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

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EDITORIAL

The Changes

Surprise!

Operative Dentistry is bigger. We still have the same 40 pages, but we have changed to the standard 8½" x 11" journal format. This break from our traditional size gives us room for more articles, book reviews, abstracts, and awards. Most importantly, you will get more for the same subscription price. This size change will give us almost 13 more pages of surface area compared to our old size. The reason that we were a smaller size dates back to the beginning of the journal. Our previous size was the standard size for journals when we began publishing 19 years ago. Most journals have changed to this larger size. Journals today use the 8½" x 11" size. By taking advantage of printers' bulk buying practices and purchasing a standard paper size, we can bring you more printable space for the same money.

Another change is also coming to our journal. We are moving the editorial offices to Indiana University School of Dentistry in Indianapolis. I have taken a position at Indiana University School of Dentistry. The board of the journal's corporation met in Portland, Oregon, on 2 November 1993 and approved this transitional movement of the editor and our editorial offices. A final decision on moving the journal's entire operations will be made by the board of the corporation of *Operative Dentistry* in February 1994. Our new editorial office address will be:

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This journal is the publishing arm of the Academy of Operative Dentistry and the American Academy of Gold Foil Operators. Our Academies should recognize the University of Washington faculty and staff for the 18 years of support they have provided. Washington provided rent-free space and other support for the journal. Without this support, our journal might not have survived some difficult economic periods in its history.

In addition to the two previous editors of the journal, our Managing Editor has close ties to the University of Washington. Dr J Martin Anderson has faithfully served in this position since the inception of the journal. Marty freely gives his time and energy to our journal and clearly deserves our recognition and thanks.

I believe that a move will be healthy for the journal. Indiana University has a long history of excellence in operative dentistry and direct gold. The School of Dentistry and Dean Gilmore have provided the journal an editorial office within the dental school and other support. We will continue to try to improve the quality of *Operative Dentistry*. Our new size will allow us to decrease the time between receipt of an article, and its publication. Right now, it takes about a year's time to publish an article. That time will be reduced to about 8 months by late 1994. This will allow us to bring you the latest information in a more timely manner and to compete for the best articles with other journals.

The Editorial Board, our staff, and I take the stewardship of *Operative Dentistry* very seriously. We understand the trust and the faith the board places in us. We will continue to serve you to the best of our abilities.

MAXWELL H ANDERSON
Editor

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ORIGINAL ARTICLES

Fracture Resistance of Premolars with MOD Amalgam Restorations Lined with Amalgambond

A C SANTOS • J C MEIERS

Clinical Relevance
MOD amalgams bonded with Amalgambond demonstrated no strengthening of the teeth after thermocycling.

SUMMARY

A comparison was made of the fracture resistance of premolar teeth with mesial-occlusal-distal (MOD) amalgam preparations lined with either a resin containing 4-META (Amalgambond) or copal varnish (Plastodent) and restored with a spherical alloy (Tytin). Restored teeth were aged for 7 or 67 days at 37 °C in 100% humidity and thermocycled between 5 and 55 °C for 3500 cycles. There was no significant difference in the mean fracture resistance between teeth lined with Amalgambond and teeth lined with Plastodent under any of the test conditions. SEM analysis of thermocycled specimens showed no evidence of maintained adhesion between the Amalgambond and amalgam.

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INTRODUCTION

Dental amalgam alloy has been used as a direct restorative material in the United States since 1826 (Craig, 1985; Staninec & Holt, 1988). Amalgam does not adhere to tooth structure and must rely on cavity design for retention. Amalgam cannot increase fracture resistance of prepared teeth unless complete cuspal coverage is provided (Eakle, 1986; Gelb, Barouch & Simonson, 1986) or a cross-pinned amalgam technique is used (Lambert, Robinson & Lindenmuth, 1985). Therefore, teeth that have been restored with class 1 and class 2 amalgam preparations are prone to have an increased frequency of cuspal fracture away from the amalgam (Lacy & Staninec, 1989).

The use of adhesive materials to reinforce weakened teeth was first proposed by Denehy and Torney in 1976. Studies with composite resin and etched porcelain inlays have shown that enamel-composite bonded restorations are effective in restoring much of the original strength of posterior teeth weakened by preparations (Morin, DeLong & Douglas, 1984; Lacy & Staninec, 1989). The use of dentin bonding agents in conjunction with acid etching of enamel further enhanced the strengthening effect of these resin restorations (Jagadish & Yogesh, 1990). However, composite restorations have certain disadvantages when compared with amalgam. Increased wear, various problems associated with polymerization shrinkage, long-term

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microleakage, and greater technique sensitivity have precluded this material from completely replacing amalgams (Sheth, Fuller & Jensen, 1988).

Adhesive bonding of amalgam to tooth structure may provide intracoronal support of weakened cusps and improved resistance to fracture similar to the adhesively retained composite resins. Initial studies have reported that teeth restored with Panavia EX (J Morita USA Inc, Tustin, CA 92680) and amalgam fracture at significantly greater load than teeth restored with conventional amalgam alloy (Eakle & others, 1990; Eakle, Staninec, & Lacy, 1992). Ianzano, Mastrodomenico, and Gwinnett (1991) reported that the strength of amalgam restorations benefitted significantly from bonding with a formulation containing 4-META.

Presently there are few reports in the literature comparing the effect of both aging and thermocycling on the ability of a resin containing 4-META (Amalgambond, Parkell Products, Farmingdale, NY 11735) to increase the fracture resistance of teeth restored with amalgam. The purpose of this investigation was to study the effect of aging and thermal stress on the fracture resistance of premolar teeth with MOD amalgam preparations lined with either a 4-META resin (Amalgambond) or copal varnish (Plastodent, Plastodent, Inc, Bronx, NY 10461) and restored with a spherical alloy (Tytin, S S White Dental, Holmdel, NJ 07733). SEM analysis of the tooth/Amalgambond/amalgam interface was also performed to gain insight into the nature of this junction.

METHODS AND MATERIALS

Tooth Selection

Sixty-four unrestored, noncarious, extracted premolars stored in 0.2% sodium azide were used. The teeth were measured faciolingually and mesiodistally to establish crown size. To decrease variability due to unequal crown sizes, the sum of these measurements for each tooth was used to distribute the specimens among test groups so that the grand totals within all test groups were equal.

Tooth Preparation

Teeth were embedded to 1 mm below the cementoenamel junction in autopolymerizing acrylic tray resin contained within a metal cylinder. An MOD slot preparation through the central groove with parallel walls and without an approximal step across the pulpal floor was performed on each tooth. All preparations were prepared with a #56 FG bur in a high-speed handpiece equipped with a water spray. A bur guide was used to maintain a uniform, 4 mm-deep by 3 mm-wide slot preparation. Teeth were stored in distilled water at 37 °C between all procedures.

Test Groups

The following restorative treatment groups, (n = 8), were used for the MOD preparations:

Group 1	amalgam/copal varnish/aging for 7 days
Group 2	amalgam/copal varnish/aging for 7 days/thermocycling
Group 3	amalgam/copal varnish/aging for 67 days
Group 4	amalgam/copal varnish/aging for 67 days/thermocycling
Group 5	amalgam/Amalgambond/aging for 7 days
Group 6	amalgam/Amalgambond/aging for 7 days/thermocycling
Group 7	amalgam/Amalgabond/aging for 67 days
Group 8	amalgam/Amalgambond/aging for 67 days/thermocycling

Treatment groups were selected based on a 2^3 factorial design. This design studied the primary factors under investigation: cavity liner type, copal varnish versus Amalgambond; time after placement, aged for 67 days versus aged for 7 days; and the effect of thermocyling, thermocycled versus nonthermocycled. Also studied were the possible interactions between the liner type, aging, and thermocycling. All treatment factors were randomly assigned to four blocks of 16 specimens each for specimen treatment.

Tooth Restoration

Teeth were restored immediately after being prepared according to the random assignment order. All restorative materials were used following the manufacturer's recommendations. All groups were restored with a high-copper spherical amalgam (Tytin). Groups 1-4 had two coats of copal varnish placed prior to amalgam condensation, and groups 5-8 had the adhesive resin Amalgambond placed following the manufacturer's recommendations. All restorative procedures were performed by the same investigator throughout the study. Amalgam was condensed for the Amalgambond groups before the liner had set. Carving instruments were used to remove excess amalgam and to

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develop anatomical tooth form and contour.

Aging/Thermocycling

Teeth in groups 2, 4, 6, and 8 were thermocycled for 3500 cycles from 5 to 55 °C in a water bath with a dwell time of 1 minute at each temperature. Aging for 7 or 67 days was accomplished in deionized water at 37 °C. All specimens were stored at 37 °C and 100% humidity prior to fracture-resistance testing.

Fracture-Resistance Testing

Specimens were tested for fracture resistance on a Universal Testing Machine (United FM-10, United Calibration Corp, Garden Grove, CA 92145). A metal bar approximately 5 mm in diameter was placed perpendicular to the long axis of the tooth in a mesiodistal direction. The bar contacted only the inner cuspal inclines and not the amalgam of the restored teeth (Figure 1). A cross-head speed of 0.5 mm/min was used to apply loading force measured in Newtons until the specimen fractured (Figure 2).

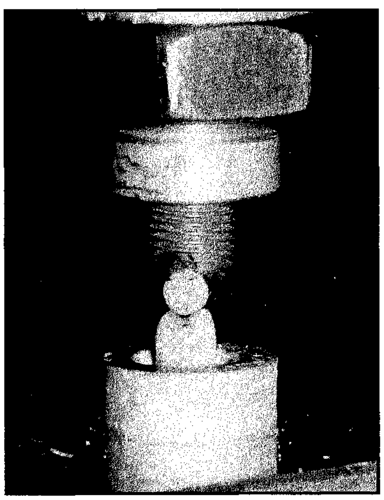

Figure 1. *Premolar mounted in acylic tray resin: metal bar contacting only the inner cuspal inclines*

Scanning Electron Microscope Analysis

Representative tooth specimens of aged and thermocycled MOD preparations restored with Amalgambond/Tytin were sectioned faciolingually with an Exakt band saw (Exakt Medical Instruments Inc, Oklahoma City, OK 73148). Sections were dehydrated in a graded series of alcohol infiltrated with a visible-light-cured infiltrating and embedding medium composed primarily of hydroxyethyl methacrylate (Technovit 7200, Exakt Medical Instruments Inc) and attached to a plastic slide. The section surfaces were flattened and smoothed by sanding with 1000-grit paper on a rotary sanding/grinding machine (Exakt Medical Instruments Inc), and the resultant smear layer was removed with 5% citric acid. Specimens were then sputter coated with gold and examined with an Amray 1200B SEM (Amray Inc, Bedford, MA 01730) at an acceleration voltage of 30kV.

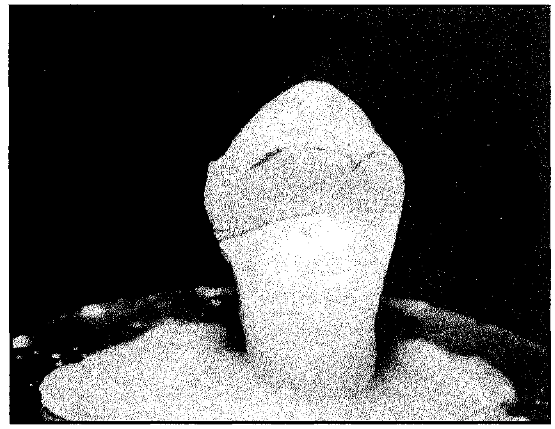

Figure 2. *Fractured premolar test specimen, typical fracture pattern with either the buccal or palatal cusp separating from amalgam*

RESULTS

ANOVA and Student *t*-tests were performed on the fracture data with Design-Ease software (Stat-Ease, Minneapolis, MN 55455) to evaluate the effects from each of the three primary experimental factors and any interactions between these factors at a significance level of $P < 0.05$. The fracture strengths for the eight test groups are presented in the table. None of the three primary factors, liner type, aging, or thermocycling, had a statistically significant effect on fracture load of the restored teeth. There were also no significant interactions between the liner type and period of aging or thermocycling that affected the fracture load of these teeth.

Figure 3 is a scanning electron micrograph of a typical dentin/Amalgambond/Tytin interface after the specimen had been thermocycled 3500 cycles and stored for 7 days. There was little evidence of mechanical interlocking of the resin to the amalgam. Figure 4 shows the same evidence of adhesive failure between the liner (Amalgambond) and Tytin at the enamel/liner/amalgam interface.

DISCUSSION

The present in vitro study did not show any significant differences in premolar fracture resistance between the amalgam specimens treated with or without Amalgambond. This is in contrast to the results of

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*Premolar Fracture Resistance: MOD Preparations Restored with Tytin (X ± SD)**

	VARIABLE GROUP			
	7-day Aging	7-day Aging + Thermocycling	67-day Aging	67-day Aging + Thermocycling
Amalgambond	1310 ± 370	1300 ± 420	1470 ± 210	1350 ± 480
Copal varnish	1110 ± 410	1420 ± 480	1590 ± 410	1380 ± 400

*All units in Newtons

Christensen and others (1991), which showed that cusp fracture resistance of molars with MOD preparations, Amalgambond, and amalgam was higher than that for those teeth treated with amalgam alone. We had expected to see an increase in fracture resistance in the teeth lined with Amalgambond versus copal resin, if the tooth/liner/amalgam bond was enduring and strong. However, these results are similar to those of Cooley, Tseng, and Barkmeier (1991), who reported only modest but not significant increases in bond strengths obtained with a 4-META adhesive system when investigating shear bond strength of a composite to an admixed alloy and a spherical alloy. Chang and others (1992) reported that amalgam bonded to dentin with a 4-META adhesive yielded low and highly variable bond strengths. They recommend additional use of mechanical retention to improve the bond of amalgam to dentin with a 4-META adhesive. Hadavi and others (1991) reported that the use of Amalgambond did not increase the strength of repaired high-copper spherical and admixed amalgam alloys.

Previous studies evaluating fracture resistance of Amalgambond-lined amalgam-restored teeth have not examined the impact of both prolonged aging and thermocycling on the bond between tooth/adhesive/amalgam. Nakabayashi, Ashizawa, and Nakamura (1992) reported that long-term immersion of a 4-META test specimen in 37 °C water actually decreased adhesive bond strengths to dentin. This was attributed to hydrolysis of collagen peptides not protected by hydroxyapatite. Chang and others (1992) reported that thermocycling appeared to decrease the shear bonds established with the adhesive after 1000 thermocycles. The results of this investigation showed there was no significant bond increase or decrease within the Amalgambond groups with either aging for 67 versus 7 days and/or thermocycling. The 67-day time period was chosen to provide a 2-month data set to investigate the possibility of any relatively short-term aging loss of dentin/enamel/amalgam bonding that could affect

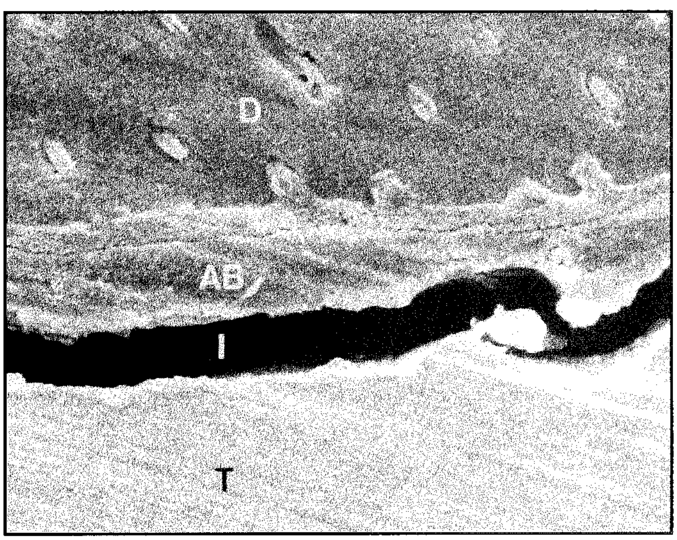

Figure 3. *SEM of the dentin (D)/Amalgambond (AB)/Tytin (T) interface (I) with separation at the resin liner/amalgam junction (magnification X870)*

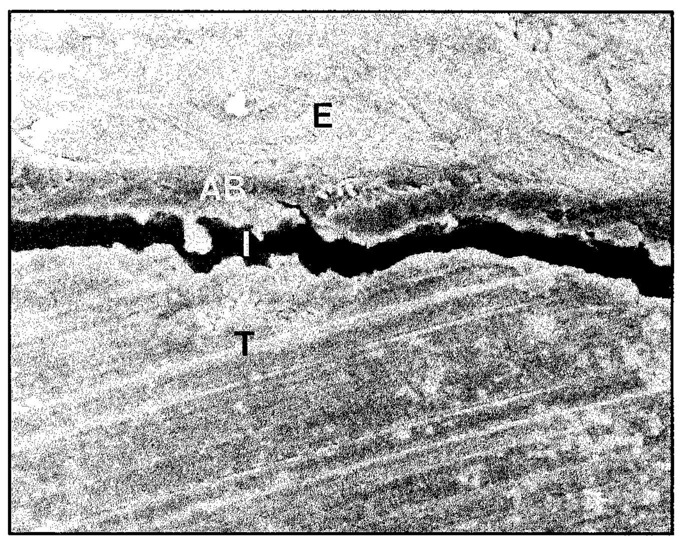

Figure 4. *SEM of the enamel (E)/Amalgambond (AB)/Tytin (T) interface (I) with separation at resin liner/amalgam junction (magnification X870)*

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fracture resistance values.

