

S = Shear force — $lbf \cdot in^{-2}$ (Pa)
F = Displacement force — lbf (N)
d = Diameter of specimen — in (mm)

The data were subjected to Student's *t* test for ungrouped data and analysis of variance.

Results

The forces required to shear the specimens of glass-ionomer cement are shown in the table. There was a statistically significant difference between the forces required for Groups 1 and 2 and also between Groups 1 and 3, but between Groups 2 and 3 the difference was not statistically significant.

Force Required to Shear Glass-ionomer Cement from Enamel and Dentin

Group	Shearing Force $lbf \cdot in^{-2}$ (MPa) Mean SD	Range
1: Enamel	548 ± 114 (3.8 ± 0.8)	233 - 1242 (1.6 - 8.6)
2: Enamel & Dentin	354 ± 56 (2.4 ± 0.4)	155 - 699 (1.1 - 4.8)
3: Dentin	359 ± 42 (2.5 ± 0.3)	233 - 699 (1.6 - 4.8)

Discussion

The results of this study confirm the claims that glass-ionomer cements adhere to tooth structure (McLean & Wilson, 1977). More force was needed to dislodge the cement from enamel than from dentin or from a combination of enamel and dentin. This difference might be explained in part by the cleansing of the surface of the tooth with 50% citric acid. The formation of tags of cement in the etched enamel provides mechanical retention in addition to the molecular interactions bonding the glass-ionomer to the tooth and could be expected to increase the force required to dislodge the material from the surface of enamel. Hotz & others (1977) have proved that citric acid, while not as powerful an etchant as the more commonly used phosphoric acid, is more effective in conditioning and cleansing the surface of the tooth. Moreover, Wilson, Crisp & Ferner (1976) have shown that citric acid is compatible with glass-ionomer cement and actually improves its setting properties. Bonding is greater to enamel, which consists of almost 100% apatite, than to dentin (Hotz & others, 1977) and this difference is apparently further increased by the mild etching with citric acid.

Of concern to the practitioner is the potential for citric acid to irritate the dental pulp. Lee & others (1971) have shown that citric acid used with a liner and composite resin produced no gross or irreversible pulpal irritation when applied to the dentin of dogs' teeth, and furthermore have demonstrated no penetration of human dentin with 50% citric acid (Lee & others, 1973). However, other studies (Eriksen, 1974; Vojinović, Nyborg & Brännström, 1973) have shown a more intense pulpal reaction under cavities etched with 50% citric acid than under cavities that have not been etched. The practitioner must use his or her own judgment about the use of citric acid until studies of pulpal response are more definitive. Some factors that must be considered include the size and depth of the lesion to be treated and the particular teeth involved. Hotz & others (1977) have recommended that citric acid is the preferred cavity cleanser in erosion lesions, where no tooth surfaces have been cut. They discourage its use on those areas of dentin that have been exposed where a cavity has been prepared.

The difference in strength of bond between enamel and dentin is further illustrated in the electron micrographs showing the results of a shear force on cement attached to enamel (Fig 3) and to dentin (Fig 4). Shear force applied to the bond between cement and enamel produced fracture that was almost uniformly cohesive, that is, occurring almost completely within the cement rather than at the bond of cement and enamel. On the other hand, failure of the bond between cement and dentin was both adhesive and cohesive, with the primary failure at the bond itself, but with large particles of cement remaining attached to the surface of the dentin. This further supports the findings of Hotz & others (1977) and verifies the greater strength of the bond of the cement to enamel when compared with the bond of the cement to dentin.

While the lower forces necessary to dislodge the cement from a surface of dentin or a combination of enamel and dentin indicate an absence of significant effect when dentin is etched or cleansed with citric acid, the forces appear to be great enough to indicate that the use of glass-

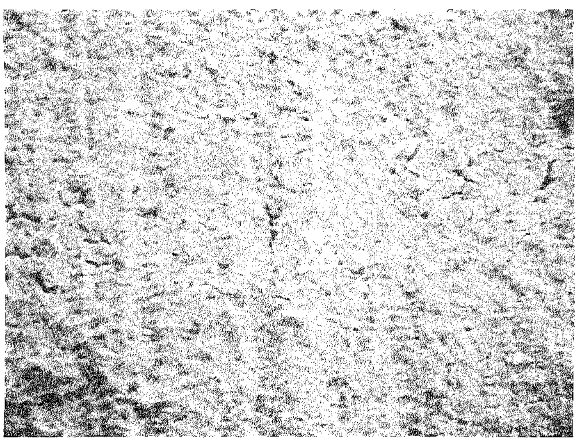

FIG 3. *Scanning electron micrograph of enamel after fracture of cement. Note almost uniform layer of cement remaining attached to the enamel, indicating fracture primarily* **within** *cement rather than at the interface of enamel and cement. (original ×400)*

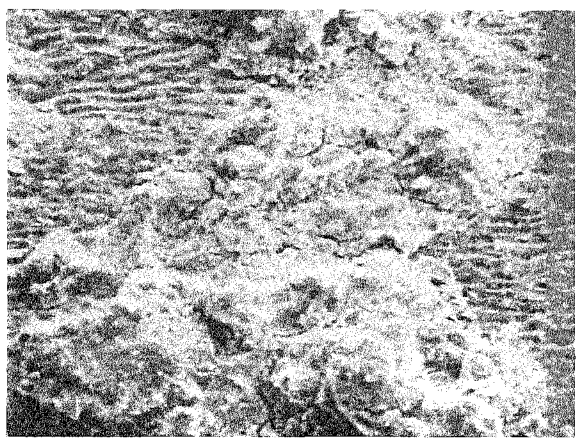

FIG 4. *Scanning electron micrograph of dentin after fracture of cement. Note large particles of cement attached to dentin, indicating fracture primarily at the interface of dentin and cement, but the bond was sufficiently strong to retain some cement. (original ×400)*

ionomer cements in areas not subject to stress, such as class 5 cervical lesions, may result in clinically acceptable restorations. In fact, the shear force required to dislodge cement from dentin as determined in this study (2.5 MPa) differs little from the value obtained by Hotz & others in their 1977 study (2.9 MPa).

This study did not determine if there was chemical bonding between the cement and tooth structure as claimed by the manufacturer. This, however, may be merely a matter of semantics. As Hotz & others (1977) have reported, the bond formed is more likely a result of secondary molecular attraction than primary chemical bonding. In any case, the demonstrated adhesion is specific or physicochemical rather than mechanical.

The glass-ionomer cements appear to offer a rather limited alternative to the mechanical preparation of teeth as a means of restoring class 5 lesions. The laboratory values obtained in this study cannot fully predict clinical behavior of these cements because of less controllable clinical variables. While the shear values for dislodgment of cement from dentin in this study are slightly higher than for the related and clinically accepted zinc polycarboxylate cements, it must be remembered that the glass-ionomer cements are being advertised as more permanent restorative materials. Long-term clinical studies that test definitive pulpal reactions to etching with citric acid, that compare the efficiency of glass-ionomer cements to other esthetic restorative materials, and that report on the clinical longevity of such restorations are needed before the practitioner can fully accept these cements as viable alternatives to mechanical preparation for the restoration of class 5 lesions.

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SPECIAL ARTICLE

Scarcity of Materials—A Dental Problem, Too

Increasing dependence on foreign countries for materials essential to industry affects everyone in the United States, including dentists. The problem must be alleviated by measures such as conservation, stockpiling, and development of alternative materials.

R P KUSY

Summary

Dependence on foreign sources for 36 materials that are strategically important is a grave problem for the United States. Of the 15 that are essential for dentistry the reliance on foreign sources for 12 of them exceeds that of oil. Overall strategies to alleviate the problem involve conservation, alternative materials, stockpiling, and revitalizing the mining industry. Specific measures to reduce dentistry's dependence on noble metals as well as cobalt, chromium, and nickel include the continued development of alloys low in gold, composites for posterior teeth, coatings on base metals, and alloys of titanium.

INTRODUCTION

Three decades ago the President's Materials Policy Commission convened to study the nation's future needs for materials and to recommend action to ensure the needs would be met.[1] At that time the United States supplied nearly half the world's steel, yet 10 years later had become a net importer. Not until the mid-70s was attention again drawn to the seriousness of our increasing dependence on foreign materials. As the decade ended, with steel imports swollen to about 25 million tons per annum, more than 20 reports warning of impending crisis appeared. Their ominous themes prompted many serious questions: "Materials Crisis Next?"[2] (Is it really that serious?), "Productivity, Energy Costs, Strategic Materials Challenges of the '80s"[3] (Will it be a key issue of the '80s?), "Materials Availability—Alternatives, Conservations, Coatings Favored"[4] (Has industry gone so far as to map out strategy?), "Substitution Concepts for Steel"[5] (Yes—), and "Critical Materials and Substitution Strategies in the Communications Industry"[6] (—apparently so). Indeed a longstanding problem has come home to roost.

Often called the "nonfuel crisis," the scarcity of materials has been addressed by a small segment of the community of metallurgical engineers; but dentistry, in general, is unaware of the potential impact of the scarcity on the effective provision of health care. Two questions must be considered: Is today's situation as critical as described; and if so, what action should be taken to cope? This report attests to the seriousness of the issue and discusses the

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overall strategies available along with specific solutions for dentistry.

METALS AND DENTISTRY

A dental operatory is a virtual repository of alloys of base metals, particularly stainless steel: countertops, sterilizers, trays, dental engine, and instruments. These alloys are selected for their outstanding resistance to corrosion and usually contain 18% chromium and 8% nickel. Further inspection of the equipment reveals parts made of monel alloy (68% nickel and 15% manganese) and dental flasks made of brass containing 35% zinc. The cabinets contain matrix bands, temporary crowns, and broaches of stainless steel; burs of tungsten carbide or of diamond with a binder of 10% cobalt; capsules containing amalgam as atomized powder (65% silver and 29% tin); liquid mercury; and gold crowns and bridges (75% gold, 8% silver, 4% platinum, and 4% palladium). An entire family of alloys of cobalt and chromium might be found having 70% cobalt and 30% chromium for frameworks for partial dentures, or, in an orthodontist's operatory, 40% cobalt, 20% chromium, 15% nickel, and 2% manganese for archwires. Alongside those archwires would be nickel-titanium wires (50% nickel and 50% titanium) and beta-titanium wires (79% titanium). Stainless steel would be found again as archwire and as pliers of many configurations. In short, whatever the dental operatory, you will find yourself amidst noble metals, cobalt, chromium, and nickel.

