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EDITORIAL

What Does the Editor Do?

I am often asked what the Editor of *Operative Dentistry* does. I think that a good way to answer that question is to follow the editorial process from the receipt of an article through publication.

When an article arrives in the journal's office, the first step is to assign the paper a sequence number. This number assures that the paper is published in the order of receipt. Next, we send a letter to the corresponding author acknowledging receipt of the manuscript. The Editorial Assistant then sends me the manuscript for a preliminary reading and assignment to the appropriate members of the Editorial Board (referees). I determine who should referee the paper based on their known areas of expertise and their interest in the subject matter. We prepare the manuscript for the review process by removing all traces of the author's name and duplicating this "clean" copy for the three Editorial Board members. This assures impartiality in the review process. I ask the referees to critically review each paper they receive and to make suggestions for improvements in the research or the paper itself. They must also decide whether to accept or reject the paper for publication. They complete their review within 30 days of receipt of the manuscript. The refereeing of manuscripts and selection of publishable papers is a major responsibility for the members of the Editorial Board, and they discharge that duty very carefully.

When I receive the reviews from all three Editorial Board members, I review their comments and their decisions on whether or not to publish the paper. I abide by the decisions of the Editorial Board, which are often conditional. Many papers are acceptable for publication with minor or major revisions. I correspond with the authors and let them know the decision of the Editorial Board. If the decision has been to not publish the paper, then I return the manuscript and any photographs to the authors. If the article has been conditionally accepted pending appropriate revisions, I communicate that to the authors and generally give them 30 days to make the appropriate changes. Once I receive an acceptable manuscript, we begin the formal editing process.

Ms Darlyne Bales, the Editorial Assistant, begins the editorial process by checking the references for accuracy in the library. You should know that we have never received a perfect bibliography. (The record for inaccuracy is 48 inaccuracies in 48 citations.) When the references have been verified, Ms Kate Flynn Connolly, our Editorial Associate, edits the text for readability, punctuation, grammatical errors, and to put the paper into the "style" of the journal. When we complete the preliminary edit, we return the edited manuscript to the authors for their review. We take this precaution to ensure that we have not changed the author's meaning during the editorial process. The authors have 30 days to review the manuscript. Once the paper is returned, we make any changes recommended by the authors and begin the typesetting process.

Mr Mark Berg puts the paper into a desktop publishing format and produces the first page set draft of the article. He returns this to me, and Ms Connolly and I review the article for errors. We return the paper to Mr Berg for corrections. We repeat this process an average of three to four times for each article. Once we correct all the problems we can find, we sequence the articles for the best page layout. One final proofing and correction sequence later, we send the "camera-ready copy" to the printer. After several weeks, the printer assembles the proofs as a "blueline" and returns them for one final proofreading. We correct any newly discovered errors and send the journal for printing and distribution. The journal is then printed and mailed to you.

While the Editor is responsible for a number of other duties, the primary duty is to provide you, the reader, with quality articles relevant to the practice of operative dentistry and direct gold. The technical aspects of the job have changed significantly since Dr Hamilton began as Editor. They changed again during Dr Bales's tenure, and I am sure they will change during my term as Editor. We will continue to strive to bring you the best articles available in *Operative Dentistry*.

MAXWELL H ANDERSON
Editor

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ORIGINAL ARTICLES

Effect of Grooves on Resistance Form of Class 2 Amalgams with Wide Occlusal Preparations

J B SUMMITT • J W OSBORNE
J O BURGESS • M L HOWELL

Clinical Relevance
Approximal retention grooves for amalgam restorations with a wide isthmus do not increase the restoration's fracture strength.

SUMMARY

This study evaluated in vitro the necessity of retention grooves in approximal boxes in class 2 preparations with faciolingually wide occlusal extensions (occlusal isthmus width 1.8 mm). Thirty-six class 2 mesio-occlusal cavities were prepared in sound human maxillary premolar teeth and divided into three groups of 12. In one group, the preparations had no retention grooves. In another group, retention grooves 0.3 - 0.5 mm deep were prepared at the axioproximal line angles and extended from the gingival floor occlusally to just gingival to the occlusal dentinoenamel junction. In the third group, a 1 mm-long groove was prepared extending from the axiopulpal line angle occlusally to just gingival to the occlusal dentinoenamel junction. The marginal ridges of the amalgam were loaded at an angle of 13.5° from vertical in an Instron Testing Machine until the restorations failed. Results indicated no significant difference in load to cause failure in any of the three groups. Restorations without approximal retention grooves possessed as much resistance to failure as those with grooves.

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INTRODUCTION

Several investigators have recommended retention grooves in the axiofacial and axiolingual line angles of the approximal

boxes of class 2 amalgam preparations based on in vitro studies (Crockett & others, 1975; Mondelli & others, 1974; Mondelli & others, 1981; Caplan, Denehy & Reinhardt, 1990).

Sturdevant and others (1987) studied conservative preparation designs for class 2 amalgam restorations using metal dies with retention grooves of two lengths. The long grooves in the study extended from the axiogingivofacial and axiogingivolingual point angles to the occlusal surface and were consistently deep along their entire lengths; the short grooves were conventional grooves that extended from the same point angles occlusally to approximately 1.5 mm below the occlusal surface, their depth being 0.5 mm at the gingival extent and tapering out at their occlusal extent. In slot preparations (approximal box only, with no occlusal extension), retention groove length did not significantly affect the failure load; in preparations with an occlusal extension, neither the presence nor length of the retention grooves affected the failure load. The faciolingual dimension of the occlusal preparation in that study was 1 mm. The authors reported that the box-only restorations failed by displacement more frequently than restorations with occlusal extension.

In clinical studies, Terkla and Mahler (1967) and Terkla, Mahler, and Van Eysden (1973) reported that retention grooves were unnecessary to avoid bulk fracture of amalgam at the isthmus. The retention grooves used by Terkla and Mahler were conventional grooves in the axiofacial and axiolingual line angles, tapering out at the occlusal extent of each groove. In the 1967 study, only "conservative" (narrow) amalgam restorations, with and without retention grooves, were compared. The 1973 study included 422 restorations, some narrow and some wide, some with retention grooves and some without. Neither study found a difference in the clinical success of restorations with and without retention grooves. The restorations of Terkla and Mahler (1967) were conservative compared to earlier restorations, but occlusal preparations were used that were wider faciolingually than conservative preparations advocated by Markley (1951) and by Almquist, Cowan, and Lambert (1973). The restorations pictured in the Terkla and Mahler article (1967) showed possibly more removal than necessary of cuspal tooth structure in rounding and blending the outline of the approximal box with the outline of the occlusal preparation.

Childers (1985) stated that "one of the more difficult tasks for dental students to accomplish is the accurate and adequate instrumentation of approximal retentive grooves." He also stated that it is probable that many teeth treated in private practice suffer "rotary abuse" during retention grooves placement.

Summitt and others (1991) evaluated the effectiveness of retention grooves in very conservative class 2 restorations, with an occlusal extension (isthmus) 0.7 mm wide faciolingually, and reported that short (< 1 mm) retention grooves located just gingival to the occlusal dentinoenamel junction provided significantly more resistance than conventional grooves (primarily gingival to the axiopulpal line angle) or no grooves.

This study compared resistance form in the approximal boxes of class 2 amalgam restorations with wide occlusal extensions, provided by two different types of retention grooves and by no grooves.

METHODS AND MATERIALS

Specimen Selection

Thirty-six extracted human maxillary premolars, free of caries or restorations, were sorted by faciolingual dimensions. Teeth were divided into three groups of 12 teeth, with sizes distributed to give approximately equal mean dimensions in each group. Roots were notched and embedded in Cerro-Bend Alloy (Cerro Metal Products, Bellefonte, PA 16823), which was confined by cylinders of polyvinyl chloride tubing 3/4 inch high with an outside diameter of 1 1/16 inch. Specimens were stored in tap water when not being prepared or tested.

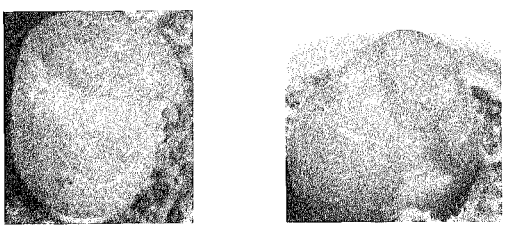
Cavity Preparations

Mesio-occlusal preparations were cut by one operator to the following dimensions

using a #330 pear-shaped bur and a #1/4 round bur (Midwest Dental Products Corp, Des Plaines, IL 60018-1884) in a high-speed handpiece (Star Futura 2, Star Dental, Valley Forge, PA 19482) and appropriate sharp hand instruments: faciolingual width of the occlusal preparation 1.8 mm ± 0.2 mm; depth of occlusal preparation measured at margins 1.8 mm ± 0.2 mm; faciolingual dimensions of approximal box at occlusal 2.25 mm ± 0.25 mm, at gingival 2.75 mm ± 0.25 mm; occlusogingival height of axial wall 1.75 mm ± 0.25 mm; depth of box gingivally from marginal ridge 3.5 mm ± 0.5 mm; width of gingival floor axially 1.25 mm ± 0.15 mm; and width of 45° bevel of axiopulpal line angle 0.5 mm - 1.0 mm.

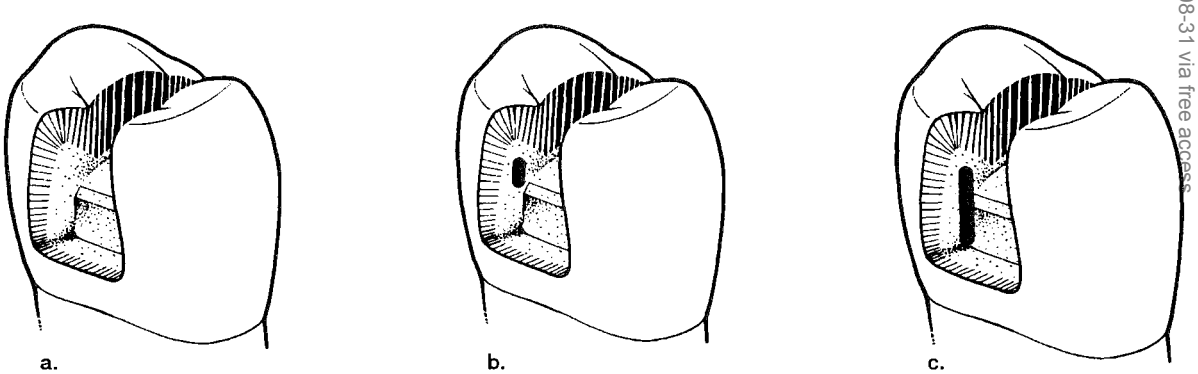
Figure 1 shows a typical preparation from the occlusal and from the mesial. No attempt was made to provide any dovetail whatsoever in the occlusal preparation. After all cavities were prepared, retention grooves were placed by one operator to a depth of 0.3 to 0.5 mm and a width of 0.5 mm using a #1/4 round bur in a high-speed handpiece at very low speed. Grooves extending gingival to the axiopulpal line angle were cut to bisect the axiofacial and axiolingual line angles. Grooves placed occlusal to axiofacial and axiolingual line angles were cut parallel to the dentinoenamel junction. Retention grooves in each of the three groups are illustrated in Figure 2 and were as follows:

Group	Retention Grooves
A	No grooves placed (Figure 2a)
B	Short retention grooves or retention points (1 mm occlusogingivally) located just occlusal to axiopulpal line angles and gingival to occlusal dentinoenamel junction (Figure 2b)
C	Extending from gingival floor occlusally to just gingival to occlusal dentinoenamel junction (Figure 2c)



a. b.

Figure 1. *Typical outline of a preparation shown from the occlusal (a) and the mesio-occlusal (b)*



a. b. c.

Figure 2. *The three preparation designs tested in the study: (a) Group A, no grooves; (b) Group B, short retention grooves or points located just gingival to occlusal dentinoenamel junction; and (c) Group C, conventional grooves extending from gingival floor occlusally to just gingival to occlusal dentinoenamel junction*

Restorative Procedure

Two Tofflemire #1 (double thickness) matrix bands (Union Broach Corp, Long Island City, NY 11101) in a Tofflemire retainer were adapted to each premolar. Amalgam (Valiant PhD, L D Caulk Division, Dentsply International, Milford, DE 19963-0359) was triturated in an amalgamator (Caulk Vari-Mix III, L D Caulk) for nine seconds at the "M" setting and inserted by one operator using vertical and lateral condensation with condensers that fit all areas of the preparations.The amalgam was condensed to overfill the preparation by at least one-half millimeter, then carved to contour with sharp carvers.