The SEM analysis of the tooth/adhesive resin/amalgam interface indicated that when stressed by thermocycling, the weak link was the resin-to-amalgam junction. The chemical/mechanical link to the amalgam was not strong enough to withstand the differences in either the contraction or expansion that took place either during thermocycling or through SEM preparation. There was consistent loss of attachment of the resin to the amalgam; this attachment loss could be responsible for the lack of difference in fracture strengths between copal varnish and Amalgambond groups.

CONCLUSIONS

This in vitro evaluation demonstrated that the fracture resistance of premolars filled with MOD amalgam restorations was not significantly different between premolars lined with a 4-META adhesive (Amalgambond) and those lined with a copal varnish. Clinically, these results may indicate it is not possible to reinforce weakened cusps as a result of cavity preparation with a resin-bonded amalgam technique with the product Amalgambond.

(Received 14 July 1992)

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Tapered Cross-Pin Attachments for Fixed Bridges

F C EICHMILLER • E E PARRY

Clinical Relevance
A technique is presented for rigidly fixing a broken stress bridge.

SUMMARY

The design and fabrication of multi-unit fixed prostheses where abutment teeth are misaligned have been difficult technical challenges for dentists and dental technicians. There have been a number of methods developed to attain a common path of insertion, including modified preparation designs, telescopic copings placed on abutments to correct alignment, adhesively retained bridge frameworks, and mechanical precision attachments between sections of a segmented prosthesis. This paper describes a method of fabricating a precision attachment on a segmented prosthesis that can be rigidly fixed after cementation. The technique involves the use of a cast tapered pin to permanently attach the prosthesis segments together. All parts can be fabricated by conventional lost-wax techniques with a minimum of instrumentation. The technique has the added advantage of being reversible should the prosthesis ever need to be separated for repair or recementation.

American Dental Association Health Foundation, Paffenbarger Research Center at the National Institute of Standards and Technology, Gaithersburg, MD 20899

Frederick C Eichmiller, DDS, associate director

Edward E Parry, CDT, senior laboratory technician

INTRODUCTION

The clinical dilemma of misaligned fixed partial denture (FPD) abutments has resulted in many unique engineering approaches. One approach involves altering preparation designs to achieve a common insertion path such as buccal-approximal-lingual 3/4 crown abutments or inlay abutments (Guyer, 1970). Another approach is to use resin-bonded retainers on one or more of the abutment teeth (Rochette, 1973; Livaditis & Thompson, 1982). Telescopic copings cemented to one or more of the abutments are used to correct the insertion path for the final prosthesis (Weaver, 1989). Precision attachments are often used to correct the insertion path by segmenting the prosthesis and inserting it in serial segments (Preiskel, 1979). The approach outlined in this article combines a variation of a precision attachment that can be fabricated in any commercial or private practice laboratory and the technique for application of this attachment.

Precision attachments are generally a key-in-slot design where a dovetail-shaped slot is formed in the approximal surface of an abutment crown. This slot receives a precision-fit key that is cast as part of the adjacent crown or pontic and is either cemented or passively inserted into the dovetail slot. The assembled prosthesis has a semi-rigid attachment with one direction of movement along the insertion path of the keyed segment. Once placed, these attachments are often subject to wear as the parts move in function, or they become misaligned as the abutments change position over time.

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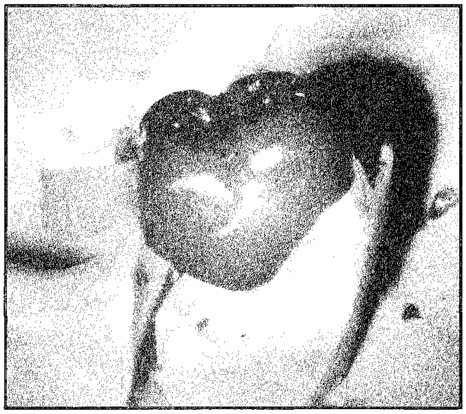

Figure 1. *The wax pattern of the attachment wing on one of the abutments. This wing should extend approximately 3 mm into the pontic space, be 1 mm below the occlusal plant, and have a gingival contour matching the contour of the final pontic. The wing should be oriented parallel with the insertion path of the pontic segment.*

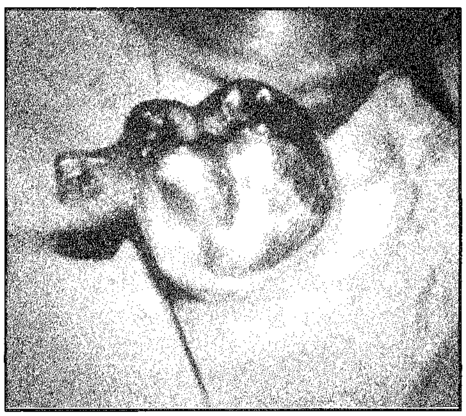

Figure 2. *The abutment casting with a small hole drilled through the wing to receive a 0.7 mm pencil lead to align the hole in the pontic pattern. The hole is drilled with a bur or a retention pin twist drill.*

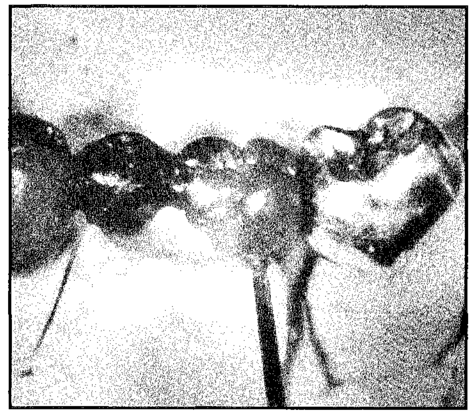

Figure 3. *The pontic segment pattern is formed over the wing and pencil lead. The pattern can be made in wax or acrylic, and the graphite pencil lead will establish the hole in the final casting.*

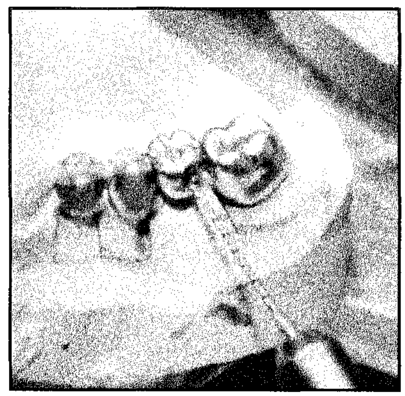

Figure 4. *The castings are fit to the model, and the pin hole is reamed to a taper with an 8/0 machinist tapered pin reamer.*

The technique outlined here is similar to the key-in-slot design but improves upon the design by locking the attachment in place with a transverse pin. This prevents any translation of the attachment parts along the insertion path but can be modified (if desired) to allow some rotational movement around the center of the pin. The technique can be performed with a minimum of special parts or equipment on a variety of FPD designs.

The technique is as follows.

1. The abutment preparations are cut with standard partial or full crown designs without the necessity of developing a common path of insertion. This is followed by standard impression procedures and die model fabrication.

2. Wax patterns for the retainers are fabricated, and one retainer is selected to receive a wax wing extending into the pontic space. This wing is oriented with the vertical sides parallel to the path of insertion of the second abutment section (Figure 1). The wing should be approximately 1 mm short of the occlusal surface of the pontic and have a gingival profile matching that of the final pontic shape. The mesial-distal extension of the wing should be approximately 3 mm with a buccal-lingual thickness of 1 mm. This wax pattern can be formed from flat inlay or baseplate wax.

3. The abutment containing the wing is cast, and a hole is drilled through the wing just large enough to hold a 0.7 mm mechanical pencil lead. The hole can be drilled with a small twist drill in a lab handpiece (Figure 2).

4. Pencil lead is placed through the hole and the pontic is formed to lap over the wing and around the pencil lead (Figure 3). Duralay (Reliance Dental Mfg Co, Worth, IL 60402) acrylic can be used to form a more durable pattern for this procedure. The pencil lead is removed, the pattern is lifted, and the lead is then replaced while investing the pattern. This will maintain correct alignment of the hole in the cast pontic.

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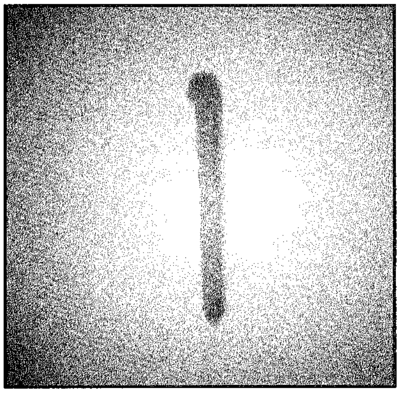

Figure 5. *The acrylic pattern used to make the tapered pin is fabricated from a mold made of any convenient material with the 8/0 reamer used to form the mold cavity. The pin pattern is made from Duralay acrylic and cast in the same alloy as the FPD.*

Figure 6. *The pin is fit to the tapered hole so that it passes completely through the pontic casting.*

5. The pontic and abutment section of the FPD are cast and fitted to the model and the winged abutment. A number 8/0 tapered machinist reamer (KBC Tools & Machinery, Sterling Heights, MI 48314) is used in a lab handpiece to ream the hole through the pontic and wing to a smooth, even taper (Figure 4). Care should be used to not distort the hole out-of-round while reaming.

6. From the same alloy as the bridge, a pin is cast that corresponds to the size and shape of the tapered reamer (Figure 5). This can be done by making a mold from any material such as aluminum by drilling and reaming a hole with the same 8/0 reamer. This mold is used to form a wax or Duralay pattern matching the reamer. Several pins can be cast at one time to save time and materials.

7. The pin is tried for fit and length on the model. The pin should be long enough to travel all the way through the pin hole so it can be cut and finished flush with the back side of the pontic (Figure 6).

8. The FPD is cemented with the wing abutment seated

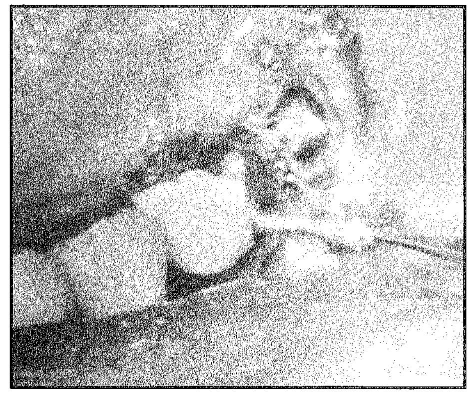

Figure 7. *The segments of the bridge are cemented to the teeth and the pin is placed by tapping it into place with a punch and mallet.*

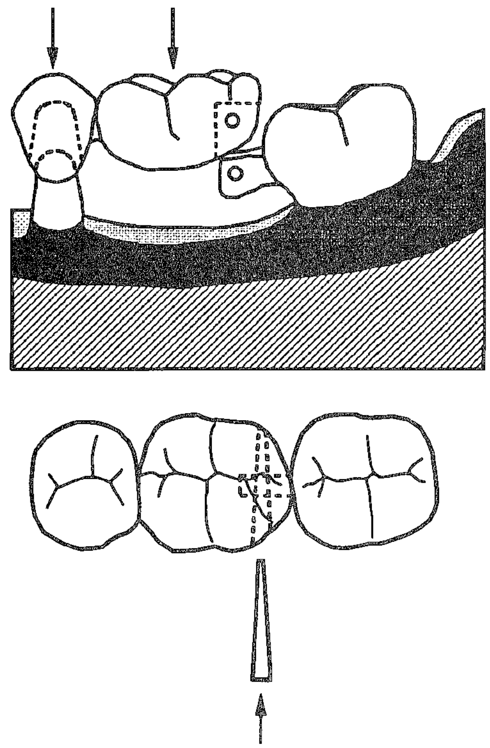

Figure 8. *The excess is cut from both ends of the pin and the ends are polished flush with the surface of the pontic.*

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first and the pontic segment second. After the cement has set, the pin is placed in the hole and driven into place with a punch and a few taps with a mallet (Figure 7). The gradual taper of the pin will firmly wedge it in place; no cement is necessary on the pin.

9. The excess pin length is cut from both sides of the pontic and the ends are disked and polished flush with the surface of the pontic (Figure 8). The pin can be removed if ever necessary by tapping it out in the direction opposite from the direction of insertion.

There are several features favoring the use of this type of attachment. The obvious advantage is that once the pin is set, neither segment can migrate to change the fit or orientation. Another feature is that the bridge can be disassembled by removing the pin. The pin is removed by tapping it from the small end in the direction opposite from the direction of insertion. A small degree of rotation about the pin axis can be achieved by relieving the top surface of the wing to leave a small amount of clearance between the wing and the pontic above the pin hole. An attachment of this type also does not require precision attachment fixture patterns to be incorporated into the waxings.

The only special materials needed for this procedure are:

1. Mechanical pencil lead, 0.7 mm, available at any office supply store and

2. an 8/0 machinist tapered pin reamer. This is a standard tapered pin reamer with a taper of 20.8 mm per meter (1/4" per foot). The reamer is available by direct order from most machine supply catalogs or it can also be ordered through a local machine shop.

With a very small investment in tooling and a little ingenuity, this type of attachment can be used for many of the difficult prostheses encountered in daily practice.

(Certain commercial materials and equipment are identified in this paper to specify the experimental procedure. In no instance does such identification imply recommendation or endorsement by the National Institute of Standards and Technology or the ADA Health Foundation or that the material or equipment identified is necessarily the best available for the purpose.)

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Radiopacity of Resin-based Inlay Luting Cements

O M EL-MOWAFY • C BENMERGUI

Clinical Relevance
Some cements were found to have radiopacity values less than that of enamel.

SUMMARY

The radiopacity of a group of seven resin-based inlay luting cements in addition to two porcelain veneer cements was determined. Four inlay cements (Indirect Porcelain System Dentist Bonding Kit, Dicor MGC, Duo, and Twinlook) were found to have radiopacity values significantly greater than the radiopacity of enamel. Two other inlay cements (Dual and Porcelite Dual Cure) were found to have radiopacity values not significantly different from that of enamel, while All-Bond Crown and Bridge cement had a radiopacity value significantly lower than the radiopacity of dentin. For the two porcelain veneer cements examined, one material (Mirage Bond) had a radiopacity value significantly greater than that of enamel, while the other (G-Cera Porcelain Veneer Bonding System) had a radiopacity value significantly lower than that of dentin. It was concluded that only the materials that have radiopacity values greater than or equivalent to the radiopacity of enamel are suitable for use as inlay cements. For porcelain veneers, a relatively high radiopacity value of the cement is advantageous.