DEPENDENCE ON IMPORTED METALS

Of the 36 metals and minerals critical to our nation's needs, we depend on foreign suppliers for 22. Over half of these are used extensively in dentistry. Figure 1 shows that at least 90% of our requirements for manganese, cobalt, chromium, and the platinum group of metals must be imported.[7] Some place tin and nickel also

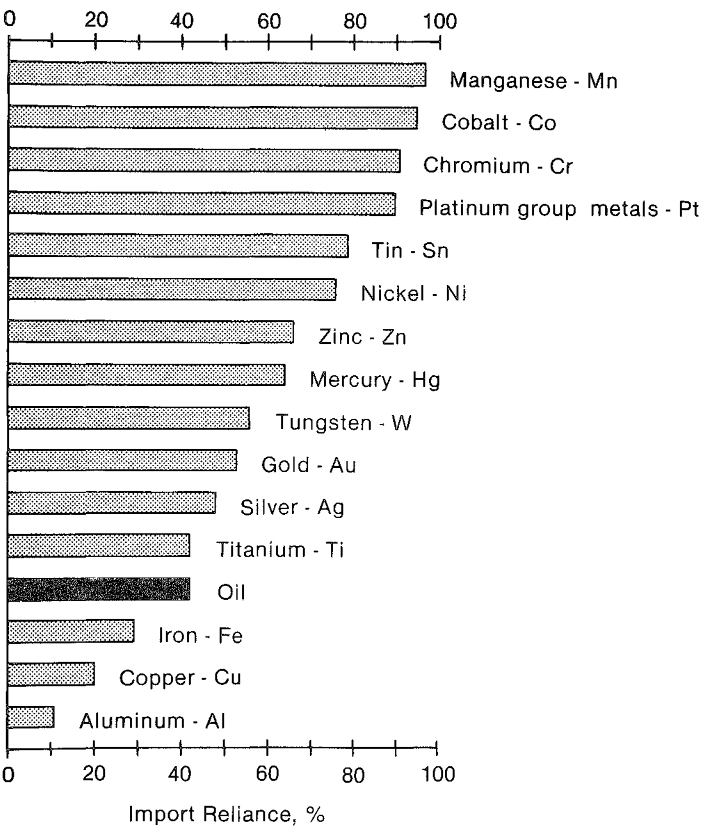

FIG 1. *More than half of the 15 key dental materials are dependent on foreign importation over and above a critical 50%. The black bar representing the amount of crude oil imported from foreign sources is nearly last on this list of critical materials.*

[Adapted from Gray (7), Piepgras & Metz (8), Warshofsky (10).]

in this category.[8,9] Our dependence on six more metals, namely, zinc (66%), mercury (64%), tungsten (56%), gold (53%), silver (48%), and titanium (42%), equals or exceeds our dependence on foreign crude oil.[7-10] One need only reflect for a moment to 1973 to recall the problems associated with a similar dependence on that commodity.

Not only the levels of reliance but also the sources of supplies give cause for concern. In Figure 2 the shaded portions of the map of the world show that many of the known reserves come from two general locations: third-world nations and the Soviet bloc.[7,11] Particularly noteworthy is the dependence of the United States on South Africa and Russia for three of the four most critical metals, plus gold.[9] Speaking before a House Subcommittee on Mines and Mining in 1979, E F Andrews, an executive of the mining industry, expressed fear that "the entire Western World could be brought to its knees within six months if the Soviet Union formed a cartel with southern African nations for key minerals, including manganese (98%), platinum (99%), and chromium (99%)."[2] There is no doubt that our industrial capability is jeopardized severely by the state of our dependence on foreign materials.

OVERALL STRATEGIES

What can the nation do? Conservation is a good place to begin, with stockpiling and revitalizing the mining industry also desirable.

Conservation

RECYCLING

Recycling is sensible. For instance, the recovery program of the aluminum industry has enabled the United States to reclaim from scrap some 0.6 million tons, or about 10% of the production of the United

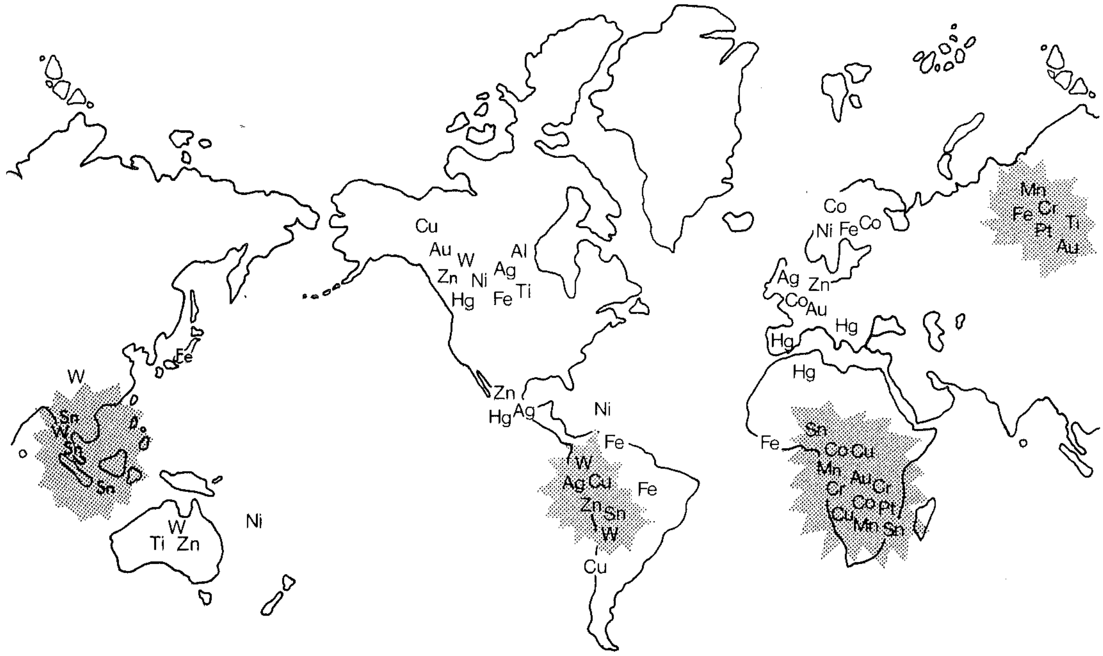

FIG 2. *The shaded portions on the map are those areas that are either antagonistic to the United States or politically unstable. From these comes our predominant supply of five critical metals: manganese, cobalt, chromium, platinum, and tin. They are also among the major suppliers (over 50%) of our tungsten and gold.*

States in 1980.[12] The communications industry has done even better, recycling more than a third of its need for copper.[6] Similarly, the steel industry could recover scrap stainless steel, which is now being exported,[13] and recapture over 150 pounds of nickel and 350 pounds of chromium per ton of scrap. Since 99% of the world's reserves of chromium are in South Africa and the USSR,[9] to export our stainless steel scrap is irrational.[13,14] Furthermore, if more discrimination were used in selecting alloys, if greater durability were engineered into less wasteful designs, and if reconditioning were an alternative to replacement, not only raw materials but also energy would be saved.

ALTERNATIVE MATERIALS

Another form of conservation is to use alternative materials.[5,15,16] Besides downgrading alloys[17,18] or even substituting alloys of base metal where applications are not critical, we should develop alternative materials and processes.[19]

One process advertised by a manufacturer of plate steel involves cladding a higher grade alloy over a lower one, by either hot rolling or explosion bonding.[20] When a thinner protective layer is acceptable, plating may provide an alternative.[21] Some research has been devoted to strengthening metals by fractional melting.[22] In this novel process, pressure is used to squeeze out the lower-melting brittle phases of aluminum parts, thereby increasing the structural properties and reducing the dimensions. Proponents of superplastic forging of titanium claim that less machining is necessary, thereby reducing labor, wear of tools, and metal scrap.[23] Recently, in the 1981 forecast of materials, coatings have been billed as "economical alternatives to alloys."[4,24] In conjunction with the conventional technology of coating with liquid and powder many applications are possible in which these polymeric materials would provide esthetic and functional substitutes. There is even a family of porcelain powders available for electrostatic-fluidized bed coating.

Finally, plastics and composites should be considered when chemical resistance and high strength are critical.[25,26] A particularly interesting development of these materials is a self-reinforcing fibrous composite.[27] Before polymerization of the solution, sound is used to nucleate small polypropylene fibers within the slowly cooled solution of styrene.

Stockpiling

Another safeguard would be to replenish the inventories of critical materials, which are down as much as 80% today.[28] Replenishing them would be expensive—possibly $6 billion—[10] but necessary to ensure an adequate stock of raw material in times of heavy demand, scarcity, or national emergency. The political turmoil in Zaire and Zambia, for example, has shown how an interruption in the supply of a strategically critical material, cobalt, can interfere with international productivity and ultimately drive the price up fourfold within two years.[7,8,11]

Revitalizing the Mining Industry

Along with conservation and stockpiling, all aspects of the mining industry should be revitalized. In the past, governmental regulations have penalized our industries to the benefit of foreign agents. While it is true that we want and enjoy clean air and water and prefer an unspoiled natural landscape, the environmental restrictions are so extensive that the result is the closing of not only the smelters but also the mines—two industries essential to our nation's welfare.[2,29] Congressman James Santini (D-Nev) has noted that over a period of five years this country regressed from 25% to 50% dependence on foreign lead and zinc as eight smelters were closed.[2] With further environmental restrictions planned, 13 of the 15 domestic smelters are likely to be forced to close in the 1980s. The real irony is that the industry reopens in countries where restrictions are more relaxed—ultimately adding to the pollution of the world.

Along the same lines, the government has withdrawn some two-thirds of the public lands from the development of minerals. This amounts to one-third of all land west of the Mississippi. If facilities for mining and extraction are not maintained at a modest level in this country, domestic reserves, such as the deposit of cobalt found in Idaho,[29] are going to be of little value in a crisis. As one official estimates, it takes over three years to overcome just the red tape of the government.[10]

In addition, the government can improve the nation's security by providing new incentives to the mining industry. To those already involved in the industry, the government can passively accept the horizontal growth of businesses. The oil industry appears to be doing this in part already by becoming more involved in the solar power industry and industries for mining coal, copper, and uranium. Some vertical development should be encouraged, too, as the success of the reclamation program of the aluminum industry demonstrates. Tax incentives should be given to new techniques of mining, extracting, processing, and recycling that conserve resources of any kind.[8] Government should actively entice others into the field by providing funds to both academia and industry[8,15,19] through the use of attractive procedures for licensing patents to provide incentive.[30]

Other legislation could provide further incentives. For example, the National Materials and Minerals Policy, Research and Development Act of 1980 (PL 96-479) purports to stimulate research and development, to stabilize industries using domestic materials, and to encourage cooperation of federal agencies.[31,32] Along with this law, additional legislation could offer incentives for acquiring and disposing of national stockpiles (PL 96-41 and PL 96-175), could reduce import duties on titanium ore (HR 3591), and could encourage recycling of materials (HR 3994).[8]

SPECIFIC MEASURES FOR DENTISTRY

Rising costs have prompted the reclamation of alloys of gold and of amalgam as well as the reconditioning of orthodontic brackets and appliances. Research, too, has been skewed toward the use of materials with fewer and less noble metals. Hence, the current research on alloys with a low content of gold and on composite materials is appropriate. The effect of reducing the content of gold, from 75% to as little as 15%, on physical properties and resistance to corrosion has been evaluated.[33-35] The most recent results indicate that resistance to corrosion does not suffer appreciably until the content of gold falls below 42%.[35] Unfortunately, a more critical material, the platinum group, is usually substituted for some of the displaced gold.

Composite resins need further development and at an accelerated pace.[36] The present generation of materials is satisfactory on facial and interproximal surfaces of anterior teeth but wears excessively when subjected to the forces of occlusion.[37] Improvement in resistance to wear would reduce dentistry's dependence on three metals used in amalgam, namely, silver, tin, and mercury.

The development of coatings should help to retard the escalating cost of health care; however, in this country this topic has received attention from only a few investigators.[38-40] Efforts have been made to use techniques of sputtering[38] and coating with powder[39] to fabricate temporary crowns of stainless steel that resist wear; and techniques of coating with liquid and powder have been used on archwires to improve esthetics and sliding mechanics.[40] Dentistry should explore in greater detail coatings of both polymers and porcelain, particularly for use on carbon steel as substitutes for the myriad uses of stainless steel.

Titanium remains one of the better candidates for the development of dental alloys, despite the fifteenfold surge in the price of titanium sponge over the last decade.[8] Newly developed processes of extraction using extensive domestic ores of this metal should lessen or even eliminate our present dependence on higher grade ores of foreign countries.[41] Recently a new generation of alloys was introduced by Titanium Metals Corporation of America, one of which is characterized as a beta-stabilized, low cost, formable sheet.[42,43] Within dentistry only one alloy based on titanium is in use, a beta-titanium (79% titanium) material for archwire. In certain orthodontic applications this wire is favored over an alloy of 50% nickel and 50% titanium for its enhanced ability to be formed and welded, and over stainless steel for superior springiness and flexibility.[44-46] Richard Waterstrat, research associate at the National Bureau of Standards, suggests that for crowns and bridges traditionally fabricated out of either noble metals or alloys of cobalt, nickel, and chromium, an alloy of 87% titanium and 13% copper could be substituted.[47] Since some of the metals mentioned here may not be readily available at any price, the development of alloys of titanium seems most wise. For the United States, titanium remains the most abundant[7] and secure[29] of the alternative materials.

