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ORIGINAL ARTICLES

Fracture Strength of Premolars with Class 2 Silver Amalgam Restorations

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A NOUR EL-DIN

Summary

This article reports the fracture strength of maxillary premolars in which class 2 amalgam cavities were evaluated and were prepared and restored with silver amalgam. Preparations with isthmuses of differing faciolingual dimensions were compared to sound, unrestored teeth. The ability of unrestored teeth to withstand fracture was superior to that of teeth with MOD, MO, and DO preparations of any tested dimension.

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Introduction

Historically, most cavity designs used today are based on the principles of G V Black. For class 1 and class 2 cavity preparations, Black advocated an occlusal width of one-third the faciolingual intercuspal distance for molars (Black, 1908).

Vale (1956, 1959) reported that premolar teeth with MOD cavities in which the width of the occlusal portion was only one-fourth the intercuspal distance were as strong as sound teeth with unprepared cavities. However, when the width of the occlusal portion of the cavity was increased to one-third the intercuspal distance, the teeth were weakened significantly.

Amalgam is the first material considered when conservative management of posterior approximal caries is indicated. Where there is an adequate amount of tooth structure, amalgam is considered to be unexcelled, especially when it is finished to improve the appearance and plaque-resistant properties (Gilmore & others, 1977). Conservative cavity preparations for amalgam restorations require minimal removal of sound tooth structure and maintain the strength of the tooth (Mondelli & others, 1974; Rodda, 1972; Almquist, Cowan & Lambert, 1973).

Previous fracture studies have dealt with the effect of varying the occlusal preparation width in restored and unrestored molar teeth (Re & Norling, 1980; Re, Norling & Draheim, 1982) and in unrestored premolar teeth (Vale, 1956, 1959;

EDITORIAL

On State Board Examinations for Dentistry

With the passing of the self-taught itinerant dentist and the days of apprentice training, there evolved a true profession requiring formal academic training of a specified period of time. To protect the public, it was deemed necessary to require licensure to ensure an acceptable standard of care within the community. State board examinations originated, in part, to ensure that dental schools, which in earlier years were not regulated or evaluated, would provide dentists capable of practicing the quality of dentistry the public deserves. State examining boards, and now regional boards as well, continue to ensure that the educational process stays on track.

Schools do need to have someone looking over their shoulders, so to speak, but who looks over the shoulders of the various examining boards? Should such licensing agencies be free of scrutiny of any kind? Reviewing the pass/fail statistics of the various examining agencies would certainly indicate that some boards are much tougher than others. Why? Is it because some have higher standards than others? Or is it the examination process they use that produces these results?

Let us look at the pass/fail rates in the State of Washington over the past few years. From 1971 through 1976 failures for University of Washington graduates averaged 7%, while the non-UW graduate failure rate was 32%. For the years 1981-1987 the UW failure rates were 24%, 21%, 19%, 33%, 22%, 42%, and 20%, while the corresponding failure rates for out-of-state graduates were 54%, 52%, 61%, 79%, 66%, 75%, and 61%. Now I ask you, is this reasonable? For the UW graduates the figures given are the cumulative effect of many of those failing the June board but passing the September examination; they are shown here as having passed and are not reflected in the failure rate. If only the June scores were shown, the failure rate would be higher. It is interesting to note that when the passing rate percentage increases or decreases for UW graduates, the out-of-state graduates also demonstrate the same increase or decrease. When the board members tell me that it is our school's problem and not the examination, then it must also mean that all schools are making the same mistakes. Hardly seems likely.

For the Washington examination, during the past ten years there have been at least three new examination forms to score the proceedings, and with each new scoring system the pass-rate decreased significantly. Board members tell me that it is our problem and not the examination. Does that seem logical? Remember, as the UW graduates' failure rate climbs, so does that of all non-UW graduates.

For this examination, as it relates to the UW graduates, we have found that class standing has no correlation to the pass/fail rate. Almost as many failures occur in the top 10% of the class as in the bottom 10%. In addition to the three restorative procedures, an inlay, foil, and amalgam, the examination includes a periodontal and prosthodontic section. Almost all of the failures, however, are noted to occur in the restorative areas. Even the top graduates in restorative cannot be assured of a fair chance to pass this examination; they recognize that luck plays a big part in passing. Is this a reasonable expectation?

The present scoring system for the examination in the State of Washington is said to be a pass/fail examination based upon the University of Michigan criteria. It is not conducted that way, however. Instead of pass/fail scoring, there is a regimented system: one score sheet for the preparation of each of the three cavities and one for each finish and polish. There are three columns for the examiner to check, noting a deficiency in any of the categories (up to 20+ categories for evaluation on each sheet): one column for gross errors (an automatic failure), one for moderate errors (three points deducted for each check mark), and one column for minor errors (one point per mark). To pass the total examination, the candidate must not have a total of more than eight points on any sheet. This is not a pass/fail examination but one which allows examiners to score all candidates severely.

I am certain the members of the board are honorable professionals who have what they perceive as the best interest of the profession at heart, as are the members of organized dentistry who consistently back the actions of the board of examiners in this state, but the devastation they have caused in the lives of many recent graduates has been great. One cannot help but wonder about the future. These fellow members of the profession who eventually get licensed, and always are able to get licensed elsewhere, will never be the same. They are certainly not big supporters of organized dentistry.

The question to be asked today is: Can the states which place such obstacles in the path of the new graduate continue to do so and still maintain the right to give an examination? With the courts of this country continually addressing issues of human rights and fairness, I wonder how long such examinations can continue.

I have always been a strong supporter of states conducting dental examinations. They must be fair and equitable, however, passing the good and only failing the poorer candidates. If we cannot accomplish this, then we will surely lose the right of examination for licensure.

David J Bales

Mondelli & others, 1974; Mondelli & others, 1980).

This study was designed to evaluate the effect of the ratio of isthmus width to occlusal intercuspal distance on the strength of the remaining tooth structure in maxillary premolars restored with class 2 silver amalgam restorations.

Materials and Methods

One hundred freshly extracted, sound, maxillary premolars were collected and stored in 10% formalin. The teeth were then divided into 10 groups of 10 teeth each, as follows:

Group 1: Sound, unprepared teeth, as controls

Group 2: MO preparation, one-fourth the intercuspal distance

Group 3: MO preparation, one-third the intercuspal distance

Group 4: MO preparation, one-half the intercuspal distance

Group 5: DO preparation, one-fourth the intercuspal distance

Group 6: DO preparation, one-third the intercuspal distance

Group 7: DO preparation, one-half the intercuspal distance

Group 8: MOD preparation, one-fourth the intercuspal distance

Group 9: MOD preparation, one-third the intercuspal distance

Group 10: MOD preparation, one-half the intercuspal distance

Table 1. Average Dimensions of the Maxillary Premolars Used in the Study

	BL Width		MD Width		ICD	
Group	Mean	SD	Mean	SD	Mean	SD
Unprepared	9.25	0.50	6.97	0.43	5.71	0.48
one-fourth ICD	8.85	0.54	7.04	0.50	5.14	0.36
one-third ICD	9.42	0.62	6.90	0.45	5.62	0.41
one-half ICD	8.95	0.57	6.88	0.80	5.61	0.33

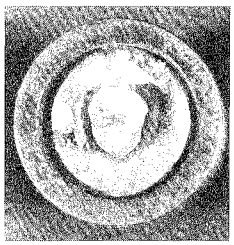

FIG 1. *Tooth mounted prior to testing in low-fusing alloy*

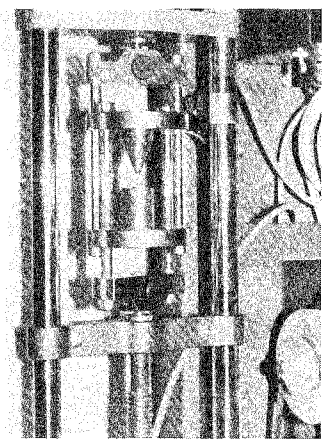

FIG 2. *Steel sphere in contact with the cusps of the crown during tesing of the Tensometer testing machine*

All teeth were prepared using a high-speed handpiece with water/air spray for cooling. The mean cavity depth from the center of the tooth was 2.5 mm. The approximal depth varied from 1.0 mm at the gingival wall to 2.0 mm at the axiopulpal line angle. All prepared teeth were restored with Indiloy, a zinc-free amalgam (Shofu Dental Corporation, Menlo Park, CA 94025). The average dimensions of the maxillary premolars used in the study are shown in Table 1.

The teeth were mounted prior to testing in a low-fusing metal alloy, as shown in Figure 1. Compressive forces were applied using a Tensometer Universal Testing Machine (Monsanto, Ltd, Tokyo, Japan). Forces were applied axially and centrally to the occlusal surface with a steel sphere 5.0 mm in diameter so that both cusps of the crown were contacted, as shown in Figure 2.

Table 2. Mean Force Required to Fracture Teeth Prepared with Isthmus Width one-fourth the Intercuspal Distance (ICD)

Group	Force (Kgs) Mean ($\bar{X}$)	SD
Group 1: Sound, unprepared teeth	176.0	15.05
Group 2: MO preparation	120.5	17.55
Group 5: DO preparation	117.5	15.14
Group 8: MOD preparation	123.5	17.49

Table 3. Mean Force Required to Fracture Teeth Prepared with Isthmus Width one-third the Intercuspal Distance

Group	Force (Kgs) Mean ($\bar{X}$)	SD
Group 1: Sound, unprepared teeth	176.0	15.05
Group 3: MO preparation	104.5	10.12
Group 6: DO preparation	105.0	12.02
Group 9: MOD preparation	106.0	12.20

Table 4. Mean force required to fracture teeth prepared with isthmus width one-half the Intercuspal Distance

Group	Force (Kgs) Mean ($\bar{X}$)	SD
Group 1: Sound, unprepared teeth	176.0	15.05
Group 4: MO preparation	92.0	10.06
Group 7: DO preparation	91.0	12.20
Group 10: MOD preparation	89.5	13.00

Results

Tables 2, 3, and 4 show the mean force and standard deviation required to fracture the teeth. Analysis of Duncan's multiple range test indicated no statistically significant difference existed for the strength of teeth with MOD preparations when compared to teeth with MO or DO preparations of the same width. The results also indicate that when the width of the isthmus is varied, all mean scores differ significantly from each other. Data for teeth prepared to one-fourth the intercuspal distance were statistically superior to those with an isthmus measuring one-third or one-half the intercuspal distance, as shown in Figures 3, 4, and 5.

Discussion

The results indicated that even with a narrow preparation there was a significant reduction in the strength of the crown of a tooth compared with an unprepared tooth.

The results of this study disagreed with the results of Black (1908) and Blackwell (1955), who advocated an occlusal width of one-third the intercuspal distance. Vale's studies (1956, 1959) do not agree with Black's concept of one-third the intercuspal distance. He reported that MOD

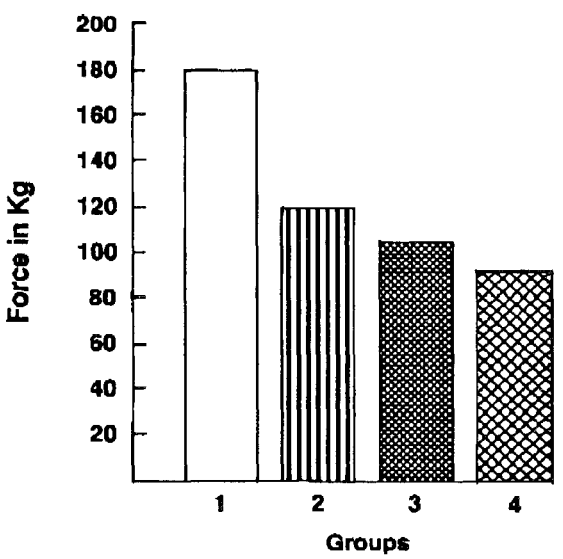

FIG 3. *Mean force required to fracture teeth in Groups 1, 2, 3, and 4*

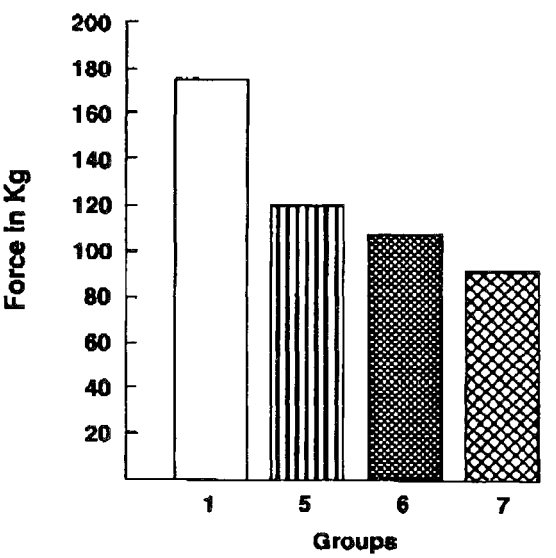

FIG 4. *Mean force required to fracture teeth in Groups 1, 5, 6, and 7*

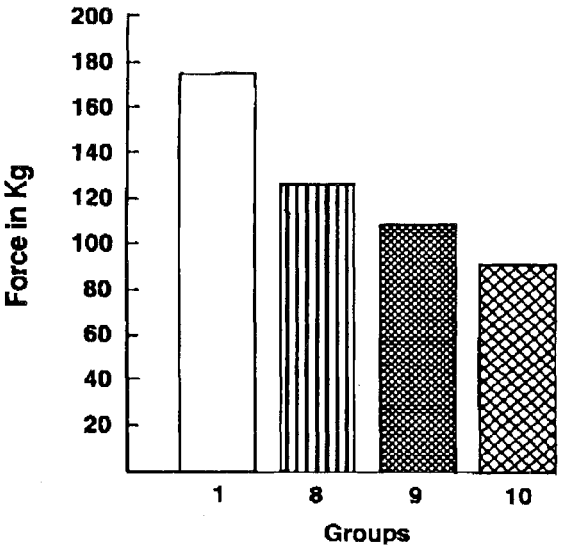

FIG 5. *Mean force required to fracture teeth in Groups 1, 8, 9, and 10*

preparations with an isthmus of one-fourth the intercuspal distance required only a slightly greater load than a sound tooth to cause fracture. These results support the trend toward the conservation of sound tooth structure (Re, Norling & Draheim, 1982; Mondelli & others, 1980; Almquist, Cowan & Lambert, 1973).

Conclusions

From this study it was concluded that:

•All cavity preparations decrease the strength of teeth in proportion to the isthmus width as related to the intercuspal distance of the preparation.

• There is no difference in the strength of teeth with MOD preparations and teeth with MO or DO preparations that have the same isthmus width.

• As long as clinically feasible, the isthmus width should be minimal in relation to the intercuspal distance.

• Sound tooth structure should be conserved as much as possible.

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Longevity of Complex Amalgam Restorations

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Summary

Although dental amalgam has been the primary material used in restoration of complex cavities, its longevity for multisurface restorative procedures in which one or more cusps is onlayed has not been evaluated. In this study, records at a large military base were screened for complex amalgams with one or more cusps restored in amalgam. Patients identified were recalled for evaluation and the study demonstrated the 50% survival rate to be 11.5 years.

Introduction

Although amalgam is the most commonly used restorative material, there is minimal clinical research on the durability and longevity of amalgam restorations. Moore and Stewart (1967) surveyed the records of 907 dental school patients. They found that 42% of the 6505 amalgam restorations were defective and that more than one-third of the operative effort was consumed in replacing defective restorations. In another study of a dental school patient population, Crabb (1981) reported on a retrospective study of patients treated at a British dental school. Reporting on all classes of amalgam restorations, he found the 50% survival to be approximately nine years and that 43.9% of the restorations survived more than 10 years. More recently, Bentley and Drake (1986) reported on amalgam longevity in an American dental school. They found that 65.3% of the multisurface amalgam restorations functioned for 10 years or longer. The 50% survival rate was in excess of 14 years for all amalgam restorations. In a longevity study in Scotland, Elderton (1983) estimated the 50% survival of all amalgam restorations to be less than five years. Paterson (1984) conducted a retrospective study of 2344 amalgams placed in adults during a 16-year period. He also constructed a time-life survival table. The 50% survival time for occlusal amalgams was eight years and for approximal amalgams seven years.

Robinson (1971) described the "life of 145 fillings" in 43 patients from one dental practice over a 20-year period. His criteria for failure were fairly severe. When a tooth was extracted for periodontal or endodontic reasons, all restorations in that tooth were considered failures. He

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reported that after five years approximately 25% of the amalgam restorations had failed; after 10 years approximately 50% had failed; and after 20 years approximately 77% had failed. Allan (1977) conducted a similar 20-year longitudinal study of 47 patients. He reported that approximately 50% of the amalgam restorations failed in eight years and 90% in 20 years. Lavelle (1976) reported on a 20-year longitudinal survey of the records of 400 patients. He found that approximately 20% of amalgam restorations failed within the first five years, 50% failed within 10 years, and 90% failed in 20 years.

Skogedal and Helöe (1979) invited all 25-year olds in a middle-sized Norwegian town to participate in a clinical examination and interview. Three hundred thirty class 2 and 5 amalgam restorations were examined in 246 subjects. Approximately one-third of the restorations were considered unacceptable. Mjör (1981) conducted a survey of 5487 restorations placed by 85 dentists during a two-week period. He found that 71% of the amalgam restorations placed were replacements. Of the restorations replaced, approximately 46% were 4-10 years old and 40% were over 10 years old. In a similar design, Klausner and Charbeneau (1985) conducted a survey of 5392 amalgam restorations placed by 122 dentists during a two-week period. They reported that 41% of the restorations were replacements. Approximately 6% of the total restorations placed were complex amalgams.

With the exception of the study conducted by Klausner and Charbeneau, no reference has been made specifically to the longevity of complex amalgams. The purpose of the present study was to determine the longevity of complex amalgams and the factors which might affect this longevity.

Materials and Methods

Approximately 10 000 randomly selected records in a large Air Force dental clinic were reviewed. From these records, 209 patients were identified who had had at least one complex amalgam placed. These patients included active duty and retired military personnel and family members. The following patients were excluded from the study: 1) patients who had received radiation therapy to the head and neck region, 2) patients receiving long-term medications which cause reduced salivary flow, and 3) patients with collagen diseases such as Sjogren's syndrome. For the purpose of this study, a complex amalgam was defined as a posterior restoration which replaced one or more cusps in amalgam. Each restoration was required to have opposing occlusion.

Once a record was identified, the history of each restoration was documented from the record. All restorative failures that were determined from review of the records, beginning from the time of restoration placement, were included in the study. Forty-three failures in 35 patients were recorded in the records review. Reliable causes of failure were difficult to obtain from the treatment record; therefore, cause of failure was not recorded.