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INTRODUCTION

In the last few years, the use of composite resin inlays for the restoration of posterior teeth gained increasing interest compared to directly placed posterior composite restorations. There are a number of reasons for this interest, which include: 1) polymerization shrinkage of composite resin restorations, with subsequent postoperative sensitivity (Bausch & others, 1982; Eick & Welch, 1986), is reduced to a minimum if not totally eliminated when curing of the composite resin inlay takes place on a die prior to cementation; 2) microleakage is reduced significantly with the composite resin inlay technique (Robinson, Moore & Swartz, 1987); 3) superior contact with the adjacent teeth can be achieved under more controlled conditions in the case of an inlay; and 4) heat and/or pressure treatment of the inlay during light curing may be carried out, which enhances the physical and mechanical properties of the inlay to some extent and thus may improve its intraoral longevity. However, unlike direct composite restora-

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tions, a resin-based cement is necessary to cement the composite resin inlay.

Another type of esthetic posterior inlay restoration that is also bonded to the tooth structure by means of a resin-based cement is the porcelain or ceramic inlay. The use of porcelain or ceramic inlays has also gained popularity recently following a combination of new developments. These include the introduction of a new bonding technique that allows acid-etched and silane-treated porcelain to be bonded to the tooth structure (Deines, 1986; Nathanson, 1987), the introduction of newer restorative materials such as Cerec inlay materials, and introduction of newer manufacturing techniques such as the CAD-CAM systems (Rekow, 1987; Duret, Blouin & Duret, 1988; Mormann & others, 1989).

Current techniques for the placement of these bonded inlays, whether they are made of composite resin or porcelain, vary considerably, and the cementing procedure may or may not involve the use of a matrix system (Bergmann, Noack & Roulet, 1991). If a matrix system is not used, the chances of creating a gingival overhang are relatively high, particularly if the operator fails to remove excess cement completely from the depth of the gingival embrasure prior to polymerization of the cement. This may probably happen more frequently with cements with low viscosity, as they might tend to run more readily into the gingival embrasure, and if left unremoved prior to curing, an undesirable overhang is produced.

Even with the use of a matrix system, the formation of a gingival overhang can sometimes occur. Therefore, it is desirable that the resin-based cement used for inlay cementation must be sufficiently radiopaque to permit detection of marginal overhangs. Sufficient radiopacity of the cement will also allow detection of open gingival margins. The aim of this study was to determine the radiopacity values of a group of resin-based inlay cements and compare them to those of enamel and dentin.

Table 1. The Nine Resin-based Cements that Were Tested and Their Codes as Used throughout This Paper

Material	Code	Manufacturer
All-Bond Crown and Bridge Cementation Kit	C&BC	BISCO Dental Products Itasca, IL 60143
Dicor MGC cement	DMGC	L D Caulk Milford, DE 19963
Dual cement	DUAL	Vivadent Schaan, Liechtenstein
Duo cement	DUOC	Coltène AG Altstätten, Switzerland
G-Cera Porcelain Veneer Bonding System	GCER	G-C Dental Industrial Corp Tokyo, Japan
Indirect Porcelain System Dentist Bonding Kit	IPSD	3M Dental Products St Paul, MN 55144
Mirage Bond	MIRB	Chameleon Dental Products Kansas City, KS 66101
Porcelite Dual Cure cement	PDCC	Sybron/Kerr Romulus, MI 48174
Twinlook	TWLK	Heraeus Kulzer GmbH Wehrheim, Germany

METHODS AND MATERIALS

Using a silicone mold, specimens measuring 7.5 x 7.5 mm with a thickness of 2.5 mm were made from a group of resin-based cements (Table 1). Although two of the included cements (MIRB and GCER) are made for cementation of porcelain veneers and not inlays, their inclusion was purely for comparative purposes. Following the manfacturers' instructions for mixing and curing, six specimens were prepared from each material. The prepared specimens were stored dry at 37 °C for 24 hours. Six longitudinal sections 2.5 mm thick were also obtained from recently extracted permanent molar teeth using a microslicing machine (Accutom, Struers Co, Copenhagen, Denmark). The specimens and the tooth sections were randomly divided into six equal groups, each group consisting of one specimen of each material and one tooth section. Three groups of specimens were randomly selected for dry storage prior to testing. The other three groups were stored in water at 37 °C for 2 weeks. Each group of specimens was placed on an occlusal x-ray film, Ultraspeed D (Eastman Kodak Co, Rochester, NY 14650), together with an aluminum step wedge with a thickness increasing by approximately 1 mm in each step to 13 mm. This step wedge was used to enable accurate correlation of the optical density of the images of the specimens to that of aluminum in each film. Using a dental x-ray machine (General Electric, Model 46-181121Gl, Milwaukee, WI 53201), the films were exposed at 65 kVp with a focus object distance of 40 cm and a time of 0.8 seconds. Following standard techniques the films were developed in an automatic x-ray processor at a temperature of 25 ± 1 °C using a 4.5-minute cycle.

The optical density of the materials' images on the x-ray films was measured by means of a transmission

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densitometer (Macbeth TD-504, Macbeth Corp, Newburgh, NY 12551-0230). This densitometer has variable aperture diameter and is capable of measuring optical density of areas as small as 1 mm in diameter. A minimum of four readings was obtained from each image of specimens and from those of enamel and dentin. Following methods described previously (Abou-Tabl, Tidy & Combe, 1979; Cook, 1981), the optical density measurements of the images of the examined materials were used to express their radiopacity in terms of aluminum equivalents (mm Al). However, in this study the aluminum optical density data were entered into a computer, and the best possible exponential fit was used to draw curves for aluminum optical density values using the equation y = 29.605 * 10^ (-7.8045e-3x). Two curves were generated using this method with R^2 = 0.999, one from the data of specimens stored dry and one from the data of specimens stored wet (Figure 1). The experimental aluminum equivalency values for each material were extrapolated directly from the graphed curves.

One-way analysis of variance (ANOVA) and multiple comparisons using Tukey's Studentized Range (HSD) test were conducted to statistically analyze the differences in the optical density values of the images of the materials under each of the two storage conditions, i e, dry and wet storage. Student's *t*-test was used to compare the optical density values obtained from specimens stored wet and specimens stored dry for each material.

RESULTS

A radiograph of representative specimens of all the tested materials, a tooth section, and the aluminum step wedge are shown in Figure 2. Table 2 records mean radiopacity values expressed as millimeter equivalents of aluminum for all tested materials. Results of the statistical analyses are also reported in the same table. ANOVA conducted on data obtained from specimens stored dry indicated significant differences among the materials ($P = 0.0001$). Tukey's HSD test showed IPSD to have a radiopacity value (7.1 mm Al) significantly higher than those of all other materials, whereas GCER had a radiopacity value (1.2 mm Al) significantly lower than those of all the other materials. DMGC, DUOC, MIRB, and TWLK had radiopacity values (6.0, 5.6, 5.2, 5.1 mm Al respectively) significantly higher than that of enamel (4.7 mm Al), whereas C&BC had a radiopacity value (2.6 mm Al) significantly lower than that of dentin (2.9 mm Al). DUAL and PDCC had radiopacity values (5.1 and 4.4 mm Al respectively) not significantly different from that of enamel. Data of specimens stored wet also showed similar significant differences among the materials ($P = 0.0001$) with some variability. Here the main difference was that the radiopacity values of MIRB and TWLK (5.5 and 5.4 mm Al respectively) were not significantly higher than that of enamel (5.0 mm Al). Figure 3 shows bar chart representation of mean densitometer readings and standard deviations for each material tested under both dry and wet storage conditions.

DISCUSSION

The radiopacity values reported in this study for enamel and dentin of specimens stored dry (4.7 mm Al/2.5 mm enamel and 2.9 mm Al/2.5 mm dentin) are comparable to those reported by Abou-Tabl and others (1979) (4.0 mm Al/2.5 mm enamel and 2.5 mm Al/2.5 mm dentin). They are also in agreement with radiopacity values for the two substances reported by El-Mowafy, Brown, and McComb (1991) under similiar test conditions (4.6 mm Al/2.5 mm enamel and 2.9 mm Al/2.5 mm dentin). This resemblance in radiopacity values of enamel and dentin among the three studies

Figure 1. *Exponential fit curves given in aluminum equivalency for densitometer readings of the aluminum step wedge for both the dry and wet storage conditions*

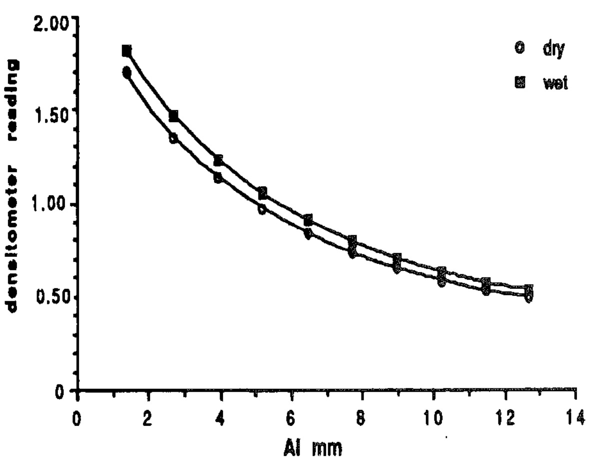
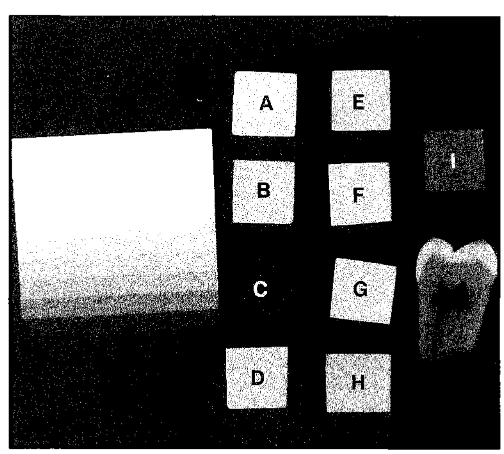


Figure 2. *A radiograph of representative specimens of all tested materials along with a tooth section and aluminum step wedge. A:IPSD, B:MIRB, C:GCER, D:TWLK, E:DUAL, F:DMGC, G:DUOC, H:PDCC, I:C&BC.*



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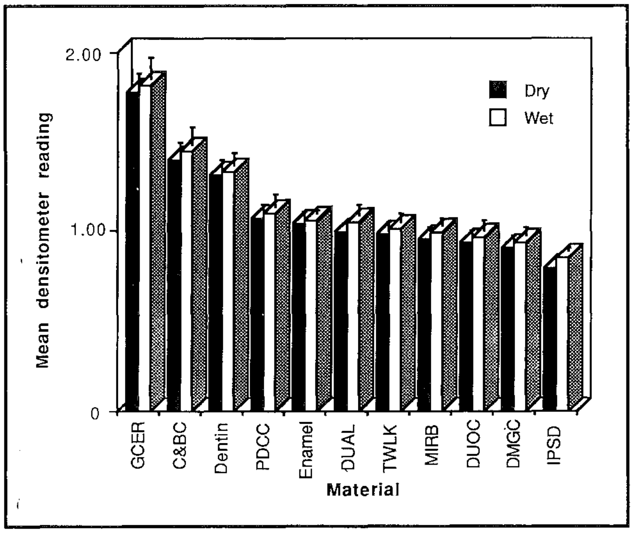

Figure 3. *Bar chart representation of mean densitometer readings for all tested materials including enamel and dentin for both the dry and wet storage conditions. Error bar shown is the sample standard deviation for each group.*

supports the validity of the radiopacity values of the group of resin luting cements reported in this study.

Lutz and others (1984) stated that ideally, the radiopacity of restorative composite resins should be greater than that of enamel. This principle can also be applied to resin-based luting cements. Out of seven inlay luting cements tested, four had radiopacity values significantly greater than the radiopacity of enamel when data of dry-stored specimens were statistically analyzed (IPSD, DMGC, DUOC, and TWLK). Two more materials (DUAL and PDCC) had radiopacity values that were not significantly different from that of enamel. For the water-stored specimens, the radiopacity value of TWLK was not significantly different from that of enamel. The remaining inlay cement (C&BC) had a radiopacity value significantly lower than that of dentin under both the dry and wet storage conditions.

When data of dry and wet storage conditions were compared, four materials (IPSD, MIRB, TWLK, and DUAL) showed statistically significant differences. The authors tend to believe that these variations are not neccessarily due to water storage. There is no logical reason or explanation for increased radiopacity of the resin cements following water storage as what had happened here with DMGC and MIRB. Rather, this variation is most likely linked with other factors of the test procedure itself. El-Mowafy and others (1991)

Table 2. Mean Radiopacity Values for All Tested Materials under Both Dry and Wet Storage Conditions Given in Millimeter Equivalents of Aluminum

Material Code	Mean Radiopacity—Dry (mm Al/2.5 mm)	Mean Radiopacity—Wet (mm Al/2.5 mm)	Statistical Result	*P* Value Wet vs Dry
IPSD	7.1	7.0	SD	0.0001
DMGC	6.0	6.0	NS	0.0599
DUOC	5.6	5.8	NS	0.0654
MIRB	5.2	5.5	SD	0.0130
TWLK	5.1	5.4	SD	0.0277
DUAL	5.1	5.0	SD	0.0013
Enamel	4.7	5.0	NS	0.2310
PDCC	4.4	4.7	NS	0.2150
Dentin	2.9	3.4	NS	0.3544
C&BC	2.6	2.8	NS	0.1270
GCER	1.2	1.4	NS	0.2982

Vertical bars indicate values that are not statistically significantly different. Column "Statistical Result" records results of statistical analysis conducted to compare data obtained from specimens stored dry with those obtained from specimens stored wet. SD: significant difference; NS: no significant difference. Note, however, that the statistical analyses were conducted on data of actual densitometer readings and not on aluminum equivalent values.

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attributed variations in radiopacity values of similar materials among different studies to a number of factors related to the test procedure that included: speed of the x-ray film used, exposure time, voltage used, and processing of the film. They further showed that a change in the voltage from 65 KVp to 70 KVp during exposure of the x-ray film can have an effect on the measured radiopacity value. In the present study, all these factors were controlled; however, the age of the developing solution and the fixer was not controlled. The films belonging to the specimens stored wet were processed 2 weeks after the films belonging to the dry-stored groups were processed. It is possible that the optical density of an x-ray film processed with fresh developing and fixing solutions can vary considerably from that of one processed with aged developing and fixing solutions. In fact, in the present study a different curve for the optical density of the image of the same aluminum step wedge was obtained when data of the wet storage condition were used to create the aluminum equivalency curve compared to data of the dry storage (Figure 1). Wet storage data were consistently slightly higher than those of the dry storage. Unlike the test specimens, the aluminum step wedge was not stored in water. Thus, it is obvious that this variation can only be attributed to the processing procedure of the x-ray films and not to loss or gain of radiopaque substance to or from the storage medium by the specimens. This variation, however, should not have an effect on the ranking of the tested materials according to their radiopacity values as was indicated by El-Mowafy and others (1991).

For the two porcelain veneer cements tested (MIRB and GCER), one material had a radiopacity value significantly higher than that of enamel (MIRB), while the other material (GCER) had a radiopacity value significantly lower than that of dentin when data of dry-stored specimens were statistically analyzed. Data of wet-stored specimens showed MIRB to have a radiopacity value not significantly different from that of enamel. Although the margins of a porcelain veneer are normally accessible for visual and tactile inspection after cementation, the authors of this paper tend to believe that a high radiopacity value (comparable to that of enamel) of a veneer cement material is advantageous.

CONCLUSIONS

Inlay cement materials IPSD, DMGC, DUOC, TWLK, DUAL, and PDCC were found to have radiopacity values greater than or equivalent to the radiopacity of enamel. Thus, these materials possess sufficient radiopacity desired for inlay luting cements. In contrast, material C&BC had a radiopacity value lower than that of dentin. This material does not possess sufficient radiopacity desired for inlay luting cements.

Acknowledgment

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Stopfgold: A New Direct Filling Gold

R L LAMBERT

Clinical Relevance
A new denser and stronger direct filling gold is described.

