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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, book reviews, and letters also are published.

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EDITORIAL

Whoever Has the Gold, Rules

In the not too distant past, fee-for-service dental treatment was the standard. When patients received a service, they paid for it in cash or worked out an arrangement with the dentist. Today, we have a definite change in this paradigm occurring within our profession, which may or may not be in the best interest of the dental patient. Third-party payers are taking over paying for treatment received by eligible patients. This phenomenon is taking the personal touch (the doctor/patient relationship) out of the practice of dentistry. Why is this happening? Certainly, patients with dental insurance are concerned about receiving treatment covered by their insurance. The problem is that these patients also feel that this treatment and that recommended by their dentist should be synonymous. That conclusion is very often wrong! The reader needs to keep in mind that dental insurance companies are not formed to lose money, no matter whether they are for-profit or not-for-profit organizations. Therefore, someone must pay for this intermediate level of administration that decreases the funds available for employee dental care. The often wide variation between the dental treatment paid for by the insurance company and that which the dentist feels is necessary becomes acutely evident to dental students shortly after they start treatment of clinical patients. Taught to do a careful, thorough diagnosis and treatment plan, students soon discover that their treatment plan, and what will be paid for by the third-party payer, often differ. It is a rude but necessary awakening for the student to learn that whoever pays the bills rules the treatment decision.

An example will better illustrate this paradigm shift. A patient presents with a dental problem. The dentist diagnoses the problem, then recommends treatment. The patient wants to know if the treatment is covered by insurance. If the procedure is not covered by insurance, the patient wants to know what alternative is available that is covered. Quite often there is such a secondary treatment available. Very seldom, if ever, is this treatment of greater cost than the primary recommendation. Patients may be willing to pay for the primary treatment; however, more often than not they choose the treatment covered by their insurance regardless of their own ability to pay for the recommended treatment. One must ask, Who is in charge? It sure looks to me like the third-party insurance company is calling the shots! The old saying, "He who has the gold, rules" still appears to be true today.

What does the future hold for payment of dental treatment? As cost containment continues in its importance, insurance companies are seriously looking at signing up dentists for capitation plans that pay dentists so much per month for each of their eligible patients. With this plan the treatment is totally up to the dentist. Unfortunately, the capitation payment is all the dentist will receive from the insurance company for dentistry provided. This puts the dentist between a rock and a hard place, even though there is no longer a need for negotiation with the third party. One fact is for sure, this type of plan causes a definite disincentive to provide complete quality care for the capitation patient. On the other hand, capitation helps the insurance company control costs much easier and get out of the expensive adjudication business.

Another change taking place involves establishment of treatment planning centers by insurance companies where their own dentists do the diagnosing and treatment planning. The patients then go to their own dentists for completion of the predetermined treatment. Thus, a third party is once again thrust between dentist and patient. The Washington State Dental Association recently initiated a campaign to return treatment planning and payment to those most affected, the patient and dentist. The goal is for employers to reimburse their employees directly for treatment paid for by the patient to the dentist. However, for this to be effective, the patient must be able to pay for the service up front, and the insurance coverage must be simplified to be understandable by the patient. It is too soon to tell how well this type of plan will be accepted by patient and employer. However, more and more companies are allowing a set, yearly dollar limit for each employee's dental treatment, beyond which any additional costs are the responsibility of the patient. Adopting this type of fee-for-service program, although not without problems, is a start toward returning dentistry to the control of those most affected—the patient and dentist.

RICHARD B McCOY
Editor

OPERATIVE DENTISTRY, 1996, 21, 46-48

CLINICAL ARTICLES

Restoration of Supporting Teeth for Existing Removable Partial Dentures

D M RYKEN • M W TYLER

SUMMARY

A technique for restoration of abutment teeth under existing removable partial dentures is presented. This technique uses rubber dam isolation for moisture control and involves condensing the amalgam with the partial denture seated to assure correct adaptation to the existing framework.

INTRODUCTION

One restorative dilemma that operative dentists face is the broken-down tooth that serves as an abutment for a serviceable partial denture. Although there are several prosthetic approaches to rehabilitate a defective abutment tooth (Elledge & Schorr, 1990; Teppo & Smith, 1978; Warnick, 1970), there are occasions when routine operative treatment may be selected as the treatment of choice. Wright (1990) recognized the possibilities for using amalgam, noting that compared with crowns, amalgam restorations require only one appointment, are economical, and conserve tooth structure.

The goal is to place a restoration that properly fits the internal surface of the existing partial denture and assures proper support of the denture. The challenges for conventional restoration become more complex for clinicians opting to use rubber dam for moisture control. Indeed, the effectiveness of rubber dam is well documented for isolation of the working field (Baum, Phillips & Lund, 1981; Helpin & Michal, 1980), in decreasing the spread of bloodborne pathogens (Liebenberg, 1992; Forrest & Perez, 1986), and for reducing the risks of inhalation and ingestion of materials by patients (Barkmeier, Cooley & Adams, 1978).

The technique for restoration of abutment teeth that will be presented uses rubber dam to provide optimum operating conditions and involves condensing the amalgam with the partial denture seated, enabling formation of accurate contours and rest seats.

CLINICAL TECHNIQUE

1. Determine serviceability of the removable partial denture. Warnick (1970) describes the appraisal to include age and condition of the prosthesis, design of the prosthesis, esthetic demands, and

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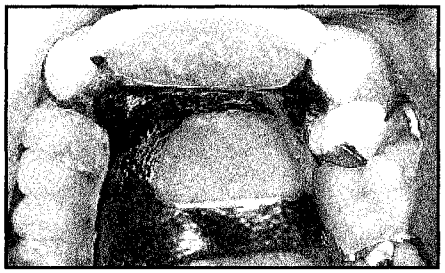

Figure 1. *Serviceable removable partial denture with abutment premolar needing restoration*

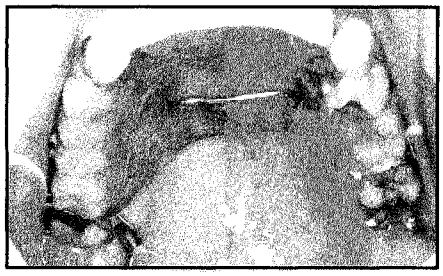

Figure 2. *Removable partial denture seated with rubber dam retainers in place*

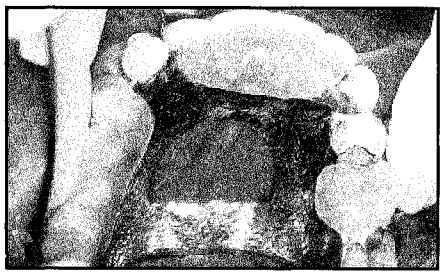

Figure 3. *Trying-in the removable partial denture over the rubber dam assembly*

history of patient satisfaction with the prosthesis. The fit and path of insertion of the partial should also be determined during this evaluation (Figure 1).

2. Select rubber dam retainers that will allow full arch isolation and complete seating of the removable partial denture (RPD). This is determined prior to placement of the rubber dam. Try in the RPD with the retainers in place (Figure 2). If it does not fit with just the retainers in place, then the retainers must be repositioned, rotated slightly, or another retainer selected until proper seating of the RPD is attained. Once the correct position is verified, remove

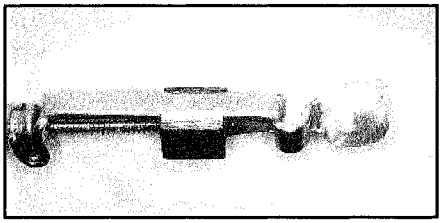

Figure 4. *Customized matrix*

the RPD from the mouth, leaving the retainers correctly positioned.

3. Place the rubber dam over the prepositioned retainers. Once again verify that the RPD fits over the rubber dam assembly in the same manner it fit prior to rubber dam placement (Figure 3). Since the RPD will be serving as a template for the replacement restoration, it is of vital importance that it seats correctly. Occasionally a rubber dam retainer cannot be placed so that the partial denture can be correctly positioned over it. In such cases, place the rubber dam retainers and rubber dam on the teeth. Then place a liberal amount of cavity varnish on the tooth with the problematic retainer as well as on the surrounding dam. The retainer can then be removed and the sticky surfaces caused by the cavity varnish will retain the rubber dam. If the RPD fits correctly over the retainers alone, yet fails to seat after rubber dam placement, the cause is due to the dam being bunched or too taut. Simply punch a new dam with a changed arch width. To prevent this dilemma and save the chairside time, the rubber dam can be prepunched as determined by a study cast of the patient's mouth. In some cases the RPD will require close adaptation to the gingival tissues to seat properly. An example is a distal extension RPD with an acrylic flange. A small slot (not a hole, which tends to cause leakage) can be cut in the rubber dam to accommodate this. The RPD acrylic extension can be slipped through this aperature when needed during placement of the restoration.

