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EDITORIAL

Mercury: The Environment and the Dental Office

In addition to the controversy of patient safety and dental amalgam, we are facing other challenges to the continued use of mercury in the dental office because of its potential impact on the environment. In some parts of the country we see activity going on that will seriously increase the cost of using dental amalgam.

The 6 January 1992 issue of *ADA News* has a front-page story about dentists in Pima County, Arizona, who had been targeted for the past two years as a prime source of mercury in the local wastewater. Pima County apparently adopted a policy that required dental offices to obtain an industrial wastewater discharge permit for mercury. They were threatening dentists with heavy fines for mercury in the effluent from their offices. Of the 183 discharge permits issued, 144 were for dental offices, with hospitals and analytical laboratories accounting for the rest. Pima County has since, as a result of heavy lobbying declaring the rule unscientific, rescinded the rule.

This issue is not dead, however, and we will see other agencies in this country monitoring and controlling the amount of mercury and amalgam particles in the effluent from dental offices. There is some evidence that dental offices produce a major portion of the amount of mercury collected in sludge generated in purifying plants. There are commercially available devices that reduce the amount of dental amalgam in the effluent from the dental operatory. The question we should be addressing is how much of the mercury we must eliminate from the effluent to meet *reasonable* standards. There are commercially available devices made in Europe to reduce the amount of dental amalgam in the effluent by varying amounts. One model purportedly reduces the amount of amalgam particulate escaping by an average of 70% and another by up to 99.8%. The problem is not deciding if we should eventually use separators, but one of deciding which of the systems should be adopted. There is no doubt that governmental agencies will sooner or later impose the use of mandatory separators for all dental offices using dental amalgam. Already we see such mandatory use of an approved amalgam separating device required in a number of countries: for example, Denmark, Germany, Sweden, and Switzerland. I suspect we cannot be far behind.

In the Seattle, Washington area, the Metro division of King County, which deals with all waste management in the area, has a committee addressing the issue of mercury contamination within the sewage system. Dentistry is one of those areas they are evaluating. Their interest in controlling the amount of mercury being released into the environment has resulted in their arranging for the European manufacturer of the dental amalgam separators to install their units in four operatories at the University of Washington. Metro is capturing and monitoring the amount of dental amalgam in the effluent leaving the operatory with and without the separators in place.

Cost is a significant factor. The separators available cost approximately $1500 for the model reducing the amount of dental amalgam by 70% and approximately $4500 for the model that claims to result in a 99.8% reduction. Keep in mind that one unit is required for each operatory. It is hard to imagine the costs that must be added in turn to the cost of dental amalgam. It certainly will be considerable. My understanding is that in Switzerland the dentists organized their activities so that the less-expensive units were installed voluntarily. When the bureaucrats addressed the issue the profession was able to say, in effect, they had already taken steps to reduce the amount of mercury and dental amalgam by voluntarily installing separators, and the standard to be set ought to be in accord with their actions. This worked and the standard for Switzerland is for the use of the 70%-effective separators instead of the much more costly 99.8%-effective models, thereby saving dentists a considerable amount of money to meet standards being adopted today.

It seems logical that our profession needs to ensure that all of its members are knowledgeable about this issue and perhaps take a good look at Switzerland's model. The time to be addressing this thorny issue is now, not after new rules are proposed. It is imperative that we take a stand.

DAVID J BALES
Editor

ORIGINAL ARTICLES

Explorer Sharpness as Related to Margin Evaluations

A P RAPPOLD • A H RIPPS • E J IRELAND

Summary

Nine experienced operative dentistry faculty each used six different explorers of varying degrees of sharpness ranging from new to well-used to evaluate marginal acceptability on a device used to simulate gradations of vertical opening. In this study, the standard for the sharpest explorer point was determined to be 68 μm in diameter measured 40 μm from the tip. There was a positive correlation between the diameter of the explorer tip at 40 μm and the mean amount of opening that could be detected until the margin was declared unacceptable. Increased explorer dullness significantly handicapped even experienced graders when the explorer alone was used to evaluate visually inaccessible margins.

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Introduction

The evaluation of marginal integrity is a crucial indicator of the clinical acceptability of a casting. All castings, regardless of how well they seem to fit, exhibit varying degrees of opening along their margins (Fusayama & others, 1963; Eames & others, 1978). Although the desirability of having the margins of castings as closed as possible is generally accepted, there are no definitive clinical studies showing the relationship between the failure rate and the size of marginal discrepancies for dental castings. The most commonly used method for determining marginal acceptance is visual inspection of the margin along with a simultaneous tactile evaluation with an

explorer. In areas where the margin is not visually accessible, such as subgingival or interproximal areas, the dentist must use the explorer alone or with radiographs to determine the acceptability of margins.

Previous studies by Christensen (1966) and Dedmon (1982, 1985) have attempted to quantify in microns the minimum vertical opening that would be accepted by experienced evaluators using only an explorer to make a determination. All of these studies demonstrated that there was often a wide range within and among examiners as to the point at which a margin was rejected. However, the mean amounts of marginal disparities accepted in these studies were comparable, allowing for the different methods employed.

Christensen (1966) reported that the rejection point for vertical openings at the gingival margin of castings cemented on extracted teeth ranged from 34 to 119 μm, with a mean of 74 μm. The gingival margins were not visually accessible and were each examined by using the same explorer.

Dedmon (1982) reported using a rectangular metal block that simulated gradations of a vertically open margin. The rejection point ranged from 43 to 196 μm, with a mean of 114 μm. The examiners used the same explorer with their eyes closed.

Dedmon (1985) repeated the study, using limited and unlimited access to the margins. The rejection point ranged from 27 to 72 μm, with a range of 53 μm. The examiners used the same new explorer and were allowed to observe the movement of the explorer handle (but not the tip) during the test.

In each of these studies, tactile sense played an important role; however, none of them addressed the effect that variations in explorer sharpness might have on the ability of dentists to determine marginal discrepancies. It must also be noted that there is, at present, no ADA specification for explorer sharpness on which to base a determination.

The purpose of this study was to determine the effects on the tactile ability of experienced graders in evaluating vertical marginal discrepancies when the degree of explorer sharpness varied, and secondly, to suggest a criterion by which explorer sharpness and effectiveness might be judged.

Methods

A device for simulating vertical open margins was constructed from two flat metal bars attached to a metal base (Fig 1). The bars were placed next to each other so that the distance between them increased from approximately 0 μm at the origin to 270 μm at the other end. The edges of the bars were straight lines, and the amount of opening increased continuously at the rate of 2 μm per mm. The amount of discrepancy in microns at any point could be determined by measuring the distance from the origin in mm and multiplying by 2. The measurements were verified by using computer imaging by means of a video camera attached to a microscope.

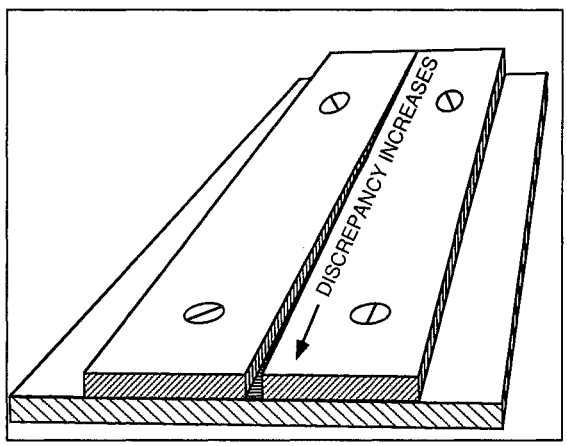

FIG 1. *A schematic diagram of instrument for simulating marginal discrepancies*

Six #5 explorers were used in this study. All originated from the same manufacturer (Hu-Friedy, Chicago, IL 60618). One of the explorers was new,but the remainder were randomly obtained from the school clinics. Prior to the start of testing, the diameter of

each explorer tip was measured using computer imaging techniques. Measurements were made at 40 and 50 μm from the tip of each explorer (Table 1) and the instruments were not numbered in any order of sharpness.

Using each of the six explorers, nine experienced clinical faculty from the Department of Operative Dentistry were asked to detect the minimal discrepancy that would cause them to reject a restoration as a clinical failure due to a vertical open margin. Clicks along the simulated open margin, if not judged open, were ignored. Each investigator evaluated the margin with his eyes closed. They were not told whether the explorer was sharp or dull, and the bar device was positioned vertically and moved under the explorer to remove any clues as to the amount of progression that had occurred.

Table 1. Diameter of Explorer Tips in Microns

	Explorer #					
Diameter	**1**	**2**	**3**	**4**	**5**	**6**
40 μm from tip	85.207	274.466	68.095	114.307	192.490	214.720
50 μm from tip	96.131	295.009	76.729	123.460	199.490	229.330

Table 2. Openings at Which Examiners Rejected Margins (in Microns)

	Explorer #					
Examiner	**1**	**2**	**3**	**4**	**5**	**6**
A	110	260	86	130	150	166
B	60	270	74	164	260	216
C	160	265	110	200	240	190
D	80	200	50	90	170	140
E	50	220	70	90	150	160
F	100	260	70	160	220	260
G	70	260	70	180	170	140
H	60	140	70	80	140	140
I	60	170	60	80	130	180
Mean	83.33	227.22	73.33	130.44	181.11	176.89
Std Dev	33.00	44.91	15.89	44.29	44.33	38.16

Results

The openings at which the examiners rejected the margins using each of the six explorers were calculated in microns, along with the mean values and standard deviations (Table 2). The size of the standard deviation increased rapidly for the three sharpest explorers, but tended to level off as the duller instruments were used (Fig 2).

The mean values for marginal rejection determined by the use of each explorer were compared to the diameter of the corresponding explorer tip using a Pearson product moment correlation. It was determined that there was a significant positive correlation ($r = 0.98$, $P < 0.01$) between the mean amount of marginal opening at rejection and the diameter of the explorer measured 40 μm from the tip (Fig 3).

Discussion

The openings at which the examiners in this study rejected margins using a new explorer ranged from 50 to 110 μm, with a mean opening of 73.33 μm. This most closely paralleled the results reported by Christensen (1966) for nonvisible gingival openings that ranged from 34 μm to 119 μm, with a mean of 74 μm. Both studies showed variation among and between individual examiners in determining the point of rejection. These variations may have been influenced by differences in individual tactile ability.

In order for a discrepancy to be recognized, an explorer tip must enter the opening and encounter resistance to back and forth movement. The minimal discrepancy that represents an open margin translates into the depth the explorer must enter the opening to transmit resistance to the evaluator.

In the present study, the amount of marginal opening necessary for rejection increased as the dullness of the explorer tip increased. Most significant was the finding that the diameter of the explorer point 40 μm from the tip positively

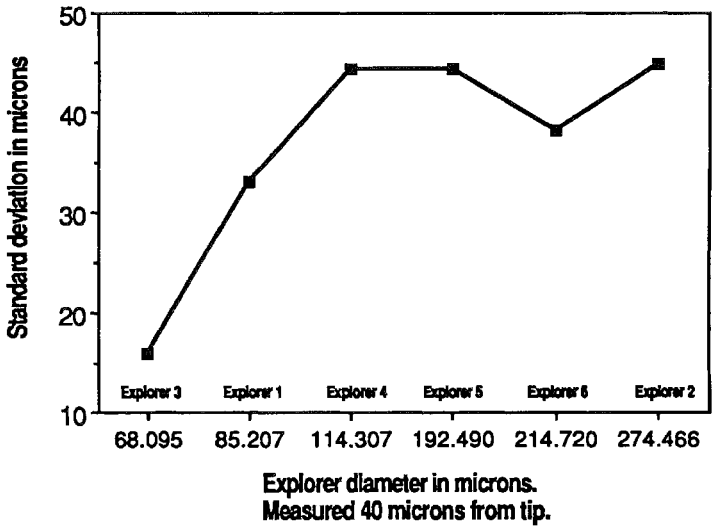

FIG 2. *Standard deviation by explorer sharpness*

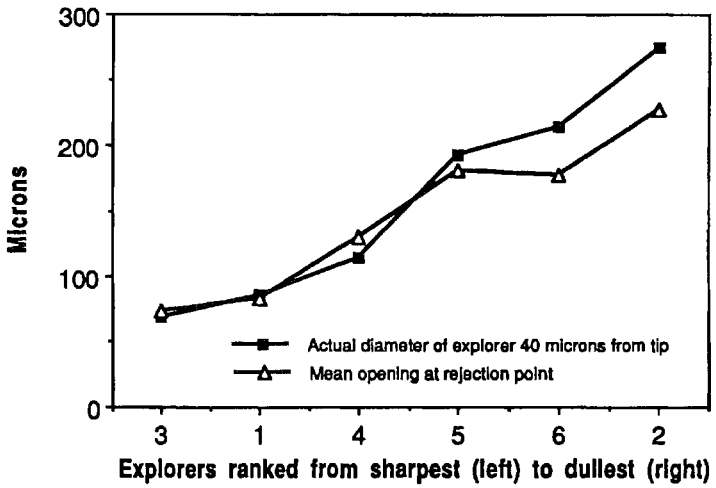

FIG 3. *Correlation between mean opening at rejection and the diameter of the explorer 40 μm from the tip*

correlated to the mean opening required to cause rejection (Figure 3). This 40 μm distance that the explorer tip entered the marginal opening was determined to be relatively constant for each of the explorers tested. By establishing 40 μm as a standard depth measurement or "depth factor," this measurement can be used to calibrate the sharpness of explorers. Based on average rejection points, a clinician, relying only on an explorer, might not expect to detect an open margin any smaller than the diameter of the explorer tip at 40 μm.