SUMMARY

A new direct gold material that is considerably different from other direct golds has been available since 1989. The advantages of this material are that the final restoration exhibits greater density than other forms of granular gold and has a 50% increase in shear strength when compared to gold foil. Clinical experience with the use of this new restorative material has been encouraging. Further clinical and laboratory research comparing this material with the other types of direct gold is anticipated.

INTRODUCTION

More than 500 years have passed since Giovanni Arcolani first reported on the use of pure gold as a dental restorative (Ring, 1985). To this day, the direct gold restoration continues to be a standard for adaptability to cavity walls, exactness of margins, and smoothness of the final surface, but most of all, no other restorative material can compare to the longevity of service provided by a properly placed direct gold restoration. Direct filling golds have been classified into four groups (Phillips, 1982): gold foil, mat gold, powdered gold, and alloyed gold. A new type of direct filling gold was introduced to the dental profession in 1989 (Diehl & Ringelstein) that morphologically differs from the types previously available (Elderton & Boyde, 1971). This material was first available in Germany but more recently has been introduced into the United States under the name Stopfgold (translation from German: direct-filling gold) (Degussa Corp, South Plainfield, NJ 07080). It is not the intent of this paper to present scientific evidence of the superiority or inferiority of this new product, but only to inform the reader of its availability and to stimulate research related to its use.

According to the manufacturer, this new type of filling gold is produced from chemically precipitated gold powder (minimum gold content of 99.8%) that underwent a milling process after precipitation. The individual particles are then loosely sintered together and cut into strips 3.0 mm wide and 40.0 mm in length. Stopfgold is available in three thicknesses; 0.7 mm, 1.0 mm, and 1.5 mm. The amount of gold in each strip is approximately 8% of the volume of the strip (as compared to 14% for Electraloy RV, (Ivoclar Williams,

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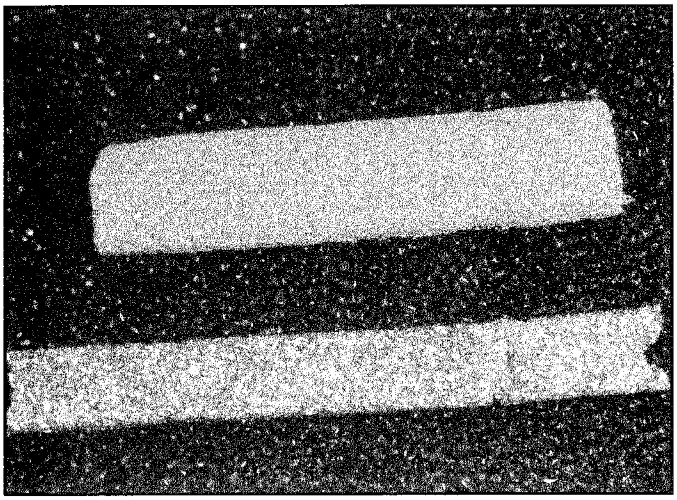

Figure 1. *Mat gold (top) and Stopfgold (bottom). Note luster related to light reflection of Stopfgold particles.*

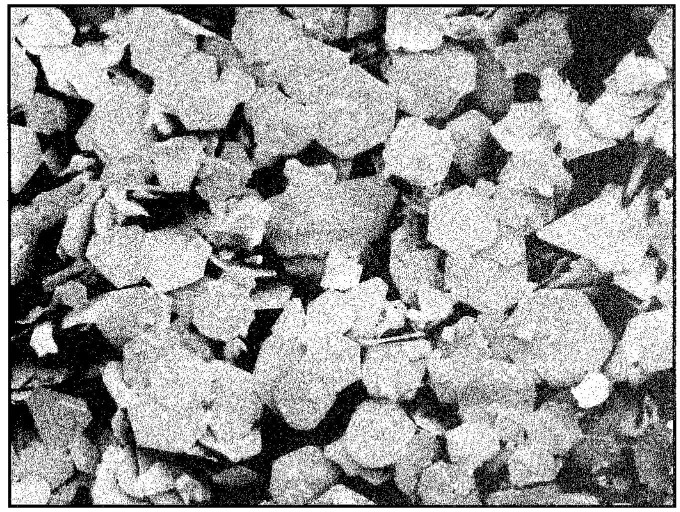

Figure 2. *Scanning electron micrograph of Stopfgold (X185)*

Amherst, NY 14228). Limited research by the manufacturer has demonstrated a 50% increase in shear strength of this material compared to conventional compacted gold foil. Shear strength is related to both the tensile and cohesive stength of a material and is a convenient method of comparing the degree of cold welding that has occurred (Phillips, 1982). The manufacturer suggests that this increased shear strength is related to the high deformation that occurs during condensation, which improves the cold welding ability.

Stopfgold is similar in size and shape to mat gold; however, it is easily discernible in that the material has a relatively high luster due to light reflection by the flat particles of gold (Figure 1). Scanning electron microscopy of the material demonstrates that it is composed primarily of flat polygonal platelets (Figure 2). Most of these platelets are hexagonal and vary in diameter from 25 μm - 75 μm. Measurement of the particles on the scanning electron microscopy (SEM) demonstrates a thickness of approximately 1.5 μm, or about the same as #4 gold foil.

Paul (1990) has demonstrated that condensed Stopfgold produced fewer porosities than either mat gold foil, Electraloy RV, or Goldent (Ivoclar Williams). Assuming a 20% increase in volume due to unavoidable porosities (Richter & Cantwell, 1965), condensation of one layer of the 0.7 mm-thick Stopfgold would produce a layer approximately 80 μm thick. The 1.0 mm- and 1.5 mm-thick material would result in condensed layers of approximately 110 μm and 170 μm respectively. For purposes of comparison, a well-condensed average-size pellet of gold foil results in a thickness of 50 μm, while a well-condensed layer of mat gold produces a thickness of 175 μm (Baum, Phillips & Lund, 1981). The availability of different thicknesses of this material allows clinicians to select a bulk of material to match their experience and condensation ability. Inexperienced operators should restrict their technique to the 0.7 mm material, while operators with prior experience and success with hand condensation technique would prefer the 1.0 mm or 1.5 mm material for improved efficiency.

CLINICAL EXPERIENCE

Following several trials of this new material on dentoform teeth, microscopic examination at X40 revealed no difference in the surface porosity or marginal adaptation when hand condensation only was compared to mechanical compaction (Electromallet, McShirley Products, Inc, Valencia, CA 91355). To determine whether hand condensation without malleting force would produce a clinically acceptable restoration, several clinical cases were selected for restoration using Stopfgold and hand condensation.

A clinical operative instructor with many years of gold foil experience placed six restorations, while another six restorations were placed by a senior dental student under the supervision of the same instructor. The restorations were reexamined 1 year postoperatively. All six restorations placed by the instructor demonstrated smooth dense surfaces with no evidence of porosity or flaking. Four of the six restorations placed by the senior student continued to demonstrate smooth, dense surfaces, while the other two had minor porosities that did not detract from the acceptability of the restoration. Figures 3 - 6 illustrate one of the cases completed by the instructor, and Figure 7 shows the 1-year recall of a case completed by the senior student.

Both the instructor and the student felt that Stopfgold was somewhat easier to condense than Electraloy. Both

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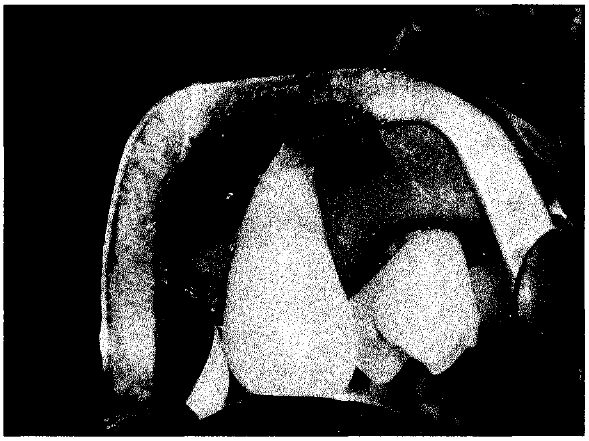

Figure 3. *Isolation of class 5 lesion for restoration with direct gold*

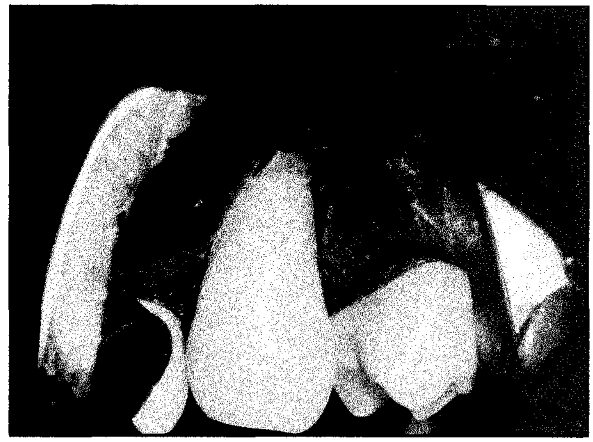

Figure 4. *Class 5 preparation partially filled with Stopfgold by hand condensation technique*

Figure 5. *Completed class 5 restoration with hand-condensed Stopfgold*

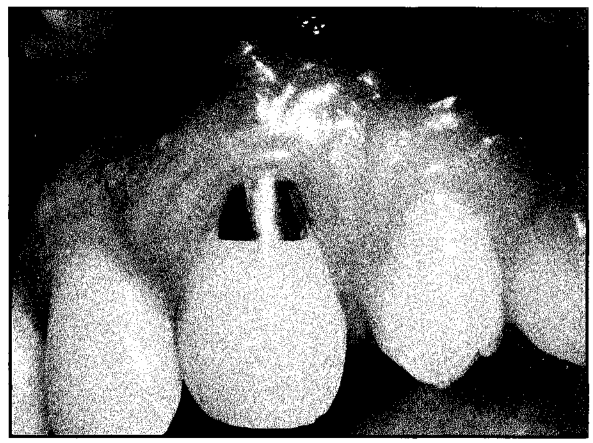

Figure 6. *1-year postoperative illustration of restoration*

Figure 7. *1-year postoperative illustration of class 1 restoration placed by senior dental student. Teeth #29 and #30 are restored with Electraloy and a mechanically compacted veneer of gold foil. Tooth #31 was restored by hand condensation of Stopfgold.*

operators agreed that the new material spread more easily and seemed softer during condensation. The amount of time for condensation was approximately the same as with Electraloy. The cost of this material is a distinct disadvantage, as it is approximately 75% more expensive than other forms of granular gold. However, the amount of material used for an average-size class 5 restoration (Figure 6) would amount to approximately 15 dollars, which should not significantly alter the fee for this service.

DISCUSSION

Research comparing the physical properties of mechanically condensed direct filling gold to hand-condensed gold (Richter & Cantwell, 1965; Thye, 1967; Xhonga, 1971; Richter & Mahler, 1973) have not demonstrated clinically significant differences between the two methods. Most clinicians prefer to mechanically condense a surface layer of gold foil whenever possible

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to create a more homogenous surface and to produce minimal microleakage (Lambert, 1980). However, the necessity to include a mechanical condenser as a required instrument for compaction of direct gold causes many new graduates to quickly dismiss the direct gold restoration from their treatment alternatives.

The continuing pressure to minimize or eliminate the direct gold restoration from the dental curriculum (Lambert, 1980, 1990; Nuckles, 1989) makes it impossible or extremely difficult for operative faculty to purchase mechanical condensers for student use. Even though condensers may be available in the school, upon graduation, very few students are equipped with a condenser of their own. To overcome this negative aspect of continuing to teach direct gold restorations as an elective course at the University of Colorado, the faculty have decided to place more emphasis on hand condensation in an attempt to convince the students that with proper technique, a clinically acceptable direct gold restoration can be achieved without expensive additions to their equipment.

The 1-year-old Stopfgold restorations illustrated in Figures 6 and 7 were placed without a veneer of gold foil and with hand condensation only. Throughout the condensation procedure, stepping of the condenser, correct line of force, and rocking of the condenser during application of 6 - 8 pounds of force was emphasized. A 0.8 mm-in-diameter, round, serrated hand condenser was the only condensing instrument used. The purpose of rocking the condenser during force application is to reduce the surface area in contact with the gold and thereby increase the amount of pressure created by the face of the condenser. During the teaching of direct gold technique, students who have difficulty maintaining 6 - 8 pounds of force are encouraged to use a smaller (0.5 mm-in-diameter) condenser.

CONCLUSION

Stopfgold, a new direct filling material, appears to combine most of the advantages of both gold foil and granular forms of direct filling gold, while eliminating the major disadvantages of these materials. Limited research and clinical experience has demonstrated that correct hand condensation technique can produce a final restoration equal to the more traditional mechanically condensed gold foil restoration.

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Comparison of Restorative Treatment Recommendations Based on Patients and Patient Simulations

J D BADER • D A SHUGARS • F E McCLURE

Clinical Relevance
The results suggest that patient simulations can be used to assess dentists' decision making for testing purposes.

SUMMARY

Restorative treatment recommendations made by dentists examining patients were compared with recommendations made by dentists examining simulations of the same patients. Simulations consisted of unmounted casts, full-mouth radiographs, three still video images of each tooth, periodontal charting, and a written dental history. Each of 117 teeth in five patients was examined by at least three and as many as 13 dentists under simulation and live conditions, with no dentists examining the same patient under both conditions. About three-fourths of teeth receiving a recommendation for treatment from at least one dentist received such a recommendation from at least one dentist examining under each of the two examination conditions. For these teeth, about three-fourths of all dentists examining under each condition recommended treatment. For teeth receiving a recommendation for treatment under only one examination condition, smaller proportions of dentists recommended treatment. Overall, there was three times as much variation in treatment recommendations among dentists in an examination condition than between the "average" treatment recommended by dentists in the two examination conditions.

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INTRODUCTION

There is an increasing need to use patient simulations in dentistry for teaching and evaluation purposes. Clearly, there is growing pressure to discontinue the use of human subjects for both diagnostic and treatment portions of licensure examinations (Buchanan, 1991). Similarly, it is no longer possible to assume that dental students will be challenged for diagnoses through a complete range of clinical conditions presented by the patients they examine. While typodonts are being substituted successfully for live patients in evaluations of technical skills (Yaple, Metzler & Wallace, 1992),

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more complete patient simulations are necessary to evaluate assessment and treatment decision skills. Such simulations are beginning to appear in dentistry; an extremely limited version is now incorporated in the Part II National Board Examination (Kramer & DeMarais, 1992), and the Dental Interactive Simulations Corporation is developing a computer-based system for a variety of teaching and testing applications (Foti, 1992). However, there is some question whether such "nonclinical" examinations represent appropriate methods for evaluating a provider's abilities to make appropriate decisions concerning the need for treatment.

Consideration of simulated and live clinical encounters suggests that two elements of live encounters inevitably are lost in patient simulations: tactile information derived from probing and interpersonal information derived from conversation with the patient. Most of the uncertainty about the appropriateness of using simulations stems from the effects of loss of the tactile component, which is usually considered to be an essential aspect of a caries examination in the US. However, there is evidence suggesting that the tactile component is not as critical to diagnosis as is commonly assumed. Recent European reports suggest that use of an explorer does not result in a greater rate of valid diagnoses (Downer, 1989). It is argued that the majority of lesions are detected radiographically (Kidd & Pitts, 1990), and even on surfaces where, reputedly, tactile information is essential for detecting early lesions due to the reduced effectiveness of radiographs, use of an explorer has not been found to improve the validity of the caries diagnosis (Lussi, 1991). The possibility that tactile information does not necessarily improve the probability of a valid diagnosis is suggested by observations concerning variation in dentists' reactions to marginal discrepancies (Dedmon, 1982, 1985).

If the effects of the tactile examination on dentists' treatment decisions are not clear, the effects of patient-dentist interpersonal interaction on dentists' treatment decisions are even less well understood. Although the process by which dentists examine patients and arrive at decisions to intervene is thought to be influenced by interpersonal factors (Bader & Shugars, 1992), the nature and magnitude of these effects are entirely unknown.