Figure 5. *Seating pressure during amalgam placement*

4. Prepare the tooth preparation in the conventional manner.

5. Try in the removable partial denture to evaluate the extent of matrixing that can be accomplished by the partial itself. A conventional matrix can be customized with crown-and-bridge scissors to complete the matrixing as necessary (Figures 4 and 5). Other types of matrices may be used (e g, partial custom matrix, T-band, or Automatrix) depending upon the position of the cavity preparation and

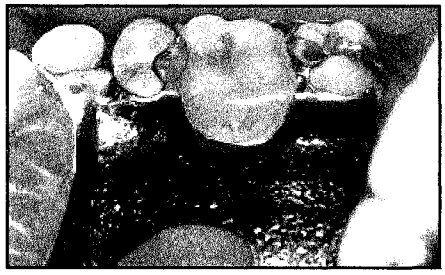

Figure 6. *Carved amalgam under removable partial denture, occlusal view*

Figure 7. *Carved amalgam under removable partial denture, facial view*

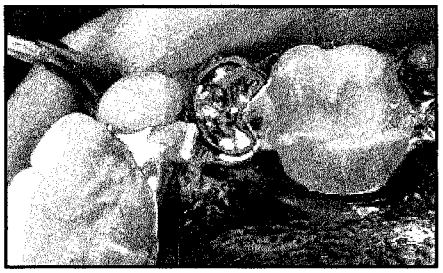

Figure 8. *Polished amalgam under removable partial denture, occlusal view*

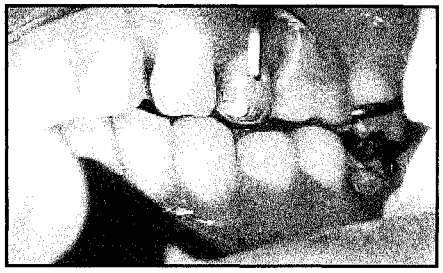

Figure 9. *Polished amalgam under removable partial denture, facial view*

access difficulty. Select amalgam condensers and evaluate for accessibility.

6. Condense the amalgam, seating the removable partial denture during placement. This seating pressure must be maintained until the amalgam is set (Figure 5).

7. Carve and finish conventionally (Figures 6 & 7).

8. At a subsequent appointment, the restoration should receive a final polish (Figures 8 & 9).

Disclaimer

The opinions expressed herein are those of the authors and do not necessarily reflect the opinions of the Department of Defense, the U S Navy, or of other federal agencies.

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Restoring Class 6 Abrasion/Erosion Lesions with Direct Gold

H A ST GERMAIN, Jr • J E RUSZ, Jr

INTRODUCTION

The class 6 cavity, an addition to Dr G V Black's original classification system, refers to the preparation design of incisal edges of anterior teeth or the cusp tip areas of posterior teeth, and receives limited discussion in modern operative dentistry textbooks. During the formative stages of enamel maturation, an incomplete union at the cusp tips or incisal edges may result in exposed dentin and a caries-susceptible area. More frequently, these sites may present with aging as a slowly developing localized abrasion/erosion wear process. As this process continues and exposes dentin, a typical "worn-off" or "cupped-out" area develops.

The treatment-planning decision of whether or not to restore these defects often requires a careful clinical judgment. Since caries is infrequently encountered in areas where enamel is lost due to wear, the judicious use of enameloplasty to recontour and smooth any enamel roughness followed by a topical fluoride application to exposed dentin may be considered a preventive definitive treatment. However, when wear in combination with a "cupped-out" erosion in dentin has occurred, a restoration can be justified to minimize further loss of dentin and adjacent enamel.

Composite resin, amalgam alloy, and direct gold are all possible restorative material options when a restoration is indicated for the class 6 cavity. When esthetics is not a primary concern, direct gold is a nearly ideal restorative option due to the excellent wear compatibility of enamel opposing gold. Physical types of direct gold for use in this situation may include gold foil, powdered gold, or combinations of mat/powdered gold and gold foil. The hardness of well-condensed direct golds have Knoop values ranging from 55 to 75. The acquired finished restoration hardness does not necessarily have a direct relationship to the effectiveness of a particular physical type of direct gold and may be more indicative of the quality of the clinical condensation procedures. A well-condensed and burnished direct gold restoration will have the highest hardness values. A direct gold combination using platinized gold foil over a powdered or mat gold is suggested as a desirable choice for the class 6 cavity. The surface veneer of platinized gold foil may facilitate achieving the highest hardness possible with direct gold materials. During clinical function the platinized gold will be further work hardened and will ideally provide an excellent protective restoration for the class 6 cavity.

When designing this type of restoration no attempt is made to build back lost contour or cuspid guidance. The direct gold class 6 restoration can be expected to help maintain or stabilize existing occlusal schemes. This clinical article will present

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the restorative dentist with an outline of the procedural steps for the use of direct gold when restoring a class 6 abrasion/erosion defect on a mandibular cuspid.

CLINICAL PROCEDURE

Prior to placement of the rubber dam for isolation, it is helpful to mark the maximum intercuspation and excursive occlusal contacts with Accufilm articulating paper (Parkell, Farmingdale, NY 11735) (Figure 1). Coating the teeth with a copal varnish prior to marking the teeth will help preserve the occlusal markings after placement of the rubber dam and

Figure 1. *Abrasion/erosion lesion on incisal edge of mandibular cuspid; maximum intercuspation and excursive occlusal contacts marked*

through numerous rinses during the procedures. The occlusal markings are of importance when determining the outline limitations of the cavity preparation. Whenever possible, margins should not terminate directly on areas of occlusal function. However, when this is not possible, extension of the preparation outline form to include the entire occlusal contact should be seriously considered.

Labial and lingual walls are established with a #170 tapered fissure bur or a #56 straight fissure bur. These walls should basically be parallel and may have a slight occlusal divergence with increasing width of the preparation. The preparation should only include dentin removal and not removal of adjacent enamel. The depth of the preparation should allow an approximate 1.5 mm thickness of direct gold. The pulpal floor line angles are prepared with a #33 1/2 inverted cone bur. Slight undercuts can be placed at the mesial and distal areas, which is usually where the greatest bulk of remaining dentin is found. If desired, these internal features may be refined with hand instrumentation such as a (6 1/2 -2 1/2 -9) monangle chisel (Thompson Dental Mfg, Co,

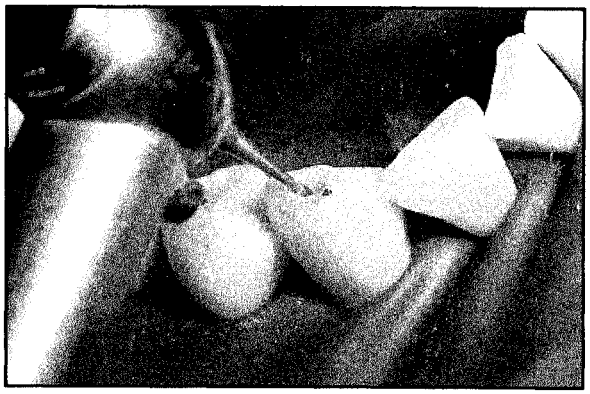

Figure 2. *Preparation walls have been prepared with a #170 tapered fissure bur. Pulpal floor line angles and mesial/ distal retentive areas are prepared with a #33 1/2 inverted cone bur. Internal features may be refined with a monangle chisel such as the (6 1/2 - 2 1/2 - 9).*

Missoula, MT 59806). Care must be taken not to undermine remaining tooth structure (Figure 2). The entire cavosurface angle is then beveled with a Wedelstaedt chisel. A cavosurface bevel is appropriate in this area in order to produce a structurally supported enamel margin consistent with the orientation of occlusally divergent enamel rod patterns. This bevel should be less than 0.5 mm to avoid producing a thin edge of gold, which may fracture during function.