Testing

After aging one month in tap water at room temperature, specimens were positioned in a fixture at a 13.5° angle, and a #57 bur (Midwest Dental Products Corp) in a straight handpiece (Bell International, Burlingame, CA 94010) mounted in a paralleling device was used to flatten a 1 mm x 1.5 mm area of the amalgam at the marginal ridge (Figure 3). Specimens were positioned in the same fixture to hold them at a 13.5° angle for loading. A rectangular rod (1.0 mm x 1.3 mm) was used to load the flattened amalgam in compression using an Instron Testing Machine (Model 2511, Instron Corp, Canton, MA 02021) at a crosshead speed of 1 mm/minute (Figure 4).

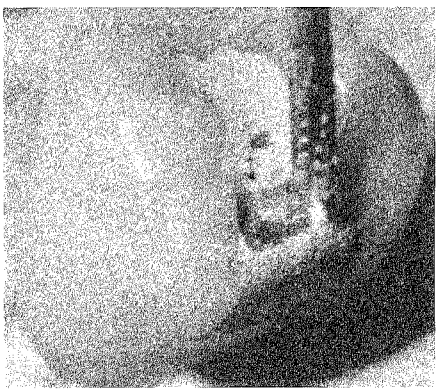


Figure 3. *Specimen positioned in fixture at 13.5°. The marginal ridge area was flattened with a #57 bur in a straight handpiece.*

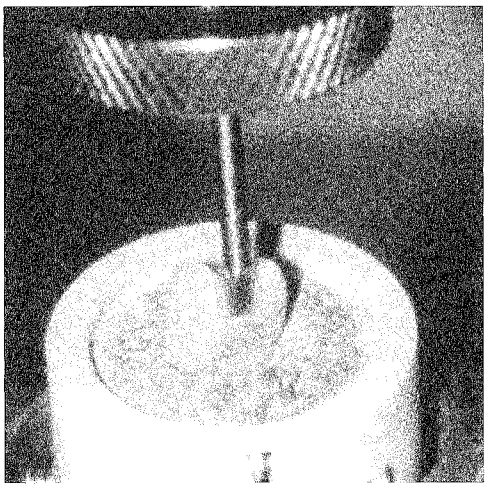


Figure 4. *Specimen loaded in compression in an Instron Testing Machine, using a rectangular loading rod with dimensions 1.0 mm x 1.3 mm*

RESULTS

Failure load in newtons and mode of failure were recorded for each specimen (table). The data were analyzed using a one-factor

Mean Failure Loads [Newtons (N)] of Wide Class 2 Mesio-occlusal Amalgam Restorations in Maxillary Premolars with No Retention Grooves and with Two Configurations of Retention Grooves

Group	Retention Grooves Extending	Load to Fracture	SD
A	No grooves	221	± 78
B	Short grooves (1 mm occlusogingivally) just occlusal to axiopulpal line angle	183	± 57
C	From gingival floor occlusally to near occlusal dentinoenamel junction	254	± 90

analysis of variance (ANOVA) and a Newman-Keuls post-hoc analysis. Results indicated no significant difference between groups. The group with no retention grooves was as resistant as the groups that had grooves. In all specimens, the amalgam in the occlusal portion of the preparation remained intact.

DISCUSSION

This study evaluated the effect of approximal retention grooves on the resistance form of class 2 restorations with faciolingually wide occlusal extensions. Although the merits and advantages of narrower occlusal portions of class 2 restorations have been reported by numerous authors (Vale, 1956; Berry & others, 1981; Larson, Douglas & Geistfeld, 1981; Blaser & others, 1983; Osborne & Gale, 1990), greater width may be required due to caries or previous restorations.

Several authors (Charbeneau, 1988; Sturdevant & others, 1984; Baum & McCoy, 1984; Almquist & others, 1973) have stated that resistance and retention form of the approximal and of the occlusal portions of a class 2 restoration should be independent of each other. This study and others do not support this contention in preparations with faciolingually wider occlusal extensions (isthmuses). Sturdevant and others (1987), in an in vitro test using a 1 mm-wide occlusal extension, reported no increase in fracture load by adding approximal retention grooves. The clinical study by Terkla and others (1973) reported no fracture at the junction of the occlusal and approximal box portions of 422 class 2 restorations with and without retention grooves. The findings of this study indicate that, in fact, the two portions of the restoration are not independent, but the occlusal portion provides added resistance and retention for the approximal portion.

There is data to indicate that retention grooves or points should be placed when the interface between the occlusal and approximal portions is minimal. A recent report (Summitt & others, 1991) indicated that retention grooves that extended occlusal to the axiopulpal line angles, and retention points placed just gingival to the occlusal dentinoenamel junction, provided increased resistance to fracture at the junction of the approximal and occlusal portions of class 2 restorations in which the occlusal portion was very narrow (0.7 mm width faciolingually).

The approximal boxes in this study were faciolingually narrow. With a wider approximal portion, there is a possibility that retention grooves would supplement resistance form provided by the junction of the approximal portion with the faciolingually wide occlusal portion.

With evidence from this study and others that retention and resistance are provided to the approximal portion of a class 2 amalgam restoration by the occlusal portion, and with evidence that reduced interface between the two portions gives reduced resistance and retention for the approximal portion, it is reasonable that additional resistance/retention features be added to the approximal portion when the interface between the two parts is minimal. Retention grooves or points as described by Summitt and others (1991) should provide adequate resistance and retention for the approximal portions of class 2 restorations with very conservative occlusal extensions. For class 2 restorations with wider occlusal extensions, the use of retention grooves is probably not beneficial.

CONCLUSIONS

The approximal portions of class 2 amalgam restorations with faciolingually wide occlusal extensions (1.8 mm ± 0.2 mm) were no more resistant to displacement when retention grooves were placed than when there were no retention grooves. Results of this study suggest that in class 2 restorations with faciolingually wide occlusal extensions, retention grooves provide no additional resistance to displacement over that provided by the attachment of the approximal amalgam to the occlusal amalgam.

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The Influence of Light Exposure on Polymerization of Dual-Cure Resin Cements

F A RUEGGEBERG • W F CAUGHMAN

Clinical Relevance
Light curing is a requisite for polymerization of dual-cure resin cements.

SUMMARY

This study investigated the degree of monomer conversion of four commercial dual-cure resin cements. The products were subjected to various postmix treatments: no light exposure, a 60-second exposure through Mylar only, and either a 20-second or 60-second exposure through an overlying cured wafer of composite 1.5 mm thick. The infrared spectrum of the treated specimens was recorded at specified times postmix for each cure treatment: 2, 5, 10, 30, and 60 minutes as well as after 24 hours. The degree of cure was then determined from the infrared spectra. The results demonstrate a wide range of potential cures among the various brands. Regardless of brand, the chemical component of cure was always lower than when the specimens were exposed to any lighting condition. For most resin systems tested, the cure observed 10 minutes postmix was almost equivalent to the cure after 24 hours. Despite manufacturers' claims, there is no evidence for a substantial chemically induced polymerization of dual-cure resins that occurs after light exposure is completed.

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INTRODUCTION

Resin cements have been used extensively in restorative dentistry for a variety of applications. One of the most recent uses involves resin cements to bond porcelain and resin laminate veneers as well as inlays to teeth. Chemically cured resins were initially used for these purposes. However, these products

had the disadvantages of lengthy working and setting times that were not under the control of the clinician. The use of light-cured resins for these applications would seem quite appropriate. However, there is a distinct decrease in the curing of resin with attenuation of light (Cook, 1980; Ruyter & Øysaed, 1982; Rueggeberg & Craig, 1988). This attenuation may be caused by the light-absorbing characteristics of the restorative material (porcelain or cured resin) (Breeding, Dixon & Caughman, 1991; O'Keefe, Pease & Herrin, 1991) as well as the inability of light to penetrate beneath gingival margins.

To remedy these limitations in the cure of light-polymerized resin cements, manufacturers introduced products that had both chemically and light-induced polymerization initiation. Thus the coin of the term "dual-cure resin cement." Conceptually, the benefit of such a product is that the portions of the cement that had initially received too low an intensity of light to initiate adequate polymerization would be polymerized after light exposure by the delayed chemical reaction that formed free radicals.

This concept of continued cure after initial light polymerization is often highlighted in the advertising of these products. The implication to the clinician is that the extent of cure throughout the resin cement will eventually become equal as a result of the slow, continuous action of the chemical-cure component (Cook & Thomasz, 1983). Breeding, Dixon, and Caughman (1991) have demonstrated the importance of the thickness of overlying composite, its shade, and the duration of light exposure on the hardness of dual-cure resin cements. They have also determined that the chemical cure component never reaches the extent of hardness that the surface of the resin exposed to light does. To date, there have been no time-based studies that have quantified the degree to which the dual-cure materials cure under various lighting conditions.

The purpose of this paper is to examine the extent of cure using infrared spectroscopy of four brands of commercial dual-cure resin cements that were subjected to various light-curing conditions. Specifically, the ability of the chemical-cure component to reach equivalent levels of monomer conversion as that of the light-cured reaction is tested.

METHODS AND MATERIALS

Four commercial dual-cure resin cements were tested (Table 1). Each of these materials consists of two paste components that are mixed together for a specified time. Equal weight proportions of the two components of each material (0.20 g) were dispensed on a mixing pad. A stopwatch was started at the beginning of mix. Each resin was mixed according to the manufacturer's directions. Upon completion of the mix, a small amount of product was placed on one side of a 10 x 5 x 1 mm KRS-5 crystal (Buck Scientific, Norwalk, CT 06855).

A small piece of Mylar (0.07 mm, Du Pont Company, Wilmington, DE 19898) was placed over the resin and pressed flat, causing the material to spread across the crystal face. The material then received either of the following treatments:

1. The material was immediately placed in a light-tight drawer, resulting in no light exposure (CHEMICAL), or
2. The material was light-cured for 60 seconds (MYLAR) using a 14 mm curved tip of the Max Light (L D Caulk Co, Milford, DE 19963).

These two resin treatments represent the most and the least light exposures that were designed to test the maximum use of the light-curing component and the chemically based component alone.

Table 1. Dual-Cure Resins Used

Brand Name	Manufacturer	Lot Number	Shade
Ultra-Bond	Den-Mat Corp Santa Maria, CA 93456	684008 692002	n/a Paste 65
Mirage FLC	Chameleon Dental Kansas City, KS 66101	E032291 F051791	Universal A-2
Porcelite	Sybron/Kerr Romulus, MI 48174	1-2029 1-1029	Untinted n/a
Heliolink	Vivadent USA, Inc Amherst, NY 14228	394506 413201	gray n/a

A second set of samples was prepared using a 1.5 mm-thick cured wafer of Heliomolar (Universal shade, lot #260264, Vivadent USA). This cured wafer was pressed against the uncured, mixed, dual-component resin. Curing through the wafer occurred as follows:

1. A 20-second exposure to the Max Light (20 WAFER) described above, or
2. A 60-second exposure (60 WAFER) to the same light.

These methods simulated clinical conditions involved with the cementation of a 1.5 mm-thick composite inlay that was exposed for two different times.

At various times after the start of mix (2, 5, 10, 30, 60 minutes, and 24 hours), the specimens were placed in the sample compartment of a Fourier transform infrared spectrometer (FTS-40, Bio-Rad Corporation, Digilab Division, Cambridge, MA 02139). The infrared spectrum of the specimen was obtained using eight scans at a resolution of 2 cm^{-1}. The specimen was then placed in a dark drawer until sufficient time had passed that another spectrum was required. Figure 1 indicates the testing apparatus diagrammatically. The use of attenuated total reflectance spectroscopy allows the capture of the infrared spectra of opaque thin films placed upon the KRS-5 crystal (Wilks, 1980). In this manner, only the resin cement in contact with the crystal appears on the spectral plot, and the influence of the Mylar or the cured composite wafer is absent. Thus, this apparatus simulates the clinical situation where the crystal is equated with the tooth surface to which the resin cement is being bonded. Three separate specimens were made for each testing condition using each product, resulting in a total of 48 individual specimens.