The second phase of the study involved a clinical examination of complex amalgam restorations which had been placed at least five years prior to the examination. No restoration was considered to be a success unless it had been in function for at least five years. Longevity of both failed and successful restorations was recorded. Of the 193 patients identified as having a complex amalgam with one or more cusps restored in amalgam, 86 patients with 128 complex amalgam restorations were available for examination. In each clinical examination, a current (less than six months old) series of four bitewing radiographs of diagnostic quality was used. Margins were evaluated clinically with a sharp #23 explorer. The criteria for failure of those restorations examined clinically were:

(1) Marginal failure--a subsurface discrepancy between the tooth-amalgam interface in which the explorer sticks. Margins were classified as either acceptable or unacceptable (requiring replacement).
(2) Fractured tooth adjacent to restoration
(3) Fractured restoration
(4) Caries associated with restoration
(5) Occlusal morphology inadequate for masticatory function

Light or open interproximal contact and overhangs were not classified as failures since these discrepancies are repairable. There were two examining dentists; therefore, rater standardization was introduced at the outset. Two patients were examined simultaneously by both dentists for the purpose of calibration. Each

Life Table and Survival Analysis

Time Interval (Years)	Number at Risk	Number Withdrawn	Number Failed	Probability of Failure	Probability of Survival	Percent Intact	Standard Error (%)
0-1	171	0	6	0.0351	0.9649	100.00	-
1-2	165	0	5	0.0303	0.9697	96.49	1.41
2-3	160	0	11	0.0688	0.9312	93.57	1.88
3-4	149	0	7	0.0470	0.9530	87.13	2.56
4-5	142	0	5	0.0352	0.9648	83.04	2.87
5-6	137	27	11	0.0891	0.9109	80.12	3.05
6-7	99	20	1	0.0112	0.9888	72.98	3.46
7-8	78	11	6	0.0828	0.9172	72.16	3.51
8-9	61	13	6	0.1101	0.8899	66.19	3.98
9-10	42	5	3	0.0759	0.9241	58.90	4.52
10-11	34	8	1	0.0333	0.9667	54.43	4.86
11-12	25	6	2	0.0909	0.9091	52.61	5.02
12-13	17	3	0	0.0000	1.0000	47.83	5.59
13-14	14	2	2	0.1538	0.8462	47.83	5.59
14-15	10	2	1	0.1111	0.8889	40.47	6.73
15-16	7	1	2	0.3077	0.6923	35.98	7.33
16-17	4	0	0	0.0000	1.0000	24.91	8.26
17-18	4	0	0	0.0000	1.0000	24.91	8.26
18-19	4	0	1	0.2500	0.7500	24.91	8.26
19-20	3	2	0	0.0000	1.0000	18.68	8.21
20-21	1	1	0	0.0000	1.0000	18.68	8.21

dentist then independently examined an additional 10 patients and these results were compared. No additional calibration was required. The data collected from the records review and the clinical examinations were pooled for a total of 171 restorations. These pooled data were used to calculate the time-life analysis.

In addition to looking for failure versus success, restorations were divided into groups as having been placed in molars versus bicuspids and having covered 25%, 50%, 75%, or 100% of the occlusal surface.

The time-life survival table was calculated using the Cutler-Ederer method. The chi-square test was used to compare categorized data. Analysis of variance was used for between-group comparisons. Duncan's multiple range test was used for post-hoc analysis.

Results

In terms of longevity, no difference was demonstrated between restorations in molars and premolars. Similarly, no difference in longevity was noted in relation to the percent of cusps restored with amalgam. A time-life survival analysis was calculated for the total sample (see table). The 75% survival rate was estimated to be 5.7 years; the 50% survival was estimated to be 11.5 years; and the 25% survival was estimated to be 16 years. The percentage of restorations surviving for 10 years was 54%, for 15 years 36%, and for 20 years 19%.

Discussion

The results of the time-life analysis are not in total accord with previous studies which were not limited to complex amalgams and in which the 50% survival rate was reported as ranging from less than five to more than 14 years. The Crabb (1981) study (Britain, 50% survival--9 years) and the Bentley and Drake (1986) study (USA, 50% survival--14 years) were both accomplished in dental schools; however, the results were much different. The Paterson (1984) study

(50% survival--7 to 8 years) was accomplished in a British National Health Service practice, and the Elderton (1983) study (50% survival--less than five years) in a Scottish population.

The restorations in this study were placed in a well-controlled military environment where the patients, for the most part, received annual examinations. Also, during the long span of time over which these restorations were placed, a change from γ-2-containing alloy to high-copper alloy was implemented. It would be expected that this newer alloy would positively affect the longevity of the restorations. There is a temptation to compare results across studies; however, because of the large number of uncontrolled variables, Maryniuk (1984) warns that it is unwise to compare these types of studies too closely.

Conclusion

As with other types of restorative dentistry, the placement of a complex amalgam is a technique-sensitive procedure. However, under the conditions of this study, the complex amalgam, which had a 50% survival rate of 11.5 years, proved to be a durable restoration.

The opinions expressed herein are those of the authors and do not necessarily reflect the opinions of the Department of Defense or the United States Air Force.

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Effect of Fluoride from Dental Materials on Acid Demineralization of Enamel

Jan G Stannard • Anthony D Viazis

Summary

A precision cavity preparation instrument was used to place different fluoride- and nonfluoride-releasing dental materials. Material-enamel solubility under conditions of demineralization was evaluated. Fluoride release and solubility values were determined in vitro using distilled water and a demineralization solution. Resistance to demineralization, for some polycarboxylate cements, was greater than simple laboratory tests and indicated positive interaction between fluoride release, material properties, and enamel protection.

INTRODUCTION

Fluoride release has been evaluated for a number of dental materials which contain fluoride (Derkson, Poon & Richardson, 1982; Swartz, Phillips & Clark, 1984). Several factors governing fluoride release have been studied (Cranfield, Kuhn & Winter, 1982) and mathematical models presented which describe this behavior (Kuhn & Jones, 1982). Fluoride has also been measured in enamel and cementum via placement of fluoride-containing materials (Shannon, 1980; Retief & others, 1984). Fluoride uptake from a dental cement, when from stannous fluoride, also reduces calcium solubility from enamel and increases enamel microhardness (Shannon, 1980).

The sequence of fluoride release, enamel fluoride incorporation, and subsequent reduction in enamel solubility certainly offers a good rationale for placing fluoride in restorative materials. Early observations on silicate cement which reduced secondary decay, while showing disintegration, suggest a basis for this action. The widespread use of fluoridated drinking water today limits, to some extent, the potential for making similar clinical observations with the materials used at this time. Several important questions regarding the restorative material-tooth interaction, however, require further study to properly formulate and select fluoride-releasing materials. The proper level and rate of fluoride release while maintaining restoration integrity are prime areas of concern.

The purpose of this experiment in vitro was twofold. (1) To evaluate the disintegration process of a fluoride-releasing dental material when measured under the conditions of carious lesion formation, and in contact with enamel. (2) To measure the influence of fluoride release from different dental materials upon the progress of a carious lesion.

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MATERIALS AND METHODS

Tooth Protection and Resistance to Demineralization

Forty-two noncarious, extracted molar teeth were selected for use in this experiment. The teeth were sealed with an acid-resistant nail polish and embedded in cold-cure acrylic using a metal mold. Tooth orientation placed each tooth so that when viewed from the front the buccal surface was to the left and the lingual surface was to the right. All teeth were radiographed. The teeth were then sectioned using a lathe, high-speed handpiece, and cutting disk in the mesial-distal direction to produce a section thickness 5 mm in width. This section was centered along the axial midline of the tooth. Each tooth was again sealed along the newly exposed surfaces. All teeth were radiographed and films developed under uniform conditions.

A precision-cavity preparation instrument (Fig 1) that provided three-dimensional control of a high-speed handpiece was used to make cavity preparations in the teeth (Stannard & Walgren, 1985). Two box-like preparations were made on the buccal and lingual surfaces of each tooth as shown diagrammatically in Figure 2. The floor of each preparation, axial and occlusal, is parallel to the other. Each cavity preparation was initially 1.025 mm in axial length and 0.635 mm in depth. The most axial preparation in all cases was later filled with amalgam.

The most occlusal preparation was filled with one of the materials identified in Table 1, as applied to one of three groups of 14 teeth, and

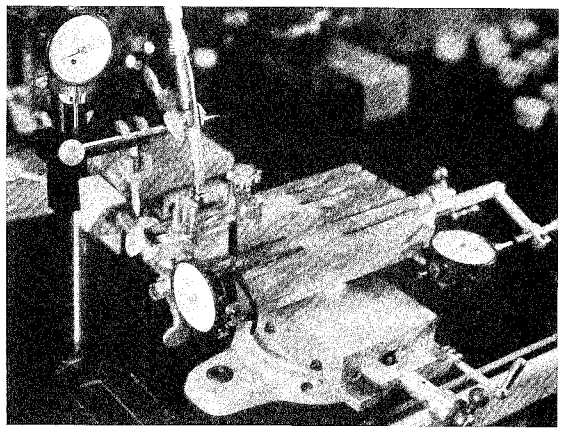

FIG 1. *Precise cavity preparation instrument. A high-speed handpiece with water spray was mounted on a table lathe. Three-dimensional control of the handpiece was measured with the dial gauges.*

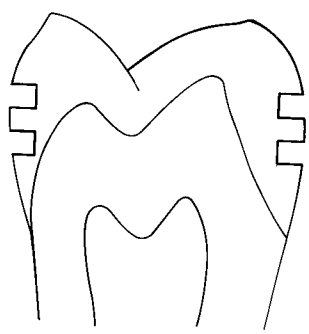

FIG 2. *Diagram of a tooth showing two box-like preparations on the buccal and lingual surfaces. This tooth was then modified, as shown in Figures 3 and 4.*

Table 1. Restorative Materials and Their Manufacturers

Group No	Material Classification	Product Name	Fluoride Present	Manufacturer	Address
I	Zinc phosphate cement	Zinc cement	none	S S White	Philadelphia, PA 19102
I	Polycarboxylate cement	Tylok	stannous fluoride	L D Caulk	Milford, DE 19963
II	Composite resin	Brilliant	none	Coltene, AG	Hudson, MA 01749
II	Glass ionomer - silver	Ketac-Silver	silicate glass with F	ESPE/Premier	Norristown, PA 19401
III	Glass ionomer	Ketac-Fil	silicate glass with F	ESPE/Premier	Norristown, PA 19401
III	Polycarboxylate cement	HyBond	tannin fluoride	Shofu Dental	Menlo Park, CA 94025

placed to produce a balance in the number of buccal and lingual surfaces treated with each material. The materials after placement are shown diagrammatically in Figure 3. After complete setting of the materials, a minimum of one hour, the occlusal preparation was modified to create an open margin as shown in Figure 4. This open margin was made using the cavity preparation instrument without removing the tooth during restorative replacement.

Each tooth was then fitted with plastic tubes, buccal and lingual, each 1 ml in volume, placed to surround the restorative materials. The tube was filled with a demineralizing acid solution containing 2.2 mM calcium, 2.2 mM phosphate, and acetic acid adjusted to a pH of 3.0. This solution, similar to typical demineralizing treatments, produces a carious lesion in the tooth. The teeth were radiographed daily and fresh acid placed into each tube at 24-hour intervals.

The teeth were followed radiographically for 21 days to observe changes in lesion size and amount of restorative material present. Initial size of the cavity preparation, lesion size, initial amount of restorative material placed, and the amount of restorative material present after acid exposure was measured using computer-aided design (Computer Vision, Bedford, MA 01730). Radiographic images of the teeth were projected onto an electronic digitizing surface as shown in Figure 5. Magnification factors and absence of distortion were measured separately for this procedure. Tracing of lesion boundaries or restorative material boundaries allowed calculation of the area of these zones by the computer.

Acid Solubility

American Dental Association Specification No 9 (American Dental Association, 1974) was used to measure solution solubility of the restorative materials identified in Table 1. The dissolving solution, however, was the demineralization solution described above, rather than distilled water. Fifty milliliters of this solution was evaporated separately to determine the mineral contribution to the material solubility value measured from this test. Theoretical calculation of the expected mineral deposit was in good agreement with the experimental value; experimental solubilities of the restorative materials were corrected using this factor.

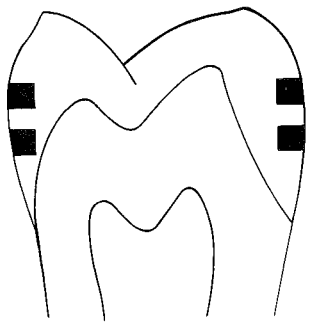

FIG 3. *Tooth diagram of preparations which have been filled. The occlusal-most preparation on each side is filled with one of the restorative materials, as listed in Table 1; the axial preparations are filled with an amalgam control.*

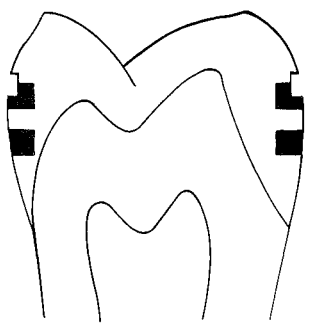

FIG 4. *Tooth diagram in which the occlusal preparations have been partially removed to expose unprotected enamel. This condition simulates an open margin condition while the remaining surface enamel has been protected with an acid-resistant coating.*

Fluoride Release

The amount of fluoride released from a uniform sample was determined from two disk samples of each material in a manner similar to the solubility test. The disk samples were submerged in 50 ml of the demineralization solution.

Fluoride was measured using a fluoride-ion-specific electrode, buffered with TISAB II at 24-hour intervals (Orion Instruments, Cambridge, MA 02140). After each 24-hour interval, the disks

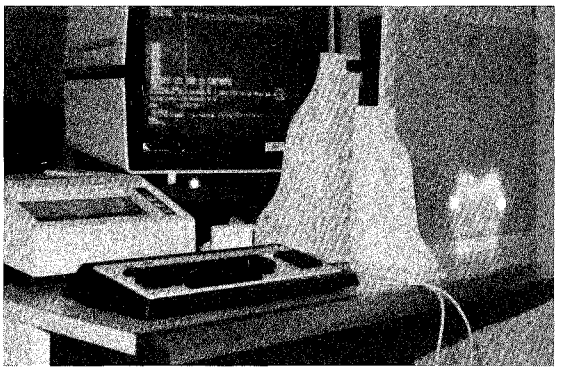

FIG 5. *Computer-aided design work station. Radiographs were projected onto a digitizing surface that allowed calculation of the restorative material and lesion areas present. Magnification and correction factors were measured separately and used to convert measured areas into real areas for the specimen. The projected radiographic image of the tooth appears on the right.*

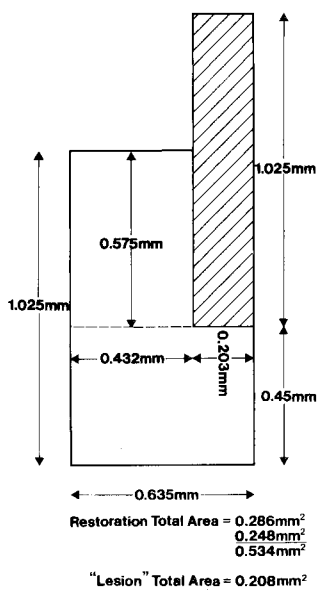

FIG 6. *Calculation of experimental treatment areas based upon precise cavity preparation measurements. The total restorative material present and lesion area (theoretical) were compared with the actual measured areas indicated in Tables 2-4.*

were transferred to fresh solution. Fluoride ion release was measured at 24-hour intervals for seven days. Determination of fluoride amount released was obtained using a fluoride calibration curve prepared for this purpose. Fluoride release, in distilled water, was also measured in a similar manner for all materials listed in Table 1.

RESULTS

Group I

Area measurements of the restorative materials in Group I are shown in Table 2. The initial size of the restorative material, the size of the restorative material at day 10, the area amount of change between the initial preparation and day 10, with standard deviations in parentheses are indicated in mm^2. The measurements are separated into buccal, lingual, and a computed average for that restorative material.

The measured restoration area, shown in Table 2, is in very good agreement with the calculated restoration area as shown in Figure 6. The initial area and material change at day 10 are very similar for the buccal and lingual preparation for each material in Group I (zinc phosphate and polycarboxylate). A t-test comparison of means for buccal and lingual amount of restorative material indicated no difference for the zinc phosphate or polycarboxylate (Tylok) at the initial measurement either within or between the groups. At day 10 a significantly larger amount of the zinc phosphate cement appeared missing from the preparation ($P < 0.05$).

A radiograph of a tooth at the initial pre-acid stage, prepared with zinc phosphate cement on one side and polycarboxylate cement (Tylok) on the other is shown in Figure 7. The same tooth after four days of acid exposure is shown in Figure 8. The occlusal preparation (zinc phosphate) on the left indicates a lesser amount of material than the occlusal preparation (Tylok polycarboxylate) on the right.