In this study, the sharpest explorer point was 68 μm in diameter when measured 40 μm from the tip and the dullest measured 274 μm

(Fig 4). It was apparent from examination of the explorers in the study that increased dullness occurred with clinical use of the instrument, and that this plays a significant role in handicapping even experienced graders when the explorer alone must be used to evaluate visually inaccessible margins. These results should raise the consciousness of the operator regarding the necessity for maintaining sharp explorers in the evaluation of all margins.

Conclusions

1. Based on averages, an examiner relying only on an explorer might not expect to be able to detect an open margin any smaller than the diameter of the explorer point measured 40 μm from the tip.
2. In this study, the standard for a sharp explorer point was determined to be 68 μm in diameter when measured 40 μm from the tip.
3. Explorers dull from clinical use significantly handicap even experienced graders when the explorer alone must be used to evaluate visually inaccessible margins.

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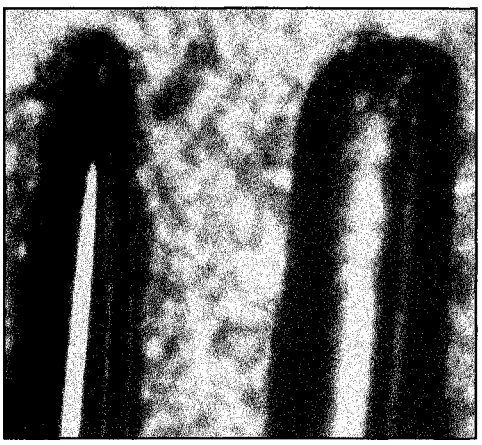

FIG 4. *Sharpest and dullest explorer tips side by side (X82.5)*

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In Vitro Marginal Leakage of Cervical Composite Restorations Lined with a Light-cured Glass Ionomer

S K SIDHU • L J HENDERSON

Summary

The purpose of this research effort was to investigate the microleakage of cervical restorations lined with a light-cured glass-ionomer liner. Wedge-shaped cervical cavities were cut on extracted teeth with the gingival cavosurface margin involving dentin. The cavities were randomly assigned to each of three groups: (1) restored with a microfilled composite resin, (2) restored with a light-cured glass-ionomer liner and microfilled resin as in the "sandwich" technique, and (3) restored entirely with the light-cured glass-ionomer liner. Half of the specimens in each group were thermocycled. Microleakage of these restorations was assessed by dye penetration. The results showed that differences were more pronounced at the gingival margin. Composite restorations inserted over the glass-ionomer liner demonstrated significantly less leakage than when the liner was not used.

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INTRODUCTION

The aspect of microleakage has been the focus of much attention in assessing the success of any restorative material used in the oral environment. The dental literature is inundated with experimental research on the diffusion of fluids through tooth structure and around restorative materials. There is a constant search for a material or technique that ensures adhesion to tooth structure in order to minimize the leakage potential.

Restoring class 5 abrasion and erosion lesions has been a perennial problem, presenting a special challenge when the margins are

on dentin or cementum. Composite resins have been widely used for the esthetic restoration of such lesions. The acid-etch technique is now used universally since Buonocore (1955) first introduced it, and this has proved successful in significantly reducing microleakage (Galan, Mondelli & Coradazzi, 1976; Hembree, 1980; Mitchem & Granum, 1976). However, no such claim has been made for cervical cavities where no enamel is present for bonding to the gingival margin (Monteiro & others, 1986). There is now a heavy reliance on the newer generation dentin bonding agents as a potential solution to this problem. In another attempt to overcome such problems, an initial report (McLean & others, 1985) on the use of glass-ionomer materials under composite restorations has also generated considerable interest. Recently, light-cured varieties of the glass-ionomer materials for use as cavity liners have been introduced. This study was initiated to investigate the degree of marginal leakage of cervical composite restorations lined with a light-cured glass ionomer, by means of dye penetration.

MATERIALS AND METHODS

Cavity Preparation and Restoration

Sixty extracted noncarious human teeth were selected, cleaned, and stored in distilled water at room temperature to prevent dehydration. Wedge-shaped cavity preparations of uniform size (mesiodistal width of 3 mm, occlusogingival length of 2 mm and a depth of 2.5 mm) were made in the cervical third of the buccal surfaces of the teeth with a tungsten carbide bur operated at high speed with constant water spray. The occlusal cavosurface margin of each cavity was placed in enamel and this was bevelled. The gingival cavosurface margins of all preparations involved dentin/cementum. The specimens were pumiced with a soft polishing brush in a slow-speed handpiece and washed thoroughly with water. The teeth were randomly divided into three groups, each of 20 teeth. Specimens in Group 1 (control group) were restored with Silux Plus Resin (3M Dental Products Co, St Paul, MN 55144), using Scotchbond 2 (3M) as the dentin adhesive. Cavities in Group 2 were restored with a light-cured glass-ionomer liner, Vitrabond (3M), in addition to the Scotchbond 2 and Silux Plus Resin. Specimens in Group 3 comprised teeth restored entirely with the Vitrabond material. Each group of specimens was further subdivided into two equal subgroups, one of which was thermocycled. The groups and treatment procedures involved are outlined in Table 1.

Table 1. Specimen Groups and Treatment Procedures Involved

Group	Number of Specimens	Restorative Material(s) and Procedure
1a	10	Scotchbond 2/Silux Plus Thermocycled
1b	10	Scotchbond 2/Silux Plus Not thermocycled
2a	10	Vitrabond/Scotchbond 2/Silux Plus Thermocycled
2b	10	Vitrabond/Scotchbond 2/Silux Plus Not thermocycled
3a	10	Vitrabond Thermocycled
3b	10	Vitrabond Not thermocycled

In all specimens, the cavosurface enamel was etched for 15 seconds with a 37% unbuffered phosphoric acid solution, washed with copious amounts of running water for one minute and dried with oil-free compressed air. All materials were handled according to the manufacturers' instructions. Each cavity was incrementally restored with the last layer held under pressure by a celluloid cervical matrix. The glass-ionomer liner used in the "sandwich" technique (Groups 2a and 2b) was placed on the dentin surfaces and chamfered out to the gingival cavosurface margins to an almost negligible thickness at this margin. All restorations were finished to the cavosurface margins using coarse- to fine-grit discs (Shofu Super-Snap Rainbow Technique Kit, Kyoto 605, Japan). They were then stored for 24 hours in distilled water before thermocycling.

Thermocycling Regimen and Dye Penetration

Specimens in Groups 1a, 2a, and 3a were subjected to thermocycling. The regimen employed consisted of thermocycling 200 times between baths of 5 ± 2 °C and 55 ± 2 °C, with a dwell-time of 10 seconds in each bath. In preparation for dye penetration, the teeth were sealed with varnish and utility wax, leaving the restorations and 2 mm beyond the margins exposed to the dye. The teeth were placed in 0.5% aqueous basic fuchsin dye for 24 hours at room temperature. After removal from the dye solution, the teeth were dewaxed, cleaned, washed, and sectioned longitudinally through the restorations.

Evaluation of Dye Penetration

The degree of marginal leakage as indicated by the depth of dye penetration around the gingival and occlusal margins was evaluated under a dissecting microscope at X40 magnification. The grading scale used to assess the extent of dye penetration at the tooth/restoration interface was as follows (Fig 1):

0 = No evidence of dye penetration
1 = Dye penetration along the interface to ≤ 1/2 depth of cavity
2 = Dye penetration to full depth of cavity
3 = Dye penetration to the base of the cavity and beyond

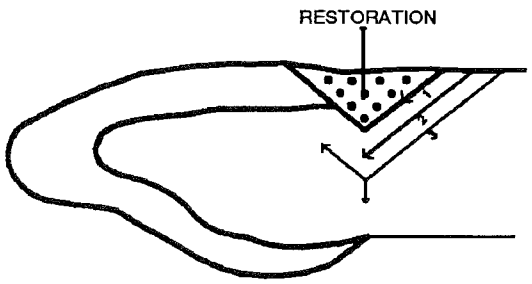

FIG 1. *Diagrammatic representation of scale used to measure the degree of dye penetration at the tooth/restoration interface*

Scoring was carried out by an independent examiner and the specimens were photographed.

RESULTS

There was no evidence of dye penetration at the occlusal margin in Groups 1a and 1b and Groups 2a and 2b. The situation was similar in Group 3 except for one specimen in each of Groups 3a and 3b exhibiting minimal dye penetration (score of 1).

A summary of the degree of gingival dye penetration in relation to the various restorative procedures is thus presented in Table 2. Specimens restored entirely with the resin (Groups 1a and 1b) displayed extensive leakage from the gingival margin in spite of the

Table 2. Degree of Dye Penetration at Cementum/Dentin Gingival Margin

Treatment Groups	Degree of Marginal Leakage 0	1	2	3	Total Number of Restorations
1a: Scotchbond2/Silux Plus Thermocycled	0	0	2	8	10
1b: Scotchbond 2/Silux Plus Not thermocycled	0	1	3	6	10
2a: Vitrabond/Scotchbond 2/Silux Plus Thermocycled	4	5	1	0	10
2b: Vitrabond/Scotchbond 2/Silux Plus Not thermocycled	5	5	0	0	10
3a: Vitrabond Thermocycled	5	3	2	0	10
3b: Vitrabond Not thermocycled	5	4	1	0	10

use of the appropriate dentin adhesive (Fig 2). The results were tested by the Kruskal-Wallis one-way analysis of variance by ranks. The comparison between treatment groups (Group 1 versus Group 2 versus Group 3) showed a significant difference at $P = 0.001$ ($H = 34.36$; Siegel, 1956). The comparison of all the treatment groups using Vitrabond (2a versus 2b versus 3a versus 3b) showed no significant difference ($H = 2.25$).

DISCUSSION

In this study, the materials used were handled according to the manufacturer's (3M) instructions. All materials used were from the same manufacturer in order to ensure compatability between the materials. Results of a previous study (Robinson, Moore & Swartz, 1988) have shown that microleakage increases significantly when dentin adhesives are interchanged between different resin systems.

The specimens were divided into thermocycled and nonthermocycled groups for each treatment procedure to rule out the possibility of the results being a function of the thermocycling regimen. It was decided that a dye-penetration investigation be conducted in this study, as opposed to a radioisotope one. There is no compelling evidence in the literature to suggest that one method addressing microleakage is more effective than others (Crim, Swartz & Phillips, 1985).

There was no observable microleakage at the occlusal enamel margins of the restorations in Groups 1a and 1b and 2a and 2b (Fig 3), proving the effectiveness of the acid-etch technique in sealing restoration margins to the cavity, as other workers have clearly shown (Galan & others, 1976; Hembree, 1980; Mitchem & Granum, 1976; Phair & Fuller, 1985; Hembree & Andrews, 1978). Hence it was decided to confine the microleakage assessment to the gingival margin, as this is the area of concern with composite resins.

In general, there is no consensus in the literature regarding ways of reducing the microleakage at gingival cavosurface margins. Reports on dentin bonding agents are varied. Some workers (Fuks, Hirschfeld & Grajower, 1985) have reported measurable reduction in leakage at the gingival margins of cervical restorations with the use of the earlier dentin

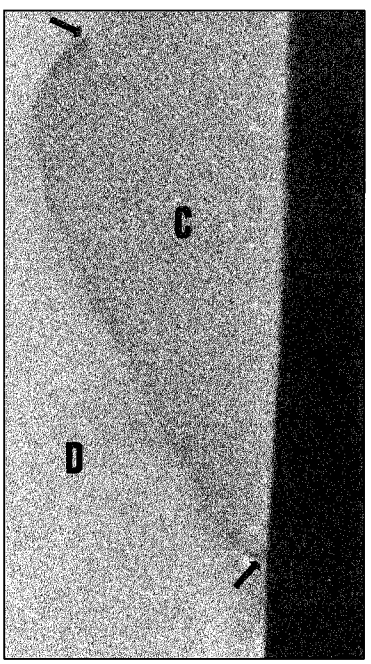

FIG 2. *Specimen restored entirely with the composite resin (Group 1), showing extensive leakage arising from the gingival margin. Extent of dye penetration indicated by arrows (X30) (D = dentin, C = composite resin)*

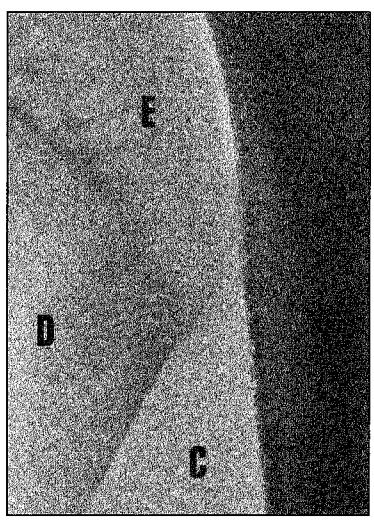

FIG 3. *Typical resin specimen indicating no dye penetration at the occlusal margin of the restorations that were acid-etched (X30) (C = composite resin, D = dentin, E = enamel)*

bonding agents.