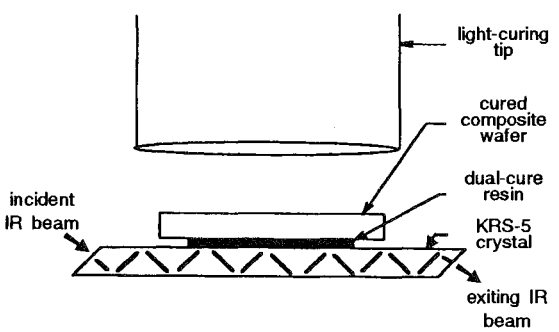

Figure 1. *Diagram of curing dual-cure resin on KRS-5 crystal and obtaining the infrared spectrum of the exposed specimen*

The infrared spectrum of the uncured, mixed product was obtained by mixing equal weight proportions (0.20 g) of each paste as directed, placing the mixture immediately on the KRS-5 crystal, and then scanning the resin as previously described. Triplicate infrared spectra were obtained for each resin product in this manner.

The monomer conversion of each specimen was determined by monitoring the ratio of the absorbance of the aliphatic carbon double bond (C=C) peak (1636 cm^{-1}) to that of the aromatic absorbance peak (1608 cm^{-1}) for the uncured and cured specimens (Ruyter & Svendsen, 1978; Vankerckhoven & others, 1982; Rueggeberg, Hashinger & Fairhurst, 1990). A decrease in this ratio indicated that, as compared to the uncured material, aliphatic C=C was being used to form polymer product. The aromatic peak is used as an internal reference so that component concentrations do not need to be determined (Medeck, 1968; Wilks, 1969). This absorbance group can be used as a reference, because it does not react during polymerization and therefore should not change in its concentration. If polymerization has progressed totally, the aliphatic C=C peak would completely disappear with respect to the aromatic peak. The percent of monomer converted into polymer was calculated for each specimen at each of the specified times after mix, using standard techniques (Ruyter & Svendson, 1978). The mean conversion for each resin at each postmix time and cure condition was determined. A one-way ANOVA (the independent variable being postmix time) was used to test for the presence of a significant difference among the mean conversion values for the various postmix times within each product. Tukey's hsd post-hoc procedure was used to test for significant difference between specific pairs of mean monomer conversion values at specified postmix times within each product. All statistical tests were performed at the 95% level of confidence.

RESULTS

Figure 2 indicates the monomer conversion of Ultra-Bond among the various treatments after the specified postmix times. It can be seen that maximal conversion was achieved using a 60-second light cure through only Mylar. On the other hand, the chemical cure component only provided minimal polymerization. Statistical interpretation of the data indicated that after 24 hours postmix, the cure of the chemical component was significantly less than all other resin treatments that had been exposed to light (Table 2).

The difference in cure between specimens exposed to light and those relying solely upon chemical cure is emphasized in Figure 3, Heliolink data. This figure indicates a rapid rise in cure for up to 60 minutes after mix following light exposure or when specimens were cured totally in the dark. Thereafter, there is a small increase in cure to 24 hours, but the difference in cure values between the light-treated specimens and those remaining in the dark remains constant. As was observed previously, the chemically cured reaction in Heliolink provided significantly less conversion after 24 hours than did any treatment where light was

Table 2. Statistical Differences in Cure between Treatments for Ultra-Bond

CURE VALUES ONE HOUR AFTER MIX

	CHEMICAL	20 WAFER	60 WAFER	60 MYLAR
CHEMICAL		S	S	S
20 WAFER	S		NS	NS
60 WAFER	S	NS		NS
60 MYLAR	S	NS	NS	

Above diagonal 0.05 level, below diagonal 0.01 level

CURE VALUES 24 HOURS AFTER MIX

	CHEMICAL	20 WAFER	60 WAFER	60 MYLAR
CHEMICAL		S	S	S
20 WAFER	S		NS	NS
60 WAFER	S	NS		NS
60 WAFER	S	NS	NS	

Above diagonal 0.05 level, below diagonal 0.01 level
S = significantly different.
NS = not significantly different.

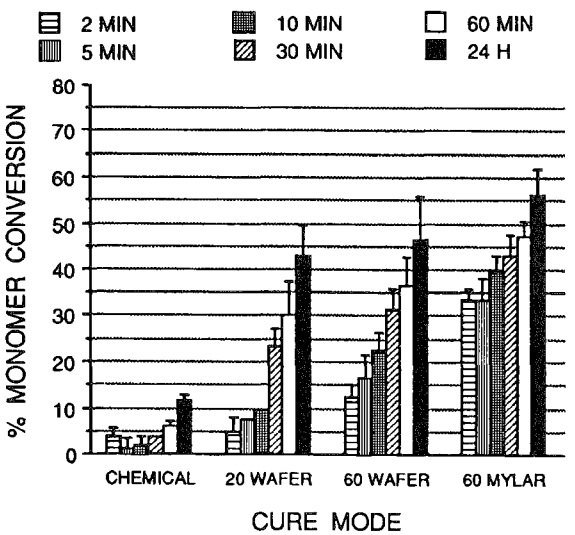

Figure 2. *Monomer conversion of Ultra-Bond for various treatments after specified postmix times (1 sd = vertical bar)*

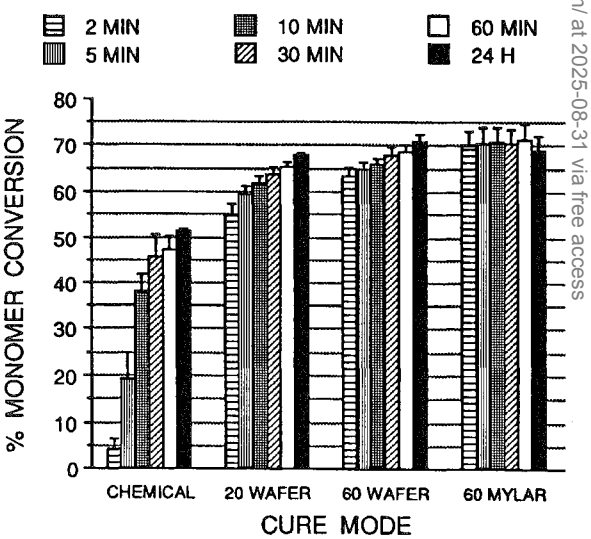

Figure 3. *Monomer conversion of Heliolink for various treatments after specified postmix times (1 sd = vertical bar)*

used (Table 3). Compared to the monomer conversion values seen in Ultra-Bond (Figure 2), those obtained with Heliolink are remarkably greater for all curing treatments.

Porcelite also demonstrated this constant lower value of conversion with the chemical-cure component compared to light-treated specimens for a given postmix time (Figure 4, Table 4). However, the absolute difference was smaller than with Heliolink. No substantial increase in conversion is observed between the 60-minute specimens and those of 24 hours for any given curing mode. After 24 hours postmix, the conversion values for Heliolink were greater than the corresponding values for Porcelite, with the exception of the chemically cured specimens, which proved similar.

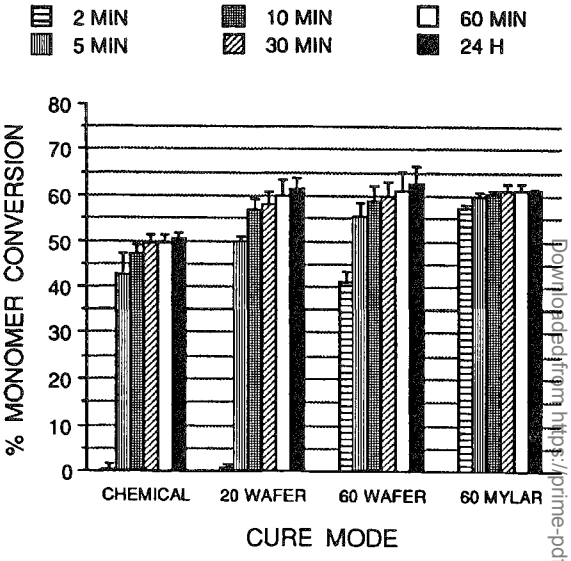

Figure 4. *Monomer conversion of Porcelite for various treatments after specified postmix times (1 sd = vertical bar)*

Table 3. Statistical Differences in Cure between Treatments for Heliolink

CURE VALUES ONE HOUR AFTER MIX

	CHEMICAL	20 WAFER	60 WAFER	60 MYLAR
CHEMICAL		S	S	S
20 WAFER	S		NS	NS
60 WAFER	S	NS		NS
60 MYLAR	S	NS	NS	

Above diagonal 0.05 level, below diagonal 0.01 level

CURE VALUES 24 HOURS AFTER MIX

	CHEMICAL	20 WAFER	60 WAFER	60 MYLAR
CHEMICAL		S	S	S
20 WAFER	S		NS	NS
60 WAFER	S	NS		NS
60 MYLAR	S	NS	NS	

Above diagonal 0.05 level, below diagonal 0.01 level
S = significantly different.
NS = not significantly different.

Table 4. Statistical Differences in Cure between Treatments for Porcelite

CURE VALUES ONE HOUR AFTER MIX

	CHEMICAL	20 WAFER	60 WAFER	60 MYLAR
CHEMICAL		S	S	S
20 WAFER	S		NS	NS
60 WAFER	S	NS		NS
60 MYLAR	S	NS	NS	

Above diagonal 0.05 level, below diagonal 0.01 level

CURE VALUES 24 HOURS AFTER MIX

	CHEMICAL	20 WAFER	60 WAFER	60 MYLAR
CHEMICAL		S	S	S
20 WAFER	S		NS	NS
60 WAFER	S	NS		NS
60 MYLAR	S	NS	NS	

Above diagonal 0.05 level, below diagonal 0.01 level
S = significantly different.
NS = not significantly different.

Figure 5 displays the conversion data obtained for Mirage. As with the previous materials, the chemically cured component indicated a lower mean conversion than other treatments (Table 5). However, the difference between the value of the chemically cured product and that exposed to 60 seconds of light through only Mylar is not as great as in any other material tested. The monomer conversion of the chemically cured specimens after 24 hours was only significantly different from the 60-second Mylar treatment. The cure values obtained with Mirage when treated with light were similar to those observed with Heliolink (Figure 3). However, it can be seen that the chemically cured component of Mirage provides a much better resin set than that of Heliolink.

DISCUSSION

The attainment of a significant chemically induced continuation of polymerization following light curing is difficult to achieve. The initial light exposure will cause a rapid increase in conversion of the resin, resulting in a very viscous gel. This rapid increase in viscosity hinders the migration of active radical components that would be responsible for further chemically induced polymerization (Korolev & Berlin, 1963). Therefore, the duration of inhibition and the level of initial conversion caused by the light exposure are highly influential factors upon the final cure of the dual-cure resins. The manufacturer must proportion the components of these materials with great care. On the one hand, a significant, delayed chemical reaction is desired. To obtain this, the initiation of chemically induced free radicals must be delayed so that adequate working time is provided during restoration manipulation and light curing. In order to achieve this end, large amounts of inhibitors are required (Cook & Standish, 1983a). On the other hand, these inhibitors will also interfere with the polymerization of light-induced initiation (Cook & Standish, 1983b). Also, large amounts of chemically

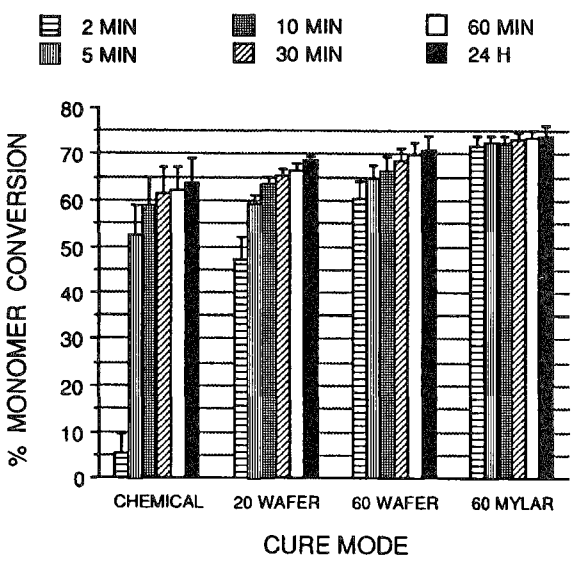

Figure 5. *Monomer conversion of Mirage FLC for various treatments after specified postmix times (1 sd = vertical bar)*

Table 5. Statistical Differences in Cure between Treatments for Mirage

CURE VALUES ONE HOUR AFTER MIX

	CHEMICAL	20 WAFER	60 WAFER	60 MYLAR
CHEMICAL		NS	NS	S
20 WAFER	NS		NS	NS
60 WAFER	NS	NS		NS
60 MYLAR	S	NS	NS	

Above diagonal 0.05 level, below diagonal 0.01 level

CURE VALUES 24 HOURS AFTER MIX

	CHEMICAL	20 WAFER	60 WAFER	60 MYLAR
CHEMICAL		NS	NS	S
20 WAFER	NS		NS	NS
60 WAFER	NS	NS		NS
60 MYLAR	S	NS	NS	

Above diagonal 0.05 level, below diagonal 0.01 level
S = significantly different.
NS = not significantly different.

induced free radical generators cannot be placed in these materials, because they would hinder shelf life (Venz & Antonucci, 1988).