Powdered gold such as E-Z Gold (1/10 oz, Product code #1100471, Ivoclar-Williams North America, Inc, Amherst, NY 14228) may be used for building up the bulk of the restoration to slightly less than the desired contour. The use of E-Z Gold as a build-up material significantly shortens the chairside time required to complete the restoration. When starting the build-up, using larger-sized E-Z Gold pellets will facilitate engaging opposing retentive areas in the cavity preparation and will quickly establish a stable base of material. Powdered gold can be used to build up approximately 75%-80% of the restoration. Platinized gold foil (1/10 oz No 4, Product code #1101401, Ivoclar-Williams North America) is then placed over the bulk powdered gold and will ultimately serve as the exposed surface of the restoration. The platinized gold is manufactured by placing a sheet of machined platinum foil between two sheets of #4 (4"x 4") regular cohesive gold foil that are bonded together by welding, rolling, and manually beating ("cladding"). An alloy with a platinum content of approximately 15-30% is produced. The platinized gold foil is then manually prepared into 1/64-sized (1/2" x 1/2") and 1/128-sized (1/2" x 1/4") cohesive pellets. In larger preparations, 1/64-sized pellets will be used to build the restoration to within 95% of the desired contour. The final veneer and the desired surface contour of the gold will then

be developed with 1/128-sized pellets, with attention devoted during the condensation procedures to banking the gold over the cavosurface margins in order to avoid chipping fragile enamel edges (Figure 3).

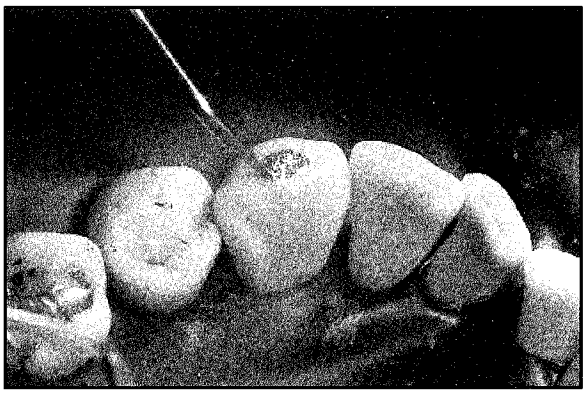

Figure 3. *After the build-up is completed using E-Z Gold, a veneer of platinized gold is placed, banking the material to the beveled cavosurface margin*

The restoration is subsequently burnished with firm hand pressure, which is integral to the process of work hardening the direct gold restoration and eliminating all surface porosities (Figure 4). After burnishing completely, the restoration can be smoothed and appropriately contoured with a garnet-grit disk (E C Moore Co, Inc, Dearborn, MI 48126)

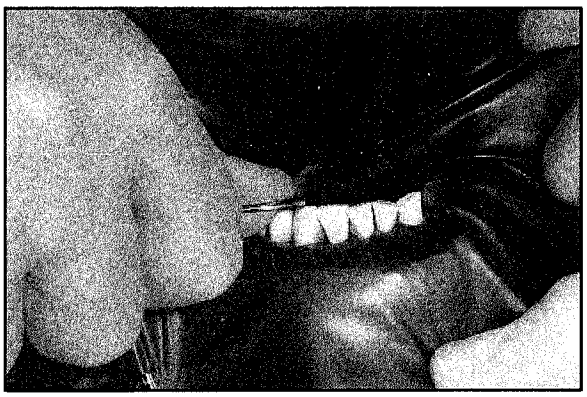

Figure 4. *Burnishing the restoration with firm hand pressure to work harden the gold*

followed by a fine cuttle disk. A large volume of air should be directed at the restoration during disking procedures to avoid overheating the tooth. Some additional burnishing will be beneficial after disking. Flour of pumice (Moyco Industries, Inc, Philadelphia, PA 19132) and tin oxide powder (Sultan Chemists, Inc, Englewood, NJ 07631) may be used to produce a high surface gloss (Figure 5). This polishing step is not as important, however, as

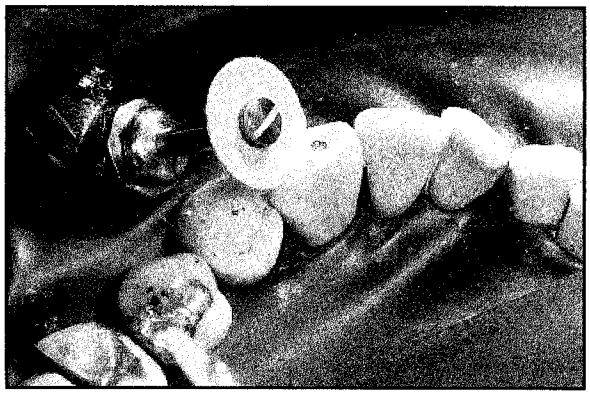

Figure 5. *The restoration is finished with garnet-grit disks followed by fine cuttle disks. Final polishing may be done with fine flour of pumice followed by tin oxide.*

burnishing is to achieve the hardest surface possible on the platinized gold foil.

The completed restoration (Figure 6) should duplicate existing tooth contours and should preserve the patient's pre-existing occlusal scheme (Figure 7). If the restoration includes occlusal contact, care should be taken to harmonize this contact area with adjacent teeth.

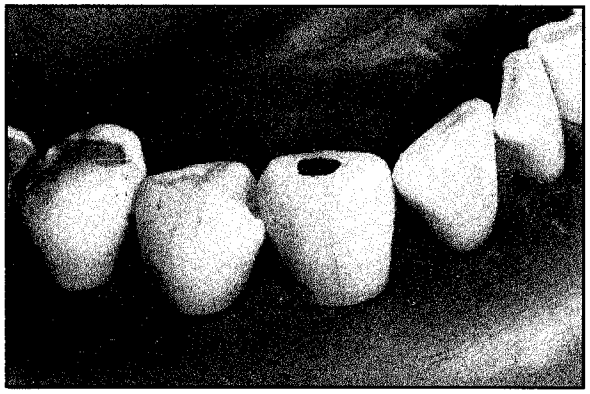

Figure 6. *Completed class 6 direct gold restoration*

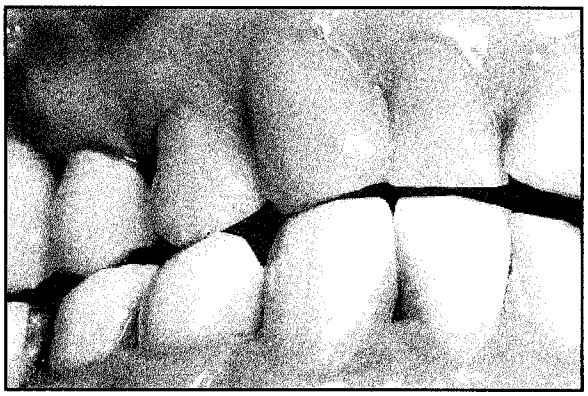

Figure 7. *Lateral excursive movements indicate preservation of pre-existing group function occlusal scheme.*

CONCLUSIONS

A clinical technique for the restoration of the class 6 cavity using direct gold has been described. While these areas are usually the result of multifactorial wear processes, active caries is not usually present. However, a restorative procedure may be selected to minimize further loss of dentin that may compromise the support of adjacent enamel. When a decision has been made to restore this lesion with direct gold, the use of platinized gold foil as a surface veneer should be considered because of its enhanced hardness. The outline form of the cavity preparation design should only involve exposed dentin and not undermine remaining tooth structure. Adequate burnishing, which work hardens the gold, is critical to the success of this procedure. Existing occlusal function in excursions should be preserved and original tooth contours replicated in the final restoration.

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ORIGINAL ARTICLES

Surface Roughness of Composites and Hybrid Ionomers

W H TATE • J M POWERS

Clinical Relevance
Aluminum-oxide disks produced smoother finished surfaces for hybrid ionomers and composites than did a 12-fluted finishing bur.

SUMMARY

This study examined the average surface roughness (Ra, μm) of two composites and three different hybrid ionomers before and after treatment with a 12-fluted finishing bur, two finishing and polishing systems, and a hybrid-ionomer glaze for the hybrid ionomers. The 12-fluted finishing bur produced a roughened surface with all materials compared to the initial surface formed and cured against glass. Both the Enhance Finishing and Polishing System and the Sof-Lex contouring and polishing disks produced smoother surfaces for the composites, Revolution and Charisma, compared to the hybrid ionomers, Fuji II LC, Variglass, and Vitremer. However, the Fuji II LC glaze and the Vitremer glaze created smoother surfaces compared to Revolution finished with the Enhance system. Overall, the Sof-Lex disk system produced the smoothest surfaces for all materials.