In vitro studies evaluating the ability of glass-ionomer cements to seal cavities are by no means unanimous in their results and conclusions. While some (Hembree & Andrews, 1978; Gordon, Plasschaert & Stark, 1986) conclude that glass-ionomer cements adhere completely to tooth structure, others (Fuks & others, 1985; Alperstein, Graver & Herold, 1983) are less enthused with this material in terms of a perfect seal.

Varying degrees of success with the "sandwich" technique further adds to the confusion. It has been suggested that glass-ionomer liners are incapable of preventing microleakage when used in combination with an enamel bonding agent and microfilled composite resin (Crim & Shay, 1987; McComb, Eddyanto & Brown, 1986). One such study reported that reduction of microleakage was a function of the bonding agent (Crim & Shay, 1987). While these earlier studies were done with conventional glass-ionomer liners, the whole scenario seems to have changed with the arrival of light-cured varieties of this material. These latter materials seem to perform better than conventional glass ionomers in reducing microleakage under composite restorations (Tjan, Dunn & Grant, 1989).

The results obtained in our study are in agreement with those of another reported recently (Holtan, Nystrom & Douglas, 1989). Close examination of the glass-ionomer liner in our study revealed that the material was neither detached from the walls of the preparation nor the composite resin overlying it (Fig 4). However, when the technique was improperly executed in terms of extending the liner out to the cervical cavosurface margin, reliance on the dentin adhesive to prevent leakage at this margin appeared to be less than satisfactory. Figure 5 demonstrates this clearly (i e, the dye penetration at the gingival margin was interrupted by the sudden appearance of the glass-ionomer liner).

It may be argued that the validity of in vitro studies is open to question. Although this was a laboratory study, the results of which may not be directly extrapolated to the clinical situation, it does provide some guide as to the performance of new materials. Long-term clinical data on this is required. An in vivo study reported recently (Reich, 1989) demonstrated the ineffectiveness of the "sandwich" technique from the perspective of microleakage. However, in that study conventional

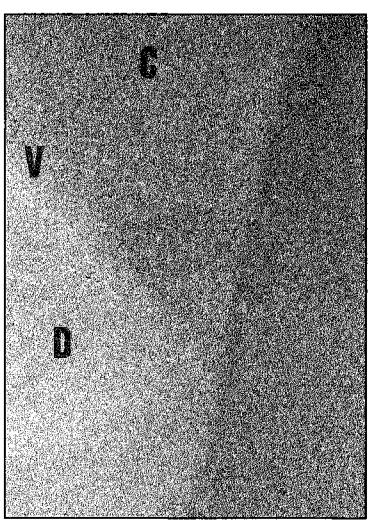

FIG 4. *Typical specimen restored with the "sandwich" technique (Group 2) showing the placement of the glass-ionomer liner at the gingival margin. Note that no dye penetration is observed at the interface between the restorative material and the glass-ionomer liner (X30) (C = composite resin, D = dentin, V = Vitrabond)*

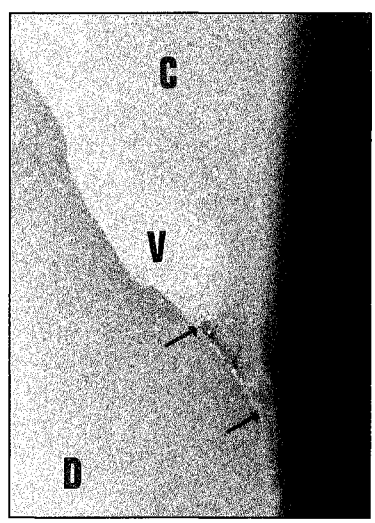

FIG 5. *Dye penetration from the gingival cavosurface margin interrupted by the presence of the Vitrabond liner in a specimen from Group 2. Extent of dye penetration indicated by arrows (X30) (C = composite resin, D = dentin, V = Vitrabond)*

glass-ionomer liners were used. There is no doubt that a reasonable method of restoring cervical lesions with an esthetic material is important, as cervical erosive lesions affect, on average, 20% of permanent teeth (Sognnaes, Wolcott & Xhonga, 1972). It is hoped that the results presented in our report provide the impetus for further research. The results of the all-important test of time and clinical experience will ultimately prevail.

CONCLUSIONS

Within the limitations of this study, the following conclusions may be drawn:

1. The acid-etch technique is effective in reducing marginal leakage along the tooth/composite restorative material interface in enamel;
2. The dentin bonding agent when used with the composite resin without a liner did not eliminate microleakage at the gingival aspect of the restorations;
3. The composite resin used in this study (Silux Plus) adheres adequately to the light-cured glass-ionomer liner (Vitrabond); and
4. Composite restorations inserted over the glass-ionomer liner demonstrated significantly less leakage than when the liner was not used.

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TJAN, A H L, DUNN, J R & GRANT, B E (1989) Microleakage of light-cured glass-ionomer under Class V composite restorations *Journal of Dental Research* **68** *Abstracts of Papers* p 945 Abstract 628.

Dentin Permeability: Sealing the Dentin in Crown Preparations

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Summary

Provisional restorations of full crown preparations may permit more microleakage of bacteria and their products than the final castings do.However, most investigations of the sealing qualities of cemented castings have reported that they too permit dye leakage. One approach to the problem is to seal the dentin with dentin bonding agents at the completion of the crown preparation. This study evaluated the ability of six different dentin bonding agents to seal the dentin of crown preparations of human teeth in vitro using two independent techniques. The first technique quantitated fluid filtration across dentin before and after treatment with dentin bonding agents at one hour, one day, one week, and one month and after thermocycling. The second method measured silver nitrate penetration of the thin veneers of dentin bonding agents into the dentin. Both methods correlated well with each other. The best seals were obtained with Prisma Universal Bond 2 or Superbond powder plus liquid. The worst seals were found using Gluma and Superbond liquid only. Clearfil PhotoBond, Amalgambond, and Scotchbond 2 gave intermediate results. Although the dentin bonding agents tend to accumulate on chamfers, thereby increasing their thickness to 200-300 μm, the method looks promising as a simple way to protect the pulp from the consequences of microleakage.

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INTRODUCTION

Full crown preparations are often required either as bridge retainers or to restore mutilated teeth to proper function and esthetics. Depending on the amount of tooth reduction and size of the tooth, crown preparations of posterior teeth can expose 1-2 million dentinal tubules if all the enamel is removed (Richardson, Tao & Pashley, 1990). The potential for pulpal irritation following crown preparation depends upon a number of variables, including preparation technique (Langeland & Langeland, 1965, 1970; Dahl, 1977), remaining dentin thickness (Richardson & others, 1991), retention of smear layer (Pashley, 1984), amount of microleakage under provisional restorations (Langeland & Langeland, 1965), method of cement removal (Dormois & others, 1982), and length of time between crown preparation and luting of final casting. Surprisingly, few studies have been done on the amount of microleakage beneath castings cemented to full crown preparations. Most of the studies that have been done indicate that all cementation systems permit some microleakage (Mondelli, Ishikiriama & Galan, 1978; Larson & Jensen, 1980; Kawamura & others, 1983; Tjan & others, 1980; Tjan & Chiu, 1989; Goldman, Laosonthorn & White, 1991).

Recent studies (Sturdevant & Pashley, 1989; Richardson & others, 1990) have indicated that the approximal surfaces of dentin are far more permeable than other surfaces. If these surfaces could be sealed with the latest generation of dentin bonding agents prior to fabrication of provisional restorations, there may be less subsequent pulpal irritation, patients may experience less discomfort, and there may be a lower incidence of pulpal pathoses following full crown preparations (Langeland & Langeland, 1965, 1970; Dahl, 1977).

The purpose of this study was to compare a variety of third-generation dentin bonding agents for their ability to seal the dentin of full crown preparations. Two different methods were used to measure sealing of dentin by thin veneers of dentin bonding agents over a period of up to one month and following thermocycling.

METHODS AND MATERIALS

Tooth Preparation

The studies were performed on extracted, unerupted human third molars within one month of extraction. The teeth were stored in isotonic saline containing thymol crystals at 4 °C until used. The teeth selected for study resembled normal maxillary and mandibular molars. Third molars with bizarre shapes were excluded. The roots were removed 2 mm below the cementoenamel junction, using an Isomet saw (Buehler, Ltd, Evanston, IL 60204), and the pulpal soft tissue was removed with cotton forceps, with care taken to avoid crushing predentin or creating a smear layer on the pulpal surface of the coronal dentin. The resulting crown segment was then cemented to a 2 x 2 x 0.7-cm block of Plexiglas, using Zapit-brand (DVA, Anaheim, CA 92808) cyanoacrylate. The Plexiglas was penetrated by an 18-gauge needle, which permitted filling of the pulp chamber with sterile phosphate buffered saline and continuity between the surface of the dentin and a pressurized fluid system (Fig 1) used to measure dentin permeability (Pashley, 1990). Conservative, full crown preparations ending with a chamfer 1.5-2 mm above the cementoenamel junction were prepared with a high-speed handpiece, copious air-water spray, and a medium-grit, bullet diamond bur (Two-stripper, Premier Dental Products, Norristown, PA 19404). The height of the preparation was between 4 and 5 mm from the gingival margin to the occlusal reduction. The preparations were tapered 10-15°. Although most of the occlusal, buccal, and lingual surfaces were covered by a thin veneer of enamel, 10-second staining with 4% erythrosine dye revealed that the mesial and

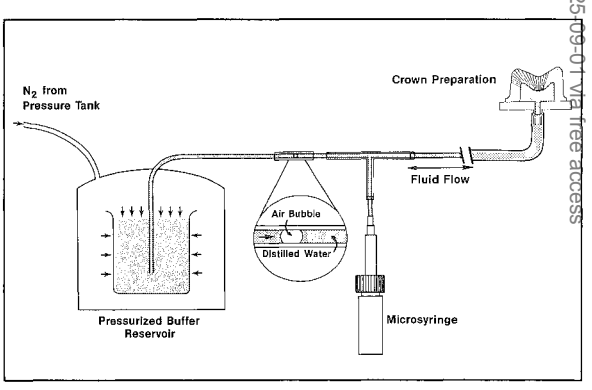

FIG 1. *Schematic of apparatus used to measure dentin permeability. Fluid under pressure passed through a micropipette to the pulp chamber. Movement of the air bubble in the micropipette quantitated fluid filtration across dentin. The microsyringe was used to adjust the position of the air bubble.*

distal approximal surfaces were prepared into dentin, as their surfaces stained pink.

Measurement of Dentin Sealing

The use of the fluid-under-pressure system permitted nondestructive, longitudinal evaluation of a series of dentin bonding agents to seal dentin. The permeability of the exposed dentin was quantitated as a fluid flow rate prior to crown preparation, and immediately following crown preparation. This measurement was repeated after dentin conditioning (if called for in the manufacturer's instructions), after application of the dentin bonding agents and one hour, one day, one week, and one month and after thermocycling (4-56 °C, two-minute dwell-time, 100 cycles).

A second method of measuring the quality of the dentin seal of the dentin bonding agent was to measure the penetration of silver nitrate. The teeth were removed from the Plexiglas blocks penetrated by 18-gauge needles, the pulp chamber dried, and then the crown segments glued to solid Plexiglas, using cyanoacrylate cement to seal the pulp chamber. The samples were then transferred to a solution of freshly prepared 50% w/v (weight per volume) silver nitrate for two hours in the dark. They were then placed in a solution of photographic developer (Dextol, Kodak, Rochester, NY 14650) under flood lights for four hours. All specimens were sectioned mesiodistally through the areas of exposed dentin. Penetration of silver nitrate stain was scored as the area of approximal dentin at risk that was stained relative to the maximum area of exposed dentin on both the mesial and distal surfaces, using a digitizing tablet on photographic enlargements of the sections (Fig 2). The film thickness of the dentin bonding agent was also measured by using a scanning electron microscope at seven different sites on each section (Fig 2a).