An initial approach to addressing the question of the appropriateness of patient simulations for evaluating providers' treatment decision skills is to compare treatment decisions made for the same patients under live and simulated conditions. The assumption is that if the treatment decisions based on examinations of patients are similar to those based on examinations of simulations of the same patients, then the simulations present dentists with sufficient information to make restorative treatment decisions, and thus can be used to evaluate those skills. This paper presents the results of an initial study that compared the restorative treatment decisions of dentists who examined a group of patients with the decisions of other dentists who examined patient simulations based on these same patients.

METHODS

The analyses presented here comprise dentists' treatment decisions for 117 teeth in five patients. For two patients, only teeth in the maxillary arch could be included in the analyses, because time limitations kept some dentists examining the simulations from completing assessments of mandibular teeth. For each of the five patients, dentists made treatment decisions for each tooth based on either a clinical or a simulated patient examination. Each of the five patients was examined clinically by between three and 13 dentists. Each patient simulation was examined by between three and nine dentists. No dentist examined both the patient and the same patient simulation. A total of 27 dentists participated, all of whom were volunteer general practitioners recruited from the four-county area surrounding the dental school. The patients were adult volunteers from among persons presenting for treatment at the dental school. They were selected to emphasize three pertinent characteristics: numerous previously restored teeth, few missing teeth, and no conditions such as advanced periodontal disease that might necessitate modification of restorative treatment recommendations.

The clinical examinations occurred in dental school operatories. Full-mouth radiographs, health histories, and periodontal charting data were provided. Dentists were asked to assume that patients were visiting their practices for the first time, and were urged to proceed in a manner as similar as possible to that usually occurring in their practices, including discussion of treatment alternatives with the patient prior to making a recommendation, if appropriate. For each tooth, a dentist's decision about whether to recommend treatment was recorded, as well as the type of restoration recommended. For the analyses presented here, type of restoration was dichotomized to plastic materials (amalgam, composite) and cast or fired materials (gold, porcelain, etc).

Dentists performing examinations of patient simulations received the same instructions as dentists performing clinical examinations. In addition to the materials made available for the clinical examination, these dentists were given unmounted stone study casts and a brief description of the patient's social history. The dentists also viewed a videotape that showed still images of each tooth from the facial, occlusal, and lingual aspects. These full-screen images were obtained with an intraoral videocamera. The tape was shown once

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Table 1. Distribution of Teeth by Receipt of One or More Recommendations for Treatment from Patient and Patient Simulation Examinations

	Patient Simulation Examination		
Patient Examination	**1+ Recommendations for Treatment**	**No Recommendations for Treatment**	**Total**
1+ recommendations for treatment	53	13	66
No recommendations for treatment	9	42	51
Total	62	55	117

without interruption, after which specific images were reshown by request. Images were originally shown for between 3 and 6 seconds, with longer times used for images that included a restoration. For each tooth, dentists were asked to indicate whether they would recommend restorative treatment, and if so, what type of treatment.

The focus of the analyses was the comparison of treatments recommended under the two examination conditions, i e, treatment recommended by dentists who performed examinations of patients was compared to treatment recommended by dentists who performed examinations of patient simulations. The unit of analysis was the tooth, the level at which dentists made their treatment decisions. At the simplest level of analysis, the proportion of all individual tooth assessments that resulted in a recommendation for treatment was determined for patient and patient simulation examinations. Also, all teeth were classified by whether they received one or more recommendations for treatment as a result of a patient examination and as a result of a patient simulation examination. Recommendations for cast restorations made under both examination conditions were classified similarly. The proportions of teeth in these classification categories that had existing restorations were also calculated to assess the relationship between existing restorations and recommendations for treatment.

Table 2. Percent of Teeth with Existing Restorations, by Source of Recommendation for Treatment

Source of Recommendation	**Percent of Teeth with Existing Restorations**
Recommendation(s) from patient and patient simulation exams	96%
Recommendation(s) only from patient exam	69%
Recommendation(s) only from patient simulation exam	89%
No recommendation from either exam	31%

Since the treatment recommendations of any group of dentists who clinically examine the same patient can vary substantially (Elderton & Nuttall, 1983; Hazelkorn, 1985; Bader & Shugars, 1993), a more sensitive analytic approach is to compare the "average" treatment recommendation for any given tooth. To this end, the proportions of dentists recommending treatment for each of the 117 teeth from patient examinations and from patient simulation examinations were determined. The intraclass correlation coefficient between proportions generated under the two examination conditions was then calculated (Fleiss & others, 1979).

In a third approach to comparing the results of the two types of examinations, a variation of the intraclass correlation, a "modified reliability index," was calculated to quantify the extent of agreement among dentists performing patient examinations and among dentists performing examinations of patient simulations (Bader & Shugars, 1993). In much the same manner as for the multiple correlation coefficient, R^2, the share of the total variance in proportions of dentists recommending treatment for a tooth that is attributable to dentist disagreement is determined by dividing the "within tooth" sum of squares by the total sum of squares. The reliability index values are used as indicators of the reliability, or relative extent of agreement among dentists across all individual tooth comparisons under one examination condition. Interpretation of index values follows the convention used for the Kappa statistic, where values below 0.40 indicate poor reliability, values between 0.40 and 0.75 indicate fair-to-good reliability, and values above 0.75 represent excellent reliability

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Table 3. Mean Percent of Dentists Recommending Treatment for a Tooth, by Source of Recommendation for Treatment

Source of Recommendation	Percent of Dentists Recommending Treatment for a Tooth from: Patient Examination	Patient Simulation Examination
Recommendation(s) from patient and patient simulation exams	70%	76%
Recommendation(s) only from patient exam	36%	00%
Recommendation(s) only from patient simulation exam	00%	56%
No recommendation from either exam	00%	00%

Table 4. Distribution of Teeth by Receipt of One or More Recommendations for a Cast Restoration from Patient and Patient Simulation Examinations

Patient Examination	Patient Simulation Examination: 1+ Recommendations for Treatment	No Recommendations for Treatment	Total
1+ recommendations for treatment	0	15	15
No recommendations for treatment	10	92	102
Total	10	107	117

(Landis & Koch, 1977).

RESULTS

Of the 891 individual tooth assessments based on examinations of patients, 393 (44%) resulted in a recommendation for treatment. Of the 541 individual tooth assessments based on examination of patient simulations, 209 (39%) resulted in a recommendation for treatment. Table 1 shows the distribution of the 117 teeth by whether they received one or more recommendations for a restoration based on the patient examination and the patient simulation examination. From this distribution, it can be calculated that 64% (75/117) of all teeth received at least one recommendation for treatment, either from a dentist performing a patient examination or a dentist performing an examination of a patient simulation. Among these teeth receiving at least one recommendation, 71% (53/75) received a recommendation by at least one dentist examining under each of the two examination conditions.

Table 2 shows the proportion of teeth in each of the four cells in Table 1 that had an existing restoration. Almost all teeth receiving recommendations for treatment from dentists examining under both conditions had been restored previously. Conversely, most teeth receiving no recommendations for treatment had no existing restorations.

Table 3 shows the mean proportions of dentists examining a tooth who recommended treatment for the teeth in each cell of Table 1. Among teeth receiving recommendations under both examination conditions, 70% of dentists examining the patient and 76% of dentists examining the patient simulation recommended treatment. For teeth receiving recommendations only from clinical and only from simulation examinations, these proportions were lower. Of 25 teeth receiving at least one recommendation for a cast restoration, none received such a recommendation from at least one dentist examining under each condition (Table 4). In effect, there was no agreement on recommendations for cast restoration between examination conditions. Agreement among dentists in either examination condition that a cast restoration was needed was also low. Among those teeth receiving one such recommendation from clinical examinations, a mean of 23% of examining dentists recommended a cast restoration; the parallel proportion was 34% for dentists examining patient simulations.

The intraclass correlation coefficient for proportions of dentists recommending treatment for each tooth under the two examination conditions was 0.753, indicating that approximately one-quarter of the variation seen in the 117 comparisons was due to the examination condition, while three-quarters was due to variation introduced by differences among dentists within the same examination condition. The modified reliability coefficient for the patient examinations was 0.64, and for the patient simulation examinations it was 0.69, indicating that while slightly better agreement was achieved among dentists examining patient simulations, agreement was less than excellent under either condition.

DISCUSSION

The results of this study can only be regarded as suggestive. The small number of patients and teeth, together with a selection bias toward teeth with existing restorations all militate for caution in generalization. Yet the results do shed some light on the appropriateness

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of examinations of patient simulations as possible substitutes for clinical patient examinations for the purpose of evaluating dentists' assessment and treatment decision skills. The results also may further our understanding of the contribution of the tactile and interpersonal components of the patient examination. The results suggest that preparation of restorative treatment plans based on examinations of patient simulations does challenge many of the same decision-making skills as does preparation of treatment plans based on patient examinations. Recommendations for treatment were made at approximately the same rate, and, for the most part, the same teeth were identified as needing treatment. Thus, it would appear that the two conditions present information that causes practitioners to make similar decisions. Although an intraclass correlation coefficient of 0.75 is not sufficient to assume that either set of examinations would be functionally equivalent to the other, it does demonstrate substantial agreement. Further, it is important to realize that there was three times as much variation among dentists examining under either condition as there was between the "average" examination results for the two conditions. Of course, because current criteria and diagnostic techniques do not permit the identification of the "right" decision, i e, the gold standard, for each tooth, it is impossible to declare either the patient or the patient simulation "average" decision superior.

Thirty percent of all teeth receiving one or more recommendations for treatment received them only from examinations performed in one condition. Because many of these teeth received only one recommendation, some lack of congruence between examination conditions was inevitable. However, condition-specific recommendations may also have been the result of the presence or absence of certain types of information in one of the conditions. Tactile information and the increased emphasis on visual assessment brought on by the clear and accessible images provided by the videocamera both may provide specific cues to recommend treatment for some but not all dentists examining under the same condition. Teeth may have been singled out in the clinical examinations by some dentists because of defects in restorations or catches in pits and fissures that could only be identified clinically and that were missed or deemed not severe enough to warrant intervention by other dentists examining clinically. The absence of any widely adopted standardized tactile criteria with which to evaluate margins of existing restorations (Bader & Shugars, 1992) and the slow evolution of any consensus on replacement criteria based on marginal discrepancies (Anusavice, 1989) certainly predispose tactile assessments of existing restorations to variation. A similar situation may exist with respect to assessing the need to replace restorations based on a magnified visual presentation (Whitehead & Wilson, 1992). Clearly, the presence of an existing restoration was an important determinant for treatment recommendations under either condition.

The complete lack of agreement between dentists examining in the two conditions with respect to identifying teeth for which cast restorations would be recommended illustrates the absence of widely accepted criteria for this treatment decision. Although 50% more teeth received one or more such recommendations from patient examinations than from examinations of patient simulations, the numbers are quite small. Nevertheless, a common assumption that interpersonal contact tends to provide dentists with additional information that, in some instances, reduces their propensity for recommending cast restorations was not supported in this study.

CONCLUSIONS

These initial results suggest that patient simulations may be appropriate substitutes for clinical examinations for the purpose of assessing dentists' restorative treatment decisions. The results also underscore the need to better understand the extensive variation between dentists' restorative treatment recommendations for the same patient. Although the extent of the variation suggests that not all treatment decisions are appropriate, better understanding of treatment outcome is also necessary before definitive determinations of appropriateness are possible.

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Effect of Light Intensity and Exposure Duration on Cure of Resin Composite

F A RUEGGEBERG • W F CAUGHMAN • J W CURTIS, Jr

Clinical Relevance
A 60-second cure time of resin increments not greater than 2 mm are recommended.

SUMMARY

Of the many factors under their control, clinicians can manipulate light-exposure duration but must deal with a set intensity of light emitted from the dental curing unit. This research investigates the interdependence of exposure duration and source intensity on resin cure at various depths within a simulated light-cured resin composite restoration. Thin wafers of composite were obtained from a simulated cylindrical restoration such that the wafer could be removed from the top or from a distance of 1, 2, and 3 mm beneath the surface. The composites used in this study were a microfill and hybrid of Universal and Gray shades. All the data concerning filler type and shade were pooled so that generalized statements could be made regarding curing of light-activated composite in general. Specimens were cured using various source intensities and for different durations at each level within the cured cylinder. The cure of the specimens resulting from the different treatments was determined using infrared spectroscopy. The results indicate a dramatic effect of depth on the cure of composite. At depths greater than 2 mm, poor cure results, and polymerization is very susceptible to changes in light intensity and exposure duration. From these results, routine exposure times of 60 seconds are recommended using light-source intensities of at least 400 mW/cm² as measured with a commercial dental light intensity meter. Incremental layer thickness should not exceed 2 mm, with 1 mm being ideal. Sources with intensity values less than 233 mW/cm² should not be used because of their poor cure characteristics.

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INTRODUCTION

Light-activated resin composite restorative material has revolutionized clinical dentistry. Before the development of photo-cured materials, composite material was self- or chemical-cured. These products were two-

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paste systems. One portion contained the free radical generator, benzoyl peroxide (BPO); the other component contained a tertiary amine (Craig, 1985). When these two materials were mixed, free radicals were generated, initiating the polymerization process (Cook & Standish, 1983). Because polymerization started immediately upon mixing, the practitioner was limited to a narrow window of time in which it was necessary to deliver the paste into the preparation and hold it in place while the reaction came to completion, often requiring minutes. Although this limitation of working time was a drawback, the fact that the pastes were mixed until homogeneous prior to placement in the preparation meant the curing reaction took place uniformly throughout the entire bulk of material (McCabe, 1984).

The development of light-activated pastes helped to maximize composite working time while minimizing setting time (Burke, 1985). Thus, the dentist could place and contour the uncured material until satisfied with the result, and then initiate and complete curing within a matter of seconds by exposure to visible light. Less material was wasted and chairside time was saved through use of the photo-curable products.

Light-cured composites have one major drawback, however. The degree to which these materials cure is proportional to the amount of light to which they are exposed. At the upper surface of a restoration, where no overlying composite interferes with light transmission, it has been found that even a curing source with relatively low intensity can cure the resin matrix to an extent almost equal to that when high intensity lights are used (Rueggeberg, 1993a). However, as light passes through the bulk of the restorative material, its intensity is decreased greatly, thus decreasing the potential for cure (Ruyter & Øysæd, 1982.) This decrease results in a gradation of the cure such that it decreases from the top surface inward. This decrement in cure has been termed "depth of cure" and has significant influence on both the physical (Asmussen, 1982) and biological properties (Caughman & others, 1991) of the restoration.

Recently, the importance of light-source intensity has been in the forefront of clinical practice. It has been found that a small change in intensity may result in significant changes in resin cure deep within the bulk of the restoration (Rueggeberg, 1993a). Manufacturers have marketed products that clinicians can use to periodically measure the intensity of their light sources to ensure they are maximizing the potential for resin cure (Rueggeberg, 1993b). However, if a light source is known to have decreased in intensity from its original state, clinicians are left in a quandary as to what they can do to compensate for this condition besides change the bulb.

The purpose of this research was to investigate the impact of variation in light-source intensity and duration of exposure upon resin cure at different depths within a light-cured composite restoration. The information gained will help clinicians optimize their use of dental curing lights and maximize chairside productivity.

METHODS AND MATERIALS

Light Source Assembly

The light source assembly used is diagrammed in Figure 1. The power coming from the wall outlet was conditioned (Model 63-12-150, Sola Electric, Elk Grove Village, IL 60007) to remove the influences of transient voltage spikes that would cause variation in source intensity. The voltage provided to the controlling unit was adjustable by means of a rheostat. Adjustment of this device allowed control of the voltage supplied to the lamp. Pilot studies indicated that maintenance of 11.2 VAC to the 100-watt quartz-tungsten-halogen lamp yielded consistent intensity readings. Throughout the study, this voltage was maintained manually through adjustment of the rheostat. Also, the intensity of the lamp was periodically monitored using a hand-held dental curing light radiometer (Model 100, Demetron Research Corporation, Danbury, CT 06810) with an accuracy of ±2% (Gaines, 1992). Maintenance of the specific voltage yielded approximately 800 mW/cm^2.