The clinician is relying upon chemically induced polymerization to cure resin cement that was neither accessible to the light nor that has received adequate light intensity. The results obtained in this study indicate that, of the products tested, none of them had chemically cured values that equaled the cure obtained when maximal light intensity was used (60 Mylar). This difference between the value of chemically caused polymerization and that caused by light differed by brand with time. The largest difference after 24 hours postmix was seen in Ultra-Bond, a difference of 44.5%. Other brands, however, demonstrated less of a difference between the light-cured values and those obtained in the dark.

It is also noted that there is a lack of significant increase in conversion in these materials following the first hour postmix. This inability to continue to increase in cure is appropriate given the tremendous increase in resin viscosity caused by the initial polymerization and the inability of radicals to migrate. Claims of manufacturers of an "infinite curing material," one that continues to significantly increase in conversion as time progresses, is not warranted by the results of this investigation.

Most of the products reached high levels of final cure, with the exception of Ultra-Bond. Of all the products tested, only Mirage demonstrated that the chemically cured component alone reached equal degrees of cure, as the resin cured for either 20 or 60 seconds through the cured composite wafer.

The importance of adequate duration of light exposure is also suggested by the findings of this research. In all cases, when exposing the cement through the 1.5 mm cured composite, the 60-second exposure yielded higher conversion values than when only a time of 20 seconds was used; however, the differences were not statistically significant.

It should be noted that in the majority of cases, the cure observed after 10 minutes postmix for each type of cure treatment was within 90% of the cure after 24 hours. This result indicates that there is not a significant amount of curing that occurs in these products after the initial set.

CONCLUSIONS

1. The polymerization potential of chemically cured and light-cured components of four commercially available dual-cure cements was found to vary greatly with brand.
2. Even after 24 hours, the chemical-cure component was found to be significantly less than that when the resin was exposed to any lighting condition for most resins.
3. There was no evidence indicating that a substantial increase in monomer conversion was found for the chemically induced reaction component after 24 hours postmix over that found after 60 minutes.
4. For most resin systems tested, the cure observed 10 minutes postmix was almost equivalent to the cure after 24 hours.

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A National Survey on the Use of Glass-Ionomer Cements

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SUMMARY

This study was conducted to determine why and how glass-ionomer cements are being used by general dentists. Data were collected by a mail survey sent to a random sample of approximately 1000 general dentists in the United States. The results showed that 94% of the respondents currently use or have used glass ionomers. The primary uses (in order of popularity) are: 1) as a base or liner, 2) as a luting cement, and 3) as a crown foundation. Eighty-two percent of the respondents who use glass-ionomer luting cements reported some postoperative tooth sensitivity, but a slightly larger proportion (85%) reported postoperative sensitivity with other cements.

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INTRODUCTION

Glass-ionomer cements were developed in the late 1960s, as a derivative of silicate and zinc polycarboxylate cements (Wilson & Kent, 1972). Most of the current glass-ionomer products are the reaction product of a calcium fluoroaluminosilicate glass powder and an aqueous solution of a polyacrylic acid/itaconic acid copolymer containing tartaric acid (Smith, 1990).

Glass ionomers offer a unique combination of favorable properties. The ability of glass ionomers to bond to tooth structure, including dentin, is a significant benefit. Methods of maximizing the bond strength have been the subject of research (Hewlett, Caputo & Wrobel, 1991).

The release of fluoride from glass ionomers, which reduces the incidence and severity of recurrent caries, is also highly desirable (Swift, 1989; McCourt, Cooley & Huddleston, 1990). Glass ionomers have also been shown to have antimicrobial properties (Scherer & others, 1990).

Because of the favorable characteristics of glass ionomers, attempts have been made to improve some physical properties and make glass ionomers more useful in areas where strength is of primary importance (e g, posterior teeth and core build-ups). Silver particles have been incorporated to improve the strength and wear characteristics (McLean, 1900; Simmons, 1990).

Pulpal response to glass ionomers, especially when used as luting agents, has been of some concern (Christensen, 1990). Numerous studies have explored the issue of biologic response to glass ionomers (Stanley, 1990; Mjör, Nordahl & Tronstad, 1991; Felton & others, 1991). The more recent studies seem to indicate that today's glass-ionomer products are relatively biocompatible, although it appears wise to use clinical techniques that minimize any pulpal inflammatory response.

This study was conducted to determine why and how glass-ionomer materials are used in general dental practice in the United States. In addition, data were collected to determine if various cementation techniques affected postcementation tooth sensitivity when using glass-ionomer luting cements.

METHODS AND MATERIALS

A random sample of 1022 general dentists living in the United States was drawn from the American Dental Association's census database. The sample frame included more than 112,000 general dentists. The dentists selected in the sample were statistically compared to the sample frame for significant differences ($P < 0.05$) regarding gender, geographic location of practice, primary occupation, and practice ownership status. No significant differences were found between the sample and the sample frame.

Letters with survey forms were sent to each dentist in the sample in late 1990. All data collected were kept anonymous, but surveys were numerically coded to identify nonrespondents. Approximately six weeks after the initial mailing, a second letter and survey was sent to nonrespondents. The survey form included 29 questions related to glass-ionomer usage in practice. Some of the survey questions dealt with general information on glass ionomers, and additional questions dealt with specific clinical uses (liners/bases, permanent restorations, crown foundations, and luting cements). For the purpose of data collection, liners and bases were organized as a single category (liners/bases) on the questionnaire. This categorization was done to avoid missing any data, since there is some variance in the use of the terms "base" and "liner" in different geographic regions and in different dental schools.

The data were entered and analyzed on a personal computer using the database software program Reflex 2.0 (Borland International, Scotts Valley, CA 95066). Chi-square statistical analysis was used to determine if there were any significant relationships between operator variables and postcementation tooth sensitivity.

RESULTS

Approximately 66% of the dentists selected for the survey responded. Of those respondents, 94% indicated that they currently use or have used glass-ionomer materials in their practice. The respondents identified three primary sources of technical and scientific information about glass ionomers (Figure 1): continuing education courses, scientific journals, and the *Clinical Research Associates Newsletter* (Clinical Research Associates, Provo, UT 84604).

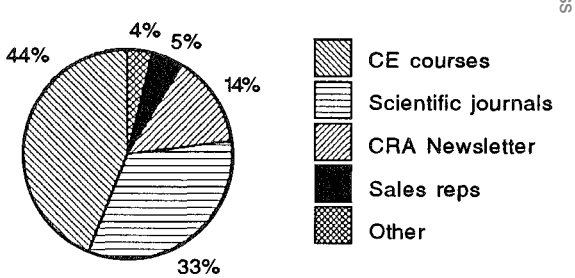

Figure 1. *Most important sources of information*

The two primary reasons for using glass ionomers were adhesion to dentin (52% of respondents) and fluoride release (33%). Specific uses by percentage of respondents are shown in Table 1.

Root caries restorations accounted for 41% of total Type II glass-ionomer use, and erosion/abrasion restorations accounted for 34%. (By definition, Type I glass ionomers are used as luting agents, Type II as restorations, and Type III as liners and bases.) Additionally, those materials were used for class 3 restorations, both in primary and permanent anterior teeth. Seventy-six percent of respondents routinely use a surface "protectant" as the restorative material is setting, most frequently the waterproof varnish provided with the product (42%). Other "protectants" included a matrix (19%), resin bonding agent (17%), and a copal resin varnish (13%).

Table 2 shows the summarized response to a question about the most serious disadvantages of conventional glass-ionomer (Type II) restorative materials. Silver-reinforced glass ionomers were the most frequently used material for core build-ups (crown foundations), chosen 39% of the time. They were followed by amalgam, composite resin, and cast alloys (Figure 2).

Frequency of use of glass-ionomer liners and bases is shown in Table 3. Eighty-six percent of the respondents use calcium hydroxide under glass-ionomer bases if the preparation is believed to be close to the pulp.

Thirty-seven percent of respondents routinely used a "dentin conditioner" prior to placement of a glass-ionomer restoration or liner. The most popular dentin conditioner reported was the liquid portion of a polycarboxylate cement (polyacrylic acid) rather than a specific dentin conditioning product.

Among those dentists who have used glass-ionomer luting cements, 11% no longer use it, and another 30% use it for less than one-fourth of their castings. In contrast, a large proportion (41%) frequently use glass-ionomer luting agents (76-100% of their castings).

Frequent users of glass-ionomer luting cements who reported the fewest problems with postcementation sensitivity (0-5% sensitivity rates) used two popular cements. Those

Table 1. Percentage of Respondents Who Use Glass Ionomers for Various Dental Procedures

Procedure	Percentage
Bases/liners	79%
Crown cementation	75%
Core build-ups (crown foundations)	69%
Permanent restorations	50%
Provisional (caries control) restorations	39%

Table 2. Most Serious Disadvantage or Problem of Conventional Glass-Ionomer Restorative Materials

Problem	Percent Response
Inferior esthetics	32%
Delayed finishing	19%
Field control (isolation)	19%
Poor shade selection	14%
Difficult placement	10%

Table 3. Frequency of Use of Glass-Ionomer Liners and Bases by Restoration Type

Type of Restoration	Percent Response
Posterior composite resin	58%
Anterior composite resin	41%
Amalgam	23%

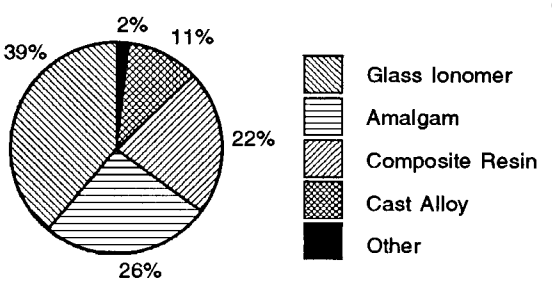

Figure 2. *Materials used for core/foundation build-ups*

cements were Ketac-Cem (ESPE/Premier Sales Corp, Norristown, PA 19404) and Fuji I (G-C International Corp, Scottsdale, AZ 85260). Seventy-three percent of the frequent Ketac-Cem users and 70% of the frequent Fuji I users reported low (0-5%) sensitivity rates.

For all users, the incidence of postoperative sensitivity with glass-ionomer luting cements was slightly lower (82%) than that reported for other permanent cements (85%). The frequent users of glass-ionomer luting cements who reported low (0-5%) incidence of postcementation sensitivity indicated that they used the techniques shown in Table 4 during the cementation process. There were no statistically significant relationships (chi-square analysis, $P < 0.05$) between any of the cementation technique variables and the incidence of high (more than 25%) and low (less than 5%) postcementation sensitivity.

DISCUSSION

The relatively high response rate (66%) to this survey indicates that the data are likely to be representative of the general dentists in the United States (Hovland, Romberg & Moreland, 1980). Based on the fact that 94% of general dentists have used glass-ionomer products, it is safe to say that glass ionomers have become an important treatment modality.

Table 4. Cementation Techniques Used by Frequent Glass-Ionomer Users Who Reported Low Incidence of Postcementation Sensitivity

Technique	Percent Response
Thick, quick mix	61%
Excess removal only when cement is hard	58%
Maintaining dry field	57%
Moistening tooth	39%
Application of varnish/sealant over margins	19%
Vibratory seating technique	18%

The primary advantages of glass ionomers (adhesion to dentin and fluoride release) make them a viable alternative for root-surface lesions. The U S population is not only living longer, but also retaining their natural teeth for a longer period, leading to increased root-surface treatment needs (Reinhardt & Douglass, 1989). Glass-ionomer restorative materials, in spite of the limitations pointed out by the respondents (inferior esthetics, need to delay finishing, necessity for field isolation, and poor shade selection) offer an important treatment option.