Materials Tested

The dentin bonding agents tested are shown in Table 1. All of the systems, with the exception of Prisma Universal Bond 2, utilized a dentin conditioner that removes the smear layer. All of the systems were used according to the manufacturer's directions except the use of Superbond liquid without the powder.

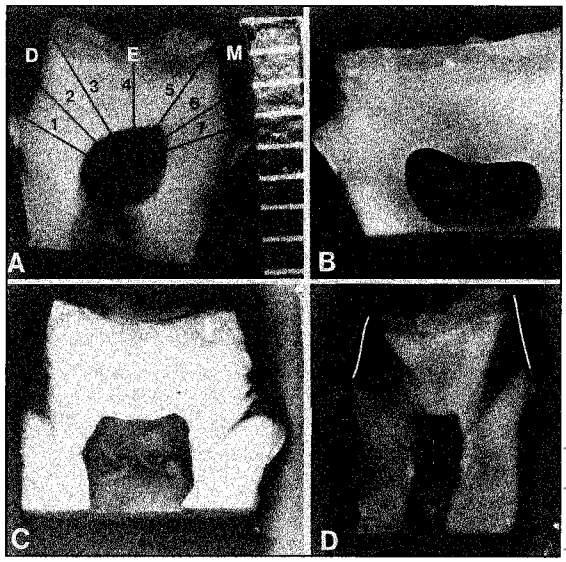

FIG 2. Sections of crown preparations exhibiting varying degrees of silver nitrate penetration. The thickness of the resin treatments was measured at seven sites showing in A. M = mesial, D = distal, E = enamel. The tooth in A showed no microleakage. B was an example of slight leakage. C was an example of moderate microleakage. D was an example of severe microleakage. The integrated areas of microleakage were: A = 0 mm², B = 0.714 mm², C = 1.625 mm², D = 3.029 mm²; expressed as a percent of the approximal dentin at risk, the values were: A = 0%, B = 10.0%, C = 18.8%, D = 35.3%.

Table 1. Dentin Bonding Agents Tested

Name	Manufacturer
Prisma Universal Bond 2	L D Caulk Co, Division of Dentsply International Milford, DE 19963
Scotchbond 2	3M Dental Products St Paul, MN 55144
Superbond C & B*	Sun Medical Co Kyoto, Japan
Amalgambond	Parkell Products Farmingdale, NY 11735
Gluma	Columbus Dental St Louis, MO 63188
Clearfil PhotoBond	Kuraray Co Osaka, Japan

*Superbond C & B includes powdered polymethyl-methacrylate and a 4-META-containing methylmethacrylate resin that is chemically cured with tetrabutylborane. As the use of powder and liquid tends to make a thick covering layer, a second group was used in which only the Superbond liquid was used. The first group was designated Superbond powder + liquid or Superbond P+L. The second group was designated Superbond liquid or Superbond L.

Gluma treatment included EDTA treatment, priming with Gluma, and sealing with light-cured adhesive. When the dentin bonding agents were applied to the crown preparations, the pulpal pressure was zero.

Statistics

The means and standard error of the means for each group were compared within any dentin bonding agent longitudinally, using a one-way analysis of variance. Differences between dentin bonding agents were also examined by ANOVA and ranked, using Duncan's Multiple Range test. Correlations between measuring microleakage using silver nitrate versus fluid filtration were done using regression analysis.

RESULTS

Prior to crown preparation, the apparent permeability of the crown segments covered with enamel was near zero when permeability was measured as a fluid filtration rate (not shown). There were no statistically significant differences between the various groups either before crown preparation or after crown preparation when all samples were covered by a smear layer (not shown).

The changes in the ability of fluid to filter across the dentin of crown preparations over time is shown in Figure 3. The values recorded at P indicate the permeability of the specimens after treatment with primers. All systems except Prisma Universal Bond 2 required the use of dentin primers. This is why the "primed" values (P in Figure 3) were lowest for Prisma ($P < 0.05$) and higher for all other systems. Scotchprep used in the Scotchbond 2 bonding system increased the primed permeability values more than those of Prisma. Gluma used 0.5 M EDTA to remove the smear layer, which resulted in an even higher permeability value. The highest primed (P in Figure 3) permeabilities were measured using Superbond, Amalgambond, or Clearfil Photobond. The primer in Superbond and Amalgambond was 10% citric acid plus 3% ferric chloride (10-3 solution). It increased dentin permeability as much as did the 37% phosphoric acid primer used in Clearfil Photobond.

When the fluid filtration rates were measured one hour after application of the dentin bonding agents to the primed dentin, there was a fall in the permeability of all groups (Fig 3, one hour). When the ability of fluid to filter across the sealed dentin was tested 24 hours later (one day in Fig 3), the lowest permeabilities were seen in the Prisma and Superbond plus powder groups. The next best seals were obtained with Amalgambond, and the worst seals were seen with Gluma and Superbond liquid only (Superbond minus powder). One week later, reevaluation of the groups indicated the same general ranking, except Scotchbond 2 and Clearfil Photobond began permitting more fluid movement. The one-month values (1 m in Fig 3) showed Clearfil Photobond to have the worst seal of dentin, followed by Scotchbond 2, Gluma, Superbond minus powder, and Amalgambond. Prisma Universal Bond 2 and Superbond (powder and liquid) gave the best seals. All groups were then thermocycled and the fluid filtration remeasured (TC in Fig 3). The only changes that were notable were a decrease in the seal of dentin by Gluma and an increase in the dentin seal by Clearfil Photobond.

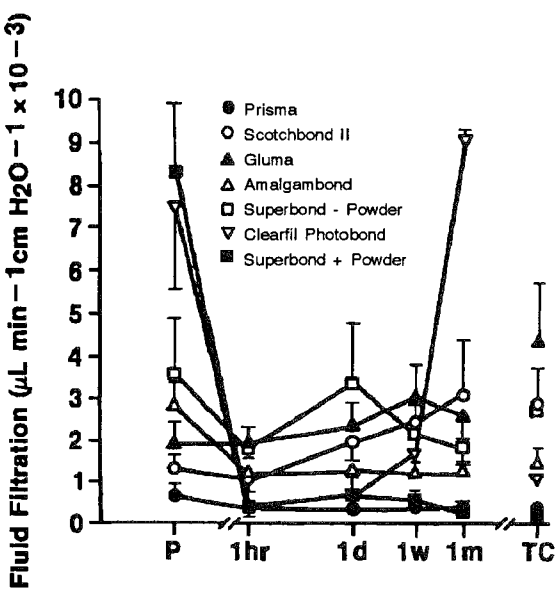

FIG 3. *Changes in microleakage as measured by fluid filtration over time (logarhythmic scale). P = primed values. TC = values obtained after thermocycling. N in all groups was 6 except in Superbond P+L, which was 4.*

Table 2. Comparison of the Sealing Ability of Dentin Bonding Agents Evaluated by Both Silver Nitrate Penetration and Fluid Filtration

Dentin Bonding Agent	% Area of Stain	($\mu L\ min^{-1}\ cm\ H_2O^{-1}$) Posttthermocycling Fluid Filtration
Prisma Universal Bond 2	1.7 ± 0.7 (6)	$3.61 \times 10^{-4} \pm 9.19 \times 10^{-5}$ (6)
Scotchbond 2	16.7 ± 4.8 (6)	$2.86 \times 10^{-3} \pm 8.28 \times 10^{-4}$ (6)
Gluma	24.0 ± 3.1 (6)	$4.30 \times 10^{-3} \pm 1.41 \times 10^{-3}$ (6)
Amalgambond	15.4 ± 3.9 (6)	$1.40 \times 10^{-3} \pm 3.13 \times 10^{-4}$ (5)
Superbond P+L	4.6 ± 1.2 (4)	$1.51 \times 10^{-4} \pm 4.16 \times 10^{-5}$ (4)*
Superbond L	19.1 ± 4.3 (6)	$2.70 \times 10^{-3} \pm 1.37 \times 10^{-3}$ (6)
Clearfil Photobond	14.8 ± 3.0 (6)	$1.12 \times 10^{-3} \pm 3.98 \times 10^{-4}$ (6)

*After sectioning the samples, two of the six had significant amounts of enamel remaining on their approximal surfaces. They were deleted from the group.

Groups connected by vertical lines in the same plane were not statistically different at $P > 0.05$. Groups connected by lines in different vertical planes were significantly different at $P < 0.05$. Groups not connected by vertical lines were statistically significantly different from all other groups at $P < 0.05$.

A second, independent measure of the ability of dentin bonding agents to seal dentin was obtained when the samples were submerged in silver nitrate following thermocycling. After sectioning, photographic enlargements were made to permit quantitation of the degree of penetration of the stain into the mesial and distal approximal areas of exposed dentin using a digitizing tablet. This method expressed the percent of stained area of the approximal dentin relative to the total approximal dentin area at risk. This method of scoring includes both the degree of the surface that stains and the depth of stained dentin. The results are shown in Table 2. The least amount of staining was observed in specimens treated with either Prisma Universal Bond 2 or Superbond powder plus liquid. These materials were significantly better ($P < 0.05$) than Clearfil Photobond, Amalgambond, Scotchbond 2, Superbond liquid or Gluma. None of these latter agents was significantly different from each other.

In order to permit a correlation between the sealing qualities of the dentin bonding agents as measured by fluid filtration and those measured by silver nitrate penetration, the latter values for the mesial and distal dentin surfaces were added together. That permitted the total fluid filtration across the crown to be compared to total silver nitrate penetration across the total dentin at risk in the same samples. Table 2 lists the results of both the silver nitrate penetration and the fluid filtration obtained after thermocycling relative to the values obtained just before application of the dentin bonding agents. The stained area of approximal dentin at risk ranged from as little as 1.7% in samples treated with Prisma Universal Bond 2, to as high as 24% for specimens treated with Gluma. There was no statistical difference between Prisma Universal Bond 2 and Superbond powder plus liquid, but both were significantly different from all other dentin bonding agents ($P < 0.05$). There were no statistically significant differences among the ability of the other dentin bonding agents to restrict silver nitrate penetration. When the posttthermocycled fluid filtration rates of the treated samples were pitted against the

percent of the stained area of dentin, a highly significant linear correlation was obtained (Fig 4, r = 0.5, $P < 0.0004$). Using this independent method of evaluating the sealing ability of dentin bonding agents, the best seal was obtained with Superbond powder plus liquid. This material was also found to be the best using the silver nitrate penetration test. The next best materials were Prisma Universal Bond 2 followed by Clearfil Photobond, Amalgambond, and Superbond liquid. Scotchbond 2 and Gluma provided the worst sealing.

The film thickness of the dentin bonding agents was of concern, but could not be easily measured from X10-20 photographic prints of the sectioned crowns. This required the use of a scanning electron microscope. The film thickness was measured at seven different sites on each specimen (Fig 2a). Positions 1 and 7 represented the dentin at the finish chamfer. Positions 2 and 6 were approximately in the middle of the approximal dentin surfaces. Positions 3 and 5 were at the junction of the approximal dentin and the occlusal enamel, and Position 4 was in the middle of the occlusal enamel. Some dentin bonding agents were not apparent on the dentin surfaces at the various positions and could not be measured. The numbers in parentheses in Table 4 indicate the number of crowns that were measured for that material at each position. Generally, the dentin bonding agent accumulated at the chamfers (Positions 1 and 7) and on the occlusal enamel

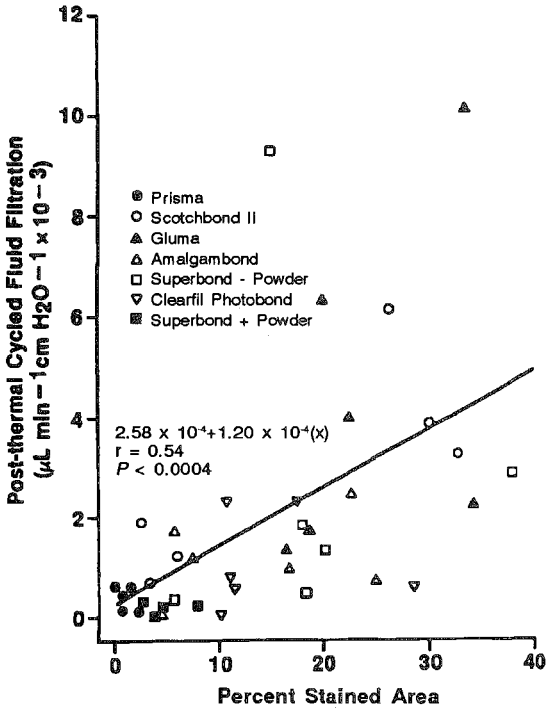

FIG 4. *Correlation between the fluid filtration rates of samples (postthermocycled) and the subsequently measured silver nitrate penetration*

(Position 4). The thickest resin veneers were obtained with Superbond powder plus liquid (Table 3), followed by Scotchbond 2 and Prisma Universal Bond 2, Amalgambond, Clearfil Photobond, Superbond liquid, and Gluma.