SUMMING UP

Dentistry is precariously dependent on foreign markets for critical natural resources, especially for the noble metals and cobalt, chromium, and nickel. The inherent political instability of some of these geographical areas and the potential for antagonism to us precludes traditional economics of supply and demand. Conservation is advocated, while alternatives to scarce materials must be sought, by either cladding, plating, and coating, or by substitution and special techniques of processing. The mining industry must be encouraged to perpetuate and develop the vital technology of mining. Government lands should be open to development under environmental controls that reduce worldwide pollution and yet retain the profit motive at home. Incentives should be given to industries to conserve the overall resources of the country, for example, by more efficient techniques of extraction or by recycling. Liberalizing the patent laws, with respect to government contracts and grants, would also provide a needed boost.

For dentistry, the continued development of alloys with a low content of gold and composite materials would reduce dependence on gold, platinum, palladium, silver, mercury, and tin. Coatings for alloys of carbon steel would circumvent the deficiencies of chromium and nickel that could interrupt the supply of stainless steel, while development of alloys of titanium would provide alternatives to alloys of cobalt, chromium, and nickel, and perhaps even gold.

Acknowledgment

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BUONOCORE MEMORIAL LECTURE

A Milestone in Dentistry

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Presented on 18 February 1982 at the annual meeting of the Academy of Operative Dentistry.

INTRODUCTION

I first heard and met Michael Buonocore on the afternoon of 17 February 1961 in Chicago at the Mid-Winter meeting of the Chicago Dental Society.

I was then still visiting associate professor at Northwestern University with Eugene Skinner. I was very young, of course, and slightly out of my depth since it was my first major dental meeting in North America. I attended a session in which Mike spoke on cyanoacrylates as fissure sealants — a new development to me — but one in which Mike had an edge on the rest of us because of the developments of the cyanoacrylates by Coover at Eastman Kodak Company in 1958. I remember Dr Buonocore's sections of fissures and his illustration of the difficulty of filling deep fissures. The impression on me was profound and stimulated my interest in adhesion to teeth.

Michael Gabriel Buonocore was born in Brooklyn, which is notable for several other reasons, among them the fact that it is the home of polymer science. Appropriately enough Michael Buonocore began his academic education with bachelor and master degrees in chemistry — a training that I consider most appropriate since I myself took the same route. This early orientation in chemistry undoubtedly influenced his research interests after he studied dentistry and entered an academic career following several years in private practice.

A chemical thread runs through his many publications, concerned as most of them are with preventive dentistry and the bonding of materials to the tooth surface. In this respect his original paper of 1955 in the *Journal of Dental Research,* "A Simple Method of Increasing the Adhesion of Acrylic Filling Materials to Enamel Surfaces," which had little impact at the time, can now be seen to have had a major effect on restorative dentistry. There must be scarcely a dental student today who has not heard of "Buonocore, 1955." Further work on the acid etching of teeth and the application of the principle to fissure sealing in the period 1963-65 led eventually to the acid-etch technique for resin bonding. When this was coupled in 1967 with the ultraviolet-activated resin sealant later marketed as Nuvalite and Nuva Seal a new era in preventive restorative dentistry can certainly be said to have begun. John Heyde of the L D Caulk Company was instrumental in that development.

In addition to acid-etch techniques Mike Buonocore was also interested in chemical bonding to enamel and dentin and made significant contributions in this area. These research and clinical aspects were reviewed in his book *The Use of Adhesives in Dentistry* (1975). His impact on dental research and practice can be gauged by his many honors including the American Dental Association Preventive Dentistry Award in 1971 and the International Association for Dental Research (IADR) Basic Research in Oral Therapeutics Award in 1974. I remember him showing me the plaque for the IADR award after the ceremony and his obvious delight in receiving it.

As we look back to its limited beginnings, the world ramifications and continual spread of the acid-etch technique are truly amazing. The continued research in this area has illuminated not only physical bonding to the tooth but renewed interest in bonding to dentin. The original contribution of Michael Buonocore has therefore its own and a continuing remembrance. It was truly "A Milestone in Dentistry" and the reason for my title which is taken from a Buonocore paper of 1961 to which I shall refer later.

It was therefore a source of great pleasure and satisfaction to be invited to present the First Buonocore Memorial Lecture and I am honored and privileged to have that opportunity. Not surprisingly and I hope appropriately, I have chosen to speak on the current mechanisms of bonding to the tooth. In the necessarily brief time we have together I can only indicate some of the trends that are emerging today. We are, after two decades, still formulating some of the questions let alone the answers. But leaving aside the detail we can, from an overview, see the directions of progress.

ADHESIVE RESTORATIVE DENTAL MATERIALS

My own interest in adhesion was stimulated in 1960 and 1961 partly by Michael Buonocore speaking on cyanoacrylates, partly by the opportunity to be at Northwestern University at that time with Gene Skinner, and partly by the Workshop on Adhesive Restorative Dental Materials in 1961 which was organized and directed by Ralph Phillips and Gunnar Ryge.

The 1961 Workshop on Adhesive Restorative Dental Materials, which was followed by two others in 1965 and 1974, contained a wealth of information and ideas, which has inspired research down to the present day. On page 172 of the proceedings, in a paper entitled "Tests of an adhesive containing glycero-phosphoric acid dimethacrylate," Michael G Buonocore concluded: "A clinically practical adhesive restorative will be predicated on the existence of a strong physico-chemical union between it and tooth structure" (Buonocore, 1961). Similarly, from my chemical standpoint, I have believed and shared that philosophy over the last two decades. When I returned from Northwestern University to England in 1961 I began to think of such approaches to the problem. I first had the idea of polyacrylic acid cements in 1963 and made the first material in 1964 although, of course, it did not appear commercially until 1968. Since then many developments have occurred in both physical and chemical modes of bonding to enamel and dentin.

The demonstration of marginal percolation by Nelsen, Wolcott & Paffenbarger (1952) and of leakage patterns around restorations in vivo by Phillips and coworkers (1961) stimulated research on adhesive restorative dental materials because of their practical importance. Many other applications of the principles of adhesion to teeth became evident, even to plaque prevention, since if we understand the mechanisms of adhesion to a surface we shall also understand abhesion.

ADHESION

An adhesive, according to a definition of the American Society for Testing and Materials, is a substance capable of holding materials together by surface attachment. There is some divergence of views on mechanisms of adhesion covered by such a definition. Some authors include both mechanical interlocking and interfacial bonding through molecular attraction; others, perhaps the larger number, consider the molecular attraction only in their understanding of adhesion. In practice both mechanisms probably contribute to the strength of a bonded joint — but one or the other predominates. I prefer the general term 'bonding' to describe all the various mechanisms of surface attachment.

Mechanical interlocking, depicted by McLean (1977), relies on penetration into surface irregularities (Fig 1). Most of our present restorative materials and cements are retained in or on the tooth in this way. Although this can be very effective, as in the acid-etch technique, the presence of voids and imperfect adaptation can lead to interfacial leakage and percolation.

Physicochemical adhesion, however, is a more attractive concept since it involves interfacial attraction between the tooth surface and the adhesive, even actual chemical reaction (Fig 2) between the calcium and the carboxyl ions of a polyacrylic acid

MECHANICAL ADHESION

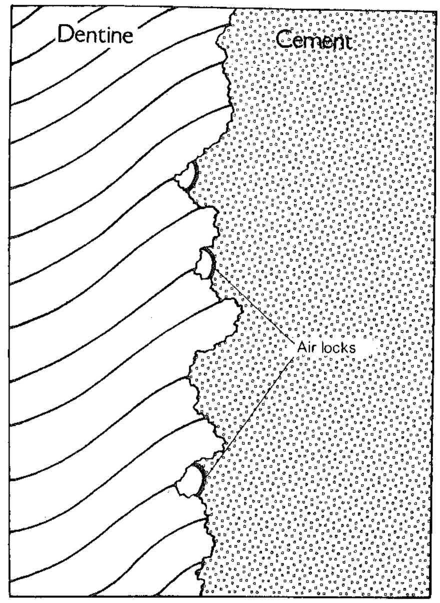

FIG 1. *Diagrammatic representation of mechanical interlocking (from McLean, 1977)*

PHYSICOCHEMICAL ADHESION

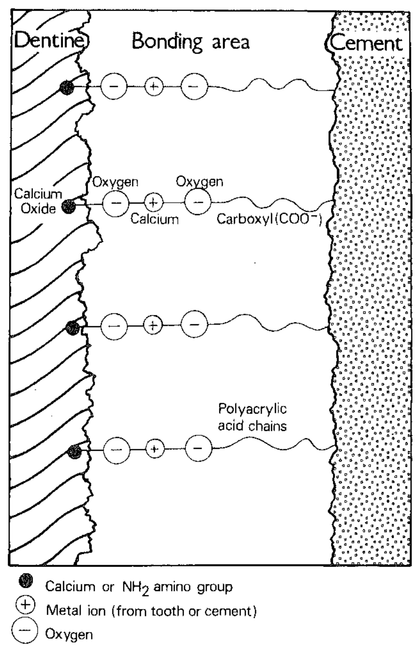

FIG 2. *Diagrammatic representation of physicochemical adhesion involving polyacrylic acid cement (from McLean, 1977)*

cement. Thus an intimate molecular relationship between the adhesive and the enamel or dentin is developed. Unfortunately, as is well known, intimate relationships are easier to initiate than to sustain.

Adhesion, in my sense, involves molecular attraction — the attractive force may involve:

1. polar forces, that is, generalized electronic attraction;
2. hydrogen bonding;
3. chemical reaction, that is, formation of an ionic or covalent interfacial bond.

Under practical clinical conditions where water is always present, polar and H-bond forces are not strong enough for durable bonding and chemical reaction at the interface is necessary (Smith, 1975).

For adequate reaction to occur the fluid adhesive must wet and spread on the tooth surface to achieve the requisite molecular closeness and must solidify without failure of the bond. Thus we see on the one hand the need for the adhesive material to be initially hydrophilic, a fluid material containing many reactive groups, that is, a polymeric material most likely, that achieves bonding in a clinically acceptable time (1-2 min) and on the other hand the need for a smooth, clean, relatively dry tooth surface to which to apply the adhesive.

So we have three things to consider.

1. The design of an adhesive molecule that will react with the calcific or proteinaceous phases of teeth or both. It would be ideal if it could also displace surface water and contaminant.
2. The preparation of an enamel or dentin or bone surface receptive to adhesion.
3. The practical application of the material.

Originally in 1961 (Workshop on Adhesive Restorative Dental Materials) there was considerable optimism that adhesion would be achieved fairly easily. The many failures of laboratory research in the last two decades in developing practical adhesives to teeth can now be explained through our greater understanding of the actual clinical surface to which adhesion has to be achieved and our realization of the difficulty of achieving a suitably receptive surface.

It is important to understand the practical limitations that affect bonding in the mouth, so we should first look at protocols for cleaning enamel and dentin, which inevitably must be involved in achieving the durable adhesion.

CLEANING ENAMEL AND DENTIN

The surface of normal enamel is covered by pellicle and plaque. Mild abrasive cleaning even with pumice may not remove all pellicle. In any event there is rapid reformation of pellicle by adsorption of salivary glycoproteins. Evans & Silverstone (1981) showed that even one second of contact with saliva contaminated clean acid-etched enamel. Further, Jendresen & Glantz (1980) have shown that pellicle (biofilm) deposition occurs on all surfaces in the mouth and is substantially complete within two hours, converting clean high-energy surfaces into low-energy, less easily wetted substrates. More vigorous abrasive or chemical cleaning can remove surface organic and inorganic layers (as in the acid-etch technique) but may involve a significant loss of surface enamel.