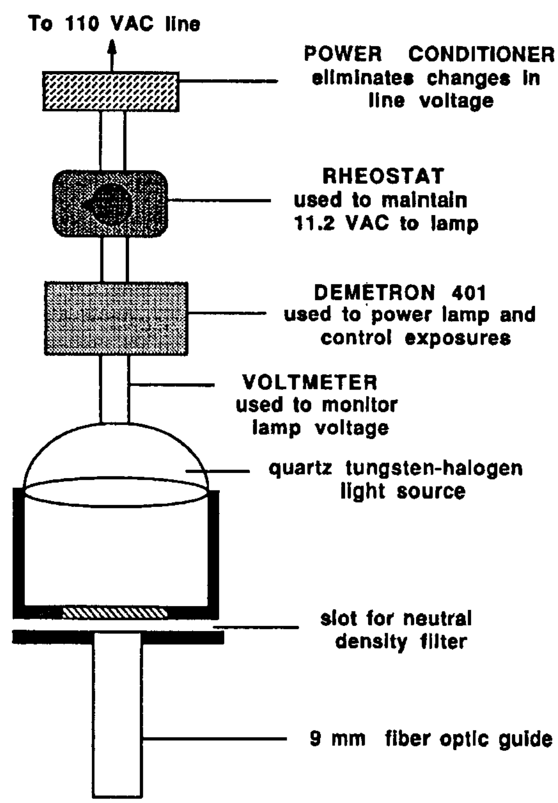

Figure 1. *Diagram of light source assembly*

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The lamp was powered and timed by use of a Demetron 401 control unit. Using this control unit, timed exposures of 20, 40, 60, and 80 seconds were made. Light emitted by the bulb was filtered by a bandpass filter commonly found in dental curing units (Demetron Research Corporation). This filter selectively passes radiation between 400 and 500 nm while also excluding infrared energy. After passing through the blue filter, the light was then subjected to one of four attenuation schemes. With the use of neutral density filters, it was possible to reduce the intensity of the source by known amounts prior to it being transmitted to the fiber optic tip. With no neutral density filter in place, 100% of the source radiation was passed (800 mW/cm^2). With the use of other filters, the intensity was reduced to 72.3% (578 mW/cm^2), 50.2% (400 mW/cm^2), and 29.2% (233 mW/cm^2) transmission.

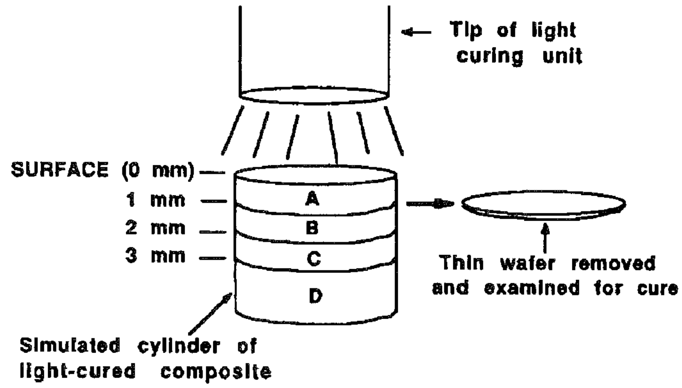

Figure 2. *Schematic representation of composite specimen fabrication. Levels A-C represent thicknesses of composite through which the light must pass (overlays) in order to cure the thin wafer of resin that was removed and analyzed. Level D represents deeper composite (the underlay) that would reflect light and influence the cure of overlying resin.*

Composite Specimens

The composites used in this study are listed in Table 1. These products were specifically selected to provide a wide range of filler type (microfilled and hybrid) as well as variation in shades (Gray and Universal). The design of specimen fabrication was directed at simulating a cylinder of composite that was exposed from the top. After exposure to light, a thin, cured wafer of composite could be taken from specific depths in this cylinder and analyzed for extent of resin cure. The positions from which specimens were taken included the top surface, as well as 1, 2, and 3 mm beneath the surface. Figure 2 diagrams the assembly of the simulated cylinder of composite and the positions from which a thin "slice" of resin was obtained.

A small amount of uncured paste was placed between two sheets of Mylar (0.07 mm thick, E I du Pont De Nemours & Co, Wilmington, DE 19898) and was pressed into a thin layer approximately 0.08 mm thick. A large, cured cylinder (20 mm in diameter and 1 mm thick) of similar filler type and shade composite was made and functioned as the layer below the removable "slice." The top surface of this large disk was coated with a small amount of immersion oil (Type B, RP Cargile Laboratories, Cedar Grove, NJ 07009). The oil acted to displace air between the cured composite and the Mylar film that would interfere with light transmission through the assembly. At no time was the oil in contact with the uncured specimen. The Mylar-encased, uncured specimen was placed over the oiled surface of the composite underlay and pressed in place to eliminate trapped air. Cured composite disks of each type of material (13 mm in diameter) were made in thicknesses of 1, 2, and 3 mm. If the removable "slice" was to simulate curing at a known depth of composite, oil was placed on the upper Mylar surface of the assembly already mentioned, and the proper thickness of cured overlay was pressed to place. If no overlay was used, the upper Mylar surface acted as the top surface of the simulated composite cylinder. After all components had been assembled, the stack was placed into a well on the platform of a jack stand. The platform was raised until the top surface of the composite was in contact with the end of the light tip. Figure 3 diagrams the assembly used for stacking and curing the composite slices. After the composite had been exposed for the selected time at the specified attenuation factor, the cured overlay and underlay were removed, and the Mylar sandwich containing the cured slice was stored in a light-tight container for 24 hours.

Table 1. Composites Used

Product*	Shade	Lot Number
P-50	Universal	1ED5
P-50	Gray	1EE1
Silux Plus	Universal	1EE1
Silux Plus	Gray	1CD1R

*3M Dental Products, St Paul, MN 55144

Determination of Composite Cure

After 1 day of dark storage, the Mylar sheets were stripped from the cured composite and the thin, cured wafer was recovered. This disk was placed in a transmission holder of a beam condensing unit (Model 4XTBC,

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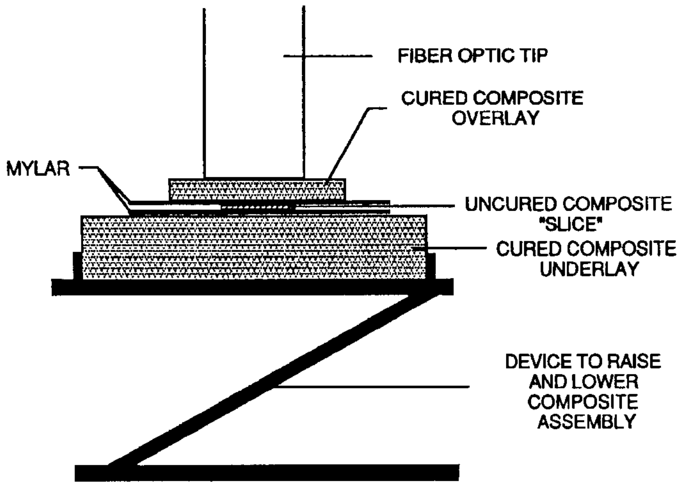

Figure 3. *Diagram of composite wafer assembly*

Harrick Scientific Corp, Ossining, NY 10562) and the infrared spectrum was obtained using eight scans at a resolution of 2 cm^{-1} using an FTIR spectrometer (FTS-40, Bio-Rad, Digilab Division, Cambridge MA 02139). The spectrum of the uncured material was obtained by pressing a small amount of the paste between two ZnSe plates and placing this assembly into the same transmission holder mentioned above. Standard methods were used to determine the percent of conversion of monomer into polymer (Ruyter & Svendsen, 1978). These methods monitor the change in absorbance of the aliphatic carbon-to-carbon double bond (C=C) at 1636 cm^{-1} in the cured and uncured states with reference to the absorption of an aromatic C=C occurring at 1608 cm^{-1}.

Statistical Treatment

Both the order of specimen fabrication and infrared testing were completely randomized to minimize the influence of operator learning on the results. Three replications were made for each test condition, resulting in a total of 768 specimens. The data were pooled for shade and filler type so that the effect of these variables was spread throughout the data. The mean monomer conversion for each pair of intensity-exposure duration combinations was determined at each thickness of overlying composite. A two-way ANOVA (the independent variables being exposure duration: four levels and source intensity: four levels) was made to test for the presence of a significant difference among these variables and monomer conversion at each of the four overlay thicknesses. Fisher's PLSD post hoc test was used to compare differences between specific pairs of mean conversion values at different duration times and intensity values for significance. Two one-way ANOVAs followed by Fisher's PLSD post hoc test were performed to detect significant differences in conversion values between either pairs of duration times or intensity values at each of the four attenuation levels. All statistical testing was performed at the 95% level of confidence.

RESULTS

The impact of both exposure duration and source intensity is seen in Figures 4-7. These figures are surface graphs and depict how two independent variables simultaneously affect a third, dependent variable. In Figure 4, it can be seen that resin cure at the composite surface is not affected greatly by either duration or intensity. There is a slight downward tipping of the corner of the top surface that is nearest the reader. This tipping is indicative of a decrease in cure caused by the combination of low intensity and exposure values.

In Figure 5, the cure values 1 mm beneath the upper, exposed surface are shown. The amount of tipping in the corner closest to the reader is greater than in the previous figure, indicating a greater influence of low intensity and duration values than at the surface. There is also a slight downward tilt of the remainder of the graph surface, demonstrating that both of these variables are causing a slight decrease in resin cure.

There is a drastic difference between the surface of the graph in Figure 5 (representing composite cure 1 mm deep) and that obtained from 2 mm below the surface (Figure 6). The tilt of the edge closest to the reader is much steeper than noted previously, indicating a rapid change in cure with variation in both intensity and exposure duration.

When 3 mm of overlay was used, the resulting surface graph shows a very skewed contour (Figure 7). The entire surface has a severe tilt, indicating that for all combinations of intensity and exposure duration, marked changes in specimen cure result. The maximum height of the table (the surface farthest from the reader) is also less than in the previous figures. This lower height indicates it is not possible to attain as great a cure value at a depth of 3 mm (despite using a high intensity and long exposure duration) as it is when thinner overlays were used.

Table 2 shows the results of the two-way ANOVA. From these data, it can be seen that at the top surface, only duration of exposure is a significant factor contributing to monomer conversion. When curing through 1 mm of composite, both exposure duration and intensity become significant factors. At the levels of 2 and 3 mm of thickness, duration, intensity, and their interaction terms are all contributing factors to resin cure.

Table 3 displays the results of the pair-wise post hoc test for the effect of duration on cure at the various thicknesses of overlay. At the top composite surface, a

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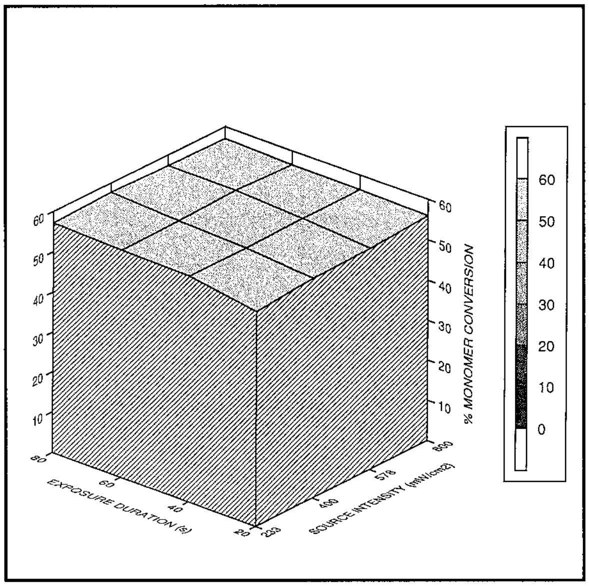

Figure 4. *Impact of exposure duration and source intensity on resin cure at the surface of a composite*

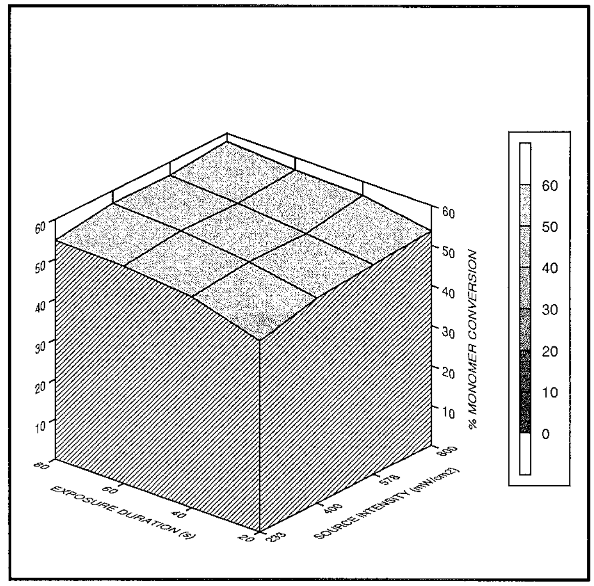

Figure 5. *Impact of exposure duration and source intensity on resin cure 1 mm beneath the composite surface*

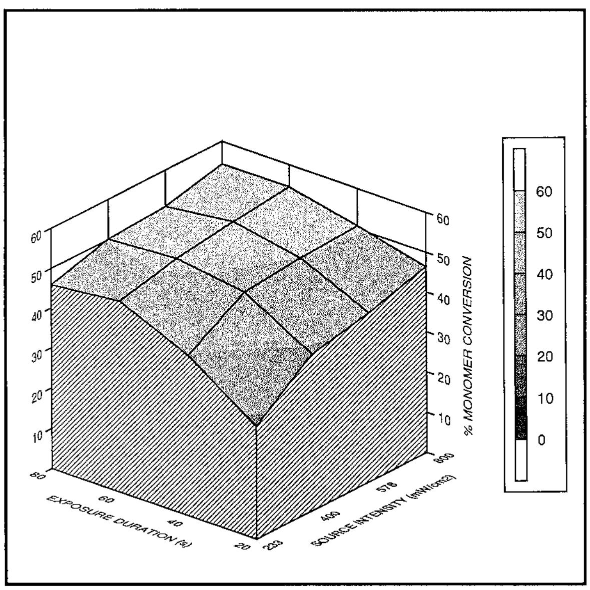

Figure 6. *Impact of exposure duration and source intensity on resin cure 2 mm beneath the composite surface*

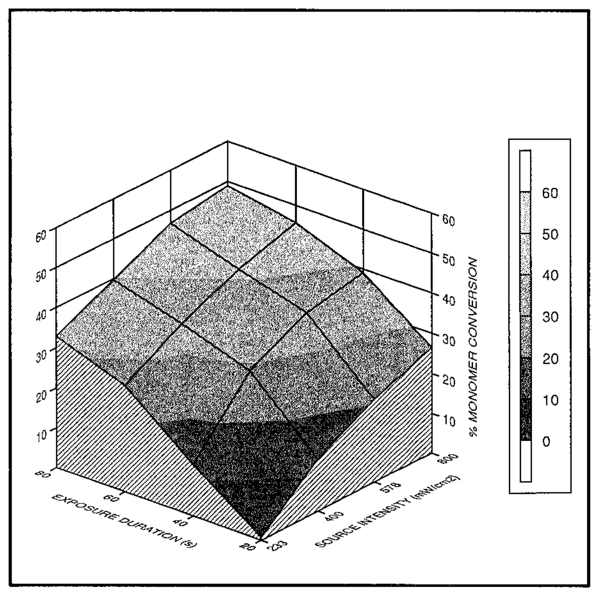

Figure 7. *Impact of exposure duration and source intensity on resin cure 3 mm beneath the composite surface*

duration of 40 or 60 seconds will produce similarly cured specimens. Exposure durations of 60 and 80 seconds are similar in their results also. When 1 mm of overlay is used, all exposure durations produce significantly different cures, with the exception of 60 and 80 seconds. This trend is also seen when curing through 2 mm of overlay. When 3 mm of overlay is used, there are statistical differences in conversion values among all duration time combinations.