Table 3. Summary Statistics for Resin Thickness ($\bar{x}$ ± SEM, N μm) in the Designated Positions Shown in Figure 2a

Product	1	2	3	4	5	6	7
Prisma Universal Bond 2	227 ± 39 (6)	65 ± 24 (3)	106 ± 56 (3)	244 ± 78 (5)	28 (1)	78 ± 17 (3)	143 ± 45 (5)
Scotchbond 2	263 ± 70 (5)	115 ± 52 (4)	33 ± 3 (4)	345 ± 56 (6)	76 ± 20 (2)	114 ± 72 (3)	276 ± 44 (5)
Gluma	63 (1)	26 ± 5 (3)	29 ± 8 (3)	277 ± 52 (6)	34 ± 6 (2)	0	28 (1)
Amalgambond	94 ± 28 (5)	32 ± 18 (3)	20 ± 4 (5)	108 ± 44 (5)	46 ± 15 (5)	81 ± 44 (5)	20 ± 30 (5)
Superbond P+L	355 ± 54 (5)	164 ± 52 (5)	66 ± 23 (5)	212 ± 48 (5)	138 ± 24 (5)	171 ± 34 (5)	340 ± 86 (5)
Superbond L	24 ± 5 (3)	37 ± 7 (3)	36 ± 13 (3)	23 ± 3 (4)	29 ± 20 (3)	14 ± 5 (4)	26 ± 8 (3)
Clearfil Photobond	77 ± 8 (6)	19 ± 4 (2)	37 (1)	111 ± 32 (6)	13 ± 11 (2)	13 ± 5 (3)	80 ± 12 (6)

Data connected by the same horizontal line are not statistically different at $P > 0.05$.

DISCUSSION

The use of adhesive resins to seal the dentin of crown preparations may provide a measure of protection to the pulp by preventing the penetration of bacterial products that may be shed from plaque microorganisms that colonize prepared dentin surfaces under leaking provisional crowns. For such resins to be effective, they must seal the dentin well, not only initially, but over time. The use of fluid under pressure to measure the sealing quality of these dentin bonding agents longitudinally, in a nondestructive manner, permitted us to evaluate these products in a reasonably realistic in vitro model. The fact that most of the dentin bonding agents did not change their sealing properties from one hour through the first month of remeasurements was an important result. Thermocycling was added as an additional stress, but did not change the sealing properties of any of the dentin bonding agents (Table 2). Previous reports in the literature found a lack of thermocycling effect on the leakage around cemented castings (Kawamura & others, 1983; Tjan & others, 1980; Goldman & others, 1991).

As the fluid-under-pressure system is a relatively new technique (Derkson, Pashley & Derkson, 1986; Pashley & Depew, 1986), it has not yet been compared to more traditional methods for measuring microleakage, such as silver nitrate penetration. The significant correlations between measurements of dentin sealing by fluid filtration and by silver nitrate penetration (Fig 3) was encouraging. Both systems identified the same dentin bonding agent as being superior to other dentin bonding agents. One of the best dentin sealing agents was Superbond powder plus liquid. This was clearly superior to Superbond liquid only. Several reasons can be advanced for the differences observed between the two uses of the same dentin bonding agent. When powdered polymethylmethacrylate was used, the film thickness was much greater (Table 3). One might argue that the use of Superbond liquid without the powder may have produced a film thickness that was so thin that the oxygen in air would inhibit its polymerization. This might be expected to occur at film thicknesses of 20-40 μm (Erickson, 1989; Rueggeberg & Margeson, 1990), values that were reached in some areas with some dentin bonding agents (Table 3). No attempt was made to exclude air, using gels. Due to the effects of gravity and the relatively low viscosity of the dentin bonding agents, the material pooled at the chamfers and on the occlusal enamel (Table 3). Had chamfers not been used, it is likely that the resin thickness in these regions would have been thinner.

The intimate relationship between dentin and enamel at the dentinoenamel junction provides an outstanding seal that is unlikely to be exceeded by any adhesive resin. Thus it is desirable to retain as much enamel covering, however thin, over as much dentin as possible in crown preparations.

CONCLUSIONS

While the data would suggest that some dentin bonding agents such as Prisma Universal Bond 2 or Superbond might be useful in sealing the exposed dentin in crown preparations, much more research is required before such procedures are attempted clinically. The smooth resin surfaces provide little opportunity for chemical bonding that may take place between glass-ionomer or polycarboxylate cements and dentin or for mechanical retention (i e, zinc phosphate cements). The use of resin cements that bond to both the dentin bonding agents and to metals may pull resin veneers from dentin during polymerization of luting resin cements. How well the resin veneers maintain dentin seals over a period of years remains to be determined. Thus there are a number of significant problems that would accompany the procedure of sealing the dentin of crown preparations with these agents. Only future research will determine whether this method will be of any practical clinical value.

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Leakage Patterns Associated with Glass-Ionomer-based Resin Restorations

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E L DAVIS • X Y YU • K CLEARY

Summary

This study compared microleakage patterns for glass-ionomer-cement-based resin systems with and without a separating agent placed between the glass ionomer and resin. Results indicated significant leakage (100%) at the dentin glass-ionomer interface for specimens without a separating agent. Those with a separating agent showed almost no leakage between the dentin and glass ionomer (10%) and some leakage at the resin/glass ionomer interface (40%). These results suggest that the forces of polymerization shrinkage are stronger than the chemical bond between glass-ionomer cement and dentin. This bond fails during resin polymerization, eliminating any supplementary retention gained through chemical adhesion to dentin and opening a pathway for microleakage.

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Introduction

Glass-ionomer cements have a number of unique properties that make their use advantageous in dentistry. When used as restorative materials, their available fluoride content can increase the caries resistance of surrounding tooth structure (Forsten, 1977). They are also among the few restorative materials that bond chemically to both enamel and dentin (Kent, Lewis & Wilson, 1973; Wilson & Kent, 1972). Because composite resin can be mechanically attached to them, they provide an additional means of restoration retention.

Microleakage studies (García-Godoy & Malone, 1988; Gordon & others, 1985) have

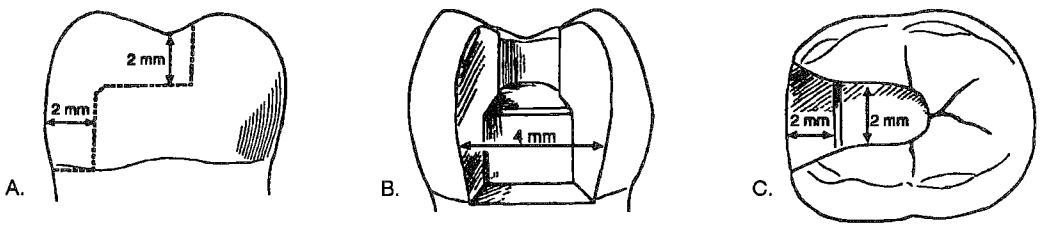

FIG 1. *Standard preparation: A, cross-sectional view; B, approximal view; C, occlusal view*

shown dye penetration at the interface between the glass-ionomer cement base and tooth structure when used in conjunction with a composite resin. Because chemical bonding between the glass-ionomer cement and tooth structure should produce an impervious interfacial seal, this observed leakage may have been due to a dissociation of glass-ionomer cement from tooth structure as a result of shrinkage of the setting composite resin restorative material. If this were the case, the potential to supplement or replace traditional cavity retentive features would be lost.

The purpose of this study was to evaluate the effect of resin polymerization shrinkage on the chemical bond of glass-ionomer cement to tooth structure.

Methods and Materials

Forty freshly extracted third molars were collected in a solution of Dulbacco's phosphate buffered saline (Gibco Laboratories, Grand Island, NY 14072) containing an antibiotic-antimycotic agent (10 000 units/ml penicillin G sodium, 10 000 micrograms/ml streptomycin sulfate, 25 micrograms/ml amphotericin B). Teeth were stored no more than 60 days before being scaled, cleaned, and placed in deionized water. Only those teeth that were free of defects and/or had minimal occlusal restorations were retained.

Specimens were prepared with class 2 cavity preparations (Fig 1). Facial and lingual walls were extended to establish an approximal width of approximately 4 mm. Gingival margins were placed in cementum just below the approximal cementoenamel junction. The occlusal segment was extended to include the central pit, at a depth and width of 2 mm. The axial wall was prepared parallel to the long axis of the tooth at a depth of 2 mm at the contact point, and a pulpoaxial bevel was placed. The facial and lingual walls were prepared at a 90° cavosurface angle. The internal form of the box portion was slightly rounded.

Manufacturers' instructions were followed for the mixing and placement of all materials used in this study. Materials were mixed in amounts appropriate for their use in a clinical situation.

The internal portion of the completed cavity preparation was cleaned thoroughly with a 40% solution of polyacrylic acid (liquid portion of Durelon cement, ESPE/Premier, Norristown, PA 19404) to remove the smear layer (Powis & others, 1982). This was left in place for 60 seconds and removed with an air/water spray applied for 60 seconds. The mixing and placement of glass-ionomer cement was done in a controlled-environment room because of its sensitivity to environmental conditions. The temperature was maintained at 27 °C (±2°), with a relative humidity of 50% (±10%). Preparations were rinsed and dried and a layer of glass-ionomer cement was placed. Half of the teeth received Ketac-Bond glass-ionomer cement (ESPE/Premier), and the remaining teeth received G-C Lining Cement (G-C International, Scottsdale, AZ 85206).

Specimens in each glass-ionomer cement group were further divided into two groups of 10 specimens each. One group was designated to receive a separating agent applied to the surface of the set glass-ionomer cement. A pilot study determined copal varnish to be an effective agent for preventing bond formation between the glass-ionomer cement and composite resin restorative system. Following placement of two layers of copal varnish to the surface of the glass-ionomer cement only, the prepared enamel surface was acid-etched for 30 seconds, followed by an air/water rinse. The other group of specimens received no separating agent. For this group, both the glass-ionomer cement and

enamel were acid-etched for 30 seconds.

All specimens were restored with P-50 posterior composite resin (3M Dental Products, St Paul, MN 55144). The resin was placed with an incremental technique described elsewhere (Wieczkowski & others, 1988).

Specimens were taken to a smooth, well-polished finish with the Sof-Lex finishing system (3M Dental Products), then stored for a minimum of 72 hours at 37 °C and 100% humidity. They were then subjected to 300 cycles of thermal stress. A complete cycle lasted one minute and consisted of 15 seconds each at 37 °C, 55 °C, 37 °C, and 4 °C.

Specimens were prepared for staining by first applying two coats of nail polish to within 1 mm of the restoration margins. This limited dye contact to the area of study. Specimens were placed in either a 2% solution of fuchsin or a 5% solution of methylene blue for 24 hours prior to evaluation of marginal leakage.

Following staining, specimens were rinsed and embedded in self-cured resin. They were then sectioned mesiodistally through the approximal box portion of the restoration at 0.75-mm intervals with a low-speed diamond saw (Buehler Ltd, Evanston, IL 60204). Leakage sites (dentin/glass-ionomer cement, glass-ionomer cement/resin) were determined under a microscope immediately after sectioning. Leakage was determined to have occurred if there was dye present between any of the components of the dentin/restoration interface. One investigator examined all specimens.

Results

Because the pattern of microleakage was the same for both glass ionomers used, results were collapsed across glass-ionomer cement groups. A chi-square analysis revealed a significant relationship between separating agent and leakage pattern ($X^2 = 32.73$, $P < 0.01$). As can be seen in the table, specimens with no separating agent showed microleakage between the dentin and glass-ionomer cement (Fig 2). Specimens with the separating agent showed some microleakage between the resin and the glass-ionomer cement (40%), but almost no leakage between glass-ionomer cement and dentin (10%) (Fig 3). Half the specimens with separating agent showed no leakage at all.

Frequency of Leakage Patterns for Glass-Ionomer-based Restorations Used with and without a Separating Agent

		LEAKAGE		
		None	Glass-Ionomer Cement/Dentin	Resin/Glass-Ionomer Cement
Separating Agent	Yes	10	2	8
	No	0	20	0

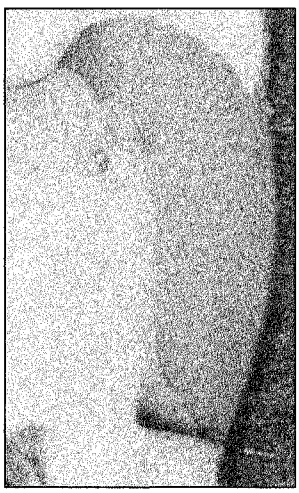

FIG 2. *Specimen section with no separating agent, showing microleakage at the dentin/glass ionomer interface (X2)*

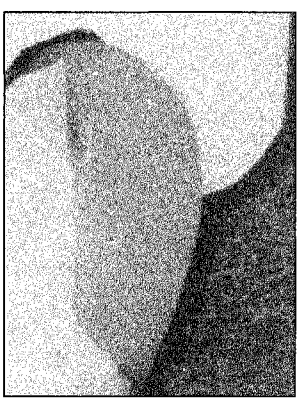

FIG 3. *Specimen section with separating agent, showing some microleakage at the glass ionomer/resin interface*

Discussion

Although the exact bonding mechanism between glass-ionomer cement and dentin is still uncertain, it is believed to be achieved by polar and ionic attraction (Beech, 1973). Polyacrylate ions have been shown to react with the apatite structure, displacing calcium and phosphate ions (Wilson, Prosser & Powis, 1983). In theory, a strong bond between glass ionomer and dentin would prevent microleakage.