The popularity of silver-reinforced glass ionomers as a core build-up material (Figure 2) is apparent. Incorporation of a fluoride-releasing material should lower the probability of recurrent caries beneath a cast restoration. In view of concerns about the release of mercury from dental amalgams, silver-reinforced glass ionomers are likely to increase in popularity as core build-ups.

Since glass-ionomer bases or liners are frequently used under other restorative materials (posterior and anterior composites, amalgams), one might assume that the properties of these liners are suitable for that use. In fact, the glass-ionomer liners offer many of the advantages of earlier base materials (strength and insulation) as well as bonding ability (to both tooth and some restorative materials) and fluoride release. This combination of properties makes today's glass-ionomer liners and bases extremely effective.

Use of glass-ionomer cements as luting agents for cast restorations has had mixed success. Initially, there was significant concern about the problem of postcementation tooth sensitivity. The fact that a large number (41%) of general dentists are using glass-ionomer cements frequently (76-100% of the time) indicates that this concern has diminished. In fact, the respondents to this survey indicated that the incidence of postcementation sensitivity with glass ionomers is no greater than that with other cements. This finding is similar to that of an earlier survey on glass-ionomer use (Klausner, Brandau, & Charbeneau, 1989).

Improvements in the delivery of the materials as well as changes in chairside techniques have contributed to the increased popularity of glass-ionomer luting cements,

as well as other glass-ionomer products. The benefits of localized fluoride release and adhesion are important, and glass-ionomer cements should continue to fulfill a significant role as a dental restorative material.

CONCLUSIONS

This national survey of general dentists found that glass-ionomer products are highly popular, especially for use as liners or bases, luting cements, and crown foundations. A significant number of dentists (41%) are using glass-ionomer luting agents as their primary cement for cementation of at least three-fourths of their cast restorations. Earlier concerns about postcementation tooth sensitivity seem to be decreasing, and the respondents reported that the incidence of postcementation sensitivity was no greater for glass-ionomer cements than for other permanent luting cements.

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The Effect of Dentin Primer on the Shear Bond Strength between Composite Resin and Enamel

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Clinical Application
Enamel adhesion may be affected by dentin primers.

SUMMARY

The purpose of this study was to determine the effect of accidental dentin primer contact with etched enamel on shear bond strength of composite resin to enamel. Four dentin bonding systems were included in this study: GLUMA Dentin Bond, Scotchbond, and Prisma Universal Bond 2 and 3. Eighty extracted human permanent anterior teeth were used and divided in eight test groups. The vestibular surfaces were ground and acid etched. For each dentin bonding system 10 samples were treated with dentin primer prior to placement of resin. Shear bond testing showed that enamel contact with dentin primer in the above two systems decreased the shear bond strength between composite and enamel by 31 to 44%.

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INTRODUCTION

The bonding of dental restorative materials to tooth structure has been the focus of dental research for many years. Improving the bond of resin restorative material to enamel by conditioning the enamel with (85%) phosphoric acid was first reported by Buonocore (1955). Bonding to dentin is a more complex process than bonding to enamel. The efficacy of acid etching of dentin to improve bond strength is rather limited, since dentin has a higher permeability and seepage of

dental fluids from the open tubules (Gwinnett, 1977; Pashley, Michelich & Kehl, 1981). More importantly, inflammatory pulpal responses have been demonstrated after acid pretreatment of the dentin (Retief, Austin & Fatti, 1974; Stanley, Going & Chauncey, 1975; Stanford, 1985). The demand for esthetic composite resins, however, has generated rapid development of a number of dentin bonding systems to provide sufficient bond strength and to minimize or eliminate microleakage (Bowen, 1965; Chohayeb, Bowen & Adrian, 1988; Bowen, Cobb & Rapson, 1982; Cueto & Buonocore, 1967; Lee & others, 1971).

Placement of composite restorations and the use of bonding agents require stringent isolation procedures and skill to ensure that the etched enamel surface is not contaminated. The clinical success of these restorations is directly dependent on proper management of these technique-sensitive materials. The more recent dentin enamel bonding kits consist of an acid etchant for the enamel, a liquid dental primer, and an unfilled resin adhesive. The manufacturers of these kits do not speculate on effects of contact of acid-treated enamel with dentin primer, although technically it is not always possible to prevent accidental contact of the enamel surface with dentin primer.

The purpose of this study was to examine the effect of dentin primer on the shear bond strength between composite resin and enamel, utilizing four different dentin bonding agents.

METHODS AND MATERIALS

Eighty recently extracted sound human permanent mandibular and maxillary anterior teeth were cleaned and stored in 0.9% saline solution for a maximum of two days prior to use in the testing. The teeth were embedded in plastic molds with cold-cure acrylic resin (Orthocryl, Stratford-Cookson Co, Newman, GA 30264), so that the vestibular surfaces projected above the resin approximately 1 to 2 mm. After the acrylic was cured, the mounted teeth were placed in a tapwater bath (37 °C) for 15 minutes prior to further tooth preparation. The samples were assigned to four test groups, each consisting of two groups of 10 specimens.

Four dentin bonding systems were included in the study: GLUMA Dentin Bond (Bayer Dental, Leverkusen, Germany), Scotchbond 2 (3M Dental Products, St Paul, MN 55144), and Prisma Universal Bond 2 and 3 (L D Caulk, Milford, DE 19963) (Table 1).

The mounted teeth were then dried and the vestibular enamel surfaces were cleaned with the coarsest-grit pop-on disk (3M Dental Products) to establish a flat surface and to expose fresh enamel. The tooth surface was well washed and dried

Table 1. Description of Dentin Bonding Systems

Dentin Bonding Systems	Primer	Bonding Resin	Composite
Prisma Universal Bond 2 (PUB2)	PENTA, HEMA, ethanol	TEG-DMA, PENTA glutaraldehyde (0.45%) camphonoquinone (1%)	Prisma-Fil
Prisma Universal Bond 3 (PUB3)	PENTA, HEMA, ethanol	TEG-DMA, PENTA glutaraldehyde (0.65%) camphonoquinone (1%)	Prisma-Fil
Scotchbond 2 (SCB)	adequous solutions of maleic acid and HEMA	BIS-GMA HEMA	Silux
GLUMA (GLU)	adequous and HEMA	GLUMA sealer BIS-GMA, TEG-DMA	GLUMA

with oil-free compressed air for 30 seconds. Conditioner gel containing 37% phosphoric acid (Caulk) was brushed on the exposed enamel surfaces, and after 60 seconds the teeth were thoroughly rinsed and dried. An opaque-white surface was evident following this conditioning step.

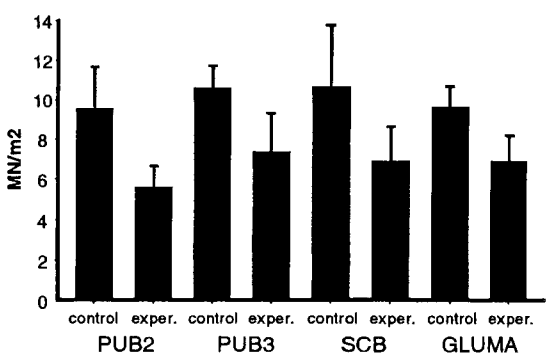
In each of the four test groups the vestibular enamel surfaces of 10 samples were treated with the dentin primer plus enamel adhesive (experimental group), and the other 10 were treated with only the enamel adhesive (control group). All materials were applied in accordance with the manufacturer's instructions. Following this a 4 mm-high plastic split die with a 4 mm-in-diameter opening was carefully placed over the prepared surface of the tooth, and the composite resin was placed in two increments. Each increment was cured for 40 seconds using a Visilux 2 visible light cure unit (3M Dental Products). The split mold was then carefully removed and the embedded tooth with the composite resin cylinder bonded at a 90° angle to the enamel surface of the tooth was placed in a 37 °C distilled water bath for 24 hours. The samples were mounted in the alignment block of a Universal Testing Machine (Lloyd Instruments, Southhampton, 503 6HP England), and a shear strength force was applied to the base of the bonded cylinder parallel to the prepared surface at a crosshead speed of 0.01 inches/min until debonding occurred. The shear bond strength was calculated and expressed in MNm^2. The data were analyzed with Student's *t*-test within each group and evaluated for significance at the 5% level.

RESULTS

The mean shear bond strength and standard deviations of the shear bond strengths in the eight test groups are presented in Table 2 and in the figure. In all four test groups in which only adhesives were used, 31 to 44% higher bond strengths were measured, as compared to the test groups treated with dentin primer. Student's *t*-test analysis showed a highly significant difference between experimental and control specimens in each group ($P < 0.01$). There was also a significant difference between the bond strength of a surface treated with dentin primer from the Prisma Universal Bond 2 group (PUB2) and the group treated with Prisma Universal Bond 3 (PUB3) and GLUMA ($P < 0.05$). In the control groups, Prisma Universal Bond 3 showed a significantly higher bond strength than GLUMA ($P < 0.05$). All samples broke at the junction of tooth surface and composite.

DISCUSSION

The acid-etch technique, accompanied by a bonding agent, has become a routine procedure for composite resin restorations. Etching of the enamel surface results in a



With shear bond strength as a test for composite/enamel bonding, the use of four dentin bonding systems was evaluated. The enamel contact with dentin primer prior to application of enamel adhesive markedly decreased the bond strength.

Table 2. Shear Bond Strength and Standard Deviation in Different Test Groups

Groups	PUB2	PUB2 with primer	PUB3	PUB3 with primer	SCB	SCB with primer	GLU	GLU with primer
Mean (MPa)	9.56	5.62	10.62	7.36	10.67	6.94	9.64	6.93
SD	2.13	0.87	1.08	1.97	3.08	1.69	1.02	1.27

superficial etched zone with underlying porous zones (Silverstone & Dogon, 1975). The inflow of resin into these porous zones results in formation of resin tags by which mechanical bonding to etched enamel is established (Retief, 1978).

Up to now there have not been any publications demonstrating the effect of enamel/dentin primer contact on bond strength between enamel and composite. It has been reported that the bond strengths of composite resins to etched enamel are adversely affected by saliva contamination (Hormati, Fuller & Denehy, 1980) and by distilled water contamination as compared to that of a dry surface (Silverstone & Dogon, 1975). O'Brien and others (1987) believed that saliva contamination of the etched enamel surface prior to the placement of composite resins should be avoided, and suggested that re-etching of enamel surfaces exposed to brief saliva contamination should be considered. It has also been reported that moisture and other debris prevent restorative resin from sufficiently contacting the enamel surface (Soetopo, Beech & Hardwick, 1978). Therefore, it is desirable not to alter the etched enamel surface. However, accidental contact of the etched enamel with dentin primer is often unavoidable due to technical limitation. Further investigation is needed to determine the exact mechanism of decreased bond strength between resin and enamel caused by dentin primer in this study.

Current recommendations by some manufacturers suggest confining the placement of dentin primer to the dentin surfaces. Furthermore, unintentional primer contact with etched enamel is mentioned, but it is advised that it will have no deleterious effect on the final outcome of the restoration. This study, however, demonstrates that contact of etched enamel with dentin primer used in this study may decrease the bond strength by 31 to 44%. Translating this finding into clinical practice could mean that the benefits of using dentin primer in terms of increased bond strength may be negated by this adverse effect on enamel bonding. This may indicate that if there is sound enamel surrounding the cavity for bonding composite, the use of a dentinal adhesive could be eliminated and/or a visible-light-cured glass-ionomer cement dual-cure liner substituted that can effectively bond to prepared dentin and enamel adhesive.

Whether one could apply dentin primer prior to etching the enamel, with its consequent contamination while washing the enamel, and still achieve reliable dentin bonding is still to be determined. The observation further emphasizes to general practitioners the need for careful management of technique-sensitive steps.

It is important to mention that the test values are not meant to be compared with other publications. Variation in test methods give different bond strength values that cannot be compared. The bond strength values are not as important as the comparison of materials and procedures with the same test method; i e, the ranking of the bond strengths are more meaningful than the actual values. The International Organization for Standardization (ISO) is working on a document that will make it possible to standardize bond strength testing worldwide (Federation Dentaire International, 1990).