The cut enamel and dentin surface produced by cavity preparation is covered with a firmly attached layer of cutting debris. This "smear" layer is related to the instrumentation used in tooth preparation and its attachment to the tooth is governed by the effects of pressure and temperature at the tooth interface during cutting (Boyde, 1976). The diamond point is particularly unsatisfactory if used as the sole preparation instrument because it creates enamel fractures and much debris (Fig 3). Even less traumatic devices such as the tungsten carbide bur or fine stone leave a smear of debris, especially on the dentin surface, filling the tubule orifices. As with the outer enamel surfaces these contaminant layers on the tissue must be removed to achieve bonding to enamel and dentin surfaces that is consistent with the cohesive strength of the hard tissues themselves.

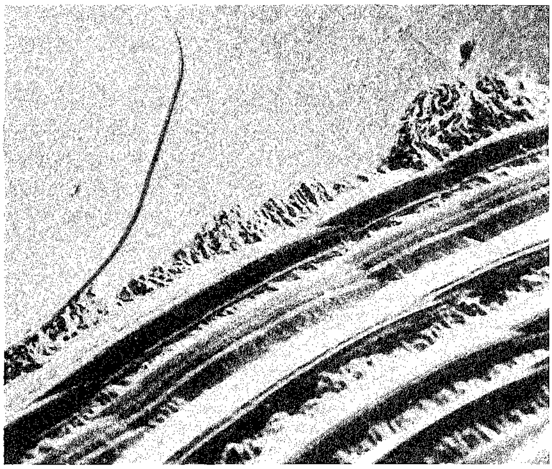

FIG 3. *Cavity prepared by diamond point showing fractured enamel margin and grooved, fractured, and debris-coated cavity surface (courtesy of Boyde)*

The normal methods of cavity toilet using water or hydrogen peroxide do not remove this smeared-on layer of debris (Fig 4). Organic solvents may remove oils or

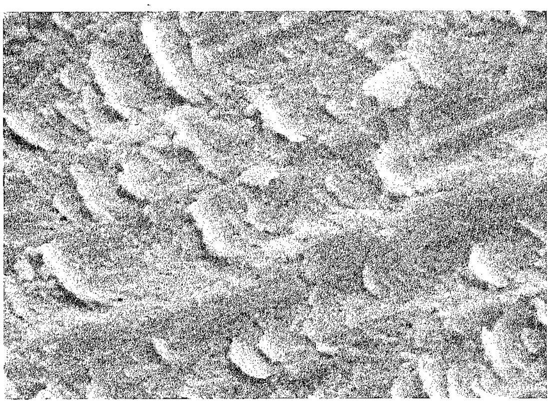

FIG 4. *Smeared on layer of debris after cutting with high-speed tungsten carbide fissure bur and water coolant (original ×2000)*

lipids but, again, do not remove the smear. Removal of the superficial layer may be effected by detergent bactericidal materials, such as Tubulicid, that are designed to leave the tubules blocked with debris and kill residual bacteria as postulated by Brännström, Glantz & Nordenvall (1982). Short exposures to acids such as phosphoric or citric acid effectively remove smeared-on debris but may open and widen dentinal tubules and so increase pulpal sensitivity and the possibility of penetration of bacterial toxins and other irritant agents if interfacial leakage occurs. This may be offset by penetration of resin bonding agents into opened tubules (Fusayama, 1980; Brännström & others, 1982), which provides also a micromechanical interlocking contribution toward bonding (Vougiouklakis, Smith & Lipton, 1982).

An effective method of removing debris from enamel and dentin surfaces at neutral pH is the use of solutions that chelate or complex calcium in the smear into a soluble form. Thus, for example, treatment of cut dentin and enamel with solutions of sodium ethylene diamine tetra-acetic acid (EDTA) for 60 seconds will give a clean surface (Smith & McComb, unpublished observations) (Fig 5). Preliminary indications are that little pulp reaction results.

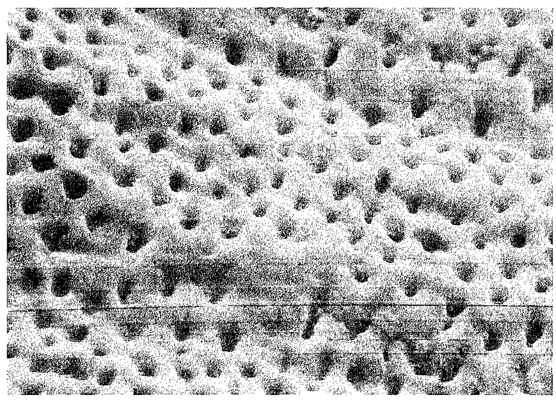

FIG 5. *Dentin after cleansing with EDTA solution for 60 seconds (original ×1050)*

Such procedures appear to be more appropriate than the use of acids to allow cleaning without surface disruption. The use of such a cleaning protocol carries with it, however, as pointed out previously, the need for an effective bonding agent that will also seal off dentinal tubules. Use of EDTA does not appear to improve adhesion (Vougiouklakis & others, 1982), and further work remains to be done on optimizing such agents for clinical use. It may be noted that the adhesive or bonding agent itself may displace and remove debris as is the case with phosphoric acid cements and this may be a feature of some resin bonding materials. This may be an advantage since another clinical problem is the maintenance of a clean surface until the adhesive agent can be placed upon it.

MECHANISMS OF BONDING

Assuming that a satisfactory surface can be prepared and isolated, mechanisms of bonding to the (largely) hydroxyapatite $Ca_{10}(PO_4)_6(OH)_2$ surface of enamel and the hydroxy-apatite-collagenous surface of dentin must be developed. The adhesive could be utilized in the form of:

1. a primer or coupling agent — a chemical treatment at molecular level that produces a receptive surface;
2. an actual adhesive coating to which the restorative material bonds;
3. an adhesive restorative material per se.

For several reasons, particularly clinical efficiency, an adhesive primer or coating has been preferred and several such systems have been made available. Most of these systems are designed to react with the inorganic phase of teeth by a) complexation with the Ca^{++} or b) reaction with the PO_4^{+++} or OH^- groups or with the bound water in the hydroxyapatite lattice.

The principle of primers, which react with the tissue surface and which must compete with and displace water for durable bonding, has been illustrated by Causton (1982) (Fig 6). The bond that is developed must resist the continued attachment of water and thermomechanical stressing, and in this respect failure may occur either on the adhesive side or on the tissue side of the interface. In this light we can look at some of the practical aspects of some of the adhesive systems recently developed.

ADHESION TO HYDROXYAPATITE

In the first Workshop on Adhesive Restorative Dental Materials, Bowen (1961)

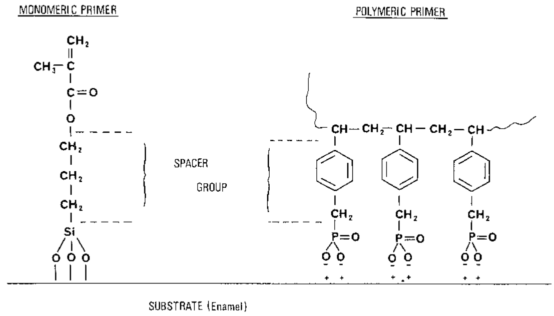

FIG 6. *Diagrammatic representation of silane and phosphonate primers on enamel surface (from Causton, 1982)*

demonstrated that surface active agents having an affinity for the surface of hydroxyapatite powders (enamel, dentin, bone) contained groups which were capable (theoretically) of forming five-membered chelate rings with calcium. Most systems for bonding to the mineral phase of teeth have incorporated this principle.

Carboxy Compounds

POLYCARBOXYLATES

Long chain molecules having multicarboxyl groups with appropriate structures can form complexes with calcium and other metals and can thus be used as primers and the basis for cements and filling materials. A simple example of this system is polyacrylic acid (Smith, 1968) on which the zinc polycarboxylate and glass-ionomer cements are based (Fig 7). The polycarboxylate cements form strong bonds to enamel and to a lesser extent to dentin (because of the lower calcium and higher organic content), provided the tissue surfaces are clean.

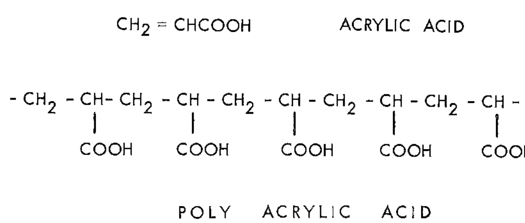

FIG 7. *Structure of polyacrylic acid*

The simple picture of setting and bonding ionic crosslinking is in fact quite complex (Smith, 1982). Certain spatial combinations of hydroxyl and carboxyl groups are required to complex calcium and other metal ions such as aluminum so that a durable bond is produced. Thus cements can be made using zinc oxide or reactive glasses with aqueous polyitaconic or polymaleic acids in place of polyacrylic acid but these materials do not stick to tooth substance. Such acids are used, however, as copolymers with acrylic acid or as additives to polyacrylic acid to improve the manipulative characteristics of polyacrylic acid cements. The adhesive bond of the polyacrylate (polycarboxylate) cements is a dynamic one (Peters, Jackson & Smith, 1974) but is durable in vivo (Mizrahi, 1972). The bond strength is limited by the cohesive strength of the cement. Contamination of the tooth surface with saliva greatly reduces the bond as does any intermediate film, for example, cavity varnish (Chan, Svare & Horton, 1976) or zinc oxide and eugenol.

The glass-ionomer cements also bond well but are more sensitive to surface conditions. The liquid composition also is responsible for differences between different products. The more fluid materials for cementing show better bonding than the filling materials because of more available reactive liquid. Retention of glass-ionomer cervical restorations on dentin may involve both adhesion and micromechanical interlocking through tubular penetration (Vougiouklakis & others, 1982). Adhesion of these materials may be improved by mineralization treatments of the tooth surface (Causton, 1982).

CARBOXY POLYMERS

Polymers which contain carboxy groups but are not soluble in water have been used as primers for composite resins and sealants on tooth surfaces. Thus Simulate primer (Sybron/Kerr) is a solution of a butyl acrylate-acrylic acid copolymer in isopropanol. The film of polymer improves wetting of the acid-etched tooth surface by sealants. Some evidence of improved retention after thermal cycling of bonded resins was observed (Jedrychowski, Caputo & Foliart, 1979) but recent work by Nation, Jedrychowski & Caputo (1980) and an 18-month clinical study of sealant retention showed no advantage of use of the primer. Further study of such primers may be warranted, however.

CARBOXY MONOMERS

A variety of carboxyl-containing methacrylate monomers has been synthesized and examined by Nakabayashi & Masuhara (1980) as adhesion-promoting additives to acrylic and BIS-GMA resin systems (Fig 8). Several of these materials show an improved bond strength to dentin, which falls after prolonged storage in water. Good results have been obtained, however, with 4-methacryloxyethyl trimellitic acid anhydride (4-META). This material results in improved bonding to dentin and to prosthodontic alloys when 5% is added to methylmethacrylate systems. The bond is said to resist prolonged immersion in water and thermal cycling (Nakabayashi & Masuhara, 1980). A denture base acrylic resin (META-DENT) and an orthodontic

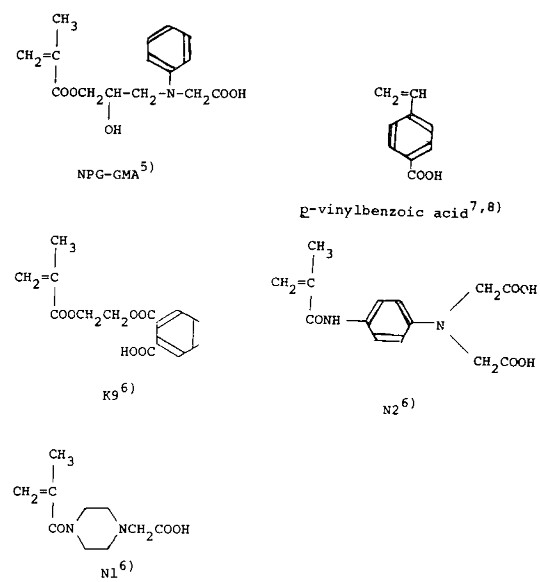

FIG 8. *Examples of carboxyl-containing methacrylate monomers for adhesion promoters (Nakabayashi & Masuhara, 1980) including NPG-GMA (Bowen, 1965)*

direct-bonding system (Orthomite SB) are now available. The effectiveness of this monomer in composite systems has yet to be demonstrated.