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INTRODUCTION

Many of the undesirable characteristics encountered with early glass-ionomer cements have been reduced or eliminated with the development of light-activated hybrid ionomers (Crim, 1993a; Mount, 1993; Wilson, 1990). They also have improved adhesion to underlying tooth structure (Hinoura, Miyazaki & Onose, 1991; Lin, McIntyre & Davidson, 1992; Mason & Ferrari, 1994; Friedl, Powers & Hiller, 1995) and reduced microleakage (Crim 1993a,b). Hybrid ionomers have also retained the advantage of fluoride release (Creanor & others, 1994). As a result, this material is being used more extensively for final restorations (Croll, 1993; Knight, 1994).

The effect of finishing and polishing on surface roughness of traditional glass-ionomer cements (Pearson, 1991; Hannig & Rahlf, 1991; Matis & others, 1988), hybrid ionomers, and composites (Tate, DeSchepper & Cody, 1992; Jefferies, Barkmeier & Gwinnett, 1992; Berastegui & others, 1992) is an important consideration in the restorative process. This is especially true of cervical restorations, where poorly finished restorations can lead to periodontal problems or plaque retention and subsequent recurrent decay.

In an earlier study, we examined finishing and polishing of hybrid composite (Tate & others, 1992). This study examined the average surface roughness (Ra, μm) of two hybrid composites and three hybrid ionomers before and after treatment with

a 12-fluted finishing bur, two finishing and polishing systems, and unfilled resin glazes for two of the hybrid ionomers.

METHODS AND MATERIALS

Products, manufacturers, and lot numbers of the restorative and finishing materials tested are listed in Table 1. Two composites and three hybrid ionomers were cured in plexiglass wells (6 mm in diameter and 3 mm in depth) against glass according to manufacturers' directions using a curing light (L D Caulk/Dentsply). The intensity of the curing light was monitored with a light meter (L D Caulk/ Dentsply). Three disks per product were fabricated. The glass formed surface on each sample was used as the baseline for all tests (Treatment A). The treatments are summarized in Table 2.

Finishing and Polishing Procedure I

Samples were surfaced with a 12-fluted carbide finishing bur (H48L) to simulate intraoral finishing of the material (Treatment B). Surfaces were then treated with a light-cured resin finishing cup impregnated with an abrasive (Enhance) for 20 seconds (Treatment C), followed by 10 seconds of fine (1 μm) and 10 seconds of extra-fine (0.3 μm) polishing paste using a foam polishing cup (Prisma Gloss, Treatment D). Treatment D samples were rinsed with water for 10 seconds and air dried for 5 seconds between and after application of polishing paste. Finally, the manufacturer's recommended glaze (Table 1) was applied to pertinent hybrid-ionomer samples and cured according to manufacturer's directions (Treatment E).

Finishing and Polishing Procedure II

Samples from Procedure I were resurfaced with the 12-fluted finishing bur (Treatment F) and finished with fine aluminum-oxide-impregnated disks (Sof-Lex, Treatment G) for 20 seconds, followed by extra-fine aluminum-oxide disks (Sof-Lex, Treatment H) for 20 seconds.

The average surface roughness (Ra, μm) was measured on each disk after initial fabrication and after each treatment by a surface profilometer (Talysurf 10, Taylor-Hobson, Leicester, England) using a tracing length of 2 mm and a cutoff value of 0.25 mm to maximize filtration of surface waviness (Bessing & Wiktorsson, 1983). The profilometer is accurate to 0.005 μm. Representative samples from each treatment of Fuji II LC and Revolution were examined by scanning electron microscopy (SEM) (JSM-820, JEOL, USA, Inc, Peabody, MA 01960).

Five tracings at different locations on each of three disks were made. The mean and standard deviation of Ra were determined. Data were analyzed by analysis of variance (Super ANOVA, Abacus Concepts, Inc, Berkeley, CA 94704). Tukey-Kramer intervals (SuperANOVA) at a 0.05 significance level for comparisons among surface treatments and products were determined.

RESULTS

Mean values and standard deviations of surface roughness (Ra, μm) are listed in Table 3 and graphically depicted in Figures 1 and 2. Tukey-Kramer intervals for comparisons among surface treatments and products were 0.13 and 0.06 μm.

The smoothest surfaces (Treatment A) occurred

Table 1. Products, Manufacturers, and Lot Numbers of Restorative and Finishing Materials Tested

Composite (shade)		**Lot #**	**Manufacturer**
Revolution (A2.5)		001	E&D Dental Products, Inc, Somerset, NJ 08873
Charisma (A20)		056	Heraeus Kulzer, Inc, Irvine, CA 92718
Hybrid Ionomers (shade)			
Fuji II LC capsules (A2)		190731	GC America, Inc, Chicago, IL 60658
Variglass (A2)		940421	L D Caulk/Dentsply, Milford, DE 19963
Vitremer (A3)	liquid	19940119	3M Dental Products, St Paul, MN 55144
	powder	19940124	
Finishing Bur			
H48L		30330	Brasseler USA, Savannah, GA 31419
Finishing and Polishing Systems			
Enhance Finishing/Polishing System			
finishers (cups)		940209	L D Caulk/Dentsply
polishing cups (foam)		5240022	
Prisma Gloss (fine)		940119	
Prisma Gloss (extra-fine)		921207	
Sof-Lex contouring/polishing disks		P931222	3M Dental Products
Glaze			
Fuji Coat LC		220931	GC America, Inc
Vitremer Finishing Gloss		3Y	3M Dental Products

Table 2. Summary of Finishing and Polishing Procedures

Treatment	Description	Surface Finishing Time
A	glass formed surface	——
	Finishing and Polishing Procedure I	
B	finishing bur (12-fluted)	——
C	resin finishing cup	20 seconds
D	polishing pastes—fine	10 seconds
	polishing pastes—extra-fine	10 seconds
E	unfilled resin glaze	——
	Finishing and Polishing Procedure II	
F	finishing bur (12-fluted)	——
G	aluminum-oxide disk—fine	20 seconds
H	aluminum-oxide disk—extra-fine	20 seconds

with one hybrid ionomer (Variglass) and one composite (Revolution) when cured against glass.

Finishing and Polishing Procedure I

Treatment B produced a rough, irregular surface with all products except Charisma, which was almost twofold smoother than the next smoothest product, Revolution. Treatment C had little effect on Vitremer or Revolution. Treatment C roughened the Fuji II LC and Charisma surfaces, but lowered the Ra of Variglass. Treatment D smoothed the composite surfaces, but only minimally smoothed the hybrid ionomers. Treatment E lowered the Ra for Fuji II LC and Vitremer almost threefold, producing a surface smoother than Treatment A for Vitremer.

Finishing and Polishing Procedure II

Treatment F produced roughened surfaces on all samples, with the Charisma again having the lowest Ra. Treatment G improved the Ra twofold or better for all surfaces, while Treatment H lowered the Ra even further, especially with the composites.

When examined by SEM, the Fuji II LC surface had a rough, pitted surface following Treatments A-D (Figure 3). Revolution, after the same treatment sequence, was visibly smoother (Figure 4). Surfaces produced by Treatments F-H (Figures 5 and 6) looked smoother than surfaces produced by Treatments A-D for the Fuji II LC (Figure 3). The photomicrographs for Revolution following Treatments A-D (Figure 4) and Treatments F-H (Figure 6) did not appear to be visually different.

DISCUSSION

Overall, Finishing and Polishing Procedure I (Treatments A-E) was not as effective as Finishing and Polishing Procedure II (Treatments F-H) for finishing the hybrid ionomers or the composites. Surfacing with a 12-fluted bur produced a roughened surface with both the hybrid ionomers and the composites. This surface requires further finishing to promote restoration longevity and periodontal health where applicable.

The hybrid ionomers tested were large particle materials, 5 µm average for Fuji II LC and Vitremer, and 10-12 µm average for Variglass (maufacturers' data on file at GC America, Inc; L D Caulk/ Dentsply; and 3M Dental Products). Voids within the Fuji II LC hybrid ionomer (Figure 3) may have resulted from the Enhance cups (Treatment C) catching and dislodging the larger glass particles. This would inhibit surface finishing and polishing and account for observed Ra values, which were even greater than those recorded after surfacing with the 12-fluted bur (Treatment B). For Variglass, the Enhance cups produced a statistically smoother surface than treatment with the 12-fluted bur, although not substantially smoother, also suggesting particle dislodgment.