Group II

Area measurements for Group II are shown in Table 3. In comparing the composite and the glass ionomer with "silver" added, difficulty was encountered in determining the initial restorative

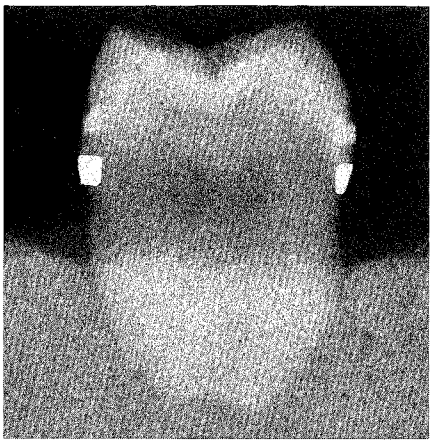

FIG 7. *Tooth radiograph from treatment Group I at the initial placement stage. The occlusal preparations were filled with polycarboxylate cement (Tylok) stannous fluoride on the right and zinc phosphate cement (no fluoride) (Zinc Cement) on the left.*

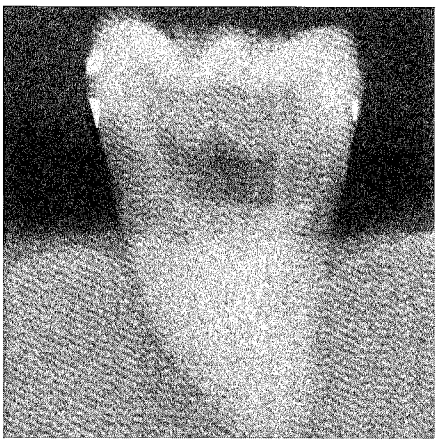

FIG 9. *Radiograph of a Group II tooth at the initial stage. The experimental preparation on the right was filled with composite while the preparation on the left was filled with glass ionomer containing silver.*

FIG 8. *Radiograph of acid-exposed tooth shown in FIG 7 after four days of exposure to the demineralization solution. Washout behavior of these cements for the 14 preparations was measured and is shown in Table 2.*

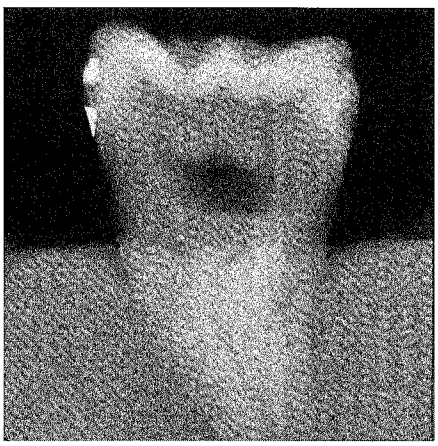

FIG 10. *Radiograph of tooth shown in FIG 9 after 15 days of exposure to the acid solution. Results of Group II and Group III are shown in Tables 3 and 4, respectively.*

Table 2. Radiographic Area Measurements for Group I

	Restorative Material Area											
	Area of Inital Material						Area of Material at Day 10		Day 10 Material Lost, Area			
Restorative Material	Buccal mm	Buccal SD	Lingual mm	Lingual SD	Average mm	Average SD	Average mm	Average SD	Buccal mm	Buccal SD	Lingual mm	Lingual SD	Average mm	Average SD
zinc phosphate cement	0.524	0.039	0.536	0.061	0.530	0.048	0.130	0.048	0.384	0.054	0.417	0.045	0.400	0.048
Tylok	0.530	0.076	0.554	0.039	0.542	0.061	0.212	0.085	0.351	0.073	0.309	0.79	0.330	0.075

Table 3. Radiographic Area Measurements for Group II

Restorative Material	Total Open Lesion Area							
	Initial		Day 5		Day 10		Day 15	
	mm	SD	mm	SD	mm	SD	mm	SD
Brilliant	0.097	0.067	0.203	0.097	0.291	0.109	0.336	0.130
Ketac-Silver	0.097	0.061	0.163	0.109	0.188	0.082	0.263	0.085

material boundary for the composite material. For this reason, measurement of the open lesion, which was more easily observed, is the area indicated in Table 3. The initial lesion area, or the area opened up by the handpiece, was considerably more difficult to measure and required using the missing surface contour as a boundary line. The measured area is not in good agreement with the calculated "lesion area" indicated in Figure 6; however, the initial area for the composite and glass ionomer are statistically the same (t-test). Standard deviation values for this group are slightly higher than Group I and larger relative to their mean values. No significant difference was observed for these two materials at any time interval, though the fluoride-releasing glass-ionomer silver product had a consistently lower lesion area.

A prepared tooth from Group II having the glass ionomer with silver on the left side and the composite on the right side is shown in Figure 9 at the initial stage. The same tooth after 15 days of exposure to the demineralizing solution is shown in Figure 10. Both restorative materials show little if any change, while the "open margin" has deteriorated. The lesion on the right extends slightly behind the composite while the lesion restored with the glass ionomer and silver has not progressed this far. The amalgam marker on the right side has been lost with a large lesion present in its place.

Group III

Measurements for the Group III materials are presented in Table 4. The glass-ionomer restorative material could not be differentiated easily from enamel so no measurements are included for this material. The restorative material present for this polycarboxylate, HyBond, is statistically the same as that of either material in Group I initially (t-test). At the 10-day observation period the buccal and lingual preparations presented the same amount of material. Of the three cements, HyBond had the greatest amount of material loss, 81%, followed by Zinc Cement, 75%, and Tylok, 62%. Tylok was much more resistant to "washout" than Zinc Cement or HyBond.

Disk solubility values in demineralization solution for the materials evaluated are given in Table 5. These values represent the average of two

*Table 5. Solubility Values for Materials Tested in Demineralization Solution**

Material	Solubility in Percent**
zinc phosphate	8.04
Tylok	7.81
Brilliant	0.42
Ketac-Silver	0.77
Ketac-Fil	1.84
HyBond	5.20

*Values reported have been corrected for mineral deposition from the solution.

**Modified ADA Specification No 9. Test modifified to use demineralization solution instead of distilled water as a solvent.

Table 4. Radiographic measurements for Group II

Restorative Material	Restoratve Material Area									
	Area of Initial Material						Area of Material at Day 10		Day 10 Material Lost, Area					
	Buccal		Lingual		Average		Average		Buccal		Lingual		Average	
	mm	SD	mm	SD	mm	SD	mm	SD	mm	SD	mm	SD	mm	SD
Ketac*	—		—		—		—		—		—		—	
Hybond	0.507	0.071	0.536	0.075	0.521	0.666	0.093	0.044	0.412	0.057	0.447	0.066	0.430	0.064

*Due to opacity contrast problems, no measurements were possible for the glass-ionomer materials.

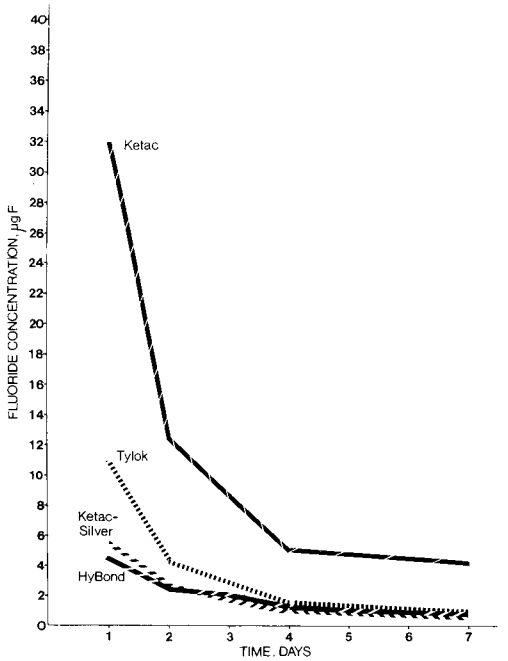

FIG 11. *Fluoride release curves for "restorative" materials in distilled water. The zinc phosphate cement did not contain any measurable fluoride if present.*

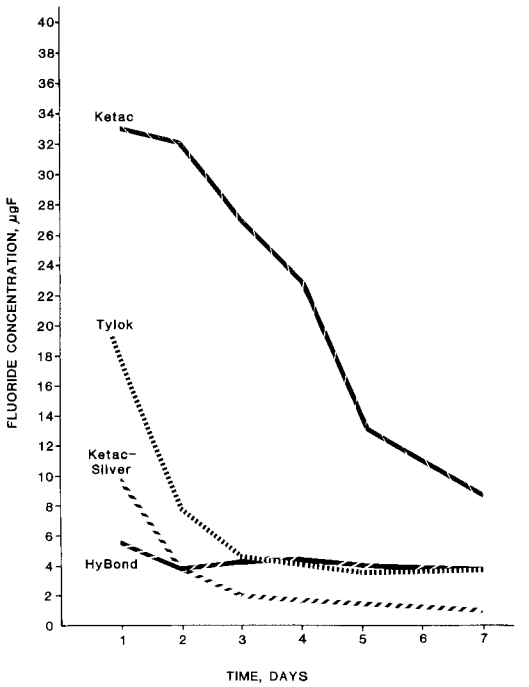

FIG 12. *Fluoride release curves for "restorative" materials in the demineralization solution*

trials, as indicated in the ADA Specification No 9 for test procedure. The cement solubility values when tested in vitro have a different ranking compared to the assessment in situ described above. Distilled water solubility values of these materials are also contained in Table 5.

The fluoride ion release data from disk samples in distilled water are presented in Figure 11. The fluoride concentration reported was that produced by the two disk samples. All fluoride-containing products released fluoride initially and decreased their release rapidly in an exponential manner with time. Fluoride release was generally greater for all products when immersion occurred in the demineralization solution, as shown in Figure 12. The glass-ionomer restorative showed the greatest fluoride release in both solutions. After 24 hours, the three other products showed the following ranking: Tylok, Ketac Silver, and HyBond; however, after 24 hours their fluoride release values in either solution were generally equivalent.

DISCUSSION

Radiography was used to measure interaction of different restorative materials with enamel under demineralizing conditions. The restorative material, observed as being dissolved, represented the surface average across a precise preparation 5 mm wide. The acidic conditions of the experiment showed a slower dissolution of traditional restoratives, such as composite and glass ionomer, compared to luting agents. Enamel solubility occurred while these restorative materials remained relatively unchanged.

As the luting agents tested presented a higher solubility over a much shorter period of exposure, the luting agents dissolved while the enamel was also being demineralized. The pH of the demineralizing solution was selected to provide results within one month of exposure and from prior experience.

An open margin condition was observed as very detrimental to the tooth and restorative

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Postoperative Sensitivity Associated with Posterior Composite and Amalgam Restorations

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Summary

In this clinical evaluation of the effectiveness of three different treatments of dentin to reduce postoperative sensitivity of posterior teeth restored with composite resin and amalgam, results were compared to unrestored controls. Compared to the controls, teeth with composite restorations were more sensitive to biting; of the three treatments, composites utilizing a glass-ionomer liner were most sensitive to biting and teeth restored with both composite and amalgam were more sensitive to cold.

INTRODUCTION

Posterior composite resin restorations are being placed with greater frequency today as an esthetic alternative to dental amalgam. Much attention has focused on evaluating the wear of posterior composites. Another problem which has been associated with their use is postoperative sensitivity of the restored teeth to biting stimuli.

Leinfelder (1982) noted that 8 - 10% of the patients treated with posterior composites reported postoperative sensitivity to biting which, in some cases, lasted several months. Leinfelder speculated that the sensitivity was associated with unconverted monomer penetrating the dentinal tubules during mastication. Nelson (1983, personal communication) documented a high incidence of sensitivity to biting with large, class 2 posterior composite restorations. The sensitivity generally lasted three to six months and then diminished. It was thought that the composite, having a low modulus of elasticity, flexed during chewing and caused cuspal deformation. Jensen and Chan (1985) reported six cases of partial cuspal fracture associated with the use of posterior composites for all patients reporting pain with chewing. It was postulated that the fractures arose from shrinkage forces placed on the cusps during polymerization. Suzuki, Jordon, and Boksman (1985) reported a clinical observation that postoperative sensitivity of posterior composites was an important problem. Potential causes given were (1) etching of the dentin, (2) toxicity of the composite, (3) polymerization contraction, and (4) deflection of the restoration. Brännström (1984, 1985) associated pulpal sensitivity with the presence of bacteria

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material compared to a closed margin. Note the pattern of enamel loss away from the open margin in Figure 10.

Solubility values of the materials in demineralization solution were greater than in distilled water (Tsukiboshi & Tani, 1984; Chamberlain & Powers, 1976). Fluoride release was also greater in demineralization solution compared to distilled water; however, similar patterns of release and concentration levels were observed after seven days of exposure. Solubility of dental materials should remain at a low value under all relevant conditions. Since intentional fluoride release presupposes solubility, the interaction of the restorative material with enamel or dentin must then also be examined.

Low solubility of the composite and glass ionomer with silver allowed observation of enamel protection from demineralization. For the selected pH and rate of enamel dissolution, no difference was observed for a fluoride-releasing product and a nonfluoride product. For the luting agents, higher solubility and good radiopacity, compared to enamel, allowed observation of "washout" behavior while demineralization was occurring. The amount of remaining cement was different from that suggested by solubility in vitro.

Tylok cement, containing stannous fluoride, had an intermediate solubility between Zinc Cement and HyBond. Tylok, however, released a greater initial amount of fluoride than HyBond while Zinc Cement does not contain any fluoride. HyBond contains a less soluble fluoride, tannin fluoride, which also promotes good physical properties for this product (Tsukiboshi & Tani, 1984).

The type of fluoride released, the amount, and its interaction with the tooth, as well as material solubility, all appear to affect how the cement will behave in contact with the tooth.

CONCLUSIONS

1. Use of this procedure for tooth preparation and evaluation of restorative materials was shown to be sensitive to different materials. Specific preparation geometry and lesion progression can be used to assess material/tooth interactions.

2. Material/tooth interactions which are more complex than laboratory solubility or fluoride release in acid can be evaluated using this model. These results indicate fluoride release can reduce enamel solubility and material dissolution.

3. Material solubility in demineralization, or acid solutions, was not sufficient alone to evaluate material solubility in the oral environment.

4. Good restorative technique was extremely important to reduce conditions which promote demineralization, such as an open margin.

5. Benefits of fluoride incorporation for polycarboxylate cements appear to be dependent on the type of fluoride used and the availability of the fluoride to the tooth. Fluoride release was increased under conditions which simulate demineralization compared to laboratory solubility procedures.

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under the restoration, and not the filling material itself or pretreatment procedures. This would imply that bacterial infection arising from microleakage is a major factor in causing pulpal sensitivity.

In order to provide pulpal protection and/or improve the bond and seal at the interface of the restoration and the tooth, several treatments of dentin and enamel preceding the placement of the composite are available. Examples of such are the use of calcium hydroxide as a dentinal liner, glass ionomer liners, and dentin bonding agents. There is little published information which addresses the effectiveness of the various treatments of dentin and enamel in dealing with postoperative sensitivity of composites. Welch and Eick (1986) presented a technique emphasizing protection of the pulp with a dentin adhesive and utilizing incremental polymerization to reduce sensitivity. The purpose of this current study is to clinically assess the effectiveness of three distinct treatments of dentin and enamel which precede the placement of a posterior composite resin restoration. It is also an objective of this study to compare these three systems to dental amalgam restorations in order to identify any differences to biting and thermal stimuli.

METHODS

Twenty-seven subjects were selected for placement of posterior composite and amalgam restorations. Selection criteria included the ability to place a minimum of three posterior restorations so that at least three of the four treatments described below could be represented in each subject. Four different restorative systems (treatments) were utilized: (1) BISFIL I (BISCO, Inc, Downer's Grove, IL 60515) posterior composite preceded by a Dycal (L D Caulk Co, Milford, DE 19963) liner and bonding resin applied to etched enamel; (2) BISFIL I posterior composite with an application of bonding resin to etched enamel and to etched Ketac-Bond (ESPE-Premier, Norristown, PA 19404) glass-ionomer liner; (3) P-30 (3M Co, St Paul, MN 55144) posterior composite restoration preceded by a Dycal liner and an application of Scotchbond (3M Co) to all internal surfaces of the preparation and to etched enamel, and (4) Dispersalloy (Johnson & Johnson Co, East Windsor, NJ 08520) dental amalgam which was preceded by two thin applications of Copalite (H J Bosworth Co, Skokie, IL 60076) cavity varnish. When used as a liner under composites, Dycal was applied in a thin, uniform layer to the pulpal floor and axial wall(s) of the preparation. With any of the systems, Dycal was also used in deep areas of the preparation. The glass-ionomer liner was applied principally to the pulpal and axial surfaces of the preparation and to a portion of the buccal and lingual walls as well. A 15-second application of Durelon liquid (ESPE-Premier) to the dentin preceded placement of the glass-ionomer liner. A 37% phosphoric acid gel was used for a 60-second etch of the cavosurface enamel and the glass-ionomer liner. The etchant was carefully applied to enamel with a syringe system (The S S White Company, Holmdel, NJ 07733). A thin layer of bonding resin was applied to the etched surfaces with a fine-tipped brush, and a stream of air was used to thin the material further.

Teeth were tested for sensitivity to biting, cold, and hot stimuli four to eight weeks after insertion of the restoration. Biting sensitivity was assessed by having the patient close with two firm #4 cotton pellets placed in the central area of the restoration. Restorations were individually isolated under a rubber dam retained and sealed with finger pressure rather than with clamps to test for sensitivity to cold and hot stimuli. Ten cc's of ice water and warm water (60 °C) were irrigated onto the isolated tooth using a monojet syringe. The patients were instructed in the rating system prior to testing with descriptions of

Table 1. Rating Criteria in Evaluating Reactions to Biting, Heat, and Cold

0	No sensitivity No discomfort No pain sensation
1	Slight sensitivity Mild discomfort Slightly irritating
2	Moderate sensitivity Uncomfortable Painful but tolerable
3	Severe sensitivity Very uncomfortable Intolerable pain Test terminated

the different levels, as shown in Table 1. The patients were then asked to respond to the three stimuli with hand signs to indicate a response of 0, 1, 2, or 3. In addition to testing the restored teeth, unrestored teeth were also tested to serve as controls. Each restored tooth therefore had a control against which its response could be compared. The control for a given tooth was always in the same arch as the restored tooth and was paired by tooth type, that is, premolar or molar. When possible, the contralateral tooth was chosen for the control if unrestored, otherwise the ipsilateral tooth was used. The treatment effect was expressed as the response of the restored tooth minus the response of the control tooth. In this manner, the data for an individual tooth can be treated as an independent observation since they can be standardized to a certain extent from subject to subject, as the perception of levels of pain differs among subjects. Thus the treatment effect is expressed as a level relative to the control as shown in Table 2. It is possible to express the effect as 0, 1, 2 or as -1 since it is possible for the control occasionally to elicit a more painful response than the restored tooth.

A total of 119 restorations were placed in 27 patients. The distribution of the restorations by treatment and by surfaces is shown in Table 3. Data recorded for each restored tooth were tooth number, treatment, class of preparation, number of surfaces, size of the restoration (conservative, moderate, large), history of sensitivity (categorized by type), and the measured responses to the biting, heat, and cold tests. Data were analyzed using nonparametric statistics. Chi-square tests for association were used for most analyses, and the Friedman two-way analysis by ranks was used to test for differences among treatments where the subject served as the independent observation rather than the individual restoration.

Table 2. Treatment Effect Levels

-1	One level less than control
0	No difference from control
1	One level more than control
2	Two levels more than control

Table 3. Distribution of Restorations by Treatment and Number of Surfaces Involved

Treatment Systems	Surfaces (%) 1	2	3	Total
Dycal/bonding resin/BISFIL	33	57	10	21
Glass-ionomer/bonding resin/BISFIL	23	54	23	26
Dycal/Scotchbond/P-30	37	58	05	38
Copalite/Dispersalloy	41	50	09	34

RESULTS

The subjects were interviewed at the time of testing regarding sensitivity to any of the fillings placed. They were asked to identify the sensitive tooth and to indicate which stimuli were bothersome. Table 4 gives the results of these histories for each treatment. A comparison of the three composite systems versus amalgam is given in Table 5 for tests of biting sensitivity. In order to examine the effect of the class of restoration or number of surfaces restored on biting sensitivity, the three composite systems combined are further analyzed by surface and class of restorations in Table 6. Sensitivity of all four restorations to biting is further delineated by the four treatment groups in Table 7.