CONCLUSION

Contrary to what manufacturers have indicated, this laboratory study is the first one to demonstrate that contact of etched enamel with dentin primer may result in a significant decrease in bond strength of composite resin to enamel. The bonding between enamel and composite was 31 to 44% higher without dentin primer treatment. This study suggests that primer be confined to dentin. However, further investigation is needed to (a) evaluate the clinical significance of this study, (b) determine if, when primer contact occurs, it is necessary to reprepare and/or re-etch the enamel surface, and (c) evaluate other bonding agents, since this conclusion is limited to the specific bonding agents tested in this study.

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Esthetic Veneering of Amalgam Restorations with Composite Resin—Combining the Best of Both Worlds?

Clinical Relevance
A technique for veneering amalgam with light-cured glass-ionomer and filled resins is presented.

P J J M PLASMANS • E A J REUKERS

SUMMARY

Patients are becoming more and more aware of the esthetic alternatives to dental amalgam and are asking dentists to offer solutions that are more esthetically pleasing. However, the difficulties in inserting clinically durable composite resin restorations in the posterior area are numerous.

With the high-copper amalgam systems, the dental profession has had an excellent restorative material. In the past there have been attempts to combine amalgam with the esthetic qualities of composite resin.

The introduction of an adhesive and opaque light-curing glass-ionomer liner has created new opportunities to bond composite resin to existing amalgam restorations on esthetically disturbing surfaces.

This paper describes a simple and quick way in which unesthetic buccal and occlusal extensions of amalgam restorations can be veneered with composite resin. Preliminary six-month results of about 100 restorations are presented. This method may prevent the premature replacement of good functioning amalgam restorations with porcelain-fused-to-metal crowns or composite resin restorations for only esthetic reasons.

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INTRODUCTION

In recent years the use of composite resins has expanded from restorations in the anterior region to the posterior area (Mitchem, 1988). This development is not without problems. The difficulties in inserting clinically durable composite resin restorations in the posterior area are numerous both in the

direct and indirect methods (inlay) (Wilson, Mandradjieff & Brindock, 1990). Mitchem (1988) and Roulet (1988) mentioned critical areas of posterior composite resins: physical properties such as wear and fatigue resistance, hardness, and strength; polymerization shrinkage, hydrolytic instability, and leakage potential (Söderholm & others, 1984); and technique-sensitivity and ease of handling.

Although the physical properties have been improved, some traditional problems remain to haunt the application of composite resin restorations in posterior teeth. Bonding to dentin in the approximal cervical region, moisture control, and the creation of an acceptable approximal contact point are especially critical. Other problems are: extended treatment times and increased postoperative masticatory sensitivity (Boksman & others, 1986; Wilson, Smith & Wilson, 1986; Johnson, Gordon & Bales, 1988).

These aspects lead to the conclusion that the replacement of amalgam with composite resin has no therapeutic value, except in those cases where an allergic reaction has been diagnosed (Mitchem, 1988). However, one of the main problems with amalgam restorations is their appearance. Consequently, there is demand for a restoration type that combines the proven clinical behavior of amalgam in the invisible part of the restoration with the esthetics of composites in the more visible parts.

POSSIBLE COMPOSITE/AMALGAM COMBINATIONS

This combination is described by several authors (Barkmeier & Cooley, 1979; Gourley & Ambrose, 1982; Gordon, Lanfer & Metzger, 1985; Kossa, 1987; Cardash & others, 1990; Roda & Zwicker, 1992). The composite resin can be used to mask the extension of an amalgam restoration in an area that is visible, e g, the buccal extension of an MOD amalgam restoration. Also the composite resin can be used within a large amalgam restoration to veneer the buccal surface of the teeth entirely.

Unfortunately this method may cause a dark or gray appearance of this type of restoration due to the amalgam shining through when no opaque layer is used. To solve this problem a composite resin opaquer can be applied. Application of a thin layer is sometimes difficult, and thus there is a need to remove more amalgam to provide sufficient thickness for both opaquer and the composite resin veneer. This results in a weakening of the remaining amalgam restoration.

Essentially, three methods have been described in the literature to retain the composite resin to an existing amalgam restoration: creating retention with undercuts and retentive grooves (Anglis & Fine, 1982; Pollack & Blitzer, 1983; Quiroz & Swift, 1986), obtaining auxiliary retention by inserting retention pins into the bulk of the amalgam restoration (Lambert, Scrabeck & Robinson, 1983; Gordon & others, 1985), and chemical and/or micromechanical bonding of composite resin or glass ionomer to the amalgam (Zalkind & others, 1981; Quiroz & Swift, 1986).

In only one of these reports were clinical follow-up data described: Gordon & others (1985) reported favorable two-year results for a small number of restorations.

With the introduction of light-curing glass-ionomer liner and base materials, the esthetic amalgam-composite restoration got a new chance. The powder component of the glass-ionomer material is highly opaque and lacks translucency (Wilson, 1990). Normally this is a disadvantage, but in the application of veneered amalgam restorations, this is of great benefit. The working characteristics of the mixed system are such that it can be applied in a very thin layer before light curing.

One of the characteristics of one of these light-curing glass-ionomer systems (Vitrebond, 3M Dental Products, St Paul, MN 55144) is a bonding capacity of 9 MPa to an existing amalgam restoration without the use of an intermediary bonding layer (Aboush & Elderton, 1991).

The precise mechanism of adhesion of the glass ionomer has yet to be fully elucidated. Several hypotheses have been advanced. Wilson and McLean (1988) stated that the adhesive bond is a chemical one, affected by chemical and not mechanical factors.

In its onset condition, the water-based Vitrebond contains unsaturated COO^- groups of organic acids. Consequently the setting

glass ionomer is mildly corrosive to amalgam; metal ions can be released from the amalgam surface. Multivalent metal ions are known to be able to cross-link the organic acid chains (Wilson & McLean, 1988). It can be speculated that metal ions residing on the amalgam surface may link to both the amalgam and the COO^- groups. This would be a similar type of bonding as has been described for the bond between glass ionomer and the inorganic constituents of dentin (Smith, 1968). Mertz-Fairhurst and Newcomer (1988) stated that at a X500 magnification the prepared amalgam surface looks like etched enamel, possibly explaining a micromechanical bonding with composite resin or the resin-modified glass-ionomer lining.

The bond strength value of Vitrebond to set amalgam of around 9 MPa is between the bond strengths of Vitrebond to enamel (13 MPa) and dentin (5 MPa) (Aboush & Elderton, 1991). A 4-META-based adhesive for bonding composite resin to amalgam developed bond strengths in the 6 to 7 MPa range (Cooley, McCourt & Train, 1989). When fracture occurred in testing, mostly a combined adhesive/cohesive fracture of the bond was present, indicating that the bonding of Vitrebond to amalgam could be regarded as a reliable procedure (Aboush & Elderton, 1991). Also the bonding capacity of composite resins to the glass-ionomer lining is relatively high, resulting in cohesive failures in the glass ionomer.

This new material has the advantage of acting both as bond and as opaquer and therefore simplifies the traditional procedure, which uses a separate bonding agent and opaquer. It also offers the potential to expand the indication for esthetic veneering of amalgam restorations to occlusal surfaces, omitting the traditional problems for posterior composite resin restorations as described in the introduction.

TECHNICAL PROCEDURE

To apply this method, a thorough evaluation of the existing amalgam restoration was essential. Some points to consider were: Was there (secondary) caries? Was there sufficient remaining bulk of the restoration after reducing the surface for the veneer? Were the approximal cervical margins adequate? Were the approximal contact areas adequate? In evaluating these points the use of radiographs was considered to be essential.

After positive evaluation, the areas of the restoration that needed esthetic improvement were chosen (Figures 1-4). In these areas a cavity of 1 to 1.5 mm in depth was prepared with margins ending where possible in

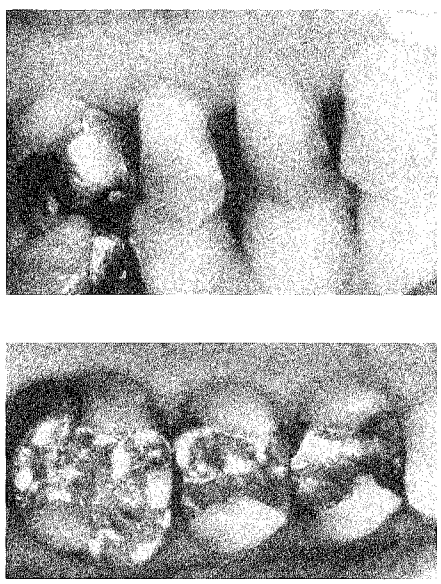


Figure 1. *Esthetically unpleasing amalgam restorations in teeth 14, 15, and 16. Patient requested esthetics to be improved. a. buccal view b. occlusal view*

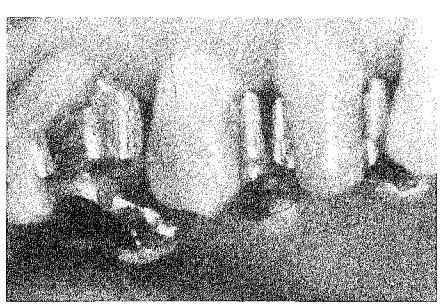


Figure 2. *Parts of the amalgam restorations have been removed to create bulk for composite resin. A thickness of 1 - 1.5 mm is considered necessary. (buccal view)*

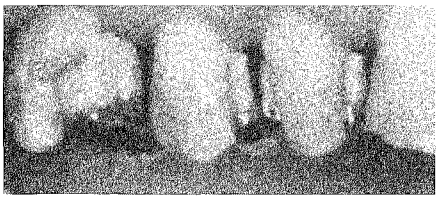
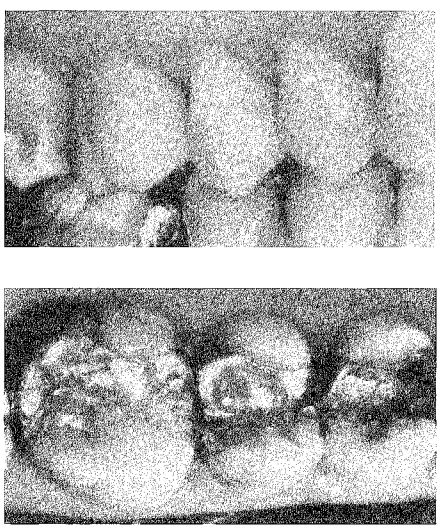


Figure 3. *The prepared amalgam surface is coated with a thin Vitrebond layer and light cured. Enamel margins are not coated as are butt joint amalgam margins. (buccal view)*



a.

b.

Figure 4. *A resin bonding agent is applied over the glass-ionomer lining, enamel margins, and butt joint amalgam margins and light cured. For the occlusal veneering P-50 is used; on the buccal surface Silux Plus is used. a. buccal view b. occlusal view*

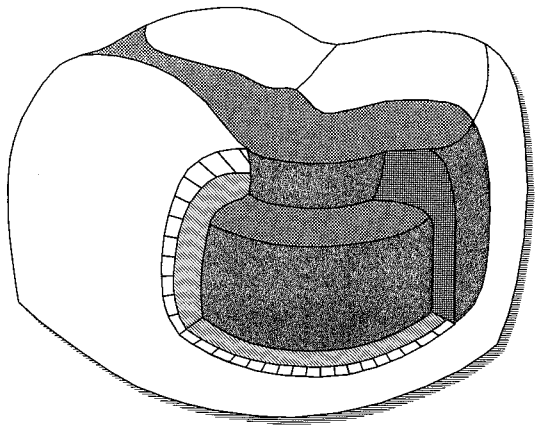


Figure 5. *3-D impression of a mesial-buccal reduction of an amalgam restoration in a molar. Enamel is beveled; amalgam ends in a butt joint.*

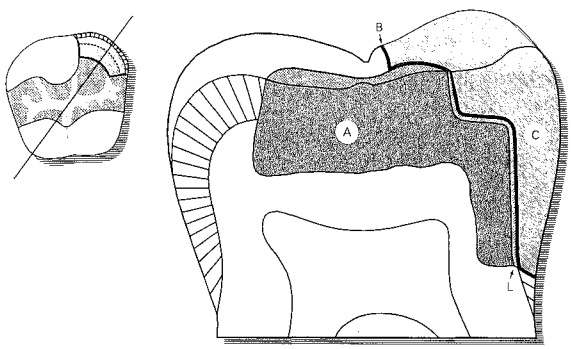


Figure 6. *Cross section of molar. Mesial-buccal cusp with amalgam is reduced and replaced with composite resin. A = amalgam; L = glass-ionomer lining; B = bonding; C = composite resin.*

enamel or in amalgam (Figures 5-6). The enamel margins were beveled, the amalgam margins ending in a butt joint. The approximal contact points in amalgam remained intact. The amalgam surface was not acid etched, only washed and dried.