The Enhance cups were more effective on the composites. Sof-Lex disks (Treatments G-H) produced smoother surfaces for all products tested than the Enhance cups and polishing pastes (Treatments C and D). The aluminum-oxide disks appear to finish the materials without dislodging the glass particles. The cups seemed

Table 3. Effect of Surface Treatments on Surface Roughness (Ra, µm) of Hybrid Ionomers and Composites

Treatment	Fuji II LC	Variglass	Vitremer	Charisma	Revolution
A	0.20 (0.08)	0.016 (0.004)	0.42 (0.32)	0.05 (0.04)	0.02 (0.00)
B	0.57 (0.09)	0.68 (0.13)	0.63 (0.21)	0.28 (0.05)	0.54 (0.10)
C	0.70 (0.19)	0.54 (0.16)	0.61 (0.16)	0.36 (0.08)	0.54 (0.11)
D	0.68 (0.19)	0.53 (0.17)	0.56 (0.12)	0.20 (0.11)	0.36 (0.07)
E	0.24 (0.50)	——	0.23 (0.14)	——	——
F	0.62 (0.12)	0.54 (0.14)	0.42 (0.10)	0.30 (0.09)	0.45 (0.08)
G	0.30 (0.11)	0.23 (0.11)	0.16 (0.40)	0.15 (0.07)	0.18 (0.05)
H	0.26 (0.11)	0.22 (0.09)	0.14 (0.08)	0.08 (0.05)	0.11 (0.05)

Surface roughness and standard deviations are listed in µm. Data were analyzed by ANOVA. Tukey-Kramer intervals at a 0.05 significance level for comparisons among surface treatments and products were 0.13 and 0.06. Treatments: A = baseline; B = 12-fluted bur; C = finishing cup; D = finishing paste; E = glaze; F = 12-fluted bur resurface; G = fine disks; H = extra-fine disks.

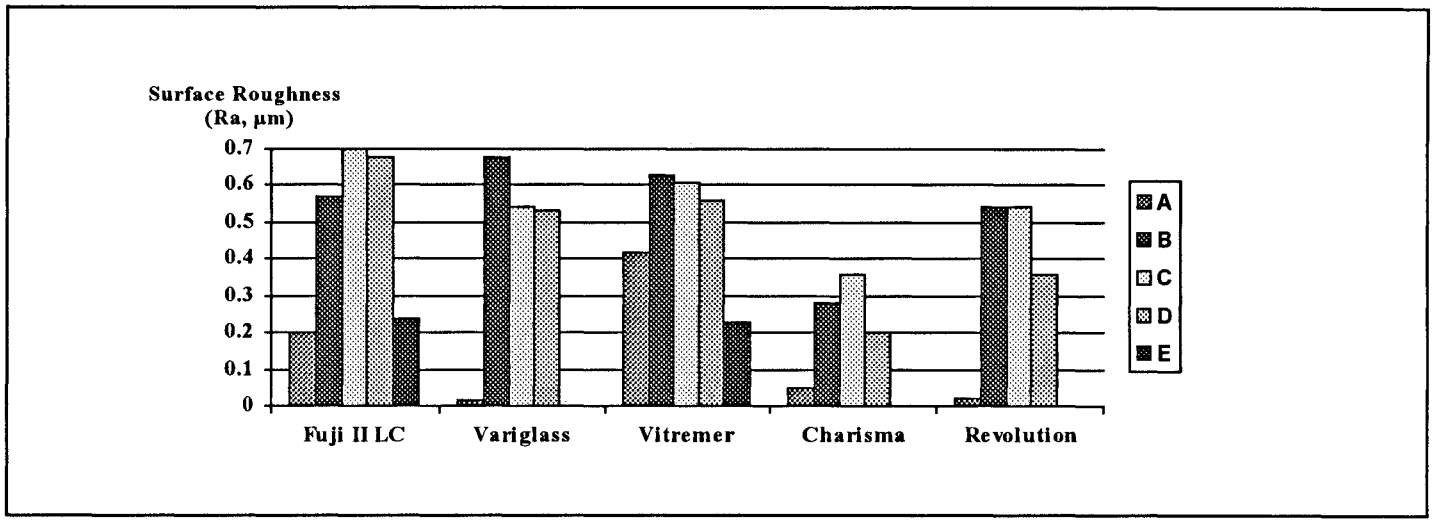

Figure 1. *Effect of surface treatments on surface roughness (Ra, µm) of hybrid ionomers and composites (Finishing and Polishing Procedure I); A = baseline; B = 12-fluted bur; C = finishing cup; D = finishing paste; E = glaze.*

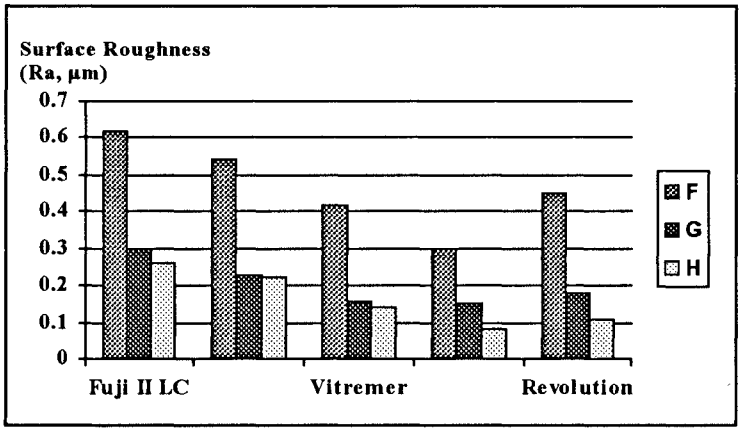

Figure 2. *Effect of surface treatments on surface roughness (Ra, µm) of hybrid ionomers and composites (Finishing and Polishing Procedure II); F = 12-fluted bur resurface; G = fine disk; H = extra-fine disk.*

to grind into the surfaces, while the disks tended to sand the surfaces without gouging into the material. The cups would appear to be better suited for gross material reduction and the disks better for final finishing and polishing.

For the hybrid ionomers, the polishing paste appeared to function only as a surface cleansing agent, rather than polisher. These pastes applied to the hybrid ionomers did not significantly lower the Ra (Table 3), but instead seemed only to remove the smear layer created by the prior finishing cup treatment. This is evidenced by the clear picture of the glass-ionomer matrix and glass particles revealed by SEM after treatment with the polishing pastes (Figure 4) as compared to an SEM taken following finishing cup treatment showing a uniformly striated, indistinct, debris-covered surface (unpublished photomicrograph). For composite resins, this study and others (Whitehead & Wilson, 1989; Tate & others, 1992) have shown that polishing pastes can improve the smoothness of resin surfaces; however, they will not be as smooth as the surfaces produced with the Sof-Lex disks.

The unfilled resin glaze produced a smooth surface for Fuji II LC and Vitremer hybrid ionomers; however, for Vitremer, a lower Ra was achieved using the Sof-Lex disks. Further, a glazing resin may erode and/or wear away rapidly in the oral environment, leaving a rougher surface.

Photomicrographs for Revolution following Treatments A-D (Figure 4) and Treatments F-H (Figure 6) do not appear to be visually different. This may be due to surface waviness produced by Treatments A-D. The profilometer detects any waviness within the 0.25 mm cutoff, which would increase the Ra; however, SEM cannot distinguish overall surface texture. Based on SEM, the actual surface roughness of the composites may be closer to each other than

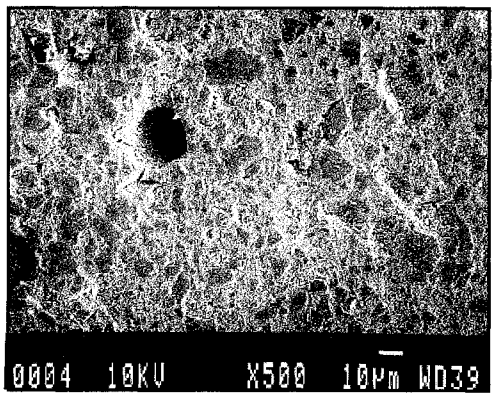

Figure 3. *SEM of the Fuji II LC surface after surface treatments A-D (X250)*

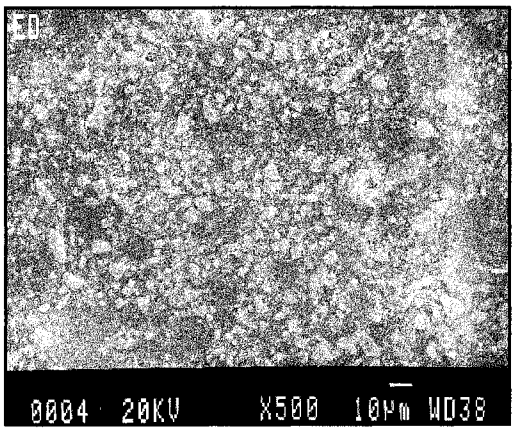

Figure 4. *SEM of the Revolution composite surface after surface treatments A-D (X250)*

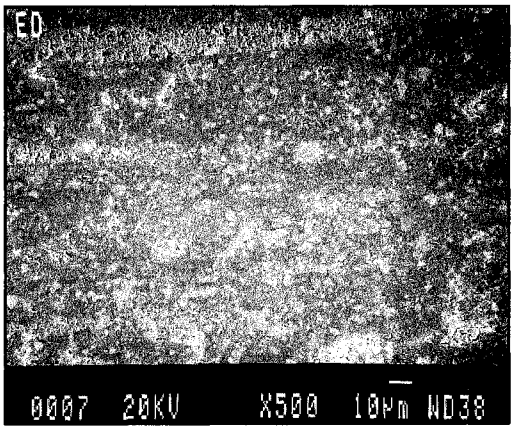

Figure 6. *SEM of the Revolution composite surface after surface treatments F-G (X250)*

the observed profilometer values. The difference may be due to surface waviness produced by Finishing and Polishing Procedure I, regardless of the low profilometer cut-off value used to decrease this influence.