In the present study, specimens with no separating agent between the glass-ionomer cement and composite resin showed microleakage at the dentin/glass-ionomer cement interface. Specimens with copal varnish between the glass-ionomer cement and composite resin showed almost no leakage (10%) between the glass-ionomer cement and dentin, and some leakage (40%) between the glass-ionomer cement and resin. The separating agent served to prevent attachment between the glass-ionomer cement and composite resin. These results indicate that when the mechanical bond between composite resin and glass-ionomer cement is prevented, there is no separation of the glass-ionomer cement from the dentin, and thus no microleakage at the glass-ionomer cement/dentin junction. When glass-ionomer cement is allowed to bond to resin, it appears that polymerization shrinkage of the setting resin causes debonding at the glass-ionomer cement/dentin interface. Percent volumetric shrinkage for P-50 is between 2.5% and 2.6% (personal communcation, 3M Dental Products, 23 May 1991). García-Godoy (1988) reported that the bond between resin and glass-ionomer cement reduces the free surface of the resin mass and that, without other mechanisms to compensate for the volume reduction induced by the polymerization shrinkage, contraction stresses are created at the tooth-restoration interface. The results of the present study indicate that the forces generated by polymerization shrinkage of the composite resin exceed the bond strength of glass-ionomer cement to dentin.

The bond strength of glass-ionomer cement to dentin has been reported to be between 30 and 100 kg/cm^2 (Davis & others, 1989; McCaghren & others, 1990). It is not clear how much force is generated on the glass-ionomer cement/dentin interface from composite resin shrinkage. However, one study (Davidson, deGee & Feilzer, 1984) reported polymerization shrinkage forces to be about 300 kg/cm^2. It is therefore likely that the glass-ionomer cement/dentin bond is not strong enough to resist these shrinkage forces.

These results raise serious questions about the ability of glass-ionomer cements to provide or supplement retention when used as bases under composite resin restorations. Further study is needed to develop a clinically acceptable technique that will either prevent dissociation of the glass-ionomer cement base from dentin during the polymerization of the composite resin or seal the gaps after polymerization is completed. One method that shows some clinical promise is marginal sealing of the gaps using an unfilled, low-viscosity resin (Kemp-Scholte & Davidson, 1988).

Conclusions

Data presented in this study indicate that glass ionomers may not have sufficient adhesion to the tooth structure to retain composite resin restorations. Further studies are indicated.

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CLINICAL PRACTICE

Rubber Dam with Washed Field Evacuation: A New Approach

R C RUÍZ BENAVIDES • H M VÁSQUEZ HERRERA

Introduction

Preparation of teeth and operating in a dry field is most important in the practice of pediatric dentistry. In 1864 in New York Stanford Barnum presented the rubber dam as a solution to this problem. Later, with the coming of new materials, it was possible to completely isolate the area with the use of a rubber dam, as we do today. The rubber dam, with its multiple advantages, permitted a better way of doing dentistry. Underneath the rubber dam the standard saliva ejector serves the purpose of removing fluids from the floor of the mouth. However, in the actual field of operation (Fig 1), washed field cutting requires the use of a dental assistant, using either a suction tip or high-velocity evacuation.

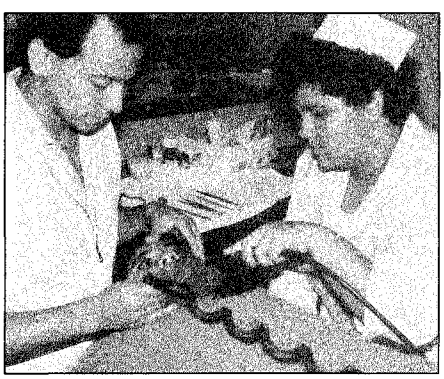

FIG 1. *Conventional system of fluid removal during washed field cavity preparation*

Children's Hospital, Department of Pediatric Dentistry, Ciudad Victoria, Tamaulipas, Mexico

Raúl Carlos Ruíz Benavides, DDS, chief

Hector Manuel Vásquez Herrera, DDS, second-year resident

The objective of this article is to demonstrate a technique of continuous aspiration of the operative field by use of multi-perforated suction tips, leaving the assistant free to do other tasks.

Technique

This technique was designed and has been used for over six years in the Pediatric Dentistry Department of the Children's Hospital in Tamaulipas, Mexico.

Two unique items are used in the rubber dam set-up: a plastic Y-type connector (available from Dental Components, Box 228, Newberg, OR 97132) and two plastic tubes of the sort used in pediatric feeding (neonatal feeding tubes, #8 FRENCH size, available from hospital supply rooms).

The feeding tubes (Fig 2) have perforations at the ends to facilitate passage of liquid into the baby's stomach. After the feeding tubes have been cut to a length of 20 cm, several holes are made in the terminal inch of the tubing with a rubber dam punch. As the holes are punched, the tube is rotated and care is taken to remove the punched-out material so that it does not remain to clog the tube (Fig 3). The other ends are attached to the Y connector, and this in turn is attached to the aspirator hose (Fig 4).

After the rubber dam is properly placed, the suction tips are passed behind the Young's rubber dam frame and underneath the wings of the rubber dam clamp. It is suggested that two tips be used for the mandibular arch, and one tip for the maxillary arch (Figs 5-7). Suction tips are held in place with the wings of the rubber dam clamps, and in the case where there are none, the bow of the clamp is used (Figs 7-8). The suction is turned on and the operative procedure is ready to begin.

To test the maximum capacity of aspiration and the effectiveness of the technique, multiple tests were performed by measuring and comparing the amount of water coming from the water syringe to the aspiration capacity of the system. It was found that the average volume of water leaving the syringe was 54 ml per minute, while the average capacity for aspiration was 89 ml per minute. This gives an ample margin of safety for any washed field procedure.

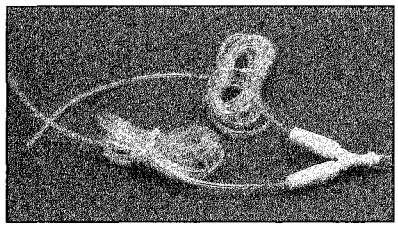

FIG 2. *Armamentarium for tubal evacuation. Neonatal feeding tubes are cut to length and incorporated into the saliva ejector.*

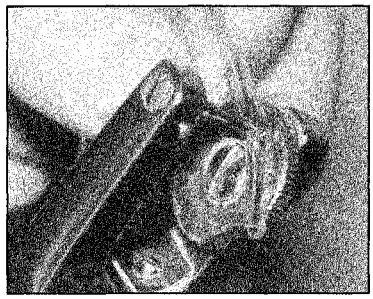

FIG 3. *Punching holes in the tubing to increase aspiration capacity*

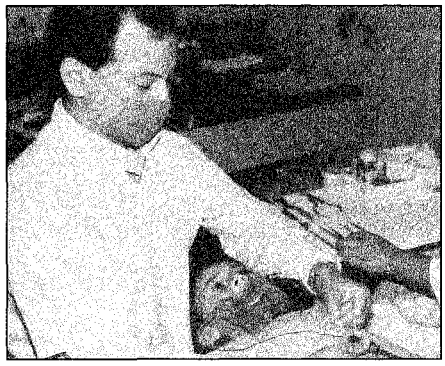

FIG 4. *Attaching the assembly to the saliva ejector*

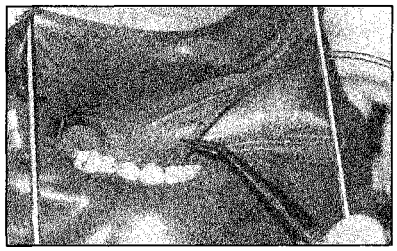

FIG 5. *Passing the tube behind the Young's rubber dam frame*

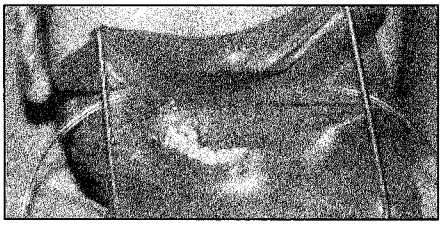

FIG 6. *Using the wings of the rubber dam clamp to stabilize and secure the tubing*

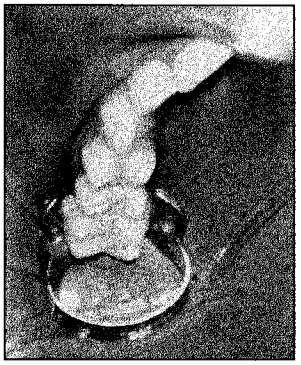

FIG 7. *Maxillary stability of tube is obtained by the bow of the clamp*

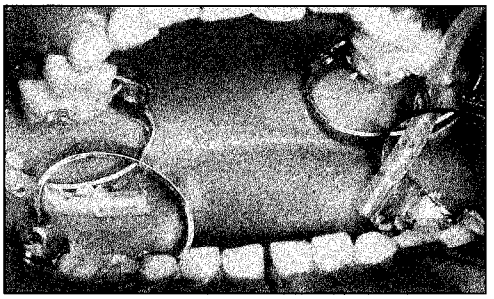

FIG 8. *Multiple tooth exposure with bilateral tubing evacuation*

FIG 9. *Operating posture for convenience. Note the independence of the operator who can function without the dental assistant to evacuate fluid*

FIG 10. *Close-up view of washed field evacuation*

Conclusions

After the utilization of this system for six years in the Pediatric Clinic of the Children's Hospital in Tamaulipas, greater chairside efficiency has been observed because our assistant is free to prepare instruments and medicaments, instead of holding the suction tip (Figs 9-10).

The advantages that were observed were:

1. Reduced work time;
2. Increased productivity;
3. Increased visibility;
4. Increased quality of work;
5. Patient comfort;
6. No need for assistant to control suction;
7. Low cost;
8. The equipment is reusable;
9. Comfort of the dentist; and
10. The system can be used with general anesthesia.

Low cost and the possibility of sterilization for reuse are features that are appreciated in depressed economic areas such as Mexico. In other places the dentist may choose to simply discard the tubes and use new ones with each patient.

Acknowledgments

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POINT OF VIEW

Retention Grooves for the Class 2 Amalgam Restoration: Necessity or Hazard?

DAVID L MOORE

Introduction

Is the placement of approximal retention grooves in class 2 amalgam preparations an asset or a liability? This question has stirred controversy through the years, and remains controversial.

Current operative textbooks indicate that approximal retention grooves function to help retain the restoration, reduce stress at the isthmus, and help to prevent fracture of the alloy. There is laboratory evidence that approximal retention grooves increase the fracture strength of conventional low-copper alloys. At least one laboratory study confirmed this positive influence when a high-copper alloy was used. However, clinical studies do not support the need for retention grooves either with conventional or high-copper alloys. Therefore, the clinical significance of the results obtained in the laboratory is questionable.

In some but not all dental schools, students are required to place approximal retention grooves in class 2 amalgam preparations routinely. The margin of error is quite small when placing retention grooves. Enamel can needlessly be undermined or the pulp encroached upon. Indeed, accidental pulp exposures become a hazard, especially in the teaching-learning environment.

Retention grooves are included in the criteria of some state and regional board examinations for evaluating a candidate's ability to place amalgam restorations of high quality. After graduation and board examinations, some dentists adopt a philosophy that does not include the routine placement of retention grooves.

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Review of the Literature

G V Black's class 2 amalgam preparations had no retention grooves. His text (Black, 1936) described the mortise (box) form and emphasized "squaring out the line angles about the pulpal and gingival walls." In a later edition revised by Blackwell (1955), the text states, "All these line angles may be definitely squared out, or slightly undercut when desired, with margin trimmers."

Bronner (1930) applied "engineering principles" to the class 2 preparation and recommended a truncated cone shape of the preparation and an inner incline of the gingival wall to prevent tipping of the restoration. Retention grooves were not included in the design.

The McGehee (1930) *Textbook of Operative Dentistry* described a "new" form for the class 2 cavity preparation. He too recommended the truncated cone shape where the buccal and lingual walls converged gingivo-occlusally. In addition, he described an added form of approximal retention: "In the new form, that portion of the buccal and lingual dentinal wall in proximity to the axial wall lying near the region of the pulp horns and recessional lines converges gingivo-occlusally even more than the buccal and lingual margins: In the old form, the buccal and lingual walls are parallel."