AMINO-CARBOXY MONOMERS

In addition to hydroxy-carboxy structures, amino-carboxy structures can also be effective in complexing with calcium. A solid monomer NPG-GMA containing such a structure — the condensation product of N-phenyl glycine and glycidyl methacrylate — was developed by Bowen (1965) and shown to adsorb strongly to calcium (Misra & Bowen, 1977) (Fig 8). This material, as a 2% solution in ethanol, has been used as a primer in a composite (Cosmic bond) and in a cervical restorative composite system (Cervident). Improved bonding of the latter to dentin could be demonstrated after careful cleaning and treatment with the primer (Vougiouklakis & others, 1982). In addition to an adsorbed layer of NPG-GMA the evaporation of the primer left a layer of crystals of the monomer, which could interfere with bonding. Thus in practice the bonding was erratic and not as good as a glass-ionomer cement.

In recent work Bowen has developed more complex amino-hydroxy or amino-carboxy structures, Poly SAC (surface active comonomer) compound, which are used as primers on tooth surfaces that have been mordanted. The mordanting principle involves surface exchanges or precipitation of ions, such as Fe^{+++}, that form more stable chelates with the primer. The concept comprises the successive use on the tooth surface of a) an isotonic acid cleaner, b) treatment with a metal salt solution, and c) application of the Poly SAC primer. Bowen & Cobb (1982) demonstrated strong bonding to dentin, at least in the short term, using a procedure in which b) is a solution of ferrous oxalate and c) is a two-stage procedure involving treatment of the dentin with an acetone solution of NTG-GMA (N-tolyl glycine-glycide methacrylate) then with an acetone solution of PMDM (addition product of pyromellitic dianhydride and 2-hydroxyethyl methacrylate). Such an approach may be effective but would require simplifying to be applicable under practical clinical conditions.

Silanes

Silane primers similar to those used to bond fillers to the resin matrix in composites (Fig 6) have been used on acid etched enamel allegedly to improve bonding. Such primers do not form strong bonds with hydroxyapatite under mouth conditions, and generally a soft layer of silane results on the tooth surface, which is liable to hydrolysis leading to a drop in bond strength (Causton, 1982).

Polyphosphates and Phosphonates

Phosphate and phosphonate groups also show strong chelation to calcium. Originally Hagger (1951) developed glycerophosphoric acid dimethacrylate as a cavity seal for Sevriton. It was found to react with the dentin surface (Kramer & McLean, 1952) but was not effective as a long-term bonding agent due to water breakdown of the bond. Phosphonates (H_3PO_3) are more resistant to hydrolysis than phosphates. Polymerizable phosphonates that can be used as primers or added to BIS-GMA resins have been developed by various workers including Anbar & Farley (1974), Farley, Jones & Anbar (1977), Bartels, Schuthof & Arends (1979), Rawls & Cabasso (1982), and Causton (1982). The extensive Japanese work in this area has been discussed by Nakabayashi & Masuhara (1980). Figure 9 shows monomers investigated by them. Vinyl benzene phosphonate was also found to be a promising material by Farley & others (1977). Yamauchi, Nakabayashi & Masuhara (1979) developed methacryloxyethyl phosphoric acid ester, which appears to be the basis of the Clearfil Bond System F (Kuraray), which has been discussed in detail as to its clinical application by Fusayama (1980).

Using the primer, Fusayama found good bonding of this product to etched enamel and to dentin which persisted for over three months of storage in water. We have obtained similar results but our data indicate that the bond strength falls on longer

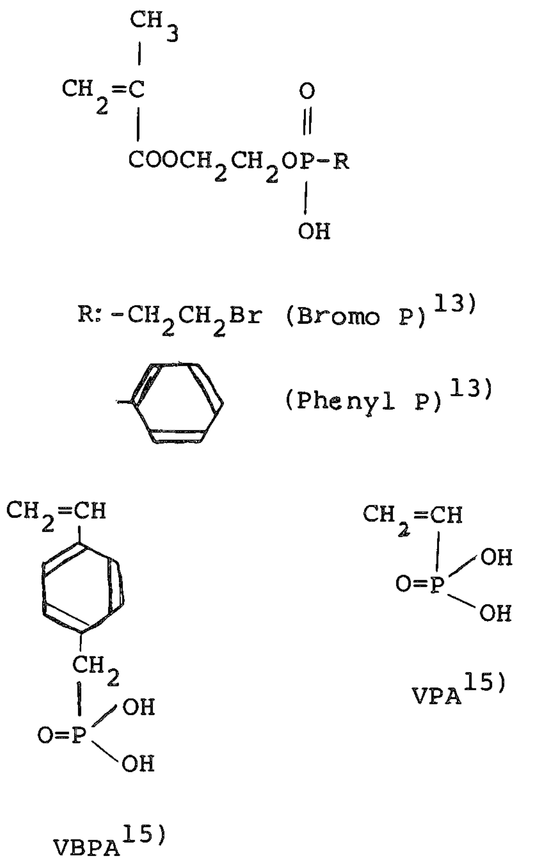

FIG 9. *Examples of phosphonate monomers for adhesion promoters (Nakabayashi & Masuhara, 1980)*

storage in water. Further, the bond to unetched enamel is not much higher than that to dentin. Further data are needed on the nature and durability of the bond.

Although the phosphonates appear promising as dental adhesive materials, toxicity data are needed because of the potential of certain phosphonates to interfere with the mineralization of bones and teeth.

BONDING TO COLLAGEN

For dentin (and bone) an alternative approach to adhesive bonding is interaction with the collagenous phase of the structure. There are many possible reactions of the sidechain groupings of the amino acids in the collagen structure especially $-NH_2$, -OH, and COOH. Monomers and polymers may be grafted to the collagen structure. Since dentin collagen is not very reactive fairly vigorous chemical conditions are needed.

Masuhara and coworkers (Nakabayashi & Masuhara, 1980) developed acrylic bonding agents containing the polymerization initiator tributyl boron, which is said to induce grafting of the methylmethacrylate to dentin collagen (Fig 10). Acrylic restorative

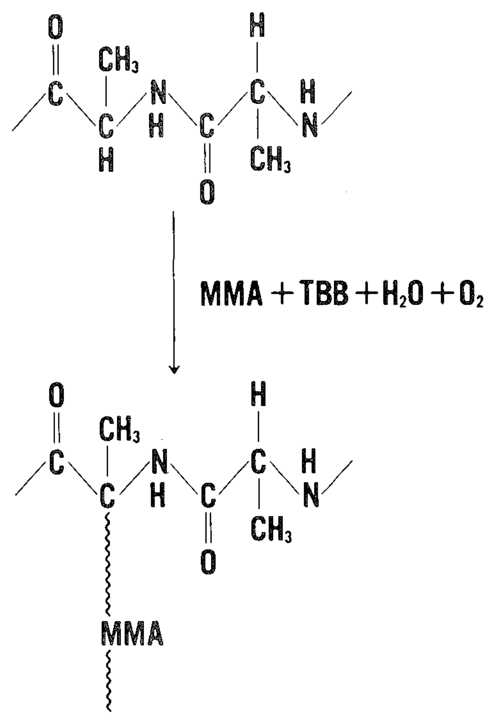

FIG 10. *Mechanism of grafting of methylmethacrylate to collagen under the action of tributyl boron promoter (Nakabayashi & Masuhara, 1980)*

materials based on this system were not successful due to lack of clinical data for successful adhesion and poorer properties. An orthodontic bonding system (Orthomite II) based on a similar composition has proven quite successful and has now been modified further by the addition of 4-META (Orthomite SB).

Nakabayashi, Hayata & Masuhara (1977) also developed a reactive nitrene methacrylate system which involved UV irradiation of a dentin primer, but the system appears to be too complex and water sensitive for practical use. Smith and coworkers (Smith, 1975) developed dichlorotriazine derivatives of polymerizable monomers. These materials react rapidly with collagen at mouth temperatures and form strong bonds. They can be used as primers or additives to composite resins and induce strong bonding. The long-term bond strength in water was found to diminish, however, probably due to hydrolysis at the dentin interface.

Experience with these materials suggests that dentin bonding by reaction with collagen may be a successful concept but achieving strong bonding under clinical conditions without degrading the dentin interface is still a problem.

CRYSTAL BONDING

A completely new method of bonding to calcified tissues has been developed that involves both chemical interaction and micromechanical interlocking. Our original observations (Smith & Cartz, 1973) of specific crystal growth of insoluble calcium salts on the surface of enamel led to the concept of this growth as a retentive mechanism for resins.

In our model system the enamel is treated with a solution of polyacrylic acid, which contains SO_4^{--} ions. Chemical reaction of polyacrylic acid with the surface of the tooth liberates Ca^{++}, which forms a gypsum ($CaSO_4$ $2H_2O$) deposit in 1–2 minutes (Smith & Cartz, 1973). The treated surface appears a dull white as in acid etching but it is actually covered with a dense mass of crystals (Fig 11).

A fluid resin monomer system can flow around the crystals and after setting is firmly bonded to the tooth surface since the crystals themselves are nucleated within the enamel surface. The bond strength with a given resin system is similar to that of the same resin using conventional acid etching to bond orthodontic brackets to enamel (Maijer & Smith, 1979).

The crystal bond system has the following advantages compared to conventional

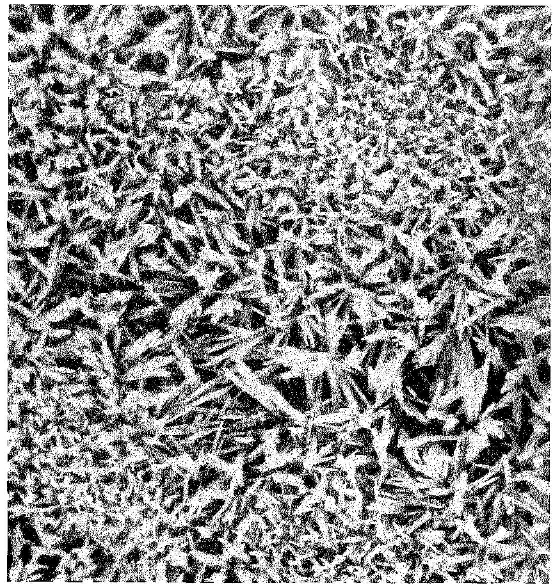

FIG 11. *Crystals of gypsum grown on enamel by reaction with polyacrylic acid containing SO_4^{--} ion (original ×500)*

acid etching: 1) much less loss of surface enamel and fluoride, 2) no resin left in the enamel surface, 3) similar bond strength to acid etching, 4) easier debonding of orthodontic brackets and easier clean up with less enamel damage, and 5) fluoride can be incorporated within the crystal deposit. This new bonding system appears to have considerable potential for bonding to dentin as well as enamel and also to bone.

FUTURE DEVELOPMENT

The problem of establishing a permanent adhesive interface with tooth substance, especially dentin, is still with us. The practical problems have become better understood and the use of biocompatible cleaning protocols coupled with reactive adhesives seems to be the path of future research. The development of adhesive molecules that form complexes with calcium continues to appear promising. Whether such systems will be most successful as primers, polymerizable monomers, or as polyelectrolytes remains to be proved. The synthesis of structures similar to glycoproteins may be a future avenue.