CONCLUSIONS

A 12-fluted finishing bur left a roughened irregular surface on hybrid ionomers and composites, which required further finishing and polishing. Overall, Sof-Lex disks (aluminum-oxide) produced the smoothest finished surfaces for both the hybrid ionomers and composites.

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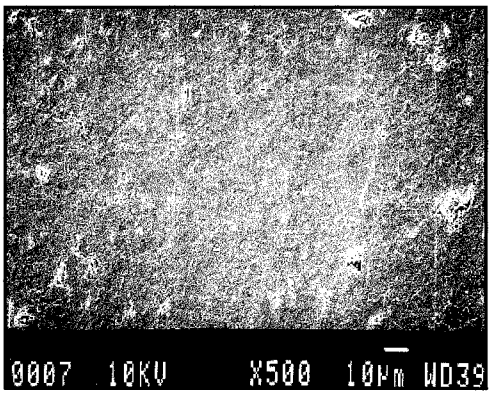

Figure 5. *SEM of the Fuji II LC surface after surface treatments F-G (X250)*

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Laboratory Evaluation of Surface Treatments for Composite Repair

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Clinical Relevance
High bond strengths can be achieved in composite repairs by roughening the surface of a cured composite.

SUMMARY

This laboratory study evaluated the strength of composite repairs using various surface treatment procedures. Roughening a previously cured composite surface, with either a diamond instrument or aluminum oxide air abrasion, yielded composite to composite repair strengths that were not significantly different ($P > 0.05$) than bonding composite to the air-inhibited layer of a cured composite. The bond strengths of composite repairs were slightly higher when using an unfilled bonding agent but not significantly different ($P > 0.05$) than the same repair techniques without the bonding agent.

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INTRODUCTION

The use of composite materials has steadily increased over the years. The clinical performance of composite materials has improved with newer-generation materials. Indirect techniques for posterior composites have also gained popularity in recent years. Several indirect composite systems are now marketed. These systems usually incorporate a secondary curing (postcuring) step to improve the physical properties of the composite materials.

Some clinical situations may require the repair of a secondary-cured composite material. Since the degree of carbon double bond conversion is generally greater with secondary-cured composites (Ferracane, 1985; Wendt,1987a,b), when compared to conventional visible light polymerization, repair is usually considered more of a challenge when bonding to secondary-cured materials. The purpose of this study was to evaluate various surface treatments for repair of a composite material marketed for indirect and secondary curing procedures.

METHODS AND MATERIALS

Several treatment parameters for repairing a secondary-cured composite were evaluated in this study. Eighty wafer-shaped composite specimens were made with approximate dimensions of 12 mm x 12 mm and 2 mm deep. The composite wafers were formed by cutting a preparation in epoxy resin that was previously poured in 1-inch phenolic rings and chemically cured. Maxxim Indirect Composite (Ceramco Inc, Burlington, NJ 08016) was placed into the preparations and cured using two 60-second curing increments across the surface, with a Max Lite (L D Caulk/Dentsply, Milford, DE 19963) visible light polymerization unit equipped with an 8 mm light guide. The composite was then secondary cured for an additional 10 minutes in a Triad 2000 unit (Equipment Division/Dentsply International, York, PA 17405).

The composite specimens were then divided into four groups of 20 each. Four composite surface treatment conditions were evaluated in this study: Group I: control—air-inhibited surface; Group II—surface ground to 600 grit; Group III—surface ground to 600 grit and then roughened with an 856 diamond; and Group IV—surface ground to 600 grit and air abraded with 50 μm aluminum oxide at 60 PSI.

The exposed flat composite surfaces were ground to 600 grit on a water-cooled abrasive wheel (Ecomet III Grinder, Buehler Ltd, Lake Bluff, IL 60044) for Groups II, III, and IV. The composite surfaces on the specimens in Group III were roughened with an 856 diamond (Brasseler USA, Savannah, GA 31419) rotating at high speed using air-water spray. In Group IV, the composite surfaces were sandblasted with 50 μm aluminum oxide using an intraoral microetcher (Model ERC, Danville Engineering, San Ramon, CA 94583) at 60 PSI. The specimens in Group I were not ground, and the air-inhibited layer was maintained. The composite bonding procedure was accomplished on the specimens in Group I immediately after the secondary-curing procedure. The composite surface preparation for the specimens in Groups II, III, and IV was completed 24 hours after secondary curing of the composite specimens.

Table 1. Specimen Groups

GROUP	COMPOSITE SURFACE FOR BONDING	ADHESIVE
IA	air-inhibited layer	no
IB	air-inhibited layer	yes
IIA	856 diamond roughened	no
IIB	856 diamond roughened	yes
IIIA	aluminum oxide air abraded	no
IIIB	aluminum oxide air abraded	yes
IVA	600 grit (smooth surface)	no
IVB	600 grit (smooth surface)	yes

Half of the specimens (10) in each group were then additionally treated with Maxxim Modeling Resin (Ceramco) before placement of composite on the surface (Table 1). The adhesive resin was cured for 10 seconds with the Max Lite.

Maxxim Indirect Composite was then applied to the treated composite surfaces using a #4 gelatin capsule (Eli Lilly and Co, Indianapolis, IN 46285), which resulted in a composite resin cylinder 5 mm in diameter. The composite was loaded into the capsules, approximately two-thirds full, and then cured in the Triad 2000 unit for 1 minute. Additional composite was used to slightly overfill the capsules. The capsules were then firmly seated against the bonding sites. Excess composite was removed with a dental explorer, and the composite cylinders were visible light cured with the Max Lite. Each cylinder was cured with three 20-second curing sequences equally divided around the circumference of the cylinder. All the specimens were stored for 24 hours in distilled water at 37° C.

After the designated storage time, the phenolic rings were mounted in a custom fixture. The mounted specimens were then placed in an Instron Universal Testing Machine (Model 1123, Instron Corp, Canton, MA 02021) for determination of shear bond strengths. A chisel-shaped rod was used on the crosshead of the Instron machine to deliver a shearing force that was parallel to the flat prepared bonding sites. A crosshead speed of 5 mm per minute was used for bond strength determinations. Shear bond strengths were calculated and recorded in megapascals units (MPa). All the debonded specimens were examined in a stereobinocular microscope (X10) to evaluate the location of the fracture sites. Data analysis was accomplished using a two-way ANOVA and post hoc Tukey test. Factors for the two-way ANOVA were surface condition/treatment of the composite and the effect of the adhesive agent.

RESULTS

The results of this study are presented in Table 2. The highest bond strength (24.1 ± 3.14 MPa) of composite to composite repair was developed by bonding composite to an air-inhibited layer on the surface of previously polymerized composite using

Table 2. Mean Shear Bond Strength of Composite Repair

COMPOSITE SURFACE CONDITION	ADHESIVE	MPa	SD	PERCENT COHESIVE FAILURES*
air-inhibited layer	yes	24.1	3.14	100
aluminum oxide air abrasion	yes	24.0	2.95	100
aluminum oxide air abrasion	no	23.1	4.15	100
air-inhibited layer	no	21.5	2.64	100
856 diamond	yes	20.8	2.30	100
856 diamond	no	19.7	3.33	100
600 grit	yes	13.1	3.02	20
600 grit	no	12.8	2.34	10

*Cohesive failures in cured composite. Groups connected by line are not different at the 5% significance level.

a bonding agent. A slight decrease in bond strength (21.5 ± 2.64 MPa) was observed when the bonding agent was not applied to the air-inhibited layer.