Table 4. Postoperative Sensitivity Reported by Subjects (in Percent)

Treatment Systems	None	Bite	Cold	Bite & Cold	Bite Cold & Hot
Dycal/bonding resin/BISFIL	66.7	9.5	14.3	4.8	4.8
Glass-ionomer/bonding resin /BISFIL	61.5	23.1	3.8	3.8	7.7
Dycal/Scotchbond/P-30	81.6	7.9	5.3	2.6	2.6
Copalite/Dispersalloy	91.2	8.8	0.0	0.0	0.0

$\chi^2 = 15.32$ df = 12 p = 0.22

Table 5. Comparison of Biting Sensitivity of Posterior Composites with Amalgam (in Percent)

	Number	0	1	2
Composites	85	81.2	9.4	9.4
Amalgam	34	97.1	2.9	0.0

0 = % of no response
1 = % with response of one level greater than control
2 = % with response of two levels greater than control

$\chi^2 = 5.26$ $df = 2$ $p = 0.07$

Table 6. Biting Sensitivity in the Three Composite Systems (by Size of Restoration)

Chi-Square Test	*P*	χ^2	*df*
One and two surface restoration	0.02	15.16	6
Class 2, two surfaces only	0.10	7.62	4
Class 1 only	0.56	4.86	6

Table 7. Frequency of Biting Sensitivity by Treatment (in Percent)

	Difference from Control		
Treatment	0	1	2
Dycal/bonding resin/BISFIL	90.5	4.8	4.8
Glass-ionomer/bonding resin/BISFIL	65.4	15.4	19.2
Dycal/Scotchbond/P-30	86.8	7.9	5.3
Copalite/Dispersalloy	97.1	2.9	0.0

$\chi^2 = 13.70$ $df = 6$ $p = 0.03$

In order to examine for differences in responses to biting stimuli for the three composite treatments, a chi-square test of each system versus amalgam was conducted, since amalgam produced virtually no sensitivity to biting. The results of these analyses are given in Table 8. The composite system that was significantly different from amalgam for biting sensitivity was the glass-ionomer liner in combination with bonding resin. Results indicate that biting sensitivity is associated with class 2 restorations ($P = 0.10$) and not class 1 restorations ($P = 0.56$). This analysis supports the notion that there is a significant difference in biting sensitivity among the three composite treatments and, based on Tables 7 and 8, it can be concluded that this difference lies with the treatment which utilizes the glass-ionomer liner. The results of the Friedman two-way analysis by ranks are given in Table 9. In this analysis the subject is treated as the independent observation, rather than the individual teeth.

Table 8. Chi-Square Test for Biting Sensitivity– Composite Systems versus Amalgam

Chi-Square Test	*P*	χ^2	*df*
Dycal/bonding resin/BISFIL vs Dispersalloy	0.41	1.80	2
Glass-ionomer/bonding resin/BISFIL vs Dispersalloy	0.00	11.05	2
Dycal/Scotchbond/P-30 vs Dispersalloy	0.25	2.79	2

Table 9. Friedman Two-way Analysis by Ranks for Biting Sensitivity

Treatment	Sum of Ranks	
Dycal/bonding resin/BISFIL	36.5	–
Glass-ionomer/bonding resin/BISFIL	–	45.5
Dycal/Scotchbond/P-30	36.5	39.5
Copalite/Dispersalloy	35.0	35.0
χ^2	0	2.8
P	1.0	0.25
n (subjects)	18	20

The results for tests of cold sensitivity are given for composites as a group and amalgam in Table 10 and for the four individual treatments in Table 11. Both chi-square tests are highly significant, indicating differences in the response of teeth restored with amalgam and teeth restored with composite to cold stimuli. Finally, differences in cold sensitivity between arches are

Table 10. Cold Sensitivity of Posterior Composites Compared with Amalgam (in Percent)

	-1	0	1	2	n
Composites	8.2	60.0	25.9	5.9	85
Amalgam	5.9	26.5	44.1	23.5	34

$\chi^2 = 15.11$ $df = 3$ $p = 0.00$

Table 11. Frequency of Cold Sensitivity for the Four Restorative Treatments

Treatment	Difference from Control			
	-1	0	1	2
Dycal/bonding resin/BISFIL	4.8	57.1	28.6	9.5
Glass-ionomer/bonding resin/BISFIL	3.8	57.7	34.6	3.8
Dycal/Scotchbond/P-30	13.2	63.2	18.4	5.3
Copalite/Dispersalloy	5.9	26.5	44.1	23.5

$\chi^2 = 19.20$ $df = 9$ $p = 0.02$

noted in Table 12. Only the control teeth were utilized in this analysis, so that the effects would not be influenced in any way by restorations. The teeth in the maxillary arch are significantly more sensitive to cold stimuli than the mandibular teeth ($P = 0.06$). A similar analysis was conducted to examine for differences in cold sensitivity for molars and premolars, and no differences were found ($P = 0.62$).

DISCUSSION

Biting Sensitivity

First comparing composites as a group to amalgam, the results from the biting sensitivity test (Table 5) showed posterior composites were more sensitive to biting pressure than amalgam ($P = 0.07$). Of the teeth restored with composite, 18.8% (16 of 85) produced biting sensitivity greater than the controls, compared to 3% for amalgam. Of the composite restorations, 9.4% (8 of 65) demonstrated sensitivity to biting pressure at two rating levels greater than the control, compared to none for amalgam.

Table 12. Differences in Cold Sensitivity between Arches for Control Teeth (in Percent)

	Levels of Sensitivity		
Control Teeth	0	1	2
Maxillary arch	40.6	46.9	12.5
Mandibular arch	68.2	31.8	0.0

$\chi^2 = 5.38$ $df = 2$ $p = 0.06$

In order to determine if biting sensitivity was related to the class or number of surfaces of the restoration, a chi-square test of associations was conducted for these factors (Table 6). There were no differences among composites for class 1 restorations ($P = 0.50$) but there were differences among composite systems for two-surface, class 2 restorations ($P = 0.10$). This substantiates a report by Nelson (1983) that class 2 restorations are the most sensitive to biting stimuli. This may be due to the fact that the interproximal gingival margin is the area most susceptible to microleakage because of the difficulty in finishing this area and in obtaining a good bond to dentin.

During the interview regarding history of postoperative sensitivity (Table 4), 12.9% of the teeth restored with composite were identified as causing biting sensitivity, which is somewhat less than what the tests revealed. The composite system utilizing the glass-ionomer liner was associated with a higher frequency of biting sensitivity (23.1%) compared to the other two composites (9 - 13%). The increased sensitivity with the glass ionomer liner may be due, in part, to etching the liner for sixty seconds which was the recommendation at the time of testing. Since then, much shorter times have been advocated. Another factor that may contribute to the sensitivity is cohesive failure of the liner due to polymerization shrinkage (Feilzer, Davidson, and De Gee, 1986) and due to the application of a single layer rather than increased thickness associated with a glass ionomer base. The information from patient histories correlates well with the results from biting tests for all four treatments (Table 7). The chi-square analysis for biting sensitivity was highly significant, and upon examining the percentages in Table 9 it was evident

that composite restorations with the glass-ionomer liner and bonding resin produced the greatest biting sensitivity and that amalgam produced very little biting sensitivity relative to the composites. Since restorations with Dispersalloy demonstrated virtually no biting sensitivity, the composite systems were compared individually to Dispersalloy (Table 8). Of the three composite systems, only the one using the glass-ionomer liner produced biting sensitivities which were significantly different from amalgam. The *P* values for the other two comparisons were 0.41 for Dycal/bonding resin and 0.25 for the Dycal/Scotchbond system. This indicates a tendency for both systems to be more sensitive to biting than amalgam, but this sensitivity is significantly less than that observed with the glass-ionomer liner.

A Friedman two-way analysis variance by ranks was also conducted to determine if treating the patient as the independent observation would change the results of the chi-square analysis in which the individual restoration is treated as the independent observation. Since the sample size would be very low for ranking all four systems in the same analysis, two separate analyses were conducted as shown in Table 9. The sums of the ranks give an indication of ranking of the three treatments for each analysis. The sums of ranks for the Dycal/resin, Dycal/Scotchbond, and Dispersalloy treatments were nearly equal, and the P value of the test was 1.0, indicating little or no difference between those three treatments for biting sensitivity. In the other comparison, however, there is a difference in sums of ranks with the glass-ionomer liner, bonding resin and BISFIL having the highest sum and amalgam the lowest. Although not highly significant in this analysis (P = 0.25), a trend is evident and is supportive of the conclusions reached with the chi-square analysis that the most sensitive liner to biting stimuli is the glass ionomer. This result is supported by a recent laboratory study (McComb, Eddyanto & Brown, 1986) where etched glass-ionomer liner was associated with a great deal of leakage, and where Scotchbond was shown to provide an effective seal.

Cold Sensitivity

The reactions of restored teeth to cold for composites as a group and for dental amalgam were quite different, as shown in Table 10. Teeth restored with dental amalgam were significantly more sensitive to cold stimuli than composites, but composites nevertheless demonstrated some sensitivity to cold. Over 75% of the teeth restored with amalgam produced responses greater than the control, compared to 32% for the composites. Based on its composition and thermal conductivity, one would expect dental amalgam to be cold-sensitive, and this result adds validity to the test method used. The thermal conductivity of composite is very similar to that of enamel and dentin, and one would expect the response of composites to cold to be similar to the controls. About one-third of the composite restorations, however, demonstrated increased sensitivity to cold compared to controls, and this frequency of sensitivity was greater than that reported for biting tests (18%). It can also be noted from Table 10 that 6% of the amalgams and 8% of the composites registered one level of sensitivity less than the control. Although this result seems contradictory, it is a reflection of the fact that control teeth can be occasionally more sensitive to cold than restored teeth.

Table 11 was utilized to examine differences in responses of the four restorative systems to cold tests. The responses of the Dycal/bonding resin and glass-ionomer/bonding resin systems were very similar, with approximately 37% of each producing more adverse responses to cold than the control. The Dycal/Scotchbond system, however, appeared to be less sensitive to cold, with only 23% of the restorations registering more discomfort than the control. Although there are differences in frequencies for cold tests among composite systems, the chi-square test applied to the three composite systems alone indicated no demonstrable statistical differences among composite systems (P = 0.61). Thus the highly significant result (P = 0.02) noted in Table 11 related chiefly to differences between amalgam and composites as a group.

A clinical observation was made during testing that maxillary teeth appeared to be more cold-sensitive than mandibular teeth. A chi-square analysis was conducted to test for differences of teeth to cold sensitivity by arch and by type (molar and premolar). The result is significant at the level of P = 0.06 for differences by arch, but not significant for differences by type (P = 0.63). Nearly 60% of the control teeth in the maxillary

arch demonstrated slight and moderate sensitivity to cold, compared to 32% for the mandibular teeth. Thus it can be concluded that unrestored maxillary teeth in general were more sensitive to cold than mandibular teeth. Similarly, one can expect a somewhat greater frequency of sensitivity of restored teeth to cold stimuli in the maxillary arch compared to the mandibular arch. This may be due to morphological and/or physiological differences in the teeth or arches.

Heat Sensitivity

Tests for sensitivity to hot stimuli were conducted as descibed in the methods section. Considering the three composite systems as a group, 35% of the restorations demonstrated more discomfort than the controls, compared to 53% for amalgam. As would be expected, amalgam appeared to be more sensitive to hot stimuli than composites. Amalgam was less sensitive to heat than cold, which was consistent with the clinical impressions of the examiners. When subjected to the chi-square test, differences between composite and amalgam to heat tests were not highly significant (P = 0.18), but the P value does confirm the trend noted above.

Treatment of Severe Postoperative Sensitivity

Three patients reported and recorded severe sensitivity (level 3) of a restored tooth to biting and cold stimuli. Each of these three teeth was restored with a two-surface, class 2, posterior composite with each composite treatment being represented. One possible cause given for postoperative sensitivity is cusp distortion and crazing due to shrinkage of the bonded resin during polymerization. In an attempt to treat the sensitivity, a narrow groove was placed in the proximal box and occlusal portion of the preparation without opening the contact. The cusps were pried apart slightly with a hand instrument and the groove was filled incrementally with the same posterior composite. The subject was brought back for sensitivity testing one week after retreatment to assess the effectiveness of the use of a groove. There were no changes in the degree of sensitivity of these three teeth; all three teeth produced the same scores after retreatment. Although the sample size is too low (n = 3) to make definitive statements about the effectiveness of this form of retreatment, these results are in opposition to those noted by Jensen and Chan (1985), since in this present study groove placement with cusp separation was ineffective in dealing with severe postoperative pain. This brings into question cusp distortion as a potential cause of postoperative sensitivity.

Patients were seen at one year following placement of restorations, and histories of sensitivity to biting, heat, and cold were again recorded. No patients gave histories of having any sensitivity, thus the sensitivity noted shortly after insertion was resolved over a period of a year. This clearly demonstrates that the symptoms of sensitivity are resolved over time and would indicate that if microleakage was the original cause of sensitivity, this is no longer a factor. If the intial sensitivity was related to a pulpitis, this condition would have been reversed as well. Two of three patients with severe sensitivity, noted above, had the composite restoration replaced with amalgam. The sensitivity to biting was immediately resolved with this treatment. The remaining patient elected not to have the composite replaced, and after one year she, too, reported no sensitivity.

CONCLUSIONS

The purpose of this research was to clinically evaluate the effectiveness of three different treatments of dentin in reducing post-operative sensitivity of posterior teeth restored with composite, and to compare the results to that of amalgam.

The posterior composite restorations were, in general, more sensitive to biting than the controls or amalgam. Approximately 19% of the composites demonstrated some sensitivity to biting, compared to only 3% for amalgam. Of the three composite systems, the one which produced the most sensitivity to biting was the treatment which utilized an etched glass ionomer in combination with a bonding resin. The sensitivity may have been the result of a 60-second etch of the glass-ionomer liner. Teeth restored with both amalgam and composite were more sensitive to cold tests than the controls. As would be expected, teeth restored with dental amalgam were much more sensitive to cold

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Clinical Evaluation and Early Finishing of Glass Ionomer Restorative Materials

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Summary

A new generation of glass-ionomer cements has been introduced with the claim that finishing can be accomplished 15 minutes after placement. Thirty patients with at least four cervical erosion/abrasion lesions participated. Of the four lesions, one was restored with Chelon, one with Cervident, one with Ketac-Fil finished in 15 minutes, and one with Ketac-Fil finished in 24 hours after placement. Six criteria--retention, anatomical form, staining, marginal discoloration, marginal adaptation, and surface roughness--were evaluated after six months, one year, two years, and three years. No significant differences were found between any of the criteria in the Ketac-Fil restorations after three years. Glass ionomers exhibited 90% Alpha ratings and Cervident presented 50% Alpha ratings in retention at the final examination.

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INTRODUCTION

A dental restorative material capable of forming an adhesive bond with dentin would have many practical applications in clinical dentistry. Such a system would improve the treatment of cervical erosion lesions, root caries, and other conditions by eliminating the need for mechanical retention by way of a cavity preparation. Buonocore (1955) introduced a method for increasing the bond strength of composite resins by acid etching of the enamel. However, the willful etching of dentin has not been an accepted technique in the United States because of the different structure of dentin as well as the potential harm to pulpal tissues that may result, according to Buonocore (1975), Brännström and Nordenvall (1977), and Stanley, Going, and Chauncey (1975).

The clinical success of adhesively bonding restorative materials to dentin has been reported with the glass-ionomer cements by Mount (1981), and with an NPG-GMA resin by Flynn

stimuli than those restored with composite. Of the teeth with amalgam restorations, 78% were more sensitive to cold than the controls, compared to 32% for teeth restored with composite.

There were no differences between molars and premolars in their response to cold stimuli, but there were differences between arches in the response of control teeth to cold. The unrestored molars and premolars in the maxillary arch were significantly more sensitive to cold than the mandibular teeth; 59% of the maxillary control teeth demonstrated slight to moderate sensitivity to cold stimuli, compared to 32% for the mandibular teeth.

Cusp distortion arising from polymerization shrinkage of the composite did not appear to contribute to postoperative sensitivity. Problems of sensitivity were resolved over the course of a year, leading to the conclusion that microleakage was no longer a factor in causing sensitivity and/or the pulp was no longer affected by the operating procedures or materials.

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(1979). These tooth-colored restorative materials have been shown to be effective in the treatment of class 3 and class 5 restorations. The bond strengths of glass-ionomer cements to dentin have been found by Hotz and others (1977) and Coury and others (1982) to surpass the cohesive strength of the material itself. However, certain disadvantages have been noted concerning the clinical use of this type of cement. Esthetics is somewhat compromised by a lack of translucency, and the current materials have low tensile and shear strengths as reported by Powis and others (1982) and Maldonado, Swartz, and Phillips (1978). Also, a second appointment has been required for final finishing, according to McLean and Wilson (1977), as the setting reaction is prolonged and the material has insufficient resistance to either hydration and/or dehydration. With the composite resins, however, the esthetics is improved and the setting reaction is relatively rapid.

In 1981, a glass-ionomer restorative material, Ketac-Fil, was introduced and reported by ESPE (Fasbrik Pharmazeutischer, Oberbay, W Germany) to have a more rapid setting reaction than previous formulations.

The manufacturer suggested that the material could be finished to its final form 15 minutes after placement. The purpose of this investigation was to evaluate the clinical performance of three materials used for restoring dental cervical abrasion/erosion lesions over a three-year period and to examine the influence of immediate finishing (15 minutes) versus delayed finishing (at least 24 hours) of the glass-ionomer cement. The following six properties were evaluated: (1) retention, (2) anatomical form, (3) staining, (4) marginal discoloration, (5) marginal adaptation, and (6) surface roughness.

METHODS AND MATERIALS

Thirty adult patients, each with at least four cervical erosion/abrasion lesions, participated in the study. The three restorative materials used were: (1) Ketac-Fil (ESPE), a precapsulated Type II glass-ionomer material; (2) Chelon (ESPE), a powder/liquid Type II glass ionomer from the same manufacturer; and (3) Cervident (S S White Dental Products, King of Prussia, PA 19406). The placement of all restorative materials was accomplished under a rubber dam. The selection of the material for the various lesions was by computer randomization. The treatment of each tooth was completed before the placement of the next restoration was started. When necessary, only topical anesthesia was used for retainer clamp placement for the comfort of the patients. There was no removal of tooth structure for retention points with any of the materials.