In the last analysis the success of an adhesive system depends on two factors — first, can it be used properly under practical clinical conditions, and second, will the tooth interface maintain its integrity as well as that of the adhesive. Causton (1982) has provided some evidence that changes in the potential adhesiveness of dentin occur after the tooth is extracted. Even in vivo the limiting factor may be structural changes in the enamel and dentin surfaces themselves. At present we may reassure ourselves that at least we now are more certain of the questions even if we still do not have (all) the answers.

RETROSPECTIVE

At the end of this presentation let me look back again to 1961. In the discussion of the Workshop on Adhesive Restorative Dental Materials Dr Richard S Manly said: "In summary, I would like to use a translation of a carefully worded statement on page 2 of Dr Buonocore's paper. He states that 'the achievement of a consistently stronger, longer lasting bond may require more precise standardization of the technique of handling this particular resin and/or a better understanding of the physical and chemical interrelationships between the dentine surface and adhesive.' I would translate this as follows: We are confident that if we fiddle around with this material enough, we can get some amazingly high values from the stuff. But if we or anyone else are going to do any better than this, someone will have to find out how to make the stuff really stick. In general this translation fits the situation as I see it. We should continue to fiddle around with all kinds of resins in hopes of finding something that works before we really know the theoretical basis for adhesions to moist enamel. But we must also encourage imaginative, diversified approaches that may develop such a helpful theory." Dr Manly's summation was indeed prescient and the Buonocore research certainly stimulated diversified approaches.

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 OPERATIVE DENTISTRY, 1982, 7, 26–27.

POINT OF VIEW

A Dream or Nightmare

MARVIN A JOHNSON

The other night I had a dream—a dream so clear that its meaning was unmistakable. As this experience remains vivid in my mind and would have as much significance for you as for me, I would like to relate the event to you.

I sat at my dinner table and heard the doorbell ring. As I opened the door, the man standing with papers in hand said, "Dr Johnson?" Assuring him that there was no mistake, I received in hand several papers stapled together. The man left with no further explanation.

The first page started with the name of a court and was labeled SUMMONS. As I again sat at my dinner table, I turned to the second page which bore the words COMPLAINT FOR DAMAGES.

Checking both pages again I found myself and my wife described as DEFENDANTS, and so were the dean, the associate dean for curriculum, the department chairmen for the clinical departments, and a number of the instructors. The PLAINTIFFS were several of our recently graduated Great State University dental students.

This complaint and the words remain so clear that I can almost quote them verbatim:

PLAINTIFFS for their cause of action against the DEFENDANTS allege as follows:

I

PLAINTIFFS are members of a class and representative of and sue for and on behalf of themselves and others similarly situated in that they are recently graduated persons having a degree of Doctor of Dental Surgery from Great State University School of Dentistry at Model City, USA.

II

DEFENDANTS are the Dean, the Associate Dean for Curriculum, the Chairmen of the Clinical Departments, and several Instructors who as a class are similarly situated and representative of the administration and teaching faculty of Great State University School of Dentistry.

III

PLAINTIFFS have recently completed a four-year prescribed course of instruction at Great State University School of Dentistry with better than passing grades, but PLAINTIFFS have been inadequately prepared for and after diligent efforts have failed to pass the clinical examination of the Great State Board of Dental Examiners and similar qualifying tests of any of the Western states; and, as a consequence of such failures, PLAINTIFFS have been denied the right and license to practice dentistry in those states.

IV

DEFENDANTS at all material times have had a duty and are authorized to and

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have developed and prescribed the curriculum for the dental education of PLAINTIFFS and in so doing DEFENDANTS have been negligent and have failed to carry out their prescribed duties and have changed the course and content of the prescribed dental instruction of Great State University School of Dentistry to allow and require numerous paradental, experimental, and administrative courses to displace basic dental education previously provided. DEFENDANTS have allowed the availability of federal grants to influence and cause addition of various socially oriented programs and required participation in extramural activities with consequent deterioration in basic dental subjects to the extent that the PLAINTIFFS do not have sufficient remaining time, energies, and opportunities to absorb dental education sufficient to pass the said required state examinations and qualify them for the practice of dentistry.

V

The said negligence and conduct of the DEFENDANTS have proximately caused the PLAINTIFFS and each of them to be damaged in the following respects for:

a) Tuition, fees, and supplies for four years:

$21,000

b) Board and room while attending dental school:

$10,700

c) Loss of income while attending dental school:

$100,000

TOTAL $131,700

WHEREFORE each of the PLAINTIFFS prays for judgment against the DEFENDANTS and each of them in the sum of $131,700 and for their costs and expenses allowable by law.

Words and Lucre
Attorneys for PLAINTIFFS

As frequently happens in dreams, my sleep ended before the dream was concluded. Now you can well imagine this experience held my attention long after awakening. I vaguely recalled a California case where high school students sued their teachers for the claimed failure of the school to provide the essentials of an education to the students.

And I also thought how **effortless** it would be for an enterprising lawyer to gather the evidence to support such a claim: a simple comparison of the 1966-67 and the current official catalog of courses, the increasing proportion of failures of our graduates in the state examinations in recent years, and a comparison of the content of the new courses with the subject matter of the state examinations. Each of you could think of other examples. All of these thoughts trouble me very much. I wonder how long it will be before my dream becomes reality.

Acknowledgment

Technical and legal assistance was provided by Delbert W Johnson, LL D, Vancouver, Washington.

OPERATIVE DENTISTRY, 1982, 7, 28-29.

Letter from Europe

ADAM J SPANAUF

The Spring Scientific Meeting of the British Restorative Society took place in Colchester in May 1982. A special highlight of the conference was the theme of the meeting: "The Standards in Restorative Dentistry from a Critical Viewpoint." Three keynote speakers introduced the subject. The speakers were invited from the Common Market countries as well as from military personnel of the USA stationed in the United Kingdom.

Professor John McLean from the United Kingdom stressed that as you get older you recognize some of your errors. He stated that the average patient in the National Health Service is treated with corrodable dental materials. This he felt to be disastrous to the dentition because of denaturation of the proteins of the tooth substance, which could in turn lead to the splitting of the tooth. A plea was made to preserve marginal ridges when restoring proximal lesions of posterior teeth. An incipient carious lesion is better restored with a fissure-filling material. Deficiencies in one's work may become apparent in ten years or earlier. The training of dental technicians should play an essential role in a dental team. Better training should be offered especially in dental anatomy. In the United Kingdom there is a lack of funds for research on dental materials. From studies of the cost effectiveness of service, dentistry ranked low in priority for research funds.

Professor Heinz Renggli, the Netherlands, discussed whether restorative dentistry in Europe has changed since Waerhaug and Lindhe. A plea was made to keep the level of plaque of the patients low. Measures to prevent plaque should include diet counseling, fluoridation, and behavioral aspects. Professor Renggli pointed out that at present there is no good method for restoring the proximal contours of a tooth satisfactorily. Practitioners should attempt to keep all the margins of the preparation supragingival to avoid retention of plaque.

Dr M A Vrijhoef, the Netherlands, discussed future trends in dental materials related to the economic situation in Europe. He pointed out that the materials that we have at our disposal for restorative purposes are in a continuous state of evolution. Some are reaching the end of their evolutionary journey, especially dental amalgams. As to the production of metal or ceramic restorations in the laboratory, the vital link between the dental practitioner and the dental technician is the impression. Dental practitioners should be careful in selecting from the whole range of materials. Exaggerated claims by

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the manufacturers may be in the long run disastrous if the work fails and increases the costs to the patient and the dentist. When it comes to the choice of an alloy for a cast restoration there are still no ethical alternative alloys. There may be slight advantages in the use of palladium-silver alloys or nickel-chromium alloys but none combine the same advantages as might be expected by the use of gold-palladium alloys as an alternative to gold-platinum alloys for restorations of porcelain fused to metal.

The American point of view in restorative dentistry was presented by Colonel Tom Wilson, USAF. He stressed that economics plays a great role in the USA. In 1982 the average net income of a dental practitioner in the USA was approximately $60,000, with overhead expenses at 54%. The fees of European dentists for the provision of services are much lower than those of their counterparts in the USA. Warehouse or department store dentistry is still unknown in Europe. It was clear from the lecture that the American Dental Association minimizes control of the profession by the government, a situation reversed in most European countries.

Dr I Whitehead, United Kingdom, discussed the medico-legal aspects of dentistry. He pointed out that many young graduates had lawsuits brought against them for malpractice. He suspected that this could be due to inadequate experience in certain fields of dentistry while in training at the dental schools.

Professor John McLean closed the meeting with the topic: "What Are We Doing for the Patients?" He stated that at this moment the use of composites in restoring posterior teeth should be discontinued. These materials, though improved, should not be used in areas of high stress. A step toward the achievement of an ideal restorative material may be found in the introduction of the glass-ionomer cements in which acid leachable glass powders, not all that different from those used in silicate cements, react with polymeric acids to produce a cement, which, by virtue of space positive charges, has the unique ability of forming adhesive bonds with enamel and dentin.

From the meeting it became obvious that the current standards in restorative dentistry in Europe are under review. However, concern was expressed over the increasing costs of the materials and laboratory fees and decrease in research grants and funds. Future developments in restorative dentistry in Europe will be directed more toward procedures that will protect the periodontium, the pulp, and occlusion; and preventive measures will get higher priority.

OPERATIVE DENTISTRY, 1982, 7, 30–32.

Hollenback Prize

The Hollenback Memorial Research Prize for 1982 has been won by Lloyd Baum. The prize is given annually by the Academy of Operative Dentistry to recognize excellence in research that has contributed substantially to the advancement of operative dentistry. Dr Hollenback had a significant impact on the direction of the recipient's career through close association when both were members of the restorative department at Loma Linda University.

Dr Baum has left an indelible mark on the profession of dentistry through his broadly based investigations that have resulted in inventions and design of instruments, the development of materials, the improvement of techniques, and the publication of many scientific articles and several textbooks.

His inventions and designs include five important dental instruments and three widely used restorative materials. Dr Baum designed the Baum interproximal carver, the Loma Linda parallelometer for drilling parallel holes for pins, and the Loma Linda hinge axis locator and facebow. He is co-developer of the TMS cable-drive pin wrench and an intraoral condensing mallet. Restorative materials developed by Dr Baum are powdered gold wrapped in foil, marketed under the name Goldent, and an experimental self-hardening dental alloy containing indium in lieu of mercury for use under direct gold. He also helped develop Die-Vestment, a refractory material for models and investment.

He is the author of four textbooks, the most recent being *Operative Dentistry* co-authored with Melvin Lund and Ralph Phillips. Dr Baum is a seemingly tireless lecturer, giving an average of two to three presentations a month consistently over the years in addition to his formal teaching.

His remarkable dental career, so unusually rich in accomplishments, began in 1946 when he received his DMD degree from the University of Oregon. After serving in the US Navy for two years, Dr Baum began a private practice, first in Cottage Grove, then Oakridge, Oregon. In 1951 he enrolled in a graduate program at the University of Michigan and received his MS

Lloyd Baum

degree in restorative dentistry the following year. After a year on the faculty at the University of Southern California, he joined the faculty at Loma Linda University. He became clinic director (1955–68), assistant dean for clinical affairs (1968–69), and chairman of the Department of Restorative Dentistry from 1969 to 1972.

After nearly two decades at Loma Linda, he moved to the State University of New York at Stony Brook where as chairman of the Department of Restorative Dentistry he designed and established the clinical teaching program and restorative dentistry curriculum. Since 1977 Dr Baum has been on the faculty at the University of Connecticut School of Medicine.

He has earned a variety of honors: he has been a member of Omicron Kappa Upsilon since 1946 and of the American College of Dentists since 1960. He was named to the roster of Outstanding University Educators of America in 1969 and in 1980 he won the Teacher of the Year Award.