The results of the pair-wise post hoc test of intensity and resin cure for the various overlay thicknesses are shown in Table 4. On the top surface of composite, there are no differences in cure among the various intensity values. When illuminating through the 1 mm-thick disk, a light with intensity between 578 and 400 mW/cm^2 will yield similar results in cure. At the level simulating 2 mm in depth, all intensity comparisons yield significantly different cure values except those between 578 and

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400 mW/cm². When the 3 mm overlay is used, all intensity values used in this study yielded significantly different cure values from one another with the exception of 800 and 578 mW/cm². An intensity of 233 mW/cm² will not cure as great as any other intensity at any depth except at the surface.

Table 2. Two-Way ANOVA of Duration and Intensity at Each Overlay Thickness

Source	df	*P*-Value for Different Thicknesses of Overlay: Top Surface	1 mm Deep	2 mm Deep	3 mm Deep
Intensity (A)	3	0.2983	0.0001*	0.0001*	0.0001*
Duration (B)	3	0.0001*	0.0001*	0.0001*	0.0001*
Interaction (AxB)	9	0.5268	0.2223	0.0001*	0.0001*

*P-value < 0.05 is significantly different.

DISCUSSION

The results of this research present many clinically relevant factors. First, the visualization of the dramatic change in resin cure as both intensity and duration change with depth within a composite only serves to emphasize the fact that increments should never be placed any greater than 2 mm. Although it may take more chairside time, a 1 mm incremental build-up will provide a much greater and more uniform cure and will be much less susceptible to changes in light intensity than will be a 2 mm increment.

For routine exposures, durations of 20 seconds inadequately cure composite at depths of 1 mm and more. At depths greater than 1 mm, the 40-second exposure yielded less resin cure than did the 60-second treatment. When curing increments of 2 mm or less, exposing composite longer than 60 seconds will not substantially increase the extent of cure at a given depth. Therefore, although a 40-second cure will suffice, a routine 60-second exposure is suggested.

Most commercial light units do not have the intensity of source light used in this study (800 mW/cm²). Although clinicians can strive for this high value, real-world situations indicate that values between 578 and 400 mW/cm² will provide adequate cure. This statement is based upon the results of cure at the 2 mm depth. At this level, the resin cure using either of these values provided statistically similar values. An intensity of 233 mW/cm² was found to produce significantly poorer cure at a depth of 2 mm than any other intensity value. It is suggested that when a light unit approaches this low intensity level, the bulb be changed.

CONCLUSIONS

1. Sixty-second exposure durations are recommended to provide uniform cure and compensate for a decrease in source intensity.
2. Increments of composite should be no greater than 2 mm in order to obtain uniform and maximal cure, although a 1 mm thickness is ideal.
3. If the source intensity decreases to 233 mW/cm², it is recommended that a new bulb be used.
4. A minimum intensity of 400 mW/cm² is recommended for routine polymerization of light-activated dental resin composites.

Table 3. One-Way ANOVA of Duration Effect on Cure at Different Depths

Comparison of Duration Groups (s)	Depth of Composite Slice: Top Surface	1 mm Deep	2 mm Deep	3 mm Deep
20 vs 40	X	X	X	X
20 vs 60	X	X	X	X
20 vs 80	X	X	X	X
40 vs 60		X	X	X
40 vs 80	X	X	X	X
60 vs 80				X

X indicates pairwise comparison is significantly different ($P < 0.05$).

Table 4. One-Way ANOVA of Intensity Effect on Cure at Different Depths

Comparison of Intensity Groups (mW/cm²)	Depth of Composite Slice: Top Surface	1 mm Deep	2 mm Deep	3 mm Deep
800 vs 578		X	X	
800 vs 400		X	X	X
800 vs 233		X	X	X
578 vs 400				X
578 vs 233		X	X	X
400 vs 233		X	X	X

X indicates pairwise comparison is significantly different.

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Acknowledgments

The authors would like to express their gratitude to the Demetron Corporation for funding of this study, providing the light source assembly, the source timing unit, as well as the neutral density filters. The Dental Products Division of the 3M Corporation is acknowledged for their supplying of composite material used in this research.

(Received 30 November 1992)

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Clinician of the Year Award

This year I have the distinct honor to present the Clinician of the Year Award. This award, donated by the Ivoclar/Williams Company, is given each year to one of the younger members of the American Academy of Gold Foil Operators to recognize an outstanding individual and rising star. This year the award is presented to Dr Warren K Johnson. Warren is well known by the members of the academy as a hard worker and an excellent operator, having operated before this academy on six occasions. In addition, he has presented clinics and lectured at many national and international meetings.

In an effort to constantly improve his skills, Warren operates in two study clubs, holding charter membership in the RV Tucker Cast Gold Study Club for sixteen years and membership in the George Ellsperman Gold Foil Seminar for 10 years. It has been a real pleasure to see the high quality of dentistry Warren delivers each month at study club meetings whether it be in gold foil or cast golds.

In an effort to share his talent with others, Warren mentors three cast gold study clubs in California, the Richard V Tucker Cast Gold Study Club of Orange County, the San Diego Cast Gold Study Club, and a study club so new, they have yet to pick a name.

When one questions Warren about the effort and expense involved in all this continuing education, he replies with one of his famous quotes, "If you think education is expensive, you should try ignorance."

When Warren is not lecturing in gold foil or conservative gold castings, you might find him on the ski slopes, where he has held a position in the National Ski Patrol since 1979. Now, just when you might be thinking, How does he find time for all this as well as run a busy private practice? I must tell you that he is also a member of the US Army Reserve at Ft Lawton, Washington, where he holds the rank of colonel.

Warren K Johnson

You can see, even from this brief glimpse, that Warren is contributing a tremendous amount of his good technique and talent for the benefit of many lucky people. As Warren often says, "Good judgment comes from experience; unfortunately, experience often comes from poor judgment."

I am very happy to present this award to a good friend and excellent clinician who is doing so much to enhance our experience.

Congratulations, Warren.

RICHARD D TUCKER, DDS

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Distinguished Member Award

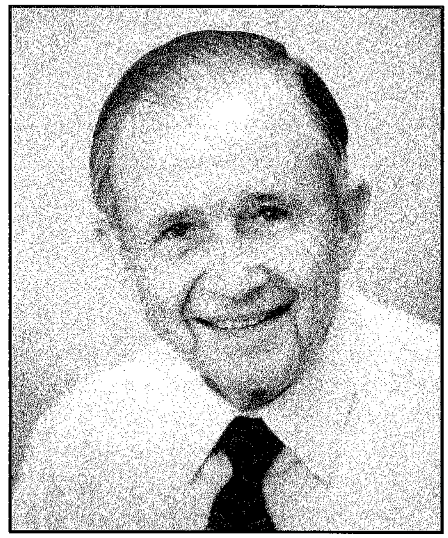
The American Academy of Gold Foil Operators proudly presents the Distinguished Member Award for 1993 to Lloyd Baum, who has held a high recognition level in the Academy since becoming a member.

Lloyd was born in Idaho, which is well known for its potatoes, Senator Borah, sugar beets, Sun Valley, and Lloyd Baum. His dental education occurred at what is now the University of Oregon, but not at its current location in the city of Portland. Dental education during the years 1943-1946 carried a distinct armed forces flavor, as they seemed very interested in the students' progress. At the completion of the dental curriculum in 1946, he was inducted into the scholastic fraternity of OKU. Directly following dental graduation, he became part of the U S Navy Dental Corps for two years, and during part of this time he was based in China.

Then followed three years of private practice in Cottage Grove, Oregon. During this time he was invited to become part of the original dental faculty at a developing dental school at Loma Linda University. Upon the dean's recommendation, Lloyd completed the requirements for a master of science degree in operative dentistry at the University of Michigan in 1952.

Lloyd's academic life was very successful. From 1955 to 1972, he was the clinic director at Loma Linda. In 1972, he became chairman of restorative dentistry at the State University of New York at Stony Brook, and in 1977, he undertook the same functions at the University of Connecticut. In 1982, he returned to Loma Linda. There he has directed general practice residency programs, which in turn led to his being director of the Division of International Dentistry, which brings him to the present year. His current level of academic activity is reduced to 50 percent, but very likely, it is difficult to distinguish this from full-time.

Lloyd holds memberships in a variety of professional organizations and has been very active in several of them. In spite of his busy academic schedule, he more than utilized the time that remained to develop items of interest to operative dentistry. This includes a variety of instruments and die and investing material. Of greatest interest to this organization is the work related to the direct filling gold. The original development led to Goldent, which emphasizes the use of powdered gold. A subsequent refinement produced the current material, which is on the market as E-Z Gold.



Lloyd Baum

A consistent aspect of Lloyd's professional life has included the treatment of patients. It is also to be noted that the dental literature includes a variety of efforts on Lloyd's part. It represents research reports, conventional articles, and the frustrating work of editing books. He has been very active in the dental accreditation process. A project that has been the focus of his attention for several years has been underway at the University of Montemorelos in Mexico. He has developed a successful training program for dental technicians, for which there is a need in that country. In addition, there is now beginning a general practice residency program at the same location.

For the last few months, Lloyd has been in residence at Hangzhou, People's Republic of China, where he has been a dental consultant to Shir Run-Run Shaw Hospital Dental Clinic. Very likely one could revamp the name to See-Lloyd-Run while he is on location.

The varied activities that Lloyd has pursued and the high level of excellence that he has achieved for many years make him highly qualified to receive the Distinguished Member Award. It is my distinct pleasure to present this prestigious award to my good friend and colleague, Lloyd Baum.

MELVIN R LUND

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DEPARTMENTS

LETTER

ON BASES, LINERS, AND VARNISHES

In current literature, many words are used to describe bases, liners, and varnishes. Because of changes in materials and techniques over the last several years, terminology in this area is not presently well defined. For that reason, a working group was formed at this institution to develop definitions from the best available sources so that students and faculty would have a common language in discussing the subject. Members of the working group included John Burgess, Dan Chan, Tom Marshall, Jerry Nicholson, Bill Robbins, and myself. The following are the definitions which were developed by the group:

1. **Cavity Sealers**--These provide a protective coating for freshly cut tooth structure of the prepared cavity.
   a. **Varnishes**--A natural gum (such as copal rosin) or a synthetic resin dissolved in an organic solvent (such as acetone, chloroform, or ether). Examples include Copalite, Plastodent Varnish, and Barrier.
   b. **Resin Bonding Agents**--Includes the primers and adhesives of dentinal and all-purpose bonding agents. Examples include All-Bond 2, Scotchbond MP, Optibond, ProBond and Amalgambond Plus.
   c. **Liners**--A resin or cement coating with minimal thickness (usually less than ½ mm) to achieve a physical barrier or a therapeutic effect (a chemical effect which in some way benefits the health of the pulp of the tooth). Examples include Dycal, Life, Cavitec, Hydroxyline, Vitrebond, and Fuji Lining LC.
2. **Cavity Bases**--A dentin replacement material, for bulk replacement of missing tooth structure to allow the material in the restoration to have less bulk, or for blocking out undercuts for indirect restorations. The material should have adequate strength and modulus of elasticity. Examples include zinc phosphate and glass-ionomer bases.

Some materials can be used, depending on thickness, as either basing materials or lining materials.

If *Operative Dentistry* is in agreement with these definitions, it might be helpful to publish them for reader comment and for future use by authors.

JAMES B SUMMITT, DDS, MS
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To the Red Queen in Alice in Wonderland, words meant what she wanted them to mean. When it comes to this particular area of dental terminology, we have had a lot of Red Queens in the dental literature. I applaud your group's efforts to bring some consistency to the use of these terms. I hope our readers will respond to any problems that they see in these definitions. Once settled, *Operative Dentistry* will use them as our standard. Congratulations, to your group for your thoughtful consideration and solution to this problem.

MAXWELL H ANDERSON
Editor

BOOK REVIEWS

PHYSICAL THERAPY IN CRANIOMANDIBULAR DISORDERS

T L Hansson, C A Christensen Minor, D L Wagnon Taylor

Published by Quintessence Publishing Co, Inc, Chicago, 1992. 80 pages, 154 illustrations. $32.00.

The purpose of *Physical Therapy in Craniomandibular Disorders* by Hansson, Minor, and Taylor is clearly stated in the preface: to be looked upon as a practical guide, not a textbook, and to attempt to initiate standardized care. The book achieves its purpose to a high degree with respect to standardized treatment but falls a little short in the diagnostic area.

The authors stress the need for a definitive diagnosis before instituting treatment of craniomandibular disorders; this is a very important concept. However, the sections dealing with diagnosis left this reader wanting more. Two basic origins of pain are discussed: myogenous and arthrogenous. Mention of the other types of pain would have been helpful.

The importance of poor body and head posture of patients needing physiotherapy is stated. The pictures and descriptions of these postures appear to depict extremes, although this is not stated. More detail of the range of postures would have been helpful, especially in diagnosis. The authors state without substantiation that one can definitively differentiate articular surface irregularities from a displaced

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disk by the character of the patient's click, an arguable premise. The pictures of range of motion evaluation were very clear and helpful, but more written explanation of the evaluative techniques would have added to the diagnostic usefulness of the book. The muscle palpation photographs were also very good, but the need to palpate with the mandible functioning was not mentioned, although it was alluded to in the chart on page 12. The evaluation charts are useful but some of the information repetitious (pp 12, 32). There was no mention of the importance of muscle reciprocation. For example, if a dorsal muscle is tender to palpation, then its balancing ventral muscle is quite often also affected.

The need to include specific goals and a specified time of treatment when formulating treatment plans is very sound advice and clearly stated in the text. The photographs of the exercises were helpful, but more detailed written instructions would have been appreciated. Mentioning the problem areas (e g, displaced disk, painful arthritis) that should be avoided by the physiotherapist is sound advice. However, on page 43, the advice that physiotherapy will be the first and only attempt to eliminate pain if there are no lateral forcing interferences between retruded contact position and intercuspal position needs to be clarified.

The book appears to be written for the physiotherapist rather than the dentist. To this reader, too many assumptions regarding the practical understanding of physiotherapy were made. A bit more "cookbook" is necessary for the average dentist. The book was very helpful and informative and, at the relatively low price, an easy addition to the library, but more detail and guidance would have been appreciated.

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AESTHETIC DENTISTRY WITH INDIRECT RESINS

Howard Stean

Published by Quintessence Publishing Co, Inc, Chicago, 1992. 95 pages, 172 illustrations. $68.00.

Howard Stean is a member of the General Dental Section of the Royal College of Surgeons and has over 20 years' experience in restorative dentistry in London, England. In this book the author uses selected cases from his general dental practice during the past 5 years to demonstrate how "the indirect resin system has extended the range of restorative possibility ... enabling durable and aesthetic restorations to be routinely carried out." The only material that is employed in this text is Isosit (Ivoclar-Vivadent), sold as Concept in the USA (Williams). Dr Stean has succeeded in demonstrating a wide variety of applications for this material, including inlays, onlays, laminate veneers, veneering cast metal crown and bridge work, adhesive bridges, endodontically treated teeth, and the restoration of implants. The extremely wide range of applications demonstrated in this text are based on the assumption that Isosit/ Concept wears at a rate that is "of the same order as the wear rate of natural tooth substance."

This book is easy to read, well illustrated, and contains a limited number of references at the end of most chapters. It is intended for general dentists, and it would be useful to those operators who are currently using indirect resins with satisfactory results. On a scale of 1 - 5 (best), I would rate it as a 3. This book is limited to applications and techniques involving one material. There are other texts such as *Esthetic Dentistry* (Dale & Aschheim) and *Esthetic Composite Bonding* (Jordan) that more adequately cover this subject as well as other materials in a more comprehensive format.

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Volume 16, 1993

Robert P Renner, Editor

Published by Quintessence Publishing Co, Inc, Chicago, 1993. 188 pages, 522 illustrations (297 in color). $54.00, softbound.