The lesions were scrubbed lightly with a fine pumice and water slurry using a rubber cup. The pumice was thoroughly washed off with a water rinse and the teeth were dried. All lesions restored with glass-ionomer cement were further cleaned for 15 seconds with 25% polyacrylic acid on a cotton pellet. After rinsing, a cervical matrix form (Premier Dental Products, Morristown, PA 19401) was glued onto the end of an amalgam condenser which had been smoothed at one end. The matrix was adapted to the margins of the lesion with a wax spatula. An index mark was placed on the tooth and matrix for rapid and accurate future replacement of the matrix. Mixing and placement of the cements were done according to manufacturers' instructions. The Ketac-Fil capsules were activated and placed in a Vari-Mix II triturator (Kerr Mfg, Romulus, MI 48174) at H-1 setting for 10 seconds. The H-1 setting was precalibrated to triturate at 4000 cycles per minute. After mixing, the material was quickly placed into the lesion and covered by the contoured matrix. The Chelon was mixed by hand to the same consistency as the Ketac-Fil, placed into the lesion, and the matrix placed. After three minutes, the condenser was twisted from the matrix and the restoration allowed to set for an additional 12 minutes. The initial finishing, after 15 minutes, was accomplished using a Bard Parker blade handle with a #12 scalpel to remove gross flash.

Since ESPE recommends early finishing, the Chelon restoration and one of the Ketac-Fil restorations were final-finished 15 minutes after placement, using Sof-Lex disks (3M Dental Products, St Paul, MN 15544) in a slow-speed handpiece with water. The final finishing of the other Ketac-Fil restoration was delayed for at least 24 hours, as is specified by other glass ionomer manufacturers, and was accomplished under a rubber dam where access to the margin was difficult to obtain. All glass-ionomer restorations were varnished before the patient was dismissed. The enamel surrounding the lesions restored with Cervident was etched with 50%

Table 1. Criteria for Clinical Evaluation

RETENTION

Alpha - Complete retention
Bravo - Partial retention
Charlie - Complete loss

ANATOMICAL FORM

Alpha - The general contour of the restoration follows the overall contour of the tooth.
Bravo - The general contour of the restoration does not follow the overall contour of the tooth.

STAINING

Alpha - No stain on the restoration, or the stain is equal on both the tooth and the restoration.
Bravo - More stain on the restoration than on the surrounding tooth structure

MARGINAL DISCOLORATION

Alpha - No discoloration between restoration and tooth
Bravo - Discoloration on less than half of the circumferential margin
Charlie - Discoloration on more than half of the circumferential margin

MARGINAL ADAPTION

Alpha - An explorer does not catch, or exhibits only a one-way catch, when drawn across the restoration-tooth interface.
Bravo - An explorer exhibits a two-way catch, indicating a crevice, when drawn across the restoration-tooth interface.

SURFACE ROUGHNESS

Alpha - The body of the restoration does not have any surface defects.
Bravo - The body of the restoration has minimal defects.
Charlie - The body of the restoration has severe surface defects.

phosphoric acid for one minute and rinsed. After the lesion was dried, a coat of the manufacturer's "adhesive promoter" was applied. The powder/liquid was mixed to proper consistency and placed into the lesion. The mixture flowed into the lesion, leaving a smooth feather-edge at all cavosurface margins. After five minutes of polymerization, Sof-Lex disks were used to contour the restoration wherever necessary. All of this work was performed according to the manufacturer's recommendations.

VALUATIONS

Two faculty members of the Department of Operative Dentistry at the Indiana University School of Dentistry experienced in clinical research served as evaluators for this double-blind study. The criteria for each of the six characteristics evaluated are listed in Table 1.

Each evaluator was provided a chairside recorder. The evaluators independently determined each rating. A consensus was required

for any discrepancy between the examiners. Interexaminer agreement is shown in Table 2.

Baseline examinations were made two weeks after placement to avoid any dehydration of the restorations before that time. Only one patient failed to return for the six-month and one-year examinations; however, she was present for the two- and three-year examinations.

RESULTS

Retention

Clinical results in Figure 1 show that the restoration of the glass-ionomer materials was significantly better than the composite resin. After three years, 87% of the Ketac-Fil finished at 15 minutes, 90% of the Chelon, 90% of the Ketac-Fil finished at 24 hours, and 47% of the Cervident restorations were completely retained. This characteristic is of principal importance as complete loss of the restoration obviously makes it impossible to measure any other parameter (Table 3).

Anatomical form

The percentage of Alpha rating at examination after three years of Ketac-Fil finished at 15 minutes was 96%; Chelon, 89%, Ketac-Fil finished at 24 hours, 100%, and Cervident, 93% (Fig 2).

Staining

At the three-year examination, all four types of restorations had 100% Alpha ratings for this characteristic (Fig 3).

Table 2. Interexaminer Correlation

Examination	Interexaminer Correlation %
Baseline	76
Six months	78
One year	82
Two years	89
Three years	85

Marginal discoloration

The percentage of Alpha ratings reported at the three-year point for Ketac-Fil finished at 15 minutes was 74%; for Chelon, 79%; Ketac-Fil finished at 24 hours, 79%; and Cervident, 87% (Fig 4).

Marginal adaptation

The percentage of Alpha ratings reported at the three-year point for Ketac-Fil finished at 15 minutes was 85%; Chelon, 71%; Ketac-Fil finished at 24 hours, 86%; and Cervident, 80% (Fig 5).

Surface roughness

The entire surface of each restoration was initially smooth; however, after contouring to the final finishing stage, some surface roughness (minor pitting) was noted in many of the restorations. At the end of three years, Alpha ratings were Ketac-Fil (15 min), 44%; Chelon, 43%; Ketac-Fil (24 hours), 41%; and Cervident, 67%.

Table 3. Percentage of Restorations Retained for Evaluation at Various Examinations

	Sample Size Patients	Restorations Evaluated					
		Ketac-Fil (15 min)		Chelan		Ketac-Fil (24 hours)		Cervident	
		%	n	%	n	%	n	%	n
Baseline	30	100	(30)	100	(30)	100	(30)	97	(29)
Six months	29	100	(29)	97	(28)	100	(29)	76	(22)
One year	29	100	(29)	97	(28)	100	(29)	69	(20)
Two years	30	90	(27)	93	(28)	97	(29)	50	(15)
Three years	30	90	(27)	93	(28)	97	(29)	50	(15)

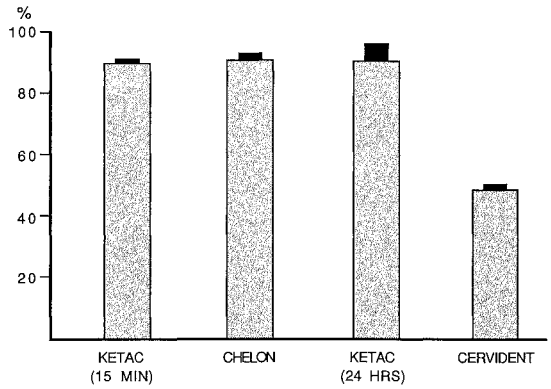

FIG 1. *Alpha rating (shaded bars) and Bravo rating (solid bars) for retention at three years*

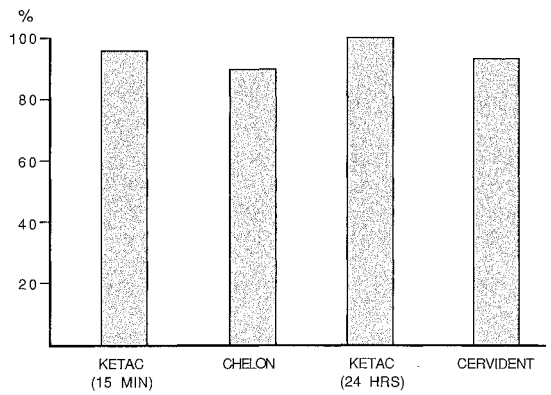

FIG 2. *Alpha rating for anatomical form at three years*

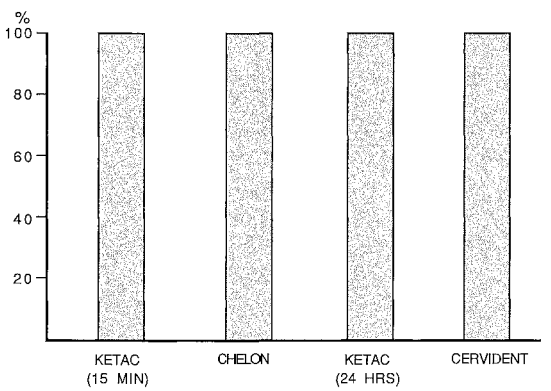

FIG 3. *Alpha rating for staining at three years*

Only Chelon had 3% Charlie ratings for surface roughness (Fig 6).

DISCUSSION

Retention is an essential property for any restoration. Mount (1981) reported placing over 2100 glass-ionomer restorations in vivo over a six-year period. Over 1283 restorations were rechecked with a 93% retention rate. His observations are similar to the three-year data collected from this study. Flynn (1979) reported 77% and Jendresen (1978) 62% retention of Cervident three years after placement. Reisbick, Sellers, and Shutte (1978) reported 73% retention after one year, and Harris, Phillips, and

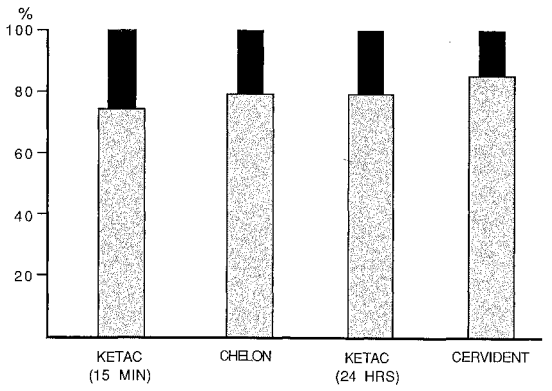

FIG 4. *Alpha rating (hollow bars) and Bravo rating (solid bars) for marginal discoloration at three years*

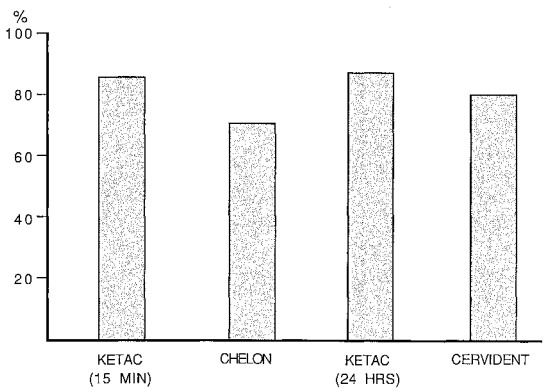

FIG 5. *Alpha rating for marginal adaptation at three years*

Swartz (1974) noted 50% retention after six months with Cervident. In this study only 50% of the Cervident restorations were present at three years. The retention of Cervident in relation to the glass-ionomer restorations is statistically different at the 0.05 level of confidence at the end of three years, using the Multigroup Generalized Wilcoxon Test.

Early final finishing of Ketac-Fil does not appear to negatively affect any of the six parameters evaluated. The evaluations of anatomic form, staining, and marginal adaptation of the glass ionomer and the composite resin restorative material reported in this study compare favorably with a study by Timmons, Laswell, and Robinson (1983) of eight composite resins.

Krauser (1986) reviewed hypersensitive teeth and suggested that glass-ionomer cement appears promising as a restorative material in terms of decreasing sensitivity. Shortly after placement of the glass-ionomer restorative materials, a questionnaire was completed by the 30 patients involved in this study. All patients had moderate to severe abrasion/erosion lesions. All of the patients who experienced sensitivity before the procedure were free of hypersensitivity immediately following the placement of the restorations (Table 4). Although three patients developed sensitivity, it was gone within one week for two of the three patients, suggesting that the sensitivity was probably due to irritation from the isolation and finishing of the restoration and not from the material itself. Within two weeks, sensitivity to cold returned to two of the nine patients.

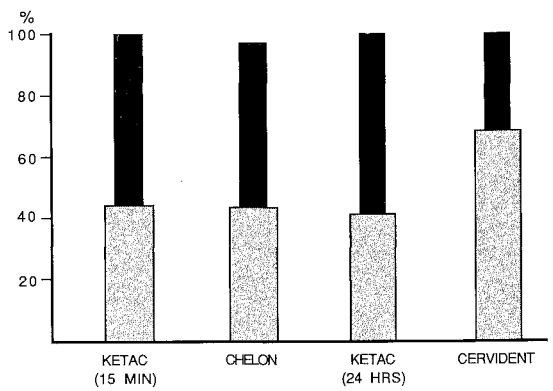

FIG 6. *Alpha rating (shaded bars) and Bravo rating (solid bars) for surface roughness at three years*

Table 4. Dentinal Hypersensitivity after Treatment in 30 Patients with Moderate to Severe Erosion/Abrasion

Reported by Patient	Immediately		Two-Weeks	
	n	%	n	%
Not present before/not present after	18	60	20	67
Present before/not present after	9	30	7	23
Not present before/present after	3	10	1	3
Present before/present after	0	--	2	7

CONCLUSIONS

The three-year data indicate that glass-ionomer cement restorations are outstanding in their retentive property. The established chemical adhesion of this system has again been substantiated in vivo. Based upon the results of this study, the glass-ionomer cements used here offer an improved alternative to the composite resin used when no tooth preparation is desirable. The final finishing of Ketac-Fil can be accomplished 15 minutes after placement without negative sequelae.

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LITERATURE REVIEW

Local Anesthesia in 1988: Review and Update

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Summary

An earlier version of this paper was presented at the 1987 Annual Meeting of the Academy of Operative Dentistry. Recent changes in dosage recommendations for local anesthetics, along with new information on local anesthetic-medical drug interactions, necessitate a review of the pharmacology of local anesthesia at this time.

Introduction

The performance of excellent tooth preparation in operative dentistry and patient tolerance of most dental procedures is dependent upon our ability to reliably produce local anesthesia. For that reason, as well as because we are now treating a generally older patient population which is being treated with an ever increasing number of sophisticated drugs, it is important to review recent developments in local anesthesia. This paper will briefly review four areas--medical complications, drug interactions, new agents which may eventually become available in the United States, and, finally, the problem of failures of local anesthesia.

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Medical Complications

Patients being treated for most medical conditions should not be treated by a dentist until a medical consultation is obtained. In many cases, patients are not familiar with the medications they are taking and may not provide the dentist with an accurate picture of the nature and severity of their problem. Furthermore, if measurement of vital signs or the patient's medical history suggest the presence of a medical disorder, the patient should be referred to a physician. The results of a medical consultation should be documented in the patient's chart. A dentist cannot legally change the medical treatment of a patient nor can a dentist use a drug when the physician has ordered against it. This is most frequently a problem with vasoconstrictors in cardiovascular patients, and, unfortunately, we sacrifice depth and duration of local anesthesia when using agents that do not contain a vasoconstrictor. If the physician understands the very small quantities of vasoconstrictor used in dentistry and the risks of endogenous release of epinephrine from the patient's adrenal gland under conditions of stress (pain) and still prohibits the use of a vasoconstrictor, the dentist may select plain 3% mepivacaine, which produces pulpal anesthesia lasting 20 minutes when infiltrated and 40 minutes for nerve block, or 4% prilocaine plain, which produces 10 minutes of pulpal anesthesia when infiltrated but which also produces up to 60 minutes of pulpal anesthesia in block injections. If the physician allows the use of a vasoconstrictor, the following maximum dosages (in adults) should be observed for

cardiovascular patients (Malamed, 1986): epinephrine: 0.04 mg per appointment, levonordefrin: 1.0 mg per appointment, or norepinephrine: 0.14 mg per appointment. It should be noted that this maximum dose of epinephrine per appointment corresponds to one cartridge with 1:50,000 epinephrine, two cartridges with 1:100,000, and four cartridges with 1:200,000 epinephrine.

Table 1 summarizes other medical conditions which may contraindicate dental local anesthesia.

In addition to patients with medical problems who must be treated with certain precautions, there are six categories of patients who should not receive any dental treatment until their medical problems have been resolved (Ma-

Table 1. Medical Contraindications for Local Anesthetics (modified after Malamed, 1986)

Medical Problem	Drugs to Avoid	Type of Contraindication	Alternate Drug
Pulmonary disease	Prilocaine	Relative*	Another amide
Anemia	Prilocaine	Relative*	Another amide
Cardiovascular disease	High concentractions of vasoconstrictors	Relative*	See text
Hyperthyroidism	High concentrations of vasconstrictors	Relative*	See test for cardiovascular disease
Malignant hyperthermia	Amides	Absolute**	Esters
Atypical plasma cholinesterase	Esters	Relative*	Amides
Liver disease	Amides	Relative*	Ester or reduced dosage of amide after consult
Kidney disease	Amides and esters	Relative*	Reduced dosages of esters or amides after consult
Allergy	Other agents in same chemical class	Absolute**	Agent in another chemical class (ester or amide) deemed acceptable after intracutaneous allergy testing or 1% diphenhydramine with 1:100,000 epinepherine, or General anesthesia

*Relative contraindication: drug can be used at reduced dosages with precautions taken

**Absolute contraindication: drug cannot be administered under any conditions

lamed, 1986). They are patients with:

1. Unstable angina pectoris (anginal pain worsening and/or increased amounts of medication required for relief),
2. Recent myocardial infarction (six months or less since attack),
3. Uncontrolled cardiac arrhythmias,
4. Uncontrolled congestive heart failure,
5. Uncontrolled hyperthyroidism, or
6. Uncontrolled hypertension (diastolic pressure greater than 115 mm Hg and/or systolic pressure greater than 160 mm Hg).

Medical problems can interfere with aspects of dental treatment other than local anesthesia, and the reader is referred to an appropriate textbook for a detailed description of these considerations (Little & Falace, 1984).

Drug Interactions

Attention was drawn to the potential for drug interactions involving local anesthetics when, in 1983, Foster and Aston reported that the administration of relatively small quantities of lidocaine/epinephrine solutions to patients who were taking propranolol (Inderal, Ayerst Laboratories, New York, NY 10017) resulted in severe hypertension with bradycardia and even cardiac arrest. Although quantities of local anesthetics used in some of these cases exceeded those that would ordinarily be required in operative dentistry, in one case, 13 ml of 0.5% lidocaine with 1:200,000 epinephrine was injected and in another, 8 ml of the same preparation was used, both of which resulted in cardiac arrest. In this interaction, epinephrine apparently causes an elevation of blood pressure through its effects on alpha receptors, which, through a reflex mechanism, induces a vagal slowing of the heart. In patients taking beta blockers, the stimulatory (beta) drive to the heart is already reduced, which results in an exaggeration of the reflex vagal slowing.