His active involvement in a long list of professional organizations includes chairman of the Research Committee and member of the Board of Directors for the American Academy of Gold Foil Operators; chairman of the Awards Committee for the Academy of Operative Dentistry; Board of Directors, Universidad de Montemorelos, Mexico; consultant since 1972 to the Council on Dental Education of the American Dental Association; member of the Curriculum Survey Committee for the ADA, 1975-1977; and consultant with the American Dental Mfg Co.

With the exception of a brief period in private practice at the beginning of his career, Dr Baum has devoted his entire professional life to full-time dental education and research. His relentless search for improvement of quality through streamlining of procedure and applying precise but simplified technique has become his characteristic. His sensible and conservative guidance and his creative contributions have brought the art of dentistry to life.

From the presentation by Anna T Hampel, Chairman, Research Committee, Academy of Operative Dentistry, 19 February 1982.

Response by Lloyd Baum

It is really tremendous to be honored by this Academy of Operative Dentistry, which has chosen George Hollenback as its standard bearer. The research style of George — with its blend of art and science — and the influence of this active organization fill a real need in our profession today.

This is a fantastic organization. Who, 10 years ago, would have dreamed it would grow to its present size! And think of its potential growth; consider what it stands for. It can be most influential in providing a stabilizing influence in preventing many of our misguided visionaries from transforming their thoughts into action. And there **is** a need to provide stability and direction. One illustration comes to mind. During the construction of one of our recent dental schools the new dean was passing through the new technique laboratory and noticed two casting wells installed in the bench. "No student is going to make a casting in my dental school!" he exclaimed — and ordered the wells to be welded over.

On a more sober note, I accept this award on behalf of all teachers of operative dentistry who seek better and more effective ways to teach. Seldom are developments the result of one person; invariably they are the result of joint efforts. Goldent is a good example. I was virtually pushed into this venture by Earl Collard and John Mosteller. Some idea people who helped in its development were Jim Vernetti, Harold Schnepper, Mel Lund — and where would it have been without Walter Smith and Williams Company for promotion and production? — and Bill McKay of American Dental Mfg Co who rendered valuable assistance in instrument design.

It is great to be honored by you here today. It is the nicest thing that has happened to me in my professional career. Thank you very much.

WIT AND WISDOM

Titanium Foil

The mad scientists at the Paradental Research Institute continue the feverish pace of their research to aid the general practitioner. This issue presents a report on a new restorative material.

RICHARD E LOMBARDI

Summary

Titanium foil is discussed. The need for protecting the pulp is mentioned. Tit-Dent is described.

Cavity Preparation and Insertion for Class 5 Cavities

The purpose of this paper is to discuss the cavity preparation for, and insertion of, titanium foil, a new filling material designed to last 670 years. Science and Technology have produced many changes in our world and in our profession. A new material, titanium foil, is being studied. Current studies indicate that fastidious attention to detail in the use of this material produces a restoration of extraordinary longevity in the laboratory.

Paradental Research Institute, 221 S W 155th, Seattle, WA 98166, USA

RICHARD E LOMBARDI, DDS, investigative director

Reprinted with permission of the Washington Unit, Academy of General Dentistry, from its *Bulletin,* April 1968.

CAVITY PREPARATION: Cavity preparation is begun with a 33½ inverted cone bur; an old 33½ inverted cone bur. Those dating since 1940 are acceptable only if their edges are redulled. If an old enough bur is not available a suitable substitute may be carved from balsa wood. The properly prepared bur is then attached to the movement of a Big Ben wind-up clock in such a manner that it makes one revolution per minute. This is used as the handpiece. This speed must not be exceeded to protect the health of the odontoblasts. Standard cavity preparation procedures are then followed. The method of choice for cavity preparation, however, is not this radical. An improved method requires the isolation of the tooth with rubber dam in the usual manner. Following this, plaster is poured over the head and rubber dam of the subject until only the desired outline form of the cavity is left exposed. After the plaster hardens, the patient is transported to the nearest coast and placed on a rocky outcrop in such position that wind, rain, sun, and salt water can gently erode the exposed tooth surface into its designed cavity form. This method produces the least temperature change and greatest protection of the pulp.

INSERTION: Titanium foil is available commercially in standard sizes, but the conscientious operator will roll his own foil rather than gamble on the gross inaccuracies of the machine-age product. Just as the hand-rolled cigarette is far more symmetrical and accurately measured than the commercial cigarette, hand-rolled titanium foil is a superior product.

Slight modification of standard foil insertion instruments is required. All dimensions are reduced by 400% and a mallet made from a hummingbird drumstick is substituted for the conventional mallet. The mallet is further modified to be attached to the eyelid of the assistant, who strikes the blow of the mallet by blinking her eyes. The conscientious operator will select an assistant who winks better with the left eye.

The foil is passed through a flame by the assistant. This drives off the evil spirits. The pellet is transferred to the cavity where the operator holds it with his holding instrument. The modified condenser is placed upon the pellet at an angle of 12 degrees, four minutes, and 59 seconds. The assistant then mallets it into place at the rate of two blinks per minute.

A recent development in this field is the product known as Tit-Dent, which consists of small balls of titanium foil rolled up in an outer layer of titanium foil. These are used like the Mexican piñata. They are placed in the cavity and struck a blow to see what comes out. The big advantage claimed for Tit-Dent is the elimination of the need for malleting. It is claimed that all that is required is to place the material in the cavity and drive the patient along a bumpy road and complete condensation occurs. For some reason condensation does not occur on Saturday.

Dr Lombardi demonstrates the wrong *variety of hummingbird to be used with his Titanium Foil technique.*

Cartoon by Kurt Labberton, dental student in the class of 1983 at the University of Washington

DEPARTMENTS

Book Review

AN ATLAS OF PEDODONTICS
Second Edition

by John M Davis, David B Law, and Thompson M Lewis

Published by W B Saunders Co, Philadelphia, 1981. 504 pages. Illustrated, black/white and color, and indexed. $37.50

The goal of the authors to give a pictorial presentation of clinical pedodontics characterized by clarity and brevity, which was achieved in their first edition, has been improved upon in content, clarity, and thoroughness in this second edition.

The text follows a logical pattern with the first four chapters involving diagnosis. These chapters cover growth and development, oral diagnosis, anomalies of the dentition, and radiography. The balance of the text deals with the treatment aspects of pediatric dentistry, with chapters on prevention, anesthesia, rubber dam, and operative dentistry. In addition, all phases of pulp therapy and endodontics, oral surgery, space management and orthodontic diagnosis, trauma, child management, sedation, and treatment of the handicapped child are shown. Added to the second edition are chapters on pediatric oral surgery, orthodontic diagnosis, and sedation. The table of contents has been subdivided to permit the reader quick access to items of special interest.

The quality of the clinical photography is a credit to the authors and a model of excellence for the clinician. Both the authors and publishers are to be complimented highly, not only on the standard of photography and reproduction but also on the standard of the dental work and the presentation of the material.

The color photographs in the section entitled "Anomalies of the Dentition" help the reader to judge anomalies of color. The chapter on radiography has been significantly expanded; the description of "common errors involved with intraoral radiography" and "normal anatomic landmarks shown on a panoramic radiograph" are very useful to the practicing clinician. Radiography for the handicapped child is demonstrated well, leaving the dentist with no excuse regarding obtaining first-class diagnostic films for these patients. The reference chart on radiation exposures is most pertinent during these times when the profession is under close scrutiny.

The chapter on pediatric oral surgery by Dr Roger Meyer is a joy to read; it presents a logical and sequential approach to the subject. The line diagrams in this chapter together with the text provide the clinician with a check list to handle the more unusual surgical problems. The chapter on orthodontic diagnosis is one of the highlights of the second edition; Dr Marc Joondeph is to be complimented on the thoroughness of this chapter. In line with the increased amount of orthodontic care being performed by the general practitioner and the pediatric dentist, this chapter provides a sound basis for identifying diagnostic problems utilizing a planes-of-space concept. It is encouraging to see the emphasis being placed on diagnosis rather than on treatment; however, approaches to treatment are appropriately related to the diagnostic findings in an excellent tabular form.

The subject of child management does not lend itself to the format of a pictorial atlas and is accompanied by a brief script. The pediatric dentist will, however, wish to refer to more comprehensive texts to obtain greater depth in this area. The commonly used sedative agents are well described, together with appropriate dosages in the chapter on sedation. Pictorial descriptions of the handicapped child are included with a summary regarding etiology, clinical features, orofacial features, and treatment and prognosis.

It is difficult to be critical of the text since it achieves its objective extremely well. However, the area of facial growth and development was afforded only one page and certainly could have been expanded. The sequential management of a supernumerary tooth and an unerupted permanent central incisor lends itself to pictorial presentation. The section on prevention could be expanded in the area of pit and fissure sealants as well as diet analysis. In this section, not everybody would agree on the fluoride recommendations for the infant. Greater emphasis is warranted, however, on nursing bottle caries since we have high rates of success with fluoride and excellent preventive programs in decay reduction. In this regard examination techniques for the infant could be more comprehensively covered. These minor criticisms of omission are suggested to aid the authors should a third edition be contemplated.

This book should be on the shelves of all of those who deal with children in their day-to-day practices. It will serve as an excellent reference to aid the practitioner in diagnosis; it may also aid as a book for educating parents. For those pediatric dentists contemplating board certification, it would be an invaluable guide in preparation for the oral section on the board.

DAVID B KENNEDY, MSD, FRCD (Can)
Vancouver, BC, Canada

Letters

Are You a Dentist's Dentist?

I found the Point of View article written by M H Carlson (Autumn 1981) most stimulating and thought-provoking. I am most happy to see articles like Dr Carlson's that speak of quality dentistry coming from dedication to perfection through excellence in all restorative situations. I am less than pleased with other colleagues selling courses dealing with psychological, sociological, and economical awareness. The best learning experience relates directly to clinical skills. That produces quality dentistry. I agree wholeheartedly with Dr Carlson's Point of View.

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Press Digest

Wetting effects of surface treatments on inlay wax-investment combinations. Morrison, J T, Duncanson, M G & Shillingburg, H T (1981) *Journal of Dental Research,* 60, 1858-1860.

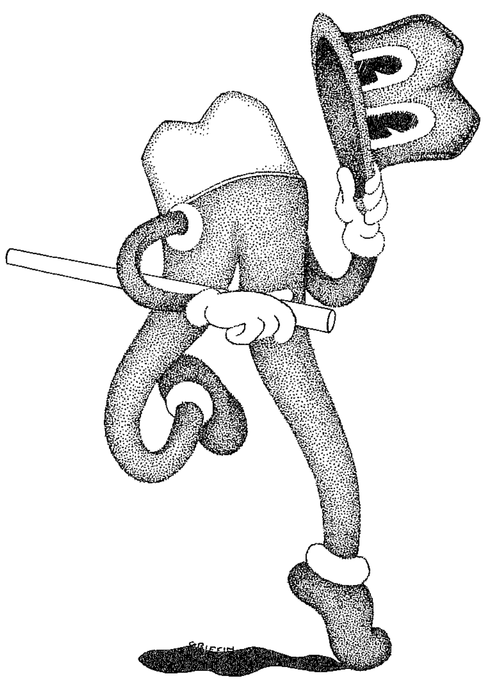
The treatment of a wax pattern with agents for reducing surface tension (Die-Sep Lubricant and Wax Pattern Cleaner, J F Jelenko & Co) enhanced the extent of wetting of investments. The lubricant was as effective as the cleaner, but excess of either should be avoided as they could interfere with the setting of the investment and cause bubbles in vacuum investing.

A laboratory report on vibration etching for fissure sealants. Tadokoro, Y, Iwaku, M & Fusayama, T (1982) *Journal of Dental Research,* 61, 780-785.