High bond strengths (24.0 ± 2.95 MPa) were also developed by bonding composite to a previously cured composite surface that was air abraded with 50 µm aluminum oxide and then treated with a bonding agent. The same surface treatment without the bonding agent yielded a bond strength of 23.1± 4.15 MPa. Roughening the composite surface with a diamond instrument also produced high bond strengths. The diamond-roughened surface yielded a bond strength of 20.8 ± 2.30 MPa using a bonding agent on the surface and 19.7 ± 3.33 MPa without the adhesive agent.

The lowest bond strengths were found when bonding to a smooth 600-grit composite surface. The bond strengths to the 600-grit surface using the adhesive agent was 13.1 ± 3.02 MPa, and the bond strength without the adhesive was 12.8 ± 2.34 MPa.

The two-way ANOVA (Table 3) showed that the surface condition of a cured composite made a significant difference ($P = 0.000$) in the bond strength of a composite to the surface (Table 3). The use of an unfilled resin adhesive did not significantly ($P = 0.600$) improve the bond strengths of composite repairs. The bond strength of composite to an air-inhibited surface was not significantly ($P > 0.05$) different than to composite surfaces that were roughened with an 856 diamond or air abraded with 50 µm aluminum oxide (Table 2). The bond strength of composite to a 600-grit surface was significantly lower ($P < 0.05$) than to the air-inhibited surface or surfaces roughened with a diamond instrument or air abraded with aluminum oxide particles.

The composite surface treatments that produced the highest bond strengths (Groups I, II, and III) also produced the highest percentage of cohesive failures in the cured composite bonding surface (Table 2). One hundred percent cohesive failures were observed in specimens in the air-inhibited layer group (Group I), the composite specimens roughened with an 856 diamond instrument (Group II), and air abraded with 50 µm aluminum oxide particles (Group III). The 600-grit surface produced 20% cohesive failures in the specimens treated with the adhesive resin and only 10% when composite was bonded directly to the surface (Group IV).

DISCUSSION

Several studies (Bausch, DeLange & Davidson, 1981; Wendt, 1987a,b; Powers & others, 1993; Reinhardt, Boyer & Stephens, 1994) have shown increased in vitro mechanical properties of composite resin material using secondary curing techniques. These studies certainly support the use of secondary-cured, indirect composite restorations for posterior teeth. Several products are now marketed that include a variety of recommended methods for secondary curing. While the mechanical properties of these composite systems are greater, when compared to conventional visible light curing, wear and material fractures still occur because of the demands placed on these restorations in the posterior region.

Intraoral repair of indirect, secondary-cured composite restorations may be a viable alternative to restoration replacement in many clinical situations. Numerous laboratory studies (Crumpler & others, 1989; Söderholm & Roberts, 1991; Swift, LeValley & Boyer, 1992; Gregory & others, 1992; Turner & Meiers, 1993) have evaluated the strength of repaired composites. These studies indicate that the surface roughness of composite has a greater influence on repair strength than the use of a bonding agent. The

Table 3. Two-Way Analysis of Variance

Source	Sum of Squares	DF	Mean Square	F Ratio	P
Surface	1473.85	3	491.284	49.192	0.000
Adhesive	2.768	1	2.768	0.277	0.643
Surface x Adhesive	64.364	3	21.455	2.148	0.102

results of this laboratory study confirm those of earlier studies that indicated that the surface irregularity of a composite is an important parameter in developing high repair strength for composite repair.

The lowest bond strengths determined in this study were to a smooth 600-grit polished surface without the use of a bonding agent (12.8 ± 2.24 MPa). The use of an unfilled adhesive agent only slightly increased the repair strength (13.1 ± 3.02 MPa). Roughening the surface of the composite with either a diamond instrument or aluminum oxide air abrasion significantly ($P < 0.05$) improved the bond strength when compared to the 600-grit surface (Table 2). Again, the use of a bonding agent only slightly increased the bond strengths to these irregular surfaces.

The cohesive strength of the composite in this study is represented in Group I, which involved bonding to the air-inhibited layer on a previously cured composite. The failures in this group, with and without a bonding agent, resulted in 100% cohesive failures in the previously cured composite. The bond strength to composite surfaces roughened with a diamond or aluminum oxide air abrasion also resulted in 100% cohesive failures (Table 2).

Aluminum oxide air abrasion and a bonding agent produced a bond strength (24.0 ± 2.95 MPa) that was almost identical to that obtained when bonding to the air-inhibited layer of a cured composite and using a bonding agent on the surface (24.1 ± 3.14 MPa). The study indicates that aluminum oxide air abrasion of composite, followed by a bonding agent, will result in an intraoral repair strength that is nearly identical to the cohesive strength of the original composite.

Further research is needed to address the stability of composite to composite bonding. Long-term water storage and thermocycling studies would provide additional information regarding potential bond degradation in a moist environment.

CONCLUSIONS

1. The surface condition of a cured composite significantly affects the bond strength of composite bonded to the surface.
2. There was not a significant difference in the bond strength of composite bonded to cured composite with an air-inhibited layer on the surface or composite treated with a diamond instrument or air abraded with aluminum oxide.
3. The bond strength of composite to a cured composite was generally higher when an adhesive agent was applied to the surface.
4. Roughening of a cured composite surface with a diamond instrument or abrasion of the surface with 50 μm aluminum oxide produces bond strengths of composite statistically equivalent to that obtained when bonding to an air-inhibited layer on a cured composite.

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The Effect of Microabrasion on Restorative Materials and Tooth Surface

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Clinical Relevance
Judicious use of the Prema microabrasion technique is advised.

SUMMARY

The effect of microabrasion on human enamel has been well documented; however, no information is available on its effect on dentin or restorative materials. The purpose of this study was to evaluate the effect of the microabrasion technique on the surface roughness of restorative materials and enamel and dentin surfaces. Flat disks of amalgam, composite resin, porcelain, and glass ionomer were evaluated. Labial enamel of three maxillary incisors and three molars that were flattened buccally to expose dentin were also tested. The Prema microabrasion compound was applied to each sample with a 10:1 gear-reduction, slow-speed handpiece for 5 seconds, then rinsed for 10 seconds. Roughness was determined with a profilometer. This procedure was repeated 20 times for each sample. A polyvinylsiloxane impression of the surface was taken after 0, 5, 10, 15, and 20 applications and examined under a scanning electron microscope. Enamel surface roughness did not improve as previously reported, suggesting that changes in optical characteristics may not be as important as removal of enamel in obtaining esthetic results. Dentin and glass ionomer exhibited an increase in roughness, such that their presence contraindicates the technique. Amalgam was essentially polished. Porcelain was most resistant to the effects of microabrasion. Judicious use of the technique, especially when restorative materials are present, is advised.

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INTRODUCTION

Esthetic dentistry has become an increasingly important part of modern dental practice. Patients of all ages are becoming aware of the esthetic alternatives and are more demanding in esthetic treatment options. A variety of tooth-colored dental restorative materials, including composite resin, glass ionomer, and porcelain, has been used successfully to improve the appearance of discolored teeth.

Another adjunctive treatment modality developed towards achieving esthetic improvement is microabrasion. Various techniques employing acids to remove discolored enamel have been used since the turn of the century (McCloskey, 1984; Croll, 1991; Kilpatrick & Welbury, 1993). These techniques have been more successful in certain clinical situations, i e, brown hypomineralized enamel defects, than in others, i e, white mineralization defects (Welbury & Shaw, 1990; Coll,

Jackson & Strassler, 1991; Willis & Arbuckle, 1992). A commercial Prema compound with a patented acid-abrasive formulation (Premier Dental Products, Norristown, PA 19404) is now available for this purpose. The compound is applied to the stained enamel with a hard synthetic rubber mandrel fitted to a 10:1 gear-reduction, slow-speed handpiece. Five-second applications of the compound are interspersed with 10 seconds of rinsing. This method removes thin layers of enamel via the two processes of abrasion and acid erosion.

Microabrasion performed on children and young adolescents up to 18 years old has been cited in case reports (Nash & Radz, 1995; Welbury & Shaw, 1990). Reports of such a technique on older patients is uncommon. During this century, the number of elderly has increased from 3.1 million of age 65 or older to approximately 23.5 million, with a projected increase to 32 million by the year 2000 (U S Bureau of Census, 1988). Patients seeking esthetic improvement, especially older patients, often have various types of restorations already in place or perhaps exhibit exposed roots. Although the effects of the microabrasion technique on enamel have been well documented and its clinical use widespread, its interaction with dentin and various restorative materials has not been reported.