Another widely prescribed drug, cimetidine

Table 2. Drug Interactions with Local Anesthetics (from Gangarosa, Cilone, & Jeske, 1983)

Local Anesthetic	Second Drug	Potential Effect of Concurrent Administration
Lidocaine and other amides, procaine and other esters	Narcotic analgesics, antihistamines, benzodiazepines, barbituates, phenothiazines, nitrous oxide, general anesthetics, alcohol	Enhancement of central and cardiorespiratory depression
Lidocaine and other amides	Cimetidine, propranolol	Enhancement of local anesthetic toxicity by reduced hepatic metabolism
Bupivacaine	Verapamil	Bradycardia and hypotension
Procaine and other esters	Sulfonamides	Reduced effectiveness of antibiotic by metabolite of the ester (p-amino benzoic acid)
Procaine and other esters	Succinylcholine	Apnea (paralysis of respiratory muscles)
Procaine and other esters	Echothiophate	Enhancement of local anesthetic toxicity by decreased plasma metabolism

(Tagamet, Smith Kline & French Laboratories, Philadelphia, PA 19101), can reduce the capacity of the liver to metabolize amide local anesthetics. Other antihistamines used to treat ulcers (ranitidine and famotidine) apparently lack this side effect. In patients taking cimetidine, the maximum dosage of amide local anesthetics given in an appointment should be reduced by one-half. Other drug interactions involving local anesthetics are summarized in Table 2, and those specifically related to vasoconstrictors are listed in Table 3.

New Agents

There are two drugs in clinical use outside the US which deserve the consideration of the American dental profession. The first of these is an amide-type local anesthetic, articaine (Ultraine D-S and Ultracaine D-S Forte). Articaine is chemically unique in that it contains a thiophene (sulfated, five-member) ring instead of the benzene ring typical of most other amides. Apparently, the thiophene ring confers an exceptional degree of diffusibility on the drug, which accounts for the observation and the manufacturer's claim that facial infiltration over mandibular and maxillary premolars provides sufficient lingual and palatal anesthesia, respectively, so that extraction of these teeth can be accomplished without lingual or palatal nerve blocks. There are two studies which support this claim (Kirsch, 1985; Schulze-Husmann, 1974). The drug has been in use since the late 1970s in Europe and since 1983 in Canada and is marketed with 1:100,000 or 1:200,000 epinephrine. This drug should not be confused with the multidose vial of lidocaine marketed by Ulmer Pharmacal Company (Minneapolis, MN 55441) or with the benzocaine topical ointment sold here by Ultradent (Salt Lake City, UT 84124), both of which carry the tradename "Ultracaine."

Table 3. Drug Interactions with Vasoconstrictors (from Gangarosa & others, 1983)*

Vasoconstrictor	Second Drug	Potential Effect of Concurrent Administration
Epinephrine, Norepinephrine	Tricyclic antidepressants, monoamine oxidase inhibitors, guanethidine, methyldopa, reserpine	Elevated blood pressure
Epinephrine	Propranolol and other beta blockers	Elevated blood pressure, bradycardia, possible cardiac standstill
Epinephrine	Phenoxybenzamine, prazosin, phentolamine, chlorpromazine, thioridazine	Decreased blood pressure
Epinephrine	Oral antidiabetics and insulin	Hyperglycemia
Epinephrine	Halogenated general anesthetics, cardiac glycosides, thyroid supplements	Cardiac arrhythmias

*There are few clinical reports of interactions involving levonordefrin (Neo-Cobefrin, Cook-Waite Laboratories, Inc, New York, NY 10016). However, since the drug is pharmacologically similar to epinephrine, the same potential for interactions should be considered.

Another interesting drug in wide dental use outside the US is the vasoconstrictor felypressin (Octapressin, Astra Pharmaceutical Products, Inc, Westborough, MA 01581). This is a noncatecholamine, octapeptide that is structurally similar to the hormone vasopressin (antidiuretic hormone). It has no affinity for alpha or beta adrenergic receptors, and so exerts no direct actions on the heart and can be safely used in patients with cardiovascular disease and in patients with hyperthyroidism. Felypressin produces blood flow by constricting veins instead of arteries, and as such is not useful for producing hemostasis. It should not be administered to pregnant patients, since it has an oxytocic action and may cause contraction of the pregnant uterus.

Failures of Local Anesthesia

Failures of local anesthesia are the fault of the operator in two situations--incorrect needle placement technique and failure to administer an adequate volume of anesthetic solution. In the first case, the operator may deviate from standard technique by improper alignment or assessment of anatomic landmarks, or may use a needle that is too short for the injection. For example, a common anatomic variation is flare of the mandibular ramus, which generally requires a more posterior position of the barrel of the syringe on the contralateral side. Many operators will penetrate to a standard depth and from a conventional approach and, without having palpated the medial surface of the ramus, will deposit the local anesthetic in too medial an area. With regard to the volume of anesthetic required, nerve block injections require at least 1.0 ml of local anesthetic solution to cover a length of nerve sufficient to block impulse conduction. This is due to the fact that at least three internodal distances (a total of about 6 mm) of a myelinated nerve must be affected to interrupt nerve transmission (Rood, 1977). When the operator is in doubt as to the correct needle placement technique or volume of anesthetic required, he or she should consult a standard local anesthesia text (Malamed, 1986).

In 1972, Frommer, Mele, and Monroe demonstrated the presence of sensory nerve fibers in the mylohyoid nerve, the number of which decreased as the nerve proceeded distally along the mylohyoid groove. This study, when considered in conjunction with other studies demonstrating the presence of foramina on the lingual aspect of the mandible (Shiller & Wiswell, 1954; Chapnick, 1980), clearly indicates a role of the mylohyoid nerve in anesthetic failures in both anterior and posterior areas of the mandible. If the mylohyoid nerve is suspected of providing supplementary innervation to the mandibular teeth, the operator can infiltrate 0.6 ml of local anesthetic just below the apex of the tooth in question on the lingual side of the mandible at the junction of the attached gingiva and the floor of the mouth. Injections should never be administered into the floor of the mouth. The periodontal ligament injection and the Gow-Gates mandibular nerve block may also be effective in blocking mylohyoid innervation of the mandibular teeth.

In the mandibular anterior region, crossover innervation may result in a failure of the conventional inferior alveolar nerve block to adequately anesthetize the teeth. Rood (1977) has suggested that the contralateral mental nerve may cross the midline and penetrate the facial plate of bone. In this case, infiltration of local anesthetic on the facial aspect of a lower anterior tooth may achieve adequate anesthesia, even when symptoms (e g, numb lip) have demonstrated a successful inferior alveolar/mental nerve block on the operative side.

Inflammation is still another biological factor that can preclude dental local anesthesia in both the mandible and the maxilla. At least two studies (Brown, 1981; Najjar, 1977) in the dental literature have shown that inflammation and/or infection and the metabolites associated with these processes can render the nerve resistant to the effects of local anesthetic drugs through structural and biochemical changes of a degenerative nature. Increasing the concentration of local anesthetic appears to aid in overcoming this resistance to local anesthesia, and one study (Rood & Sowray, 1980) successfully used 5% lidocaine with 1:80,000 epinephrine in such cases. Since 5% lidocaine is neither available nor approved in the US, the author has used 4% prilocaine solutions (Citanest Forte, Astra Pharmaceutical Products, Inc, Westborough, MA 01581) in cases of suspected inflamed nerves with some success.

Finally, needle deflection can contribute to the failure of nerve block injections. In 1984, Robison and others showed that larger needles (25-

gauge) deflect significantly less than smaller gauge needles and can therefore produce a higher percentage of successful block injections with a greater resistance to breakage and a greater chance of aspiration ability. Even 25-gauge needles can deflect several millimeters when fully inserted (Jeske & Boshart, 1985). While there is no way to accurately predict the degree or direction of needle deflection due to variations in the patient's tissues, larger gauge needles offer the greatest resistance to deviation, and there is no scientific basis for the commonly held belief that 25-gauge needles cause more discomfort than smaller needles when topical anesthetic is employed (Hamburg, 1972).

Conclusion

With the development of new drugs for the medical treatment of an older patient population, the dentist must be aware of the medical complications and drug interactions which impact upon his/her selection and use of local anesthetics and vasoconstrictors. The continued safe use of local anesthetics in dentistry will depend on our continual review of pharmacology. While scientific studies have not provided solutions to all of the problems encountered in the administration of local anesthetics, they have shed a great deal of light on the areas of supplementary innervation and the role of inflammation in failures of local anesthesia. The use of techniques described above may assist the dentist in obtaining more profound local anesthesia, with the result of greater patient comfort and better cavity preparation.

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POINT OF VIEW

The Future of Restorative Dentistry

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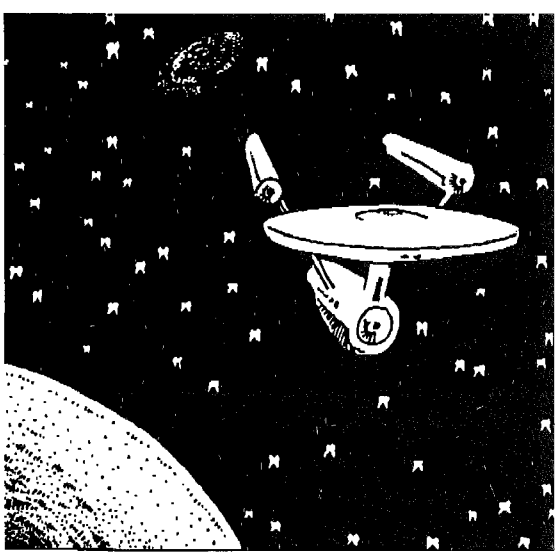
INTRODUCTION

I have seen the future--for it is now. Whether we want to recognize it or not, we all have seen the future, for we are in the middle of a significant, slow evolution in dentistry with sufficient foreshadowing for all to recognize the movements of future trends. It is an evolution and not a revolution. Some evolutionary changes, though slow, can be traumatic.



The practice of dentistry, particularly in restorative areas, is situated in an interface between science and technology on one side and people-oriented service on the other. Restorative dentistry is not unique in this position, caught in the traumatic shearing forces of two massive, solid movements, both moving at different rates. We are thus among those squeezed by these forces so aptly described by Alvin Toffler in his book, *Future Shock.* Technology is forcing changes at an ever-increasing rate, but we dentists and the patients we serve have difficulty coming to grips with such currents of change. Therefore, we cling to tradition as did Tevye in *Fiddler on the Roof.* He shouted tradition vehemently as the source of his survival, and later lugubriously as he recognized that tradition offered only the appearance of security in a changing world. We today stand as Tevye described, fiddlers tenuously perched on the roof playing our songs and being buffeted by the changes that science and technology are blowing our way. From such a perch we can see which way the future blows, weigh what traditions give us anchor from being blown away, and develop the insight to climb further onto taller and better constructed buildings.

THE FACTORS OF CHANGE

Restorative dentistry hasn't always responded quickly to changes in technology. In the early 1800s, dentistry developed the use of silver

amalgam as a filling material. The technology was available for 300 years. The hold-up was due to the patient population who hadn't accepted the concept of filling teeth and saving them and the dentist who wouldn't consider such changes in the tradition of dental "surgery." Many of the first purveyors of the technique were charlatans such as the Crawcour brothers, who profited greatly by riding the force of this new wind of change. In the early 1900s, dentistry developed the lost-wax technique to make cast restorations for the dentition. This wasn't exactly a revolution in technology. It had been around since Benvenuto Cellini used such techniques in art in the 1500s. The motivation for its promulgation in dentistry was profit, as Taggart attempted to patent the technique. A profit motive was considered an affront to health care, and dentistry resisted the effort by breaking the patent application.

Dentistry has always found some difficulty dealing with new technology and its applications to health care service. The establishment of the Council on Dental Materials, Instruments, and Equipment of the American Dental Association was in response to a need to establish norms for materials used in dental health care. The International Standards Organization is attempting the same effort at the international level. There are now pressures to establish government regulations in the same area, which means that those organizations setting the specifications will have to become an integral part of the governmental regulatory mechanism.

The results will have an impact on the availability, cost of, and responsibility for the use of new materials and applications in restorative dentistry. These regulatory mechanisms will slow the introduction of new technology to health care but, optimally, in the interests of the safety of the patient and of health care personnel.

Alloy Systems

There is no need to worry about a future slowing of new technology application, for we are already inundated with technological marvels and technological muddles. Metals have been the mainstay of dental practice. Amalgam has been the "bread and butter" of the general practitioner for many years, and the alloy is still being altered to improve it. Today new alloy systems are being created and applied in dentistry. The gold barrier has been broken. Gold castings will probably still serve as the standard to which all new metal castings will be compared, but new alloys will have an impact on the responsibilities of the practitioner. Copper aluminum alloys have been used abundantly in South America, but are just being reintroduced into North America. They preserve the appearance of the gold alloys, and serve as less expensive alternatives to metal cast restorations. Caution will be required in regard to potential allergic reactions to this alloy which may release more of its constituents due to corrosion processes. The use of titanium alloys in restorative application is also under experiment. Titanium is the latest of the dental implant phenomena. It has proven to be part of a successful dental procedure in restoring the health of an entire arch. The superstructure to be built upon the osseointegrated fixtures should ideally be supported by a titanium alloy. When the technology for casting such structures is perfected, the use of titanium in any cast restoration to achieve biological compatibility will be readily apparent. The development of porcelain esthetic facings for bonding to the alloy is being pursued in Japan right now.

It will be even more incumbent upon the practicing dentist to be specific as to the type of alloy to be used by the laboratory technician. The

dentist can no longer say, "Make me a crown," but will have to specify high-gold content, 50% gold, nickel-chromium, copper-aluminum, titanium, or any of the other alloys that have not as yet achieved the respective reputations of those mentioned, but are being developed in high-tech industries.The restorative dentist will have to know more about the material he or she is using, its physical properties to withstand the oral environment, and its biological impact on the human system. Either the dentist will have to recognize this responsibility or the laboratory technician will be elevated to the level of an independent health care provider as the one who can best prescribe the alloy system that fits the needs of the patients.

The extensive success of the commercially pure titanium and the titanium alloy systems for integration into basal bone as a dental implant opens a whole new world of restorative procedures. The restorative dentist will have to evolve criteria for successful design from a melding of the current concepts of design in both removable and fixed prosthodontics. The restorative dentist will have to work more closely with the oral surgeon in order to achieve optimum placement of the fixtures into the bone in order to accommodate biological structures and to maximize the support to the resulting dentition. A new body of information again impacts on the general restorative practice.

Technology and Materials

Another avenue opened by advances in technology has been made possible by the creation of a less expensive fixed appliance. The popular alias for this procedure is the "Maryland bridge." No one has as yet asked if that is how one crosses the Potomac, so the name and the procedure represented must be widely recognized. The technology for etching the metal--the mechanical retention mechanism for the system--was achieved by using the least corrosion-resistant alloy of its kind, which can release the most nickel and beryllium to both the technician making the bridge and the patient wearing it. Application of the technique to other alloy systems is in the experimental stage now. As the effectiveness of the technique and its limitations become better defined, the application of the system may allow a greater amount of dental care for those who could not previously afford it. Again the restorative dentist has a new technology, new applications in dentistry, new design concepts to understand, and biological impacts to consider.

Ceramics are being refined to offer greater mechanical properties. They have always offered some of the best potentials for esthetic dental restorations. But we must not be led down a primrose path. The technology is being developed under strict patents. The companies who sell the product and thus the procedure have a strong profit motive independent of concerns for patient health care. After acknowledging that ceramics are among the most abrasive of the materials we use in dental restorations, we do have to admit that the resulting restoration is a beautiful tooth that should last for quite some time and please both patient and dentist. The dentist must be able to read between the lines of the advertising, since there is a vested interest in the success of these techniques. When an ad shines a light through a set of teeth from the palatal side to reveal how natural ceramic looks, be careful. We have not as yet developed techniques for implanting lights in people's palates. Ceramics are being proposed as an inlay material in another patented process. The success of long-term bonding to the tooth is unknown, but do remember that this technique restores the centric holding stop with the most abrasive restorative material we have. Attempts are still being made to make porcelains stronger for dental applications without losing the esthetics of the material.

The third type of material being developed at an astonishing rate today is polymers. A number of years ago in a very popular movie, *The Graduate,* with Dustin Hoffman in the title role, his uncle puts his arm around him and tells him the future in one word: "Plastics." The presentation was droll, but the sentiments may indeed be true for dentistry. The material is esthetic and strong. It is being improved constantly to develop an ever-increasing ability to withstand abrasion and to bond to tooth structure. Polymers form the basis of most of the appliance for removable prosthodontics, and are an increasingly used modality in the preventive armamentarium. They are quickly applied in certain formulations to provide an abundance of temporary expedients. In the form of composites they make excellent anterior restorations. Now there is an effort to use them in the posterior dentition. The promise is there; the

reality may not be. The profession now uses composites in unproven applications to an extent that many would find surprising or appalling, depending on personal convictions. The application is being made, though, via concepts developed for metallic restorations. The extent to which the composite is now being used has probably reached a threshold level that cannot be reversed; the only recourse for dentistry is to change its concepts of the delivery of this service to accommodate the material. Again, a new set of knowledge in materials and techniques becomes important to the successful use of the service to keep the patient and the dentist satisfied. In this case, application has preceded knowledge. The reason may again lie in the pressures of vested interests. Johnson & Johnson introduced Adaptic as either an anterior or posterior material. When S S White introduced Profile as a posterior material, sufficient esthetics enabled its use for anterior application. But when 3M introduced P-10, since it was not sufficiently esthetic to be used as an anterior material, its heavy advertisement as a successful posterior material was necessary for the company to recoup its investment.

The constant changes in polymer and composite technology and the bonding to biological tissue are opening new vistas of restorative procedures in maxillofacial prosthodontics, esthetic veneers for metal crowns, modifying anterior morphology, and changing colors of the natural dentition. Future developments could include reversible occlusal adjustments, plastic permanent fixed prosthodontics, esthetic components of implant superstructures, and implants themselves of various kinds. Future acceptance of new systems will be delayed as clinical research assesses their usefulness and by the gradual process of acceptance of the new technology by dentists and patients. Application of polymer systems to dental restorative services is only limited by one's imagination.

Toxicology and TJD

Another science that will have a continual impact on restorative dentistry is toxicology, which is expanding at a tremendous rate. At present there are no widely accepted standards by which forms of toxicology can be determined. Myriad data are interpreted in order to derive some concept of the toxic potential of exogenous agents to which people are exposed. The abundant materials discussed previously each have their own risk potential. There is also the possibility that any individual could express an allergic response to any material. The science of toxicology will be increasingly called upon to assist in the establishment of regulatory standards to control the use of health care materials. The restorative dentist will have to understand the toxic potentials of materials in the treatment-planning process. Although the basic tenet of toxicology was stated 400 years ago by Paracelsus--"dosis sola facit venenum" (it is the dose that makes the poison)--it is the understanding of these limits that will allow us to use the plethora of materials that will be available to us.