The Davis (1945) *Textbook of Operative Dentistry* declares retention grooves obsolete. The text states: "Much of the retention form required is gained by laying the external surrounding walls at an angle slightly acute to the seat of the cavity. This has been termed undercutting, but the term is abandoned for fear that some might confuse the method above referred to with a now entirely obsolete practice of creating retention by the use of pits and grooves laid in the dentin walls."

Later textbooks (McGehee, True & Inskipp, 1956; Simon, 1956) described placing approximal retention with an inverted cone or fissure bur, then sharpening the angle with a gingival margin trimmer.

Textbooks currently used in dental schools continue to recommend retention grooves (Gilmore & others, 1977; Baum, Phillips & Lund, 1981; Marzouk, Simonton & Gross, 1985; Sturdevant, 1984; Charbeneau, 1988). These texts describe the truncated box form of the class 2 cavity preparation with more rounded internal angles and generally a more rounded form of approximal retention grooves.

One textbook (Baum, Phillips & Lund, 1981) shows an illustration with the following legends: "(A) Small cavity with minimal extension (no axial groove required)." "(B) Cavity begins to wrap around the tooth. Proximal retentive grooves indicated to lock the restoration into position to prevent lateral dislodgement." However, in this textbook several other illustrations of the conventional class 2 preparation show the presence of approximal retention grooves.

Another textbook (Charbeneau, 1988) states: "Although the necessity of proximal retention grooves has been questioned, it appears most reasonable to include this concept in cavity design."

Still another textbook (Sturdevant, 1984) cites references to support the use of approximal retention grooves. The text states: "Mondelli and others have demonstrated that proximal retention grooves ... significantly strengthen the isthmus of a Class II restoration." Mondelli and others (1974) in their laboratory study used a conventional low-copper alloy with a high creep value. The approximal retention grooves were shown to increase the fracture strength of the alloy.

The Sturdevant textbook further states: "To ensure retention form of the proximal portion, locks are provided to resist proximal displacement of the restoration." The reference cited is Crockett and others (1975). This laboratory investigation also used a conventional low-copper alloy. No significant difference was reported for vertical forces applied to restorations with or without retention grooves. A significant difference was reported for horizontal forces. These forces were applied by a plunger through the tooth against the inside of the axial wall of the restoration. The experimental design makes the results questionable as to clinical significance.

The same textbook continues, "Galan, Phillips and Swartz, and Terkla, Mahler and Van Eysden have shown that mesio-occlusodistal deformation and the extent of proximal extrusion... are related to creep values of the amalgam alloys." Galan, Phillips and Swartz (1973) compared high- and low-copper alloys in the laboratory and concluded that the alloy system played a far greater role in mesiodistal deformation than did retention

grooves. Terkla, Mahler and Van Eysden (1973) conducted a clinical study of 422 amalgam restorations on molar and premolar teeth. Both narrow and wide preparations were included. An approximately equal number of restorations were placed with and without retention grooves. Both high- and low-copper alloys were used, alloys with different creep characteristics. Interproximal retention grooves did not influence the extent of interproximal extrusion. After three years no bulk fractures were observed, regardless of the presence or absence of retention grooves. Differences in tooth type, restoration width, or amalgam alloy failed to demonstrate any influence on this result.

Terkla and Mahler (1967), in an earlier study, reported that in the laboratory restorations with approximal retention grooves demonstrated the highest resistance to bulk fracture when compared to restorations without approximal retention grooves. However, in the same study, it was reported that the clinical investigation of 89 restorations without retention grooves and 47 restorations with retention grooves failed to demonstrate any difference with regard to bulk fracture. A low-copper alloy was used in the study.

Amorim and others (1978), in a laboratory study using a low-copper alloy, reported that approximal retention grooves increased the strength of class 2 amalgam restorations.

Sturdevant and others (1987) in a laboratory study using alloys of different tensile and compressive strengths, determined that approximal retention grooves did not have a significant effect on failure load. However, the absence of retention grooves did increase the number of failures that occurred by displacement.

In a later clinical study, Sturdevant and others (1988) concluded that full-length retention grooves should be used with a box preparation without occlusal extension. However, in 50 conventional class 2 preparations without retention grooves, there were no failures after one year.

Caplan, Denehy and Reinhardt (1990), in a laboratory study using a high-copper spherical alloy, reported that the compressive strength of amalgam restorations was increased almost 40% by the incorporation of approximal retention grooves. It was also reported that the compressive strength of the restoration was proportional to the depth of the axial wall at the gingival floor. The axial wall depth used in this study was 1.5 mm. The depth of the pulpal floor was also 1.5 mm. This represents a minimal pulpal floor depth. Operative texts recommend pulpal floor depths of 1.5-2 mm. The texts also recommend extending the depth to 0.2-0.5 mm pulpal to the dentinoenamel junction. When this is done, the depth of the pulpal floor often exceeds 2 mm, since the mean thickness of enamel occlusally is 2-2.5 mm (Jokstad, 1989). The pulpal floor depth as well as the axial wall depth may influence the strength of the restoration at the isthmus.

Gilmore (1971) emphasized the importance of the depth of the preparation. He recommended a narrow isthmus, rounded internal angles, and cavity walls at right angles to each other. Although he recommended "interproximal locks" as being desirable for reducing stress at the isthmus, he also stated: "it is recognized that depth is the only critical extension necessary to prevent fracture of the alloy."

Rodda (1972) recommended a "modern" class 2 preparation with a narrow isthmus and rounded internal angles with no approximal retention grooves.

Lemmens and others (1987; 1988) and Letzel and others (1989) conducted controlled clinical investigations on amalgam restorations. The presence or absence of retention grooves in the preparations was not stated. However, the investigations revealed a number of influences on the bulk fracture of amalgam restorations. The amalgam alloy had a statistically significant influence on the incidence of bulk fracture; high-copper alloys had a higher survival rate. Mechanical condensation did not improve the survival rate. Restorations in mandibular teeth were more susceptible to bulk fracture than those in maxillary teeth. Restorations in molars were more susceptible to fracture than those in premolars. The operator had a statistically significant influence on the incidence of bulk fracture.

Nadal, Phillips and Swartz (1961), in a clinical study of the effects of residual mercury, reported only seven isthmus fractures of 257 amalgam restorations. They attributed all of the fractures to severe traumatic occlusion. Four fractures occurred during the first 24 hours, and one at five days. The other two

fractures were observed after nine months and one year. In all instances of fracture, a sharp, elongated opposing cusp and a shiny facet on the restoration were observed. Occlusal prematurities on the amalgam restoration undoubtedly have a major role in the instigation and propagation of fractures.

Conclusion

Dental faculty must resist relying heavily on theoretical considerations, even though they may seem most reasonable. Careful evaluation of the available research must be made, with particular emphasis given to the clinical studies which apply to in vitro research. Clinical studies thus far have not confirmed the need for approximal retention grooves.

From the standpoint of cavity preparation, according to the available evidence, it seems that the early recommendations of Black, Bronner, and Davis provide the most conservative approach to resistance and retention, e g, resistance and retention can best be achieved by providing a box or truncated cone preparation of adequate depth. Approximal retention grooves may be considered as accessory retention. For the conservative box preparation with no occlusal extension, retention grooves may be indicated. Accessory retention in the form of grooves, slots, post holes, or pins may be required for large restorations restoring cusps. However, the routine placement of approximal retention grooves in class 2 amalgam preparations may be considered an unnecessary hazard.

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DEPARTMENTS

Letters

ARE CLINICAL STATE BOARD EXAMINATIONS ARCHAIC?

The question as to whether state dental board examinations are archaic was recently brought to the fore by the editor of the *Operative Dentistry* journal. This editorial raises many interesting points. As I was reading through the article, I have to admit that I was agreeing with most everything that was being stated, i e, the fact that state boards did have their place when dentistry was more of a craft than a profession and the possible harm done to patients during board examinations. However, continuing to read, I began to have that feeling in the pit of my stomach (the one I get when I realize that someone is trying to justify the existence of state dental board exams).

As a practicing surgeon, my brother finds it very amusing when I tell him about all the hoops we dentists must go through to become licensed in various states. True, physicians must pass some type of exam in a few states to become licensed. However, do the board examiners in those states require the surgeon to perform an appendectomy on someone to grant the license? Do we dentists actually perform operations on patients that are more critical to their health than do surgeons or other medical specialties? If the answer to this is that surgeons require additional training after graduation from medical school which makes them better qualified, then maybe dentists, too, should be required to train in some sort of residency.

I also find interesting in the editorial the quote, "Ask senior members of the Armed Forces if all schools are equal (in this regard), and you will typically find their response to be negative." Were these results obtained from a controlled study, or more from "talk around the coffee pot"? As a member of the Air Force Dental Service for over 10 years, I can say with all honesty that (1) it doesn't matter from which dental school a dental officer graduated; some were good and some were not so good (not very scientific!), and (2) perhaps not all of the senior members of the military dental service are in tune with modern dental practice as many of them spend more time with administrative functions than the actual practice of dentistry.

It is unfortunate that today in our mobile society some states are missing out on the services of some fine, highly educated, and trained dentists because of the expense and inconvenience of having to take a clinical board to become licensed. Indeed, I am sure that state boards have protected the public from some incompetent dentists, but how have the states benefited from losing qualified practitioners who through spousal job transfers are forced to refrain from practice until such time that they can financially and feasibly take the state examination? Taking the examination not only requires a financial outlay for the actual examination but also for miscellaneous costs. The examination cannot be taken without patients, and a dentist new to an area does not have the patient access that a local dentist would have. Does this restriction of trade really protect the public? It was stated in the editorial that "..almost all candidates who fail to pass the examination the first time will pass on a later retake." This is primarily due to politics and economics.

I sincerely hope that the overwhelming reason for a state board is not economics. But am I really being naive when I look at some of the states that have their own state board exams? Would the states of California, Florida, and Texas, to name a few, really feel threatened by the sudden influx of dentists if they were to discontinue their state boards? Believe it or not, not everyone wants to live in these states (even though they would like you to believe it!). What would it hurt anyway if everyone moved to these states? The public

would most likely fare better with more choice as to which dentist to visit. Let free market economics do what it's supposed to do.

There are obviously no easy answers to this troubling situation. I feel that dental school faculty need to be more involved in the decision about who graduates and who doesn't. Most, if not all, dental schools should be able to graduate dentists with minimal basic skills. This is supposedly what accreditation means. Maybe there should be mandatory postgraduate training with mandatory "real" continuing education. With the money saved from eliminating the state boards, maybe these funds could be better used to monitor more important things. Is a dentist who passed a state board exam in 1950 really more qualified to practice modern dentistry than an "out-of-stater" who just happens to have some bad luck on one particular day? Unfortunately it probably all goes back to economics. That's too bad for the dental profession, isn't it?

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RESPONSE

Dr Boyarsky's comments are very interesting and certainly understandable. In the first paragraph of his response he indicates that I caused him to have a uneasy feeling because as he read on he felt that I was trying to justify state dental board exams. I was not specifically supporting either state or regional examinations. My intent was to point out that there certainly needs to be some accreditation agency, either state, regional or national that can attest to the ability of individuals to deliver quality (*not minimally competent*) dental care. I will be the first to admit that there is much wrong with the present system of state and regional board examinations. However, my point was that we must keep it in place until something better comes along. Better some of the pie than none.

Dr Boyarsky's point of comparing dentistry and its method of granting licenses to that of medicine may be well intended, but that is like comparing apples to oranges. Medical students are not licensed to practice medicine without residency training in a specialty area. Quite different from dentistry. Physicians do not and cannot practice medicine in a solo practice without anyone observing their performance. Physicians, although in a closed society which tends to defend itself, are continually observed and viewed in the practice of their profession by their colleagues. This is not the case in dentistry, where practicing dentists can hide out for years and the only review of their care may be the dental insurance companies (and I do not feel they are competent judges, either). We should stop trying to compare our profession to that of the MD and look at dentistry as a profession that is, of all the healing art professions, the most dependent upon the practicing dentist's skills.

As stated, I do not feel dental school faculty should determine who is to be licensed. Many in academia agree with Dr Boyarsky that they should be. I cannot! I live with it on day-to-day basis. The accreditation process for dental schools does not evaluate the graduates' ability but the school's administrative performance. Dental schools are unequal in the product they produce. I should have been more specific in my statement: "Ask any senior member of the Armed Forces if all schools are equal in this regard, and you will typically find the answer to be negative." When I was referring to senior people, I was referring to those in academics within the Armed Forces, something which I have some direct knowledge of, having spent more than half of my career in the Air Force, involved with graduate dental education. And not as an observer, I might emphasize.