The glass-ionomer liner was placed in a thin layer on the axial wall and occlusal surface, covering the amalgam restoration. Vitrebond was kept short of the margin.

After light curing for 30 seconds, the beveled enamel margins of the preparations were etched with a phosphoric acid gel for 15 seconds and then rinsed and air dried. A resin bonding agent (Scotchbond Dual Cure, 3M) was applied according to the manufacturer's instructions, moderately air thinned, and cured under visible light for 20 seconds. Silux Plus resin for the buccal areas and P-50 for the occlusal areas (3M) were placed over the resin bonding agent in one increment with slight overcontouring and with special attention given to marginal adaptation. If an extensive area had to be veneered, application of the composite resin in several steps was advocated. The resin was light cured for 60 seconds and finished using fine-grit finishing burs and four grades of Sof-Lex disks (3M).

The veneering of a buccal or occlusal surface takes about 8-10 minutes. If more surfaces were treated in the same session, a

significant reduction of treatment time per surface was possible.

PRELIMINARY CLINICAL RESULTS

The method described was clinically put into practice on a total of 98 restorations. The restorations in 35 patients were made by four operators. Tooth type distribution was by tooth-number: 14/24, n = 31; 15/25, n = 23; 16/26, n = 12; 34/44, n = 16; 35/45, n = 12; and 36/46, n = 4. Both buccal and occlusal parts of the amalgam restorations were veneered.

Results after the six-month evaluation indicated that in five cases the entire veneer or part of it was dislodged, and these teeth had to be retreated or repaired. Overall patient satisfaction with this treatment method was excellent. Only one patient was dissatisfied (but did not want other treatment). Evaluation in detail, however, showed that in 23% of the restorations a slight color deviation between the veneer and the tooth was present. The main reason for this was the darker overall appearance of amalgam-restored teeth. In 4% of the restorations the marginal integrity of the veneer restorations was not satisfactory.

DISCUSSION

With the high-copper amalgam systems, the dental profession has a restorative material of superior handling and physicochemical properties and corrosion resistance. However, from an esthetic point of view, amalgam is unacceptable for many patients for the restoration of buccal cusps and buccal surfaces of maxillary premolars and molars.

Veneering with composite resin can provide an esthetically acceptable result. It may preclude the need for a porcelain-fused-to-metal crown or prevent the undesired insertion of posterior composite restorations, with all their inherent problems. Roda and Zwicker (1992) described a method in which both composite window and amalgam restorations are being placed in one session. This might be a solution when the entire old restoration has to be replaced; however, if the old amalgam restoration is still functioning well except for esthetics, the removal of the entire restoration might be overtreatment.

The described method should be restricted to teeth with a solid (bulk) amalgam restoration without weakened cusps. On these teeth occlusal and buccal surfaces can be veneered. Failure will probably occur in the case of veneering entire cusps, due to the stress-bearing location of cusps. In cases where buccally in the cervical area no enamel bevel can be obtained, special attention must be paid to compensate for the polymerization shrinkage. In these cases the glass-ionomer lining should be applied as close to the margin as possible (Holtan & others, 1990).

The selection of the composite resin is influenced by the area that has to be veneered. In the nonstress-bearing (buccal) areas a microfilled composite resin (e g, Silux Plus) is advocated, because it causes minimal soft tissue irritation and plaque retention, while in the occlusal stress-bearing areas a hybrid posterior composite (e g, P-50) is recommended (Mazer & Leinfelder, 1988).

Reduction of the amalgam in the occlusal-approximal area should be avoided, to maintain the approximal contact in amalgam. It is preferable to keep the marginal ridge intact in amalgam rather than apply a too-thin layer of composite resin in this stress-bearing area.

The treatment times with this method are low. There is no need for anaesthesia, and in most cases a rubber dam is not necessary, due to the supragingival location of the restoration margins. In comparison, the treatment times for a composite resin inlay system are 1 1/2 hours for one inlay and two hours for two inlays in the same patient (Plasmans, van't Hof & Creugers, 1992). This implies that, compared to the removal of the amalgam, the veneering of the buccal and occlusal surfaces can be performed in 10 to 15% of the time needed for composite resin inlays.

CONCLUSION

The technique described above allows amalgam with its superior physical properties (compared to composite resin) to be maintained for the major portion of the restoration, while the unesthetic buccal and occlusal extensions are veneered with esthetically pleasing composite resins. This combination

may prevent the replacement of good functioning amalgam restorations with porcelain-fused-to-metal crowns or the application of posterior direct or indirect composite resin restorations, as it leaves a metal restoration (which is superior to resin) in the deepest part of the teeth. Preliminary clinical results indicate that the method is easy to perform, highly valued by the patients, and shows good half-year results. Long-term clinical studies are needed to evaluate any possible deterioration of the bond over time and its longevity. In vitro studies, including thermal and mechanical fatigue tests, may define the optimal thickness of the layers.

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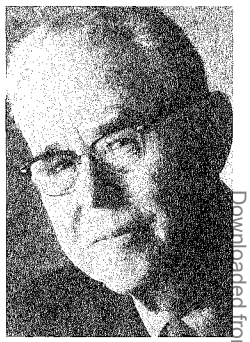
Hollenback Prize for 1993



George Hollenback

The Hollenback Memorial Prize for 1993 has been awarded to Dr William V Youdelis. Dr Youdelis is currently professor and head of the Engineering Materials Division of the University of Windsor, Ontario, Canada. He also serves as the consultant engineer to Western Metallurgical Limited and is President of Youdelis Associates Incorporated. The Hollenback Memorial Prize is given annually by the Academy of Operative Dentistry to recognize excellence in research and dedication to the advancement of operative dentistry.

Dr George Hollenback, in whose memory this award was established, had a deep appreciation for the materials being used to restore lost tooth structure. His research was related to the clinical application of materials and was directed toward improving the quality of restorative dentistry. Dr Youdelis has had similar interests during his career and in his interaction with dentistry.

Dr Youdelis earned his bachelor's degree from the University of Alberta in 1952. He received his master's degree in engineering from McGill University in 1956 and his doctorate from the same institution in 1958. His research interests are numerous and varied. He has published more than 60 papers on such diverse topics as casting nodular iron crankshafts for Ford Motor Company to solidification and nucleation entropy theory applications in space as part of the Skylab Program. He also holds more than 20 patents in various areas such as dental amalgam,

grain-refined aluminum alloys, and processes for surface coating gold alloys onto a metallic substrate to enhance corrosion resistance. It is his work in dispersion-strengthened dental amalgam alloys that we are recognizing today.

The development of dispersion-strengthened amalgam alloys has a fascinating history. Many individuals played a prominent role in the final realization of the product known as Dispersalloy. Two dentists strongly influenced its development: Drs Ralph Yuodelis and his colleague Cos Castaldi were both at the University of Alberta when Dr Bill Youdelis arrived there in 1958 to take up his duties as assistant professor of metallurgy in the Department of Mining and Metallurgy. It was customary for the Yuodelis families to gather at their parents' home for Sunday dinners. These occasions always led to lively arguments about numerous topics. It was at one of these dinners in 1959 that Ralph challenged his brother Bill to develop a better amalgam. Not one to let a challenge go unanswered, Dr Youdelis began to investigate the problems with existing amalgam formulations. Some of the major problems noted were in the areas of marginal ditching, creep, and strength.

It was Dr Cos Castaldi's enthusiasm and strong vocal support for Dr Youdelis's work that kept him going when it appeared a dead end had been reached. His irrepressible enthusiasm and praise during the initial stages of the research when others could not see the potential were paramount in the development of Dispersalloy. Dr Youdelis has said in the *Edmonton Journal* that "Many great ideas lie dormant and are lost to society for lack of exponents, and certainly without Cos shouting from the rooftops, as it were, Dispersalloy would have been stillborn."

After the 1959 challenge from Ralph, Bill Youdelis supervised an undergraduate student's bachelor's thesis project on dispersion strengthening amalgams with oxide particles. In 1961 Dr Youdelis received a Canadian National Research Council grant to investigate dispersion strengthening of dental amalgams. That same year he selected silver-copper eutectic alloy as the dispersion-phase alloy and directed another bachelor's thesis project using these materials. This became the basis for Dispersalloy and, based on this research, Dr Youdelis presented a paper entitled, "Dispersion Hardening of Dental Amalgams" at the 1962 IADR conference in St Louis. At that meeting the only positive response to the paper was from Dr Eugene Skinner, who congratulated him on his work from the floor. In 1963 Dr Youdelis built a metal atomizer to produce a spherical Ag-Cu eutectic dispersion powder and filed for both US and Canadian patents. That same year he published a paper entitled "Dispersion Strengthened Amalgams" in the *Canadian Dental Association Journal*, which described what is essentially Dispersalloy today. Production of Dispersalloy began in 1964 with its introduction at the Canadian Dental Association meeting in Edmonton. In 1967 the US patent for dispersion-strengthened amalgam alloys was granted (the Canadian patent was issued in 1968) and in 1968 Unitek Corporation began to distribute Dispersalloy in the US. However, that relationship only lasted about six months. In 1969 Dr David Mahler and coworkers reported on the superior dynamic creep behavior of Dispersalloy in the *Journal of Dental Research*. Nineteen seventy-one was a banner year for Dispersalloy. At the IADR meeting that year, Mahler's group from Oregon and Asgar's group from Michigan both reported the absence of the gamma-2 phase in Dispersalloy. It was also

William V Youdelis

the year that the ADA approved Dispersalloy. Nineteen seventy-four saw the worldwide rights to production and marketing of Dispersalloy sold to Johnson and Johnson. Since that time there have been numerous papers published by various authors in many journals regarding the superior clinical behavior and properties of Dispersalloy and many new products developed that base their chemistry on Dr Youdelis's work.

Dr Youdelis has continued his work to improve dental amalgam alloys and in his other areas of interest. He has developed an amalgam with lower mercury release and less marginal breakdown than other amalgams. Perseverance has been the hallmark of his research. Like Thomas Edison, George Hollenback, and Michael Buonocore, Bill Youdelis persisted in his research until he succeeded. Thomas Edison was asked by a colleague how he felt about his years of failure in creating the electric light. He replied that though he had not yet found the proper materials, he now knew thousands of things that would not work. "Now that is progress," he said. This unfaltering spirit, found in many great researchers, has been manifest in the work of Dr William Youdelis.

The Academy of Operative Dentistry honors William Youdelis today for his dedication to scientific investigation, his undaunting spirit, and his numerous accomplishments. His works have benefited the majority of the members of this Academy, and it is most fitting that we honor the man who has brought the level of one of our restorative materials to a significantly higher plane.

MAXWELL H ANDERSON

DEPARTMENTS

Book Reviews

EQUILIBRATION IN THE NATURAL AND RESTORED DENTITION

Hyman Smukler

Published by Quintessence Publishing Co, Chicago, 1991. 136 pages, 196 illustrations. $44.00, softbound.

The purpose of this book is to "provide practical, learnable, usable information and techniques that will permit management of most of the occlusal problems confronting the dental practitioner." To do this the author has made excellent use of superb intraoral and graphic illustrations throughout the book as well as concise, well-written explanations. Definitions of terms are consistent with the fourth edition of the *Glossary of Prosthodontic Terms* rather than the current fifth edition.

In his effort to keep this book concise yet meaningful, the author concentrated on brief explanations of the various topics rather than detailed discussions. However, several less-detailed techniques, like mandibular manipulation and fabrication of a Lucia jig, were well covered. The book is divided into five main sections, containing 13 chapters. The first section deals with the masticatory system in health and disease and begins with an interesting, well-documented overview of neuromuscular influence on the system. The other sections discuss the attachment apparatus, mandibular function, differential diagnosis of occlusal problems, and occlusal apparatus. These were especially well written and meaningful. The author's use of terms like "supporting cusps" and "guiding cusps" when addressing centric interferences was clearly illustrated and defined, even though he omitted discussion of potential interferences between maxillary posterior supporting cusps and mandibular guiding cusps.