To ignore this principle could lead to trouble. In medicine there are practitioners--called clinical ecologists--who espouse the toxic potentials of all materials to which we are exposed. Clinical ecologists sell the concept of "wellness" as an exorcism of all toxins in our body, achieved by various combinations of vitamins and other "natural" agents. The brothers of the medical clinical ecologists are the dental anti-amalgamists. Do not think that they will go away. If or when amalgam no longer exists as part of the dental armamentarium, these people will be ready to preach the hazards of plastics, composites, ceramics, and other metals. Restorative dentistry will be besieged by this minority fringe for a long time to come, because our patient population has been sensitized to fear these wraiths related to the concepts of pollution. The peer review process will have to address these tactics on the basis of more finely tuned criteria of proper dental practice. If not, we will find that the faith of our patients in many of our restorative procedures will be undermined. Patients will not maintain the high degree of trust that most still have for their dentist today.

Another area of growing expertise and skill is the diagnosis of temporomandibular joint disorders. Currently the etiologies have not been completely elucidated, and they have not been ranked in order of importance. The restorative dentists, the front-line practitioners, will have to hone and improve their diagnostic skill in this area. As knowledge of the etiologies of the

disorder increases, improvement will follow in the occlusal design and stability of restorations, and possibly in the method by which restorative procedures are delivered in order to minimize the potential for trauma to the joint. As patients and physicians become more and more aware of this etiology for head and neck pain, the number of patients seeking treatment of the disorder will grow. It will be incumbent upon the restorative dentist not only to initiate diagnostic procedures, but also to provide diagnostic and therapeutic splints, resolution of occlusal disharmonies, and definitive restorative procedures to reconstruct proper harmony between the occlusion, musculature, and joint. A wealth of new understanding will be required of the restorative dentist to achieve these goals.

Radiology, Chemistry, and Infection Control

In another area of dentistry, major technological changes will affect the delivery of restorative services. Dental radiology is growing as a potential specialty area, particularly with the rapid improvements in skills in magnetic resonance imaging. It is changing quickly and so is its acronym. Is it NMR, MR, or MRI this week? The restorative dentist will have to work more closely with a radiologist in order to interpret radiological images.

General chemistry will have an impact on restorative procedures. There are a number of proposed methods for not only diagnosing caries by chemical means, but also removing caries by chemical methods. These processes are new and still need evaluation. They do not portend changes in the way dentistry will be delivered. There may also be changes in cavity design particularly in the area of access requirements for removal of decay. Another area of concern which may drastically alter the method in which a dentist delivers restorative services is infection control. The fear of the spread of such infectious diseases as hepatitis and AIDS is finally creating a concern among dentists for their own well-being and that of other patients. We have known that we work in a bacteriologically dirty place, but these diseases are definitely dirtier. We are thus sensitized to the potential for the spread of other diseases that are not as noxious. Gloves, masks, and glasses are becoming standard items in the dental operatory. The white coat, symbol of cleanliness for dentists, is being recognized as posing cross-contamination problems. Do we spread the disease with dragging long sleeves or hairy arms? In the future there will probably be a modicum of surgical garb for the delivery of restorative services, at least from the waist up. All clinical materials will be packaged in nonreusable, disposable packages or capsules. The laboratory contact during clinical services will change. The bench lathe of the future will not be used as we see it today. There will be a change of laboratory polishing materials with each patient just as there will be for the clinical materials. Before impressions or casts are sent to laboratories, there will be routine procedures for decontaminating the reproductions. These changes may or may not affect the efficiency of restorative procedures, but they will definitely increase the cost.

The technology exists now for all of these changes. They are not radically different. The impact on dentistry is slow to be realized because of the resistance to applying new technology in patient services. The slow adaptation is to some extent understandable and appropriate, for we do not want to be reincarnations of the Crawcour brothers.

IMPACT OF CHANGES ON DENTISTRY

In this new world the dentist will be inundated with data and new technologies constantly. As in other fields, the small business of dentistry will have to plug into the master source of information. There will be central data banks and software publications that the dentist will use in the future. As data banks grow, diagnostic information will become more comprehensive and diagnoses will be aided by computer sources.

The New Patient: Aging and Esthetics

If we move away from these sci-fi predictions, there is one stark question that dentists are asking themselves now. To whom will they deliver these new high-tech services? Will we have defeated caries with fluoride? Take heart, my companions, for we may have been led to the answer by a new field--gerodontics. As the body ages, the human system becomes less resistant

to the attack of bacteriological organisms. The geriatric population will have been functioning a long time with an extensive dentition and will want to function longer. Wear and occlusal forces will have taken their toll; restorative procedures will not only be complicated by compromised health but also by more complex dental problems requiring solutions. We do not even have to rely solely upon the wealth of TMJ patients that a work life of stress will have produced.

Another new factor is the growing vanity of Americans in regard to appearance. Our patients will be looking for esthetic dentistry when they are young and will continue to demand appropriate esthetics when they are older. Resins will be applied and wear away; porcelain will be applied and fracture. If these materials survive they will still look young and unnatural when the dentition has acquired a more mature appearance. The current generation of resins used to meet the esthetic concerns of our patients are not going to last a lifetime, and will call for a change in the expectations of our patients. Just as we now ask for one-year or six-month recalls of our patients for "cleaning" their teeth, we will ask them to make five-year recalls for the routine replacement of the esthetic restorative materials. Since composite restorations can be placed in more conservative preparations, several replacements can be made without compromising the tooth structure any more than would a single amalgam filling. In addition, the older population will have been brushing regularly, thus eventually lowering the periodontal tissues and cutting into the cementum and dentin. This cervical abrasion will be treated by glass ionomers which are essentially polymers that bond to tooth structure and release fluoride. Operative dentistry will not starve for lack of direct fillings.

The work in removable and fixed prosthodontics will prosper as the population ages. Again, the procedures will be more complex and the patients will probably be more demanding of quality service. But now the rub: Can the older population afford dentistry? At present, many tailor a treatment plan in terms of Cadillac finesse or Chevy maintenance to allow those who can't afford more to maintain the dentition a little longer. The future will probably find the two-tier level of treatment entrenched in the treatment-planning process based on monetary considerations. Those who can afford it will have porcelain-fused-to-gold fixed prosthodontics completely restoring their dentition. For others, base metal alloys, Maryland bridge techniques, and direct plastic restorations will restore their dentition.

Clearly, the future of restorative dentistry is bright, with much interesting work ahead for restorative dentists. Even now with the decrease in caries, dentists are still busy and the demand for services is great. Demands will be made on fewer dentists, as the number of graduating dentists declines during a time when retirements will increase.

The only prerestorative service not yet in the dentist's armamentarium is remineralization. This technique may be effective against incipient lesions but the effectiveness will be difficult to prove clinically because of the difficulty at present in diagnosing such lesions. That will have to wait for the coming improvement in diagnostic skills that may arise from radiographic technologies.

Restorative dentists are now faced with an age-old dilemma in dentistry. Are we going to be technicians or are we going to be doctors? There is a joke that physicians try to keep to themselves. How does one tell an internist from a surgeon when both are running to catch a closing elevator? The internist sticks his hand in the door, for if it should be hurt it would not really interfere with his practice. The surgeon puts in his head. We are creating that kind of acrimony within ourselves. Don't be schizophrenic. As restorative dentists we must be excellent diagnosticians in order to prescribe and deliver the appropriate high-tech restorative procedures that require the skilled hands of the surgeon. We are legitimate doctors in the delivery of health care and will continue to be recognized as such providing we assert our responsibilities in the upholding of our profession.

THE AGENTS OF CHANGE

Where does the dentist of the future turn to keep up with all of these changes? Where do students aspiring to be dentists learn to cope with a world in future shock? Obviously the answer is the university. But is there any other lay institution more mired in tradition? Our

graduation ceremonies have all the pomp and tradition of a religious service. Symbolically we defend the white coat as the traditional and proper appearance of dentists. The school must set the example of coping with the changing technologies. It is recognized that there is danger in leaping before one looks, but how long can one stand on the fence before the fence rots away beneath him? Teachers must stay at least a step ahead of the students (including those already in practice). We educators must make an effort to update what we teach as the technologies change. It is not a question of change for the sake of change. Change is part of the evolutionary process by which progress is made. We can't just keep teaching something because we already have slides on it. We must recognize the pressures that will buffet the practicing dentist. It is important to identify those pressures applied to the restorative dentist by the industries that are supplying materials solely for monetary gain. Educators must solicit from the practitioners what kinds of demands are being made by patients. We must respond to these pressures as part of the educational process.

We in education not only must read and be aware of what is changing around us, but also must contribute to change with our own efforts. Sartre said, "There is no reality except in action." We must continue to contribute to that field of knowledge or we will fall back into an unreal world of our own making. The practice of restorative dentistry is changing. There is only so much time within a four-year curriculum in which to compress what is needed to make a competent dentist with both understanding and psychomotor skills. Therefore we must continually re-evaluate our own knowledge base and what we teach to prepare students to be dentists. We cannot hold back the inevitable movement of the hands of the clock--it will tear our arms out.

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DENTAL PRACTICE

A Cost-effective Restoration

KENNETH H PORTER • THOMAS D MARSHALL
GERALD J RE

Introduction

The current controversy regarding silver amalgam restorations has overshadowed one of its most important qualities. The cost effectiveness of this restoration when compared to any other posterior restorative procedure makes it a financially sound choice. Since silver amalgam has been the most commonly used restorative procedure over many years, the cost effectiveness of this procedure needs to be recognized and reemphasized.

The cost effectiveness of a restoration could be reasonably judged on the basis of these three criteria:

1. Time and complexity of placement
2. Cost of restorative materials
3. Durability (longevity) of the restoration

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1. Time and Complexity of Placement

Every practitioner of dentistry is basically selling his/her knowledge and skills within a time frame. The placing of a silver amalgam restoration is probably the most basic restorative procedure performed and, compared to other restorative procedures, one of the simplest. Granted that a complex pin amalgam is not a simple procedure, it is the most simple restorative method available for returning a tooth to acceptable form and function short of using a much more costly cast restoration. The technique for placing an amalgam produces a restoration that will accept more abuse and yet yield an acceptable result more often than any other restorative procedure utilized today. It is not a technique-sensitive procedure compared to that required for a posterior composite resin, and much less time is needed to accomplish an amalgam restoration than any other restorative procedure, thus achieving cost effectiveness. If patient cooperation is less than ideal and diet and hygiene fair to poor, amalgam is even more the procedure of choice.

2. Cost of Restorative Materials

The cost of many of our restorative materials has been skyrocketing. Silver alloys are usually purchased by the ounce in bulk and mercury by the pound. Twelve ounces of silver alloy average about $240 in today's market plus about $9 for a

pound of mercury. Posterior composites are purchased by the gram in small containers. If the average cost for posterior composites were figured at the pound level, the cost would be approximately $2300 (at $5 per gram, which is a very conservative figure). Enamel and dentin bonding agents are purchased by the milliliter in small containers averaging approximately $6 per ml (or $6000 per liter). Curing lights average approximately $500 each and circumferential light-passing matrices are about three times the cost of a Tofflemire matrix band. The cost effectiveness of silver amalgam materials becomes very evident when compared to any other restorative procedure.

3. Durability (Longevity) of the Restoration

Information regarding the longevity of restorations is very difficult to obtain. Silver amalgams and many of our cast gold restorations have been around long enough to give us some idea as to their durability. The newer materials (posterior composites, glass ionomers, and so on) have not been used long enough to ascertain their long-term durability. One study (Crabb, 1981) of amalgam longevity reported that of a group of 1018 amalgams, 35% failed after five years, 56% failed after 10 years, but 44% survived at least 10 years. Another study (Allan, 1977) found only 36% surviving more than 10 years, while another (Lavelle, 1976) found 60% surviving for 10 years. A recently published controlled study (Doglia & others, 1986) demonstrated an 87% survival rate at five years. Maryniuk (1985) reported that 1 - 3 surface amalgams had a longevity range of six to 11 years and 4 - 5 surface amalgams a four- to six-year range. Until more objective results are available as to the longevity of restorations, we will have to accept the fact that silver amalgams are acceptably durable in cost effectiveness. The quality of the technique employed in placing any posterior restoration has a direct bearing on the durability of that restoration.

Conclusion

More Americans are retaining their natural dentitions for a lifetime than ever before. Silver amalgam has played a large role in this constantly improving health picture, and it has done so at a cost within reach of the average person. When the controversy over amalgam use is being discussed pro and con, the cost effectiveness of amalgam in maintaining teeth should be given the recognition it deserves. Except for the extremely rare case of medically proven sensitivity to mercury, silver amalgam is a financially sound choice.

(Received 27 May 1987)

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Hollenback Prize for 1988

The Hollenback Memorial Prize for 1988 has been awarded to David B Mahler, who is currently a professor and the chairman of the Department of Dental Materials Science at the University of Oregon School of Dentistry in Portland, Oregon. This award is given annually by the Academy of Operative Dentistry to recognize excellence in research that has contributed significantly to the science of operative dentistry.

Dr George Hollenback was a pioneer in the implementation of materials technology in dentistry, strongly demonstrating scientific approach in all of his studies. He appreciated the physical limitations of existing restorative materials and intensely pursued the development of newer materials and techniques that would improve the practice of restorative dentistry. This award, in honor of Dr Hollenback, is being given to a man who has followed a similar pattern in his own career. Dr Mahler is recognized for basic research in metallurgy, including the development of the water-added investing technique to improve casting accuracy and the modification of amalgam alloy composition to stabilize dimensional change. He also created an indirect clinical evaluation instrument that has been used extensively in applied research to evaluate restoration failure along the margin interface.

Dr Mahler is a native of New York state, but came to Michigan in 1940 to begin an academic career in engineering and science. He received two undergraduate degrees from the University of Michigan, one in engineering and one in mathematics. He then spent three years as an Engineering Officer on active duty in the US Navy. He returned to the University of Michigan in 1946 for graduate work and received a MS degree in engineering, followed by a PhD degree in dental materials and engineering mechanics. During the time that he was enrolled as a graduate student, he was employed in the Department of Dental Materials under Dr Floyd Peyton, first as a research assistant, then as a research associate, and finally as an instructor.

In 1956, Dr Mahler began his professional career at the University of Oregon School of Dentistry, as an assistant professor and chairman of the Department of Dental Materials. His accelerated ascension up the academic ladder was evident in his promotion to associate professor in 1959 and to full professor in 1961. During his tenure at Oregon, he has represented the university in an outstanding manner, with nearly 200 publications, papers, and clinical presentations.

His service within the university community has been equally distinguished, with many years

of activity on the Research Committee, the Dean's Advisory Committee, the Graduate Education Committee, the Rank and Tenure Committee, and the Curriculum Council. In 1973-74, he was appointed to the Search Committee for the president of the Health Sciences Center. In recent years, he has served the School of Dentistry in a similar manner as chairman of the Search Committee for a new dean.

Dr Mahler has also been active professionally as a longstanding member of the IADR, serving as president of the Dental Materials Group in 1960-61. He is currently an active member of Sigma Xi, a science honor society, and Omicron Kappa Upsilon, the dental honor society. He is recognized nationally for his numerous activities at the National Institute for Dental Research. He has been a consultant on a number of project-site visits and has been a member of Scientific Study Sections. He has served as a program moderator on several occasions for NIH conferences and symposiums and has acted as a consultant for the American Dental Association, the National Board of Dental Examiners, and the Food and Drug Administration. Among his many honors was an invitation to speak at a Gordon Conference on the Science and Technology of Biomaterials in 1968, receipt of the Wilmer Souder Award from the Dental Materials Group of the IADR in 1967, and an award given for outstanding research in materials science by the Japanese section of the Pierre Fauchard Academy.

Perhaps his most significant contribution to the field of dentistry is evident in his effort over the past decade to coordinate laboratory findings with the clinical evaluation of dental restorations. The Mahler scale is an indirect measuring system based upon photographs of clinical restorations that exhibit varying degrees of marginal breakdown. Using this scale, numerical readings for each restoration can be evaluated statistically, making this instrument an effective and reliable tool in clinical research. Dr Mahler has shared his expertise readily with the entire profession, always seeking to improve his contributions and to enhance the practical knowledge of restorative materials.

David B Mahler

Dr Mahler has been interested for some time in the marginal fracture of amalgam and the morphology of crevice formation. Figuratively speaking, a great crevice will be opening up in dental education this coming summer at the University of Oregon with Dr Mahler's retirement from clinical teaching. The gap that this will create cannot be fully closed, even by replacement, but we will continue to profit from both the scientific and the professional legacy that this man leaves for us. His kindness and sincerity have been overwhelming, his scientific mind and innovation have been unmatched, and his enthusiasm and dedication have been an example for all of us to follow.

It is with the deepest sense of honor that the Academy of Operative Dentistry awards the Hollenback Prize for 1988 to an outstanding researcher, a respected colleague, and a personal friend.

JOSEPH B DENNISON

OPERATIVE DENTISTRY, 1988, 13, 98-99

Award of Excellence

Have you ever known a man you envy? Well, I have, and I have been frustrated trying to follow his footsteps. I have reasoned that it is okay to walk in these footsteps as long as I don't get the idea that I made them. Those of us who have had the good fortune to work closely with Jim Vernetti have all been infused with his core attribute--professionalism.

Jim began early to devote himself to improving his clinical skills and influencing the lives of young people in his community of Coronado, California. He took seriously the thought that life does not demand us to make good but does expect us to do what good we can. Too many live their lives on the cafeteria plan--self-service only. Not so with Dr James Vernetti.

Let me share with you some of the things that this consummate dentist has done with his professional life.

-- His community contributions began with a service-organized program, the 20-30 Club, of which he soon became the national president.

-- The dedication he demonstrated in working with the Boy Scouts earned him the "Silver Beaver Award." And he cosponsored an Explorer Scout program to show young men the potentials in medicine and dentistry. He also started Little and Pony League baseball in Coronado.

-- His community efforts extended into heading a gift-giving program to build a new hospital in his home city.

-- He was made Rotarian of the Year and he began a new Rotary Club in San Antonio after his retirement from private practice.

-- He has been active in numerous study clubs and has been responsible for beginning many of them. The club in San Antonio bears his name.

-- He has been an active participant in many national dental organizations. Each has made him its leader or president in recognition of his dedication to furthering their goals. As a clinician, his professional competence has won the total respect of his peers at the local, state, national, and international levels.