Quintessence of Dental Technology is promoted as an annual softbound, journal-size collection of articles on current developments and research in clinical and dental laboratory technology. In keeping with other Quintessence publications, the *Quintessence of Dental Technology 1993* is well polished in its presentation and well illustrated with numerous high-quality color and black-and-white photos and diagrams. As with previous issues, this one is clearly laid out with articles divided into sections on dental implants, ceramics, fixed and removable prosthodontics,

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orthodontics, and dental laboratory technology.

The intent of the *Quintessence of Dental Technology* is to allow the reader to "quickly catch up on the latest advances in dental technology and to 'bridge the gap' between dentists and laboratory technicians." To fulfill these objectives the publication should include articles written by forerunners in the field addressing key issues in each subject area and expressing opposing views. To this end, *QDT 1993* falls short. For example, the section on implants includes an article entitled "Laboratory Planning and Techniques for Fixed Detachable Restorations," two articles addressing the fabrication of bar-clip overdentures, and the restorative procedures for the ITI Implant system. While these articles are interesting and worth reading because they offer good step-by-step instructions, they certainly do not reflect the most current developments or key issues in the realm of implants. This reviewer would like to have found articles addressing such topics as casting to titanium, abutment selection and armamentarium; controversies in how to sprue and cast frameworks for fixed detachable prostheses to obtain passive fit; the pros and cons of the various framework designs for the fixed detachable prostheses (U, L, or Harvard designs) and the pros and cons of the various implant-supported prostheses; and the overdenture versus the fixed detachable versus the ceramometal fixed partial denture. These aforementioned criticisms are generally true of all the sections.

In addition, many of the articles in this issue of *QDT* are uninteresting and appear to be merely filler articles satisfying sectional requirements. These include the articles in the "Dental Laboratory Technology" section and the technique article in the "Fixed Partial Denture" section on fabrication of indirect provisionals, which offer nothing new. *QDT 1993* would have been better off omitting these articles and expanding on the other sections.

Articles that are interesting and worth reading, despite not reflecting the latest developments, include the feature article by Coward and Watson mentioned earlier, "Laboratory Planning and Techniques for Osseointegrated Implant Treatments," the article on the internal live stain techniques in the ceramics section, and the articles in the removable prosthodontics section about VLC resin (Triad) and rotational path partial dentures. The article by Bengel, "Principles of Object Photography" is highly recommended. It offers more than the run-of-the-mill "beginners' how-to" article on dental photography and discusses picture composition, background colors, lighting (direction and sources) at a more sophisticated level, so that the more advanced dental photographer can produce photos equal in quality to those featured in Quintessence publications.

Relevant to *QDT 1993's* attempts to "bridge the gap" between dentists and technicians, this issue would enlighten the dentist about laboratory technology more than it would the technician about clinical procedures. Hence, *QDT 1993* would benefit most the restorative dentist whose practice includes an extensive amount of prosthodontics and who has a particular interest in laboratory procedures.

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TEMPOROMANDIBULAR DISORDERS
Guidelines for Classification, Assessment, and Management

Charles McNeill, DDS, Editor

Published by Quintessence Publishing Co, Inc, Chicago, 1993. 141 pages, 4 illustrations. $18.00, softbound.

This book is a revision of *Craniomandibular Disorders*, 1990. The members of the contributing committee from the Orofacial Pain Academy have academic credentials, advanced education and training, and/or extensive clinical experience with Temporomandibular Disorder (TMD). The book is very well written, with superb literature references at the end of each chapter. Its stated goal is to provide the reader with a current updated review of the classification, assessment, and management of patients with TMD.

The short "Introduction" sets the stage for the subsequent chapters by providing a definition and history of TMD. The "Epidemiology" chapter provides excellent data on all aspects of TMD. The carefully worded chapter on "Etiology" makes it clear that much is yet to be learned when dealing with etiologic factors. It is interesting to note the increasing importance of "psychosocial factors" in the etiology and increase in research data that indicates the secondary role of occlusion in TMD. The controversial nature of the "Etiology" chapter contains 124 cited literature references through 1991 to back the discussions. Brief outlines of differential diagnoses for orofacial pain are presented, including a well-defined diagnostic classification for TMD given under the eleventh classification of the International Headache Society. In the chapter dealing with "Assessment" an impressive, brief TMD screening questionnaire (10 questions) is recommended for routine dental patient histories. A frank and comprehensive discussion of known and unproven relationships

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between etiologic factors, such as behavorial and psychological, are presented. In the "Management" chapter, conservative treatment is endorsed for initial care for nearly all TMDs. Between 50% and 60% of patients have few or no symptoms after conservative treatment. The "Addendum" presents a stimulating discussion of the problems with third parties and how medical and dental treatment claims for TMD are often quite differently viewed by third-party payers. Professional, educational, and Academy responsibilities are discussed.

Dr McNeill and the Academy members contributing to this second edition of *Temporomandibular Disorders* are to be commended for a comprehensive update. They have achieved their goal in providing this book as a nucleus for discussions on the standard of care for TMD by all interested parties.

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THE CONICAL DOUBLE-CROWN TELESCOPIC REMOVABLE PERIODONTIC PROSTHESIS

Akihiko Shiba

Published by Ishiyaku EuroAmerica, Inc, St Louis, 1993. 56 pages, 119 illustrations. $20.00, softbound.

In the age of implant prosthodontics, it is becoming more difficult to find an indication for a "coping prosthesis." Even so, these techniques for treating the periodontally involved patient should not be abandoned, since for any one particular patient the use of implants may be contraindicated. This leaves the restoring dentist in a bind if the patient prefers to avoid complete denture prosthodontics. The best treatment plan for this type of patient may be a periodontal prosthesis utilizing copings.

There are numerous techniques for the implementation of a coping prosthesis. Dr Shiba refers to his technique as the conical double-crown telescopic removable periodontic prosthesis or CDCTRPP. It incorporates the use of inner crowns of differing tapers depending on the length and physiologic mobility of the abutment teeth and the outer crowns that retain the prosthesis to the abutment teeth through a fairly elaborate adjustment sequence. This monograph is a concise, well-illustrated text that brings the reader from the patient's intial visit through final insertion of the prosthesis in cookbook fashion. All clinical steps are shown, along with the corresponding technical steps, to instruct the dental technician as well as the restoring dentist.

Dr Shiba is very generous in sharing his rationale for dealing with techniques and materials. Some of this rationale is based on dogma, some on science, but most on clinical experience that is obviously quite extensive. Although this is one of several methods of fabricating a coping prosthesis, its similarities and differences to those techniques would enhance the knowledge of anyone performing this challenging prosthodontic service.

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PROBLEMS AND SOLUTIONS IN COMPLETE DENTURE PROSTHODONTICS

David J Lamb

Published by Quintessence Publishing Co Ltd, London, 1993. 168 pages, 89 illustrations. U.S. $48.00.

Unfortunately, there is no indication of the training, academic position, and experience of the author. Actually, David J Lamb is a well-respected dentist and a member of the Department of Restorative Dentistry, University of Sheffield. He has been a major contributor to the dental literature for a number of years.

The title of the book implies that solutions are provided to solve specific problems encountered by complete denture wearers. Unfortunately, the book is not organized in that fashion. Instead, it contains the following traditional-sounding chapter titles— "Patient Assessment," "Impression Stage," "Technical Support," "Registration," "Try-In," "Denture Processing," "Denture Delivery," and "Review." The 15- page "Review" chapter is the only portion that really addresses problems and their solutions in a problem-oriented fashion. The other chapters contain solutions to problems; however, it requires considerable searching by the reader to locate the information.

One-third of the book is devoted to patient assessment. This is probably appropriate, since many of the problems encountered with complete denture patients are related to an inadequate assessment before treatment begins.

The illustrations are all black and white and are average in quality.

The book contains some excellent information; however, only the serious student or experienced dentist will probably find it interesting and helpful. I would not recommend it for someone wanting a simple and easy reference guide to solving denture problems.

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ABSTRACTS

The editor wishes to thank the second-year General Dentistry Residents at Wilford Hall USAF Medical Center, Lackland AFB, Texas, for their assistance in the preparation of these abstracts.

Efficacy of vital home bleaching. *Simon JF, Allen H, Woodson RG & Fliers AS (1993) *California Dental Association Journal* 21 72-75.

(*University of the Pacific School of Dentistry, Department of Operative Dentistry, 2155 Webster Street, San Francisco, CA 94115)

This clinical study investigated the effects of a home bleaching agent on the color change of teeth through the use of a densitometer. Alginate impressions were taken of the maxillary teeth of 25 patients for splint construction. Carbamide peroxide gel was used 2 hours in the morning and evening. Standardized slide photographs were taken initially and 4 weeks later and evaluated using a color transmission densitometer. A color change from Vita A1 to A4 is a change of 0.28 on the linear scale of the densitometer. Two patients (8%) showed no change, and one exhibited very little change. Nine patients (36%) showed a change value of 0.20 or higher. The average for all patients was 0.158. The results from this clinical study verify other subjective reports that the treatment is not successful for everyone, and that it is quite effective for others.

Idiopathic cervical lesions: in vivo investigation by oral microendoscopy and scanning electron microscopy. A pilot study. *Bevenius J, L'Estrange P & Karlsson S (1993) *Journal of Oral Rehahilitation* 20 1-9.

(*Department of Cariology, Odontologiska Klinikerna, Box 4064, S-141 04 Huddinge, Sweden)

This study looked at saucer- and wedge-shaped cervical lesions in six subjects using a detailed history, scanning electron microscopy, microendoscopy, and optoelectronic tracings of mandibular movements. The subjects had their lesions replicated and examined by scanning electron microscopy. Multiple enamel microfractures were present, and enamel cracks were seen running from occlusal wear facets to the lesions. Microendoscopic recordings of the lesions were made in vivo and documented with a color video camera magnifying X25 to X80. Recordings of mandibular excursions used an optoelectronic system. The number of cervical lesions increased with irregular lateral excursions. No correlation was found between brushing habits or dentifrice abrasion and the initiation or location of the cervical lesions.

A 2-year clinical evaluation of two pit and fissure sealants placed with and without the use of a bonding agent. *Boksman A, McConnell RJ, Carson B &McCutcheon-Jones EF. (1993) *Quintessence International* 24(2) 131-133.

(*University of Western Ontario, Faculty of Dentistry, Division of Fixed Prosthodontics, London, Ontario, N6A SC 1 Canada)

The purpose of this 2 year in vivo study was to evaluate whether the clinical effectiveness of pit and fissure sealant was increased (as demonstrated by an increased retention rate) when a bonding agent was used prior to the insertion of the sealant. Subjects had Concise light-cured white sealant or Prisma Shield light-cured sealant placed on teeth on their right side, while teeth on their left side received a bonding agent prior to placement of the same two sealants. Scotchbond 2 was placed prior to the Concise sealants, while Universal Bond was used with the Prisma Shield. Sealants were evaluated at 6 months, 1 year, and 2 years. The retention rates were: 84% for Concise alone, 77% for Concise with Scotchbond 2, 77% for Prisma Shield alone, and 77% for Prisma Shield with Universal Bond. There were no statistically significant differences in the retention rates for sealants placed with or without a bonding agent.

Effect of mixing speed on mechanical properties of encapsulated glass-ionomer cement. Gee D & *Pearson G J (1993) *British Dental Journal* 174 65-68.

(*Institute of Dental Surgery, Department of Biomaterials Science, 256 Gray's Inn Road, London WC1X 8LD)

This in vitro study examined the effects of four mixing speeds (2730, 4000, 4375, and 4650 cpm) on the mechanical properties of three encapsulated glass-ionomer cements (Opusfil, Chemfil, and Ketac-fil). Working time, setting time, and compressive strength at 24 hours and 7 days were measured. There was no significant variation in working or setting times at the different mixing speeds. The 24-hour compressive strength of Ketac-fil increased as the mixing speed increased, while those of the other two materials were unaffected. The 7 day compressive strength of all three materials was not affected by variations in mixing time. This study indicates that wide variations in mixing speeds did not significantly affect working or setting time of the three

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materials tested. In addition, despite variations in early compressive strength of one material, speed of mix did not produce significant long-term effects on the compressive strength of encapsulated glass-ionomer cement.

Influence of dentinal fluid and stress on marginal adaptation of resin composites. *Krejci I, Kuster M & Lutz F (1993) *Journal of Dental Research* 71(2) 490-494.

(*Zurich University, Dental Institute, Department of Preventive Dentistry, Periodontology, and Cariology, Plattenstrasse 11, CH-8028 Zurich, Switzerland)

This in vitro study investigated the marginal adaptation of class 5 composite restorations with enamel and dentin margins using three different dentin bonding agents (GLUMA 2000 experimental agent, Prisma Universal Bond 3, and Syntac). Respective manufacturers' hybrid composite resins (Pekafill, APH, and Tetric) were used. The percentage of "continuous margin" was calculated with an SEM following restoration placement (with and without simulated dentin fluid flow), saline hydrolysis, and stress testing (chemocycling, thermocycling, and occlusal loading). Enamel margins showed over 92% continuous margin even after stress tests, regardless of the dentin bond agent used. The dentin margins were between 93% and 98% continuous for all agents prior to stress testing. Stress testing resulted in a significant decrease for all three adhesives. The GLUMA 2000 experimental agent was the most affected by simulated dentin fluid flow with stress testing, showing only 50.2% continuous margins. Prisma Universal Bond 3 and Syntac performed significantly better than the GLUMA experimental agent after the stress tests, with a value of 79%. No significant differences were seen as a result of the type of stress testing. This study supports other research indicating that dentin fluid flow and environmental stress factors influence dentin margin adaptation for dentin bond agents and composite resins.

Prediction of root caries in periodontally treated patients maintained with different fluoride programs. *Ravald N & Birkhed D (1992) *Caries Research* 26 450-458.

(*Public Dental Service, Department of Periodontology, S-58 185 Linköping, Sweden)

Prevention of primary root caries lesions is critical, because they are often very difficult to restore and maintain. Such lesions have been associated with root surfaces exposed after some periodontal surgical procedures. The authors described a 2 year clinical study of 99 patients with root surfaces newly exposed by periodontal surgery. Participants were given one of three fluoride regimens during the study: 1) professional application every 3 to 4 months of a fluoride-containing varnish (Duraphat, Karger AG, Basel, Switzerland); 2) professional application every 3 to 4 months of an 0.4% SnF_2 gel; 3) daily home rinsing with 0.05% NaF_2 mouthwash. The authors found no statistically significant difference between these three regimens. Despite this preventive regimen, nearly half the patients developed new decayed/filled surfaces as the study progressed over two years. Significant risk factors included previous caries/restorations, plaque indices, and smoking. This study highlights the need for an aggressive prevention program for patients with recently exposed root surfaces, especially those with significant risk factors.

Quantitative contribution of resin infiltration/hybridization in dentin bonding. Gwinnett AJ (1993) *American Journal of Dentistry* 6 7-9.

(SUNY at Stony Brook, Department of Oral Biology & Pathology, Stony Brook, NY 11794-8702)

Recently the "total etch" technique has been suggested as a way to improve resin bonding to dentin. This in vitro study examined whether monomer infiltration into dentin actually increases the shear strength of the dentin-resin bond. The author prepared four groups of 10 sectioned molars as follows: Group 1, smear layer intact with dentin tubules occluded by debris; Group 2, smear layer removed with tubules occluded by debris; Group 3, smear layer removed and tubular debris removed by etching for 10 seconds with 10% H_3PO_4; Group 4, dentin exposed by transverse fracturing (no smear layer but no conditioning). The author then treated all surfaces with All-Bond 2 dentin bonding agent, added P-50 composite resin in layers, stored the teeth in water for 24 hours, and subjected the teeth to shear fracture with an Instron. Values in MPa (mean and standard deviation) were: Group 1, 10.24 (2.98); Group 2, 20.37 (4.62); Group 3, 32.68 (7.12); Group 4, 26.77 (4.85). All groups were significantly different. The study concluded that resin infiltration provided significant benefits and contributed about one-third of the shear bond strength for this total etch system.

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