When etched fissures were filled with Delton (Johnson & Johnson Co, East Windsor, NJ 08520, USA) it was found that the contents of the fissures and the prismless layer of their walls were not removed, the penetration of sealant was limited to fissures with entrances wider than 50-60 μm, and no tags were formed. The use, during etching, of a fissure needle (Shofu Dental Mfg Co, Higashi-yamaku, Kyoto, Japan) mounted on a vibrating condenser for amalgam (Shofu Dental Mfg Co) resulted in the removal of the contents of the fissures and the prismless layer of the walls, enlargement of the fissures to a width of 150-200 μm, penetration of the fissures with sealant, and its retention by the formation of tags penetrating the etched enamel.

Neurophysiological and neuropsychological function in mercury-exposed dentists. Shapiro, I M, Cornblath, D R, Sumner, A J, Uzzell, B, Spitz, L K, Ship, I I, and Bloch, P (1982) *Lancet*, 1, 1147–1150.

Of 298 male dentists, aged 30–75 years, whose concentrations of mercury in tissue of the head and wrist were measured by a new technique of X-ray fluorescence, less than one-third had concentrations of mercury exceeding 20 micrograms per gram of tissue ($\mu g \cdot g^{-1}$), the lowest concentration detectable by the technique; more than 13% had concentrations exceeding 40 $\mu g \cdot g^{-1}$. When 23 of the dentists in the upper 20% of the group were assessed for neurophysiological and neuropsychological function, seven were found to have subclinical polyneuropathies as indicated by slower conduction of nerves, five having delays characteristic of carpal tunnel syndrome. The dentists with high concentrations of mercury also exhibited more visuographic alterations and higher levels of distress than did the dentists in the control group.



Drawing by Lane Griffin, dental student in the class of 1984 at the University of Washington.

Susceptibility of oral bacteria to various fluoride salts. Maltz, M & Emilson, C G (1982) *Journal of Dental Research*, 61, 786–790.

Stannous fluoride and cupric fluoride were found to be bactericidal at much lower concentrations than were sodium fluoride or ammonium fluoride when tested on *S mutans, S sanguis, S salivarius,* Lactobacillus, *A naeslundi,* and *A viscosus.*

Announcements

NOTICE OF MEETINGS

American Academy of Gold Foil Operators
Annual Meeting: 4 and 5 November 1982
University of Southern California
Los Angeles, CA

Academy of Operative Dentistry
Annual Meeting: 17 and 18 February 1983
Westin Hotel
Chicago, Illinois

BUONOCORE MEMORIAL LECTURE ESTABLISHED

An annual lecture to comemmorate the late Michael G Buonocore has been established by the Academy of Operative Dentistry under the sponsorship of the L D Caulk Company, with which Dr Buonocore was associated. The lecture will replace the report on research that formed a part of the annual program of the Academy. The first Buonocore lecture, entitled "A Milestone in Dentistry," was given by Dennis C Smith and is published in this number of *Operative Dentistry.*

The impetus for the memorial was provided by John B Heyde, director of professional research, and Don LeRoy, vice-president and general manager, of the L D Caulk Company.

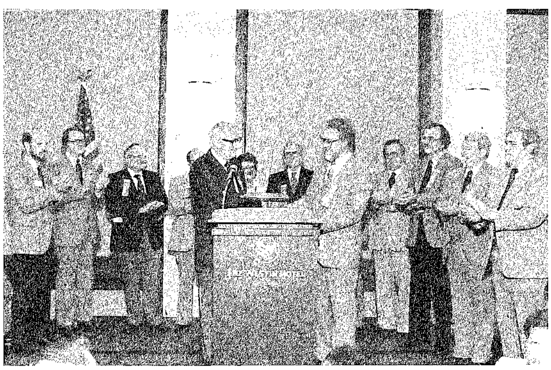
NEWS OF THE ACADEMIES

Academy of Operative Dentistry

The eleventh annual meeting of the Academy of Operative Dentistry was held 18 and 19 February 1982 in Chicago at the Westin Hotel. The program consisted of essays, table clinics, and limited attendance clinics. The first M G Buonocore Memorial Lecture was delivered by Dennis C Smith.

At lunch on the first day the Hollenback Memorial Prize was presented to Lloyd Baum and the Student Achievement Award to Lucas Stevens.

Officers elected for 1982 are: president, Paul H Loflin; president-elect, Robert L Kinzer; vice-president, William N Gagnon; secretary-treasurer, Ralph J Werner; assistant secretary, Gregory E Smith; and councilors, Lawrence L Clark, Frank K Eggleston, R Craig Bridgeman, William N von der Lehr, Barry O Evans, and Anna T Hampel.



At the podium Richard Tucker (left) and Harold Laswell (outgoing president) induct new officers of the Academy of Operative Dentistry for 1982. From left to right they are: Barry Evans, Frank Eggleston, Ralph Werner, Gregory Smith, Anna Hampel, Paul Loflin, R Craig Bridgeman (behind Laswell), William Gagnon, Robert Kinzer, William von der Lehr, Lawrence Clark.

Student Outstanding Achievement Award Presented to Third Winner

Lucas E Stevens, third-year student at the University of Florida School of Dentistry, was announced winner of the Student Outstanding Achievement Award for 1982 at the annual meeting in February of the Academy of Operative Dentistry in Chicago. Stevens is the third winner of the prestigious award since it was established by the Academy in 1976.

The award was established by the Academy of Operative Dentistry to recognize and reward a student for excellence in the presentation of a table clinic, thereby to foster interest and encourage research in operative dentistry in schools of dentistry.

The award is based on the presentation of a table clinic by a student at the annual meeting of the American Dental Association, in this instance the meeting in 1981 at Kansas City. A committee of the academy selects the winner by evaluating the table clinic for scientific value and applicability to operative dentistry and the clinician for command of the subject, neatness, and clarity of presentation. The award is a $200 cash prize, a certificate, and a place on the table clinic program at the Academy's annual meeting, with travel and expenses paid.

The topic of Stevens' table clinic, "Iatrogenic occlusal discrepancy: influence on chewing patterns and muscle activity," dealt with physiological effects of a dental restoration that is placed in supra occlusion.

Stevens, at present ranked first in his class, completed his first year with a 4.0 average. His predental record is also noteworthy. After two years of undergraduate study at the University of Florida, he spent a year as an exchange student at the University of Utrecht, the Netherlands, where he studied the history of art, particularly the early Dutch and Flemish masters.

Lucas Stevens receives the Student Outstanding Achievement Award from Anna Hampel.

AWARDS TO BE GIVEN

Nominations Invited for Hollenback Prize

Nominations of candidates for the Hollenback Memorial Prize are invited by the Academy of Operative Dentistry. The prize is given annually for research that has contributed substantially to the advancement of operative dentistry. The research may be either fundamental or applied and may deal with prevention of dental disease or its treatment. There are no geographic or occupational limits on eligibility for the prize.

Names of nominees and particulars of their research may be sent to Dr Joseph B Dennison, University of Michigan, School of Dentistry, Ann Arbor, MI 48103. Nominations should be submitted by 30 September 1982.

Achievement Award for Students

The Academy of Operative Dentistry will recognize outstanding achievement among dental students through an award for a table clinic. The awardee is to be selected from the Student Table Clinic Program at the annual meeting of the American Dental Association. The award consists of a certificate, $200, and a place on the table clinic program at the annual meeting of the Academy in Chicago. Travel and expenses for the Chicago meeting will be paid by the Academy.

NEWS OF STUDY CLUBS

Associated Ferrier Study Clubs

The Associated Ferrier Study Clubs held their 51st annual meeting at the School of Dentistry, University of Washington, in Seattle, Washington, on 7 May 1982, under the guidance of Dr J Martin Anderson, president. Over 100 members and guests attended.

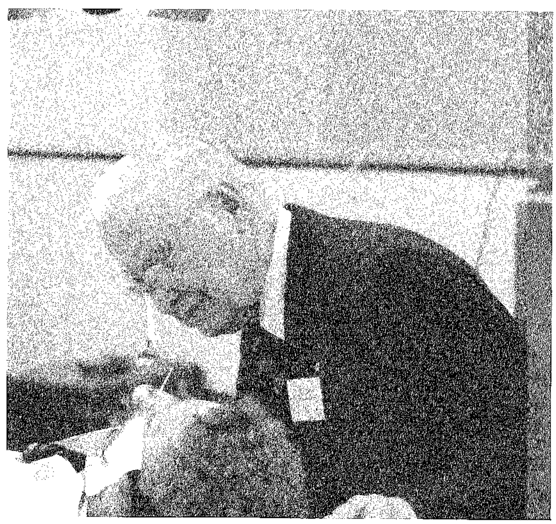
Representatives of the 11 component clubs very ably demonstrated their operative skills at the morning clinical session, where almost every classification of direct gold restorations was shown.

After an afternoon of relaxation at golf, trapshooting, and visiting with old friends, dinner was held at the Broadmoor Golf Club. The evening program consisted of a fascinating illustrated talk on "The History of Direct Gold as a Restorative Material," by Dr A Ian Hamilton, editor of *Operative Dentistry,* and a slide presentation of a wide variety of direct gold restorations by Dr Robert Murray of Anacortes, Washington.

The Association recognized one of its long-time members, Dr John T Ryan, 95, who had practiced dentistry for 64 years before retiring in 1977. The meeting was dedicated to him. Dr Ryan had been a highly competent operator and clinician and for a number of years had been chairman of the Department of Operative Dentistry at his alma mater, North Pacific College of Oregon, now the Oregon Health Sciences University. He has been a member of the Association since its formation in 1930.

Another honored guest was Dr Harold E Schnepper of Rialto, California, president of the American Academy of Gold Foil Operators. Undergraduate dental students were welcomed as guests at the clinical session.

GERALD D STIBBS



John T Ryan was honored at the 51st annual meeting of the Associated Ferrier Study Clubs. Photo courtesy of Robert R Murray.

OBITUARY

Dr F Lloyd Jacobson, DMD, FICD

The Pacific Northwest lost one of its renowned dental clinicians, teachers, and operators in the passing of Dr F Lloyd (Jake) Jacobson of Seattle. Dr Jacobson died on 31 March 1982 at the age of 71 after a long illness.

Dr Jacobson, associate professor emeritus of the School of Dentistry, University of Washington, was best known as a mentor of amalgam study clubs in Washington, Oregon, and British Columbia. A 1934 graduate of North Pacific College of Oregon (now Oregon Health Sciences University), he practiced in his home town, New Westminster, BC, before serving four years in the Canadian Dental Corps in World War II. Upon return to civilian practice, Dr Jacobson was one of the driving forces in the formation of the Intercity Gold Foil Study Club (now the Walter K Sproule Study Club) in New Westminster in 1947. He also began an extensive career of giving clinics on amalgam and radiodontics.

In 1950, Dr Jacobson accepted an appointment at the School of Dentistry, University of Washington, as chairman of the Department of Oral Diagnosis and Treatment Planning, a post he held until ill health forced him to resign in 1970. A disciple of the eminent radiodontist, Dr Clarence O Simpson of St Louis, Missouri, he taught precise radiodontic technic.

Through the years, Jake retained his keen interest in operative dentistry. He became a member of the W I Ferrier Gold Foil Study Club in Seattle. He held membership in numerous dental organizations, including the Academy of Operative Dentistry, the American Academy of Gold Foil Operators, the Academy of Oral Roentgenology, the International College of Dentists, the Canadian Dental Association, and the College of Dental Surgeons of British Columbia, as well as the local, state, and American dental associations.

At present an annual award is made in his name to an outstanding senior dental student at the University of Washington, and a memorial scholarship is being established in his name at the same school.

Lloyd is survived by his wife, Peggy, one son, John, two daughters, Carolyn Oster and Anne Martin, and by a sister, Gwynneth, in New Westminster, BC.

Jake was a dedicated dentist, clinician, and educator. He inspired countless students and made a definite impression in his chosen profession. Our warm sympathy is extended to his family; he will be missed.

GERALD D STIBBS

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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