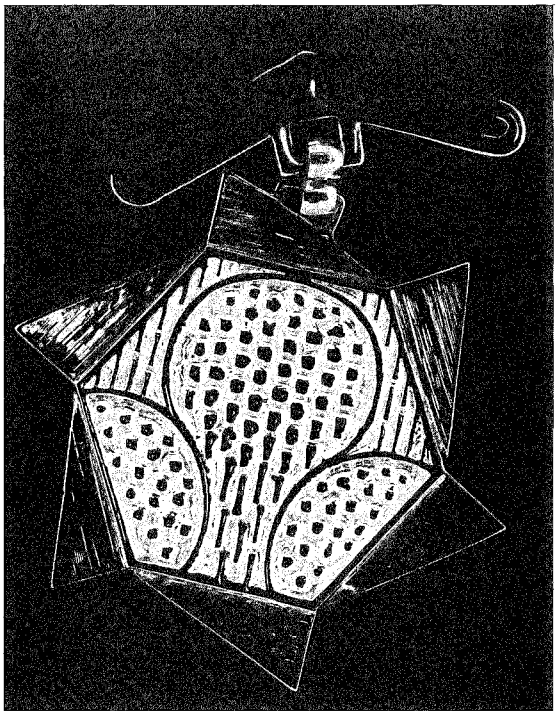
James P Vernetti

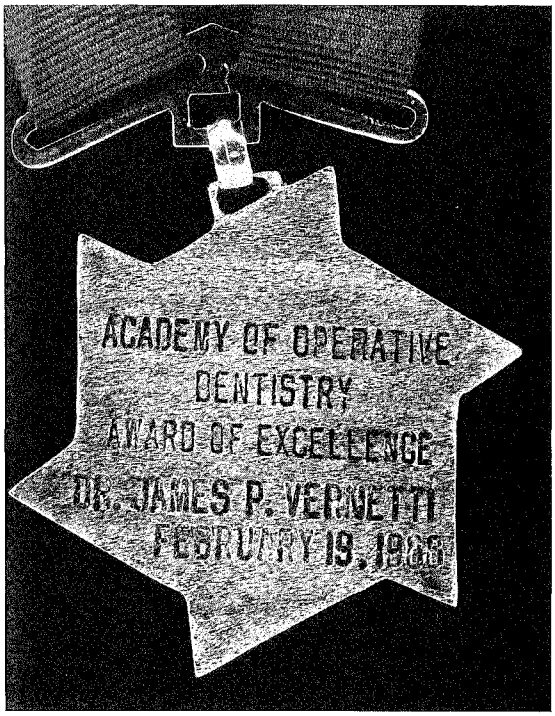
-- He was and is a regular part-time operative dentistry instructor at UCLA, despite the 280-mile round trip drive. This dedication was interrupted only by a five-year period spent as a full-time professor at the University of Texas, San Antonio. He is remembered by his colleagues there as a true teacher who didn't coddle weaknesses, but who encouraged strengths. Henry Ford once said, "My best friend is the one who brings out the best in me." This is Teacher Vernetti, also. Students and faculty alike generously and freely professed their respect and admiration for this dedicated man through numerous honors and awards.

-- Jim Vernetti has shared his knowledge of physical fitness with countless colleagues, including this speaker, who is a member of the Cardiac Club.

-- The respect given Dr Vernetti by his patients, by professional colleagues at every level, by his

The medallion, hung on a black background; back view on left





friends and immediate associates is due to his concept of "Patient Consideration." This is the central theme of his approach to patient care, his teaching, and his professional presentations.

I wonder how many of you have received a handwritten note from Jim Vernetti when you received a special recognition, or when something generous you did was made public. This has happened to many people in his city of Coronado. His philosophy is that if you admire something someone has said or done, speak up and say so. His life, and yours, will be richer for it.

It is my distinct privilege to present to Dr Vernetti on behalf of the Academy of Operative Dentistry this special Award of Excellence so richly deserved. He is a teacher with a heart, a friend without peer, and a professional man supreme.

Robert B Wolcott

The author wishes to thank Drs Carlton Williams of San Diego, Richard N Buchanan of San Antonio, and James H Zinck of New Orleans for their letters which conveyed many of the sentiments expressed in this citation.

DEPARTMENTS

Book Reviews

REMOVABLE PARTIAL DENTURES

Robert P Renner, DDS, Louis J Boucher, PhD, DDS, FACP, FADP

Published by Quintessence Publishing Co, Inc,Chicago. 416 pages, 706 illustrations. $56.00

Exhaustively illustrated with high quality photographs and informative line drawings, this comprehensive text provides a most thorough description of current clinical concepts in removable partial denture therapy.

Historical perspectives as well as references to current research results are given with special emphasis on design and treatment planning. Its depth targets it toward the graduate student or experienced general practitioner rather than the undergraduate.

The book is oriented almost entirely to the clinical and support laboratory aspects with relatively few comments towards the technical considerations of framework construction.

The most outstanding feature of the text is the number of clear and concise problem-solving tables associated with the major divisions of partial denture treatment. These tables are divided into problems, possible causes, and solutions and are presented in a horizontal format that makes for easy identification of both problem and possible solution.

The chapter on Examination, Diagnosis, and Treatment Planning contains an excellent form entitled, "Prognostic Aids for Removable Partial Dentures." The form presents both potential clinical findings and their significance and could form the basis for an examination document to allow the highest level of informed consent. Another table in this same chapter outlines the systemic changes that may occur in the RPD patient and their importance to the practitioner.

Chapters are divided into Classification, Survey and Design, Examination, Diagnosis, and Treatment Planning, Mouth Preparation, Impressions, Maxillo Mandibular Relations, Patient Instruction, and Insertion Procedures and Maintenance. The illustrations are in harmony with the text, making it easy to relate them.

Concluding with nine pages of closely printed bibliography, alphabetically ordered and most current, this book will prove to be a fine reference for the serious student of removable partial dentures.

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FUNDAMENTALS OF TOOTH PREPARATIONS

Herbert T Shillingburg, Richard Jacobi, and Susan E Brackett

Published by Quintessence Publishing Co, Inc, Chicago, 1987. 376 pages, 873 illustrations (837 in color). $72.00

The publisher's blurb on the dust jacket describes this textbook as the "only book devoted exclusively to proper preparation techniques for all types of cast metal and porcelain restorations." The authors' objective is to provide a better understanding of the rationales of tooth preparation. This book capably recasts, expands, and details with numerous colored illustrations several chapters of Dr Shillingburg's textbook, *Fundamentals of Fixed Prosthodontics.*

The first chapter thoroughly defines with references the biomechanical principles of tooth preparation. The chapter on instrumentation describes the enamel surface characteristics resulting from the use of the various diamond

and carbide instruments recommended. The chapters addressing the fabrication of complete veneer crown preparations (inaccurately termed full veneer crown preparations), esthetic veneer crown preparations, partial veneer crown preparations, and intracoronal cast metal preparations are described in a pictorial sequence sufficient to direct a beginning student through the operation. The presentation of clinical situations depicting the various preparations aids their usage and offers a reference source for the less frequently utilized preparation designs. Numerous high-resolution, accurate-color photographs with precise legends, a format frequently observed in Quintessence books, enhance the explanations.

Two very important chapters address modifications to preparation designs strategic to preparing damaged teeth, previously treated teeth, bridge abutment teeth, and teeth involved in combination with removable prosthodontic devices. Rarely is the practitioner called upon to prepare the ideal coronal form for a cast restoration the way it is taught in the second year of dental school. The modifications are a foundation for resourceful and predictably successful results with cast restorations.

Subsequent to the statement, "the chamfer is widely regarded as the gingival finish line of choice for most restorations," this textbook proceeds to describe and illustrate in a detailed manner comparable to Dr Shillingburg's previous efforts each preparation type utilizing a chamfer finish line. This unilateral perspective to tooth preparation complicates the usefulness of this textbook to those teachers presenting the benefits and rationales attendant to the beveled shoulder finish line.

This is a well-written, informative textbook addressing an area of restorative dentistry that is frequently given inadequate attention; tooth preparations are hidden by the glitter of the cast restorations. The contents are of value to everyone involved in the preparation of teeth for long-term serviceability and dental health.

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Letters

Posterior Composite Resins: A Status Report for the Academy of Operative Dentistry

I am writing in response to the literature review on posterior composite resins by Burgess, Summitt, and Laswell that appeared in the Autumn, 1987 issue of *Operative Dentistry* (1987, **12**, pp 173-178). In particular, there is a paragraph on page 174 of this article that states that "...numerous studies have reported that properly placed resin restorations can strengthen remaining tooth structure." The authors cite 14 references, including research conducted by my colleagues and me (Joynt & others, *Journal of Dental Research*, 1985, **64**, *Abstracts of Papers*, p 350, Abstract 1579) to support this statement. There are two points regarding their statement that are of concern to me.

First, a number of the references cited do not support their statement. The Joynt et al abstract, for example, reported no strengthening effect for posterior resin restorations. All prepared groups (unrestored, restored with amalgam, and restored with resin) were significantly less resistant to fracture than intact teeth, but no significant differences were found among the prepared groups. Stampalia et al (*Journal of Prosthetic Dentistry*, 1986, **55**, pp 694-698), in a comparison of intact teeth and those restored with amalgam and composite resin, found that restored teeth were significantly weaker than intact teeth. Watts (*Journal of Dentistry*, 1986, **14**, pp 130-134) found that intact teeth were significantly stronger than those restored with composite resin. Moulder, Ogle and Hood (*Journal of Dental Research*, 1985, **64**, *Abstracts of Papers*, p 651, Abstract 17) reported significantly less cuspal flexure in intact teeth compared to those left unrestored, restored with amalgam, or restored with composite resin. Herrin (*Journal of the American Dental Association*, 1986, **112**, pp 845-846) reported a clinical case in which an amalgam restoration was replaced with resin, concluding that "it is believed that the unsupported cusps have been strengthened..." Bell, Smith, and dePont (*Australian Dental Journal*, 1982, **27**, pp 283-287) reported a simulated, mathematical

model of stress distribution in an MOD cavity preparation, with no reference to posterior composite resins. None of these six reports found a strengthening effect of composite resin on tooth structure, yet each was cited in the review as supporting this conclusion.

My second concern is that the reader will be led to believe that resins have a strengthening effect on remaining tooth structure, a conclusion that is contrary to findings in many of the cited references. Most of these studies compared teeth restored with resin with those that had been prepared but unrestored. Significant results of such research indicate only that it is better to restore a prepared tooth than to leave it unrestored. The clinician who takes the authors' statement at face value will likely decide that resin must be better than the material he or she is currently using to restore posterior teeth. Our research, and that of Stampalia et al (1986), has indicated that resin provides no greater strengthening effect to remaining tooth structure than that provided by amalgam. A study that concludes, on the basis of a comparison of unrestored teeth versus those restored with resin, that resin strengthens remaining tooth structure is misleading to the practitioner. The clinician does not decide between leaving a tooth unrestored or restoring it with resin, but rather chooses between or among restorative materials.

It is critical that references cited in a summary statement be both consistent with and supportive of the conclusion of that statement. I do not believe this to be the case in this instance.

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RESPONSE:

We have carefully considered the letter from Dr Elaine L Davis in which she pointed out some differences of opinion regarding the statement in the status report that a properly placed resin restoration can strengthen remaining tooth structure. Our statement does not imply that teeth restored with composite resin were reinforced to their original uncut strength, but we believe the references cited support the contention that composite resin reinforces prepared tooth structure. We also cited the Eackle article (*Dental Materials*, 1986, **2**, pp 114-117) which reported loss of that reinforcement when specimens were thermocycled.

A number of additional articles have been published since that status report was submitted to you; the information provided by these new studies may help to clarify this issue. The research report by Joynt and others entitled "Effects of composite restorations on resistance to cuspal fracture in posterior teeth" (*Journal of Prosthetic Dentistry*, April 1987, **57**, pp 431-435) stated that teeth restored with composite resin or amalgam are more resistant to fracture than prepared unrestored teeth. In a study examining the load required to fracture mandibular molars (Watts, D C; El Mowafy, O M; and Grant, A A, "Fracture resistance of lower molars with Class I composite and amalgam restorations," *Dental Materials*, October 1987, **3**, pp 261-264), the fracture strength of mandibular molars was directly related to the diameter of the ball bearing applying the load (they compared a 4-mm and an 8-mm ball bearing). The larger diameter ball bearing produced a greater recorded fracture strength. From an examination of this article, it is apparent that variations in teeth (molars or premolars), and loading apparatus (a single rod, a spherical ball, or two rods) could well have influenced the results of studies that have tested fracture resistance. Furthermore, different composite resin restorative materials, as shown in the Watts et al study (*Ibid*), may produce different results; the teeth restored with Occlusin composite resin were strengthened to a statistically significant degree compared to those restored with another composite or amalgam. The authors stated that this might have been due to the high modulus and fracture toughness of Occlusin. Perhaps a more important finding, however, was the decreased severity of the fractures occurring in teeth restored with composite compared to the fractures in teeth restored with amalgam.

Composite resin restorations placed in beveled-etched preparations significantly increased the resistance to fracture when compared to prepared unrestored teeth or teeth restored with

amalgam (Wendt, S L Jr; Harris, B M; and Hunt, T E, "Resistance to cusp fracture in endodontically treated teeth," *Dental Materials*, October 1987, **3**, pp 232-235). This article revealed further differences in research methodology (thermocycling versus no thermocycling and bulk placement versus incremental placement of composite resin) between studies.

In the status report, we listed articles which gave evidence to the premise that teeth restored with acid-etched enamel and resin showed greater resistance to cuspal fracture than unrestored prepared teeth. We also referred to a study which showed that this reinforcement may decrease after thermocycling. Since thermal changes occur in the mouth, it follows that there is a great possibility that this increased resistance imparted to teeth by resin restorations will diminish. If we misinterpreted the intended conclusions of any author, we apologize, but we believe that the preponderance of evidence indicates that cut tooth structure is strengthened by resin, at least in the absence of thermal stressing.

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Announcements

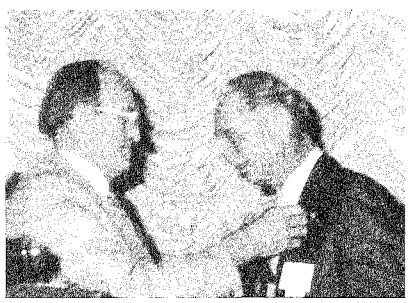
NEWS OF THE ACADEMIES

Academy of Operative Dentistry

The seventeenth annual meeting of the Academy of Operative Dentistry was held 18 and 19 February in Chicago at the Westin Hotel. An excellent program comprised of meetings, essays, and table clinics was presented. The seventh Buonocore Memorial Lecture was delivered by Sigurd P Ramfjord.

At lunch on the first day the Hollenbeck Memorial Prize was presented to David B Mahler and the Student Achievement Award was presented to Gregory H Grady of Ohio State University. James P Vernetti was presented the Award of Excellence at the luncheon on the second day.

Officers elected for 1988 are: president, J Martin Anderson; immediate past-president, William N Von der Lehr; president-elect, Anna T Hampel; vice-president, R Craig Bridgeman; secretary-treasurer, Ralph J Werner; and assistant secretary, Gregory E Smith. Councillors for 1988 are Ralph M Phelan and Robert D Cowan; for 1989, Charles F Morris and Daniel C T Macintosh; and for 1990, Thomas G Berry and Joel Morris Wagoner. Sixty-four new members of the Academy were voted in this year.



Robert Wolcott presenting the medallion for the Award of Excellence to James Vernetti

Bob Fadal of Plano, Texas lectures the academy on the art of casting gold. Bob said the Lord talked to him and informed the audience that the Lord would call him home if each member of the audience did not send him an ounce of gold by 15 April. Rumor has it that Bob is going on a long trip.

Jim Vernetti and wife Beth following presentation of the Award of Excellence.

STUDENT ACHIEVEMENT AWARD

The Student Achievement Award for 1988 is being made to Gregory H Grady, a third-year dental student at Ohio State University, for his outstanding scientific accomplishments. Mr Grady, a native of Michigan, attended the University of Notre Dame, receiving a bachelor's degree with majors in both political science and administration in 1983. Before entering dental school, he worked as a dental assistant and practice administrator in Michigan for two years while earning an associate degree in chemistry from Lansing Community College.

Mr Grady's research activity has earned him several recent awards. In 1987, he received a first-place award for his clinic at an Ohio State assembly devoted to post-college research. He was also named Ohio Dental Association Student Researcher of the Year, and he represented his school in the ADA student research table clinic competition last fall in Las Vegas. His award-winning clinic, titled "An Electronic 3-D Device for Teaching Intraoral Mirror Positions," was presented at the Academy of Operative Dentistry's annual meeting in Chicago. Mr Grady is to be congratulated on these significant accomplishments and on being awarded the Student Achievement Award for 1988.

DIRECT GOLD COURSE

Applications are once again being accepted for participation in the Direct Gold Restorative Course to be held at the Indiana University School of Dentistry, 14-17 June 1988.

As in the past, there will be a Basic level (class 1 and 5) and an Advanced level (class 2 and 3) of participation, laboratory and clinical exercises, with emphasis on patient treatment.

Tuition for the four-day course will be $100 for the Basic level, and $150 for the Advanced level. Class size is limited to four Advanced, and eight Basic enrollees. Those interested should apply as soon as possible. Class participants will be selected on 1 May 1988. No advance payment is required until notification of acceptance has been given.

Submit requests for enrollment to:

Dr Ronald K Harris
Indiana University School of Dentistry
1121 W Michigan St
Indianapolis, IN 46202

NOTICE OF MEETINGS

American Academy of Gold Foil Operators

Annual Meeting: 6-7 October 1988
Georgetown University
Washington, DC

Academy of Operative Dentistry

Annual Meeting: February 1989
Westin Hotel
Chicago, Illinois

Gregory H Grady, 1988 winner of the Student Achievement Award.

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.

Tables

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

Illustrations

Submit two copies of each illustration. Line drawings should be in india ink or its equivalent on heavy white paper, card, or tracing vellum; any labeling should be on an extra copy or on an overleaf of tracing paper securely attached to the illustration, not on the illustration itself. Type legends on separate sheets. Photographs should be on glossy paper and should be cropped to remove redundant areas. For best reproduction a print should be one-third larger than its reproduced size. Maximum size of figure is 15x20 cm (6x8 inches). The cost of color plates must be met in full by the author. On the back of each illustration, near the edge, indicate lightly in pencil the top, the author's name, and the number of the figure. Type legends on a separate sheet. Where relevant, state staining techniques and the magnification of prints. Obtain written consent from holders of copyright to republish any illustrations published elsewhere.

References

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

Reprints

Reprints can be supplied of any article, report, or letter. Requests should be submitted at the time the manuscript is accepted. Reprints ordered after the date set for printing of the journal cost substantially more.

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