The real issue dealing with mobility is: Should parts of the country or states that hold to a different standard than "minimal competency" have the right to insist that all dentists wanting to practice in those locales need to have achieved an education which makes them competent to practice? Who reading this wants to go to a minimally competent dentist?

I certainly do not. Of course I recognize that many, many excellent general dentists or specialists are denied the ability of free movement. I also agree that it is unfair, but am unwilling to accept the alternatives at this time.

From my personal perspective, I feel that most examining agencies do little if any good and many cause more problems for the public than they solve. However, as a retired military officer and department chairman of Restorative Dentistry at a major university, I do not want these examinations abolished unless replaced by something better. Doing so would allow dental schools to deteriorate rapidly by letting them do their own thing. Schools would give up much of their teaching time now devoted to clinical skills to promote research and other impractical topics for the education of the practicing dentist. We cannot allow this to happen.

DAVID J BALES, DDS, MSD
Editor

EVALUATION OF A NEW INTRAORAL ISOLATION DEVICE

Referring to the above paper published in your September-October issue (*Operative Dentistry* 1991;16:181-185), the authors unfortunately come to conclusions that are not supported by the data presented.

The authors tested a new rubber dam device and then offered comparisons based on the patients' and the dental assistants' "previous experiences" with the conventional rubber dam.

In fact no actual comparisons took place in this study. It is merely a subjective report on experiences with a new rubber dam. This information is then compared to patients' memories of previous experiences with the conventional rubber dam. Clearly it is invalid to compare previous uncontrolled experiences with the new experiences. To draw conclusions of "significant improvement" under these circumstances is inappropriate at best.

The authors admit that "most of the restorations completed were on anterior teeth" and that "several simple occlusal restorations" comprised the posterior uses of the new dam. It is difficult to understand how these "easy" procedures can be compared to patients' previous experiences which may well have been with extensive, difficult, time-consuming interproximal restorations.

No hard data were offered yet it was stated that "this dam could be applied more quickly than conventional dams." This statement was based on the subjective opinions of dental assistants without any comparison of actual times. One can see how easily such a statement can be taken out of context and misused by a manufacturer.

I am sorry to be so negative but unfortunately some manufacturers tend to use studies favorable to their products in advertising their new products. I hope the authors will contact the manufacturers of this device and make it clear that it would be embarrassing for all concerned if the conclusions offered in this study were to be used to claim superiority over conventional rubber dam technique.

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RESPONSE

In reply to the letter to the editor by Richard J Simonsen, DDS, concerning a recent article, "Evaluation of a New Intraoral Isolation Device," we wish to state that all patients who participated in this study had had extensive experience with the use of conventional rubber dams. They were longstanding patients of the clinic, and a conventional rubber dam had been used on each previous visit. Assistants and one of the research participants had worked previously with all of these patients. Neither we nor the Human Investigation Committee here at Tufts University felt it was appropriate to subject these patients to the use

of both types of dam at the one visit. The use of a stopwatch to time each application did not seem necessary.

Our recommendation of 15 December 1988 to the company who anticipated marketing this device was as follows:

"...Its use is most effective for anterior restorations and is more limited with posterior restorations where moisture control is a problem."

This recommendation is reflected in our conclusions.

Due to unforeseen circumstances, the dam is not available at this time.

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UNWARRANTED AND UNPROFESSIONAL: THE SUPERFLUOUS REMOVAL OF CLINICALLY ACCEPTABLE AMALGAMS

The "Point of View" article from Dr H Katz in the May/June 1991 issue of *Operative Dentistry* is certainly an excellent contribution to the controversy surrounding silver amalgam.

There is no doubt that the replacement of acceptable amalgam restorations is, as Dr Katz states, "one of the biggest consumer frauds in dentistry." Three options are mentioned: composite resins, gold, and porcelain inlays. Unfortunately, he continues with a general condemnation of composite resins, claiming that these materials are "weak, greatly inferior substances" which are "churned out" by (implicitly) irresponsible manufacturers.

It certainly would be foolish to claim clinical superiority for direct composite resins, with all their inherent problems related to polymerization shrinkage and technique sensitivity. Polymerization shrinkage remains the major problem. The handling difficulties can be mastered clinically, although a considerably higher time investment is required compared with amalgam.

Porcelain inlays are apparently acceptable to Dr Katz. Ceramics appear to enjoy an immunity to criticism, but may represent a greater potential problem than composite inlays for posterior restorations.

Full ceramic restorations are generally incorporated with composite resins and belong, therefore, in the same category with composite inlays. Given the clinical data at present, admittedly less substantial than the available data for amalgam, I for my part would opt for the indirect resin restoration.

This is not intended as a plädoyer (counsel for the defense--Editor) for direct composites, nor do I wish to attempt to justify the often too early market introduction of new resins. I quite simply reject the unilateral and inclusive condemnation of all "composites."

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Editor's Note: No response was received from Dr Katz.

Book Reviews

DENTAL PHARMACOLOGY
Second Edition

Fred F Cowan, PhD

Published by Lea & Febiger, Philadelphia, PA, 1992. 421 pages, $39.50, softbound.

An unfortunately all too accurate characterization of dentists is that once they get beyond the realm of prescribing penicillin and codeine, their knowledge of medications and pharmacology is lacking. Although there is a defined curriculum in pharmacologic topics in dental training, many in our discipline continue to be confused and unenlightened

about various medications. Dr Fred Cowan, a pharmacologist at the School of Dentistry of the Oregon Health Sciences University, has aspired to remedy this problem by the second edition of his book, *Dental Pharmacology*. This text, directed toward dental students, hygienists, and practitioners, is designed to define and elucidate the role of pharmacology in dentistry and to provide a framework for continuing learning in that discipline.

The book is divided into four parts: general principles, drugs used by the dental practitioner, drugs dental patients are taking, and topics of special interest. In the first section, an overview of pharmacodynamics is presented with illustrative black-and-white line drawings and charts. Though necessarily technical in nature, this is a good synopsis of the topic and defines some terms for further applications in the text.

Parts II and III discuss various drugs by broad classification (e g, analgesics, cardiovascular drugs) with varying degrees of specificity. As expected, the drugs administered by dental practitioners receive the most detailed attention (about 40% of the text) and other categories have more limited narrative. There is extensive coverage in Part III regarding drug interactions and disease states. The approach to drug interactions is conservative and often excessively cautious. An example on page 342: "The use of epinephrine in the form of gingival retraction or local hemostatic agents is contraindicated in all cardiovascular patients." This statement is unsubstantiated and clearly does not represent practical realities. Part IV includes timely topics such as drugs of abuse and mercury toxicity. The body of the book is followed by a well-organized index with helpful indicators for figures and tables.

Overall, the text does an admirable job of covering an extensive topic. It is a comprehensive discussion of pharmacologic principles and detailed descriptions of various drug actions and effects, and the approach is a pharmacological one rather than the perspective of dental care provider. The format and layout of the text is somewhat tedious. The chapters consist mainly of pages of text under subheadings and each section is broken into subtopics but in an extremely subtle fashion. Although there is moderate use of diagrams and tables, there could be improvements in their design and clarity. It would be extremely helpful to standardize the format for each subject with a summary of drug actions and a "precautions" section. Liberal use of larger, bold-faced type and a more sparkling layout would have made the book easier to use. As it is currently arranged, one must wade through considerable text to find specific facts. It is clearly designed more as a student textbook than as a reference for practitioners.

In spite of these somewhat mechanical shortcomings, *Dental Pharmacology* does a satisfactory job of covering a difficult topic. Dr Cowan's approach is particularly useful, covering various areas in differing detail, depending upon the relevance to dental practitioners. As previously mentioned, it is probably more effective for students but could also serve as a useful reference for dentists and dental hygienists.

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FUNDAMENTALS OF ESTHETICS

Claude R Rufenacht, Editor

Published by Quintessence Publishing Co, Inc, Chicago, 1991. 372 pages, 848 illustrations (804 color). $148.00.

Fundamentals of Esthetics is a text that discusses esthetic dentistry in many dimensions. As dentists, we are taught the fundamentals of tooth anatomy but not the visual, creative skills. This text teaches us about the principles of art, the influence of facial structure, and the vital role of function in esthetics. More importantly, we can learn how to combine all of these concepts to evaluate, plan, and create a beautiful dentition.

Although the introductory chapters discussing principles of art and design utilized an artistic vocabulary that made application difficult to apply in the beginning, these concepts fell into place quickly in the dental discussion.

Topics discussed include attrition, crown lengthening, gingival architecture, soft tissue management, prosthodontics, and a good discussion of the physiology of occlusion.

This book is marvelously illustrated and is a valuable text.

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Announcements

INDEX FOR VOL 16, 1991

The index for Volume 16, 1991 was inadvertently omitted from the November/December issue. The index is being printed separately and mailed to all subscribers. The editor apologizes for any inconveniences.

DR JOSÉ E MEDINA HONORED FOR AIDING ADVANCEMENT OF DENTISTRY IN CHILE

University of Florida dental professor José E Medina, DDS, was honored by the President of the Republic of Chile in ceremonies held in tandem with the recent National and International Dental Meeting in Valdivia, Chile.

Chilean President Patricio Aylwin inducted Medina into the highest rank (Knight Commander) within the Order of Bernardo O'Higgins, a society established in memory of the courageous military leader who helped Chile gain independence from Spain about 150 years ago. Medina, who is the first dentist to receive the governmental honor, was cited for providing support and consultation to dental educators and dental practitioners in Chile for more than 18 years. Dr Jorge Jiménez de la Jara, Minister of Health, presented Medina with a commemorative medallion and diploma which expressed appreciation for his leadership in strengthening academic exchange, for helping to guide the education of many Chilean dentists, and for establishing permanent friendships and enhancing cooperative relationships among health professionals in Chile. Two years ago, Medina was also honored by the Chilean Dental Association when he was recognized as an honorary member.

Dr Medina, a faculty member of the University of Florida's College of Dentistry since 1967, is current president of the Academy of Operative Dentistry and a member of the Board of Directors of the American Board of Operative Dentistry, which grants certification status to qualified dental practitioners.

José E Medina

INDIANA DIRECT GOLD COURSE

After a two-year pause, the continuing education course in Direct Gold Technique will once again be offered at Indiana University School of Dentistry in 1992. This course was originally designed to offer assistance in technique and materials relative to gold foil and other direct golds as a restorative service. It was co-sponsored by the American Academy of Gold Foil Operators and the Academy of Operative Dentistry. Response in past years has been very positive so it will be held once again on 9-12 June 1992.

As in the past, there will be Basic and Advanced Courses. The Basic Course is designed as a beginning or refresher course, and the cost will again be $100.00, including everything except room and board. Patients and equipment are provided as well as materials. The Advanced Course is primarily for those who have either taken the Basic Course, or those who feel comfortable with general technique and wish to improve their skills. The cost for this is $150.00. Anyone interested in enrolling should contact:

Dr Ronald K Harris
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In order to effectively plan the courses and faculty roles, applications should be received no later than 15 March 1992. Space is limited, so applications will be considered in the order received.

RALPH J WERNER RECEIVES THE AMBERT B HALL AWARD

The 1991 recipient of the Ambert B Hall Award of the University of Minnesota Alumni Association is Ralph J Werner, one of the founders and, to date, the only Secretary/Treasurer of the Academy of Operative Dentistry. He is a 1945 graduate of the University of Minnesota School of Dentistry, and is a clinical professor at the University and Northwestern University. Ralph served as president of the American Academy of Gold Foil Operators in 1970. In 1990 he received the Academy of Operative Dentistry Award of Excellence.

Congratulations, Ralph, on being honored with this well-deserved award!

Ralph J Werner

INSTRUCTIONS TO CONTRIBUTORS

Correspondence

Send manuscripts and correspondence about manuscripts to the Editor, David J Bales, at the editorial office: Operative Dentistry, University of Washington, School of Dentistry SM-57, Seattle, WA 98195, USA.

Exclusive Publication

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

Manuscripts

Submit the original manuscript and one copy; authors should keep another copy for reference. Type double spaced, including references, and leave margins of at least 3 cm (one inch). Supply a short title for running headlines. Spelling should conform to Webster's *Third New International Dictionary*, unabridged edition, 1971. Nomenclature used in descriptive human anatomy should conform to *Nomina Anatomica*, 5th ed, 1983; the terms 'canine', 'premolar', and 'facial' are preferred but 'cuspid', 'bicuspid', and 'labial' and 'buccal' are acceptable. SI (Système International) units are preferred for scientific measurement but traditional units are acceptable. Proprietary names of equipment, instruments, and materials should be followed in parentheses by the name and address of the source or manufacturer. The editor reserves the right to make literary corrections.

Authors who prepare their manuscripts on a word processor are encouraged to submit an IBM-compatible computer disk of manuscript (3.5 or 5.25 inch) in addition to original typed manuscript; authors need to identify the word processing program used.

Tables

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