The clarity of written explanations and the outstanding illustrations make this book attractive for introducing graduate and undergraduate dental students to occlusion, as well as being of benefit to general practitioners who would like an understandable, concise overview of occlusal problems and the influences associated with them.

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INTRODUCTION TO METAL CERAMIC TECHNOLOGY

W Patrick Naylor, DDS, MPH, MS

Published by Quintessence Publishing Co, Chicago, 1992. 196 pages, 456 illustrations. $68.00.

This book was written specifically for dental students, dental technology students, and graduate dentists. It provides a basic understanding of ceramometal restorations. The contents include a brief history of the evaluation of porcelain, the chemistry of dental porcelain, casting alloys for bonding to porcelain, substructure design and finishing, casting technique, application of porcelain, and delivery of the completed restoration.

The format of questions and answers

used in this book is a great way to convey the information to the readers. The illustrations of the substructure designs and casting procedures are clear and helpful for understanding the concept. The tables with the listed advantages and disadvantages of different alloys give readers an overview of the metallurgy related to the metal ceramic restorations.

In the chapter on substructure design, it would have been helpful if the author had given reasons for selecting different designs for various clinical situations and then supported them with examples from the literature. Nevertheless, this book provides fundamental knowledge of metal ceramic technology for the beginner in a very organized fashion.

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CLINICAL REMOVABLE PARTIAL PROSTHODONTICS
Second Edition

Kenneth L Stewart, Kenneth D Rudd, William A Kuebker

Published by Ishiyaku EuroAmerica, Inc, St Louis, MO, 1992. 695 pages, 1754 illustrations. $59.50.

Very few textbooks have been written with primary emphasis on clinical removable partial prosthodontics. The original publication of this book was in 1983; this text represents a second effort to address the majority of issues associated with removable partial denture theory, design principles, fabrication, and patient management. This book is currently used in the undergraduate dental program of prosthodontics at the University of Texas at San Antonio. Contributors, in addition to the aforementioned authors, account for six of the 24 chapters. One of the special contributors is Dr James S Brudvik, who addresses the topics of laboratory procedures for framework construction; relining, rebasing, and repairing removable partial dentures; and special considerations on the topic of removable partial dentures for the older adult.

The text is well organized and, in chronological order, addresses most of the issues associated with the process of fabrication of removable partial dentures. The illustrations are excellent. The information presented will assist not only the student of dentistry but also the seasoned professional. The many steps, theoretical issues of design, materials, and clinical application that one must face in providing the removable partial denture service in the 1990s are outlined and detailed in a manner useful to all who have an interest in this treatment approach.

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Abstracts & Table Clinics

Comparison of phenolic and a 0.2% chlorhexidine mouthwash on the development of plaque and gingivitis. Moran J, Pal D, Newcombe R & *Addy M (1991) *Clinical Preventive Dentistry* 13(4) 31-35.

(*University of Wales College of Medicine, Dental School, Department of Periodontology, Cardiff, South Wales, UK)

Over-the-counter phenolic mouthrinses have recently been shown to reduce plaque and

gingivitis compared to placebo rinses. Similarly 0.2% chlorhexidine rinses are also effective inhibitors of plaque-related disease. In this study both a phenolic rinse (Listerine) and 0.2% chlorhexidine rinse were compared for their effects on plaque regrowth, gingivitis development, and formation of tooth staining. The study group consisted of 15 people, all with high standards of oral hygiene and gingival health. The trial design was a single-blind, triple-cross-over study consisting of three 19-day periods in which participants used each rinse according to manufacturer directions but abstained from normal oral hygiene practices. Each period was separated by a 21-day washout period. Plaque scores were significantly different between rinses. The scores were lowest with chlorhexidine and highest with saline. Although saline did not reduce gingivitis and the two test rinses did, chlorhexidine and Listerine did not differ from each other statistically. Staining was significant, occurring with both the phenolic and chlorhexidine rinses, but not with saline. It was concluded that the chlorhexidine rinse offered greater oral hygiene benefits than the phenolic rinses. The final note addressed the need to reassess indications and the duration of mouthrinse use.

Abstract provided by the Residency of the Advanced Education in General Dentistry two-year program at Fort Knox, KY.

Optimal Finishing Technique for Various Composite Resins

This table clinic evaluated the effect of various finishing techniques on microfill and hybrid resins, as determined visually. Scanning electron microscopy (SEM) was used to determine surface characterization and filler particle pattern and distribution.

Six microfill (Bisfil, BISCO; Durafill, Kulzer; Perfection, Den-Mat; Prisma Micro-Fine, Caulk; Pekalux, Columbus Dental; Silux-Plus, 3M) and two hybrid (Herculite XR, Kerr; Prisma AP.H, Caulk) composite resins were included in the study. Cylindrical samples (4.5 mm x 1.5 mm) were cured and polished according to manufacturers' instructions. Bisfil, Durafill, Prisma Micro-Fine, and Pekalux were finished with three grades of Sof-Lex (3M) disks; Perfection with either Extra-Smooth Polishing Paste or Rembrandt toothpaste (Den-Mat); Herculite XR with a 12-fluted carbide bur in a water-cooled high-speed handpiece followed by Luster Paste (Kerr); Prisma AP.H with either PrismaGloss or Enhance (Caulk) finishing systems. For SEM observation, samples were polished with 4000-grit silicon carbide paper, using a metallographic polishing machine.

All microfill resins achieved a glossy surface after polishing with the Sof-Lex system. Perfection achieved a glossy appearance after polishing only with a polishing paste or Rembrandt toothpaste. Herculite XR exhibited a dull surface, while Prisma AP.H showed a semiglossy surface.

Although all microfill resins exhibited a glossy surface when examined visually, SEM examination showed wide variation among filler particle size and configuration.

For the polishing techniques used, the microfill composite resins exhibited a smoother and glossier surface than the hybrid resins, both visually and with SEM examination.

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Letter

THE INFLUENCE OF MATRIX USE ON MICROLEAKAGE IN CLASS 5 GLASS-IONOMER RESTORATIONS

I refer to the article by Sparks JD and others, *Operative Dentistry* 1992 **17** 192-195.

In recent years there has been a plethora of articles in the literature purporting to demonstrate microleakage around glass-ionomer cement restorations in extracted teeth. In this case it was suggested that the presence or absence of microleakage might be related to use or otherwise of a soft tin matrix, and the authors concluded that the cement leaks anyway whether forced to place with a matrix or not.

Sadly once again, as in so many other cases, the methodology of the experiment is seriously at fault and the conclusions are totally unjustified. The authors show a serious misunderstanding of the chemistry of the setting reaction of glass-ionomer cements, and this is highlighted in the bibliography when they make no reference to the main textbook on glass-ionomer cements by Wilson and McLean. If they had read Chapter 3 beginning at page 43 of this text, they would understand where the error lies.

Those who have studied the material understand well that the setting reaction of glass-ionomer cements is quite prolonged, and the calcium polyacrylates which evolve first remain highly soluble in water for at least an hour after placement and, in fact, if the restoration is left protected for 24 hours, the resultant cement will have superior physical properties and translucency.

In this paper it appears that the restorations were quite properly protected with Ketac glaze for the first 15 minutes but were then subject to contouring and polishing under air/water spray. They were then covered again with Ketac glaze, but by then it was far too late. Subjecting the cement to water contamination at 15 minutes will result in immediate loss of translucency and reduction of physical properties with the washing out of the calcium polyacrylate and degradation of the restoration. The methodology falls down at this point and conclusions are therefore unwarranted.

There have been too many articles in the literature in recent times denigrating the material via similar types of experiments which do not take into account the chemistry and setting reactions. This insecurity is aided and abetted by journals which continue to publish articles with such flaws.

Could I suggest that the authors repeat the experiments but this time leave the cements sealed for 24 hours. One of the most interesting aspects is that this microleakage has not been seen in the oral cavity over the 16 years since the material was developed in spite of all the apparent "proof" coming out of laboratories.

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RESPONSE

As clinicians and advocates of glass-ionomer cements, we wish to thank Dr Mount for his comments on the article concerning the relationship of matrix use to microleakage in class 5 glass-ionomer restorations (*Operative Dentistry* 1992 **17** 192-195).

Contrary to Dr Mount's implication, it was neither the intent nor the effect of this article to denigrate glass ionomer as a restorative material. Rather, it was a straightforward attempt to address the clinically relevant question of "Will the use or non-use of a matrix influence the microleakage of class 5 glass-ionomer restorations?" Dr

Mount indicates his belief that finishing after a 15-minute setting time with the use of water rather than delaying finishing for 24 hours is a fundamental flaw in methodology and invalidates the findings and conclusions of the investigation. We agree with his underlying contention that maturation of the set glass ionomer improves the physical properties of the material; however, the question that arises is "How long a delay is long enough?" Regarding the scientific evidence pertaining to the subject, there is no consensus as to whether delayed finishing will eliminate microleakage. Previous investigations, referenced in the article, reported both the absence and presence of microleakage when finishing was delayed for 24 hours. Fortunately, Dr Bruce Matis and his colleagues (*Journal of the American Dental Association* July 1991 **122** 43-46) have provided the profession with the five-year results of a clinical study comparing the effects of immediate (15-minute) versus delayed (24-hour) finishing of class 5 glass-ionomer restorations. In the case of the restorations finished at 15 minutes, the finishing procedure was exactly the same as in our study, i e, the use of Sof-Lex disks (3M) with water. These investigators found no difference in retention, staining, roughness, or crazing between the two approaches to finishing. Rarely is such a clear and direct answer to a clinically significant question found in the literature.

One other consideration in the rationale for our research technique lies in the fact that the manufacturer's recommendations for finishing of the restorative material were followed. Since most clinicians are apt to minimize the delay between placement and finishing, particularly in a busy practice setting, the use of 15-minute finishing only added to the clinical relevance *(external validity)* of the study. Mindful of these facts, and that clinical evidence unequivocally supports the techniques employed, the authors stand behind their methodology. We sincerely hope that others do not construe the study to be an indictment of glass ionomer as a restorative material, but rather that the results simply reflect our findings that microleakage is not influenced by the use of a matrix.

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STUDENT SUMMER FELLOWSHIPS 1993

The Sjögren's Syndrome Foundation Inc is offering a limited number of Student Summer Fellowships for 1993. The purpose of this program is to introduce medical and dental students to Sjögren's syndrome and Sjögren's syndrome-related research in biomedical science during the summer months.

Each trainee will receive a total stipend in the amount of $2000.

The deadline for filing is 15 April 1993.

For further information contact:

SSF Student Summer Fellowship Program
382 Main Street
Port Washington, NY 11050
Tel (516) 767-2866
FAX (516) 767-7156

RESEARCH PROPOSALS WANTED

The Academy of Operative Dentistry is accepting applications for the Dr Ralph Phillips Memorial Fellowship for 1994. The fellowship supports undergraduate research in operative dentistry and/or dental materials and is open to students from domestic and foreign institutions. This fellowship awards up to $3000, of which no more than $2000 can be used for the awardee's personal compensation. Awards will be made on a merit review of proposals.

The deadline for application is 1 January 1994.

For applications and information contact:

Academy of Operative Dentistry
Dr Gregory E Smith, Secretary
P O Box 14996
Gainesville, FL 32604-2996

INSTRUCTIONS TO CONTRIBUTORS

Correspondence

Send manuscripts and correspondence about manuscripts to the Editor, Maxwell H Anderson, 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 and a FAX number for the corresponding author. Spelling should conform to *American Heritage Dictionary of the English Language*, 3rd edition, 1992. Nomenclature used in descriptive human anatomy should conform to *Nomina Anatomica*, 6th edition, 1989; the terms 'canine' and 'premolar' are preferred. The terms 'vestibular,' 'buccal,' 'facial,' and 'lingual' are all acceptable. SI (Système International) units are preferred for scientific measurement but traditional units are acceptable. Proprietary names of equipment, instruments, and materials should be followed in parentheses by the name and address of the source or manufacturer. The editor reserves the right to make literary corrections.

Authors who prepare their manuscripts on a word processor are encouraged to submit an IBM-compatible computer disk of manuscript (3½ or 5¼ inch) in addition to original typed manuscript; authors need to identify the word processing program used.

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

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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). Only black-and-white photographs can be accepted. 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 in the text thus: (Jones & others, 1975); in the list of references list all the authors. 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.

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