The purpose of this study was to evaluate the effect of multiple treatments of a microabrasion technique on the surface roughness of restorative materials, dentin, and enamel surfaces. The materials were compared on the basis of the parameter RA (average roughness) and RQ (root mean square). Replicas of the surface at specific intervals were also examined by scanning electron microscopy.

METHODS AND MATERIALS

Circular disks of amalgam (Valiant PhD XT, L D Caulk, Milford, DE 19963), composite resin (Herculite XR, Kerr Mfg Co, Romulus, MI 48174), and glass ionomer (Ketac-Fil, ESPE-Premier, Norristown, PA 19404) were prepared using a metal mold with an internal diameter of 13 mm and 3 mm in height. Porcelain tablets (Vita, Vita Zahnfabrik, D-7880 Sackingen, Germany) were condensed in another metal device (10 mm x 10 mm x 2 mm) and fired according to the manufacturer's recommended cycle. Two indentations were placed in each sample in order to facilitate its correct realignment under the surface analyzer probe after each successive application of the compound. Three samples of each material were tested (Willems & others, 1991; Willems, 1992).

In addition, three maxillary central incisors and three molars were tested. The labial enamel of the maxillary central incisors was unaltered, but the buccal portion of the molars was surfaced to expose a flat area of dentin. All the teeth were also scored so that the exact alignment could be maintained during measurements.

The Prema microabrasion compound was applied to one surface of each specimen for 5 seconds using a hard synthetic rubber mandrel fitted to a 10:1 gear-reduction slow-speed handpiece. The mandrel and the gear-reduction contra angle are provided in the Prema kit. The sample was rinsed for 10 seconds and air dried. Each sample received a total of 20 5-second applications.

Baseline RA (average roughness) and RQ (root mean square) readings were taken prior to the first application using the Surfanalyzer System 4000 profilometer (Federal Products Corp, Providence, RI 02905). The equipment was calibrated using a standard roughness sample. RA and RQ values were obtained for a scan length of 3.65 mm. The tracing speed was 0.25 mm/second. The stylus of the profilometer probe applies a force of 2 mN; the tip of the probe has a radius of 2.5 μm.

Table 1. Average RA (n=3) of Specimen Surfaces in μm (Standard Deviation)

	Enamel	Dentin	Amalgam	Composite	Glass Ionomer	Porcelain
Baseline	0.17 (0.03)	0.13 (0.06)	2.18 (0.16)	0.28 (0.12)	1.15 (0.03)	0.10 (0.00)
1*	0.35 (0.13)	0.27 (0.08)	1.58 (0.33)	0.27 (0.06)	1.53 (0.08)	0.10 (0.00)
2	0.32 (0.08)	0.30 (0.10)	1.03 (0.43)	0.23 (0.06)	1.77 (0.15)	0.13 (0.06)
3	0.37 (0.12)	0.30 (0.05)	0.73 (0.53)	0.20 (0.05)	1.95 (0.03)	0.13 (0.06)
4	0.23 (0.03)	0.33 (0.19)	0.62 (0.55)	0.20 (0.00)	1.95 (0.08)	0.13 (0.06)
5	0.28 (0.08)	0.33 (0.06)	0.45 (0.30)	0.23 (0.06)	2.05 (0.05)	0.15 (0.05)
6	0.23 (0.03)	0.20 (0.05)	0.43 (0.19)	0.22 (0.08)	2.15 (0.05)	0.15 (0.05)
7	0.23 (0.03)	0.22 (0.08)	0.30 (0.10)	0.22 (0.03)	2.07 (0.18)	0.15 (0.05)
8	0.23 (0.03)	0.20 (0.09)	0.27 (0.08)	0.25 (0.05)	2.17 (0.06)	0.17 (0.06)
9	0.22 (0.08)	0.37 (0.13)	0.18 (0.03)	0.22 (0.08)	2.32 (0.06)	0.17 (0.06)
10	0.23 (0.03)	0.30 (0.09)	0.20 (0.00)	0.17 (0.06)	2.22 (0.16)	0.20 (0.00)
11	0.22 (0.03)	0.42 (0.23)	0.18 (0.06)	0.20 (0.00)	2.15 (0.10)	0.20 (0.00)
12	0.22 (0.03)	0.47 (0.21)	0.18 (0.03)	0.20 (0.00)	2.20 (0.05)	0.18 (0.03)
13	0.22 (0.03)	0.65 (0.33)	0.20 (0.05)	0.25 (0.09)	2.18 (0.08)	0.17 (0.06)
14	0.22 (0.03)	0.47 (0.19)	0.17 (0.03)	0.20 (0.00)	2.27 (0.13)	0.20 (0.05)
15	0.17 (0.06)	0.48 (0.37)	0.20 (0.00)	0.20 (0.05)	2.35 (0.23)	0.22 (0.03)
16	0.18 (0.06)	0.40 (0.15)	0.15 (0.05)	0.20 (0.00)	2.20 (0.08)	0.18 (0.03)
17	0.20 (0.09)	0.47 (0.21)	0.13 (0.03)	0.18 (0.03)	2.23 (0.02)	0.18 (0.08)
18	0.20 (0.05)	0.32 (0.08)	0.18 (0.03)	0.20 (0.00)	2.40 (0.08)	0.17 (0.06)
19	0.22 (0.03)	0.45 (0.10)	0.15 (0.05)	0.20 (0.00)	2.35 (0.21)	0.18 (0.03)
20	0.22 (0.03)	0.48 (0.13)	0.10 (0.00)	0.20 (0.00)	2.37 (0.13)	0.20 (0.05)

*Number of applications

Table 2. Average RQ (n=3) of Specimen Surfaces in μm (Standard Deviation)

	Enamel	Dentin	Amalgam	Composite	Glass Ionomer	Porcelain
Baseline	0.22 (0.03)	0.23 (0.06)	2.78 (0.16)	0.57 (0.18)	1.75 (0.26)	0.18 (0.03)
1*	0.48 (0.16)	0.40 (0.10)	2.15 (0.38)	0.42 (0.06)	2.08 (0.16)	0.20 (0.00)
2	0.50 (0.18)	0.50 (0.17)	1.50 (0.56)	0.35 (0.13)	2.33 (0.20)	0.23 (0.06)
3	0.60 (0.26)	0.48 (0.10)	1.07 (0.77)	0.35 (0.13)	2.53 (0.03)	0.27 (0.12)
4	0.45 (0.05)	0.57 (0.29)	0.93 (0.75)	0.28 (0.03)	2.57 (0.16)	0.25 (0.09)
5	0.45 (0.09)	0.53 (0.06)	0.77 (0.38)	0.45 (0.17)	2.67 (0.16)	0.23 (0.06)
6	0.37 (0.08)	0.35 (0.18)	0.73 (0.36)	0.38 (0.19)	2.80 (0.17)	0.27 (0.08)
7	0.35 (0.00)	0.35 (0.13)	0.47 (0.19)	0.38 (0.15)	2.67 (0.18)	0.23 (0.06)
8	0.38 (0.08)	0.28 (0.08)	0.48 (0.18)	0.45 (0.18)	2.73 (0.18)	0.28 (0.08)
9	0.38 (0.10)	0.53 (0.16)	0.35 (0.10)	0.33 (0.15)	2.98 (0.15)	0.28 (0.08)
10	0.38 (0.03)	0.47 (0.12)	0.33 (0.03)	0.25 (0.05)	2.85 (0.36)	0.27 (0.03)
11	0.38 (0.03)	0.63 (0.33)	0.35 (0.18)	0.28 (0.03)	2.78 (0.13)	0.32 (0.06)
12	0.37 (0.03)	0.68 (0.28)	0.27 (0.06)	o.28 (0.03)	2.85 (0.18)	0.25 (0.05)
13	0.32 (0.03)	0.97 (0.40)	0.30 (0.05)	0.43 (0.28)	2.87 (0.15)	0.27 (0.08)
14	0.33 (0.06)	0.72 (0.28)	0.28 (0.08)	0.28 (0.03)	2.93 (0.20)	0.27 (0.08)
15	0.32 (0.10)	0.70 (0.44)	0.30 (0.05)	0.28 (0.08)	3.02 (0.28)	0.30 (0.05)
16	0.32 (0.06)	0.63 (0.21)	0.23 (0.06)	0.28 (0.03)	2.82 (0.10)	0.27 (0.06)
17	0.35 (0.13)	0.75 (0.31)	0.22 (0.03)	0.25 (0.05)	2.97 (0.10)	0.30 (0.10)
18	0.38 (0.10)	0.52 (0.13)	0.27 (0.06)	0.28 (0.03)	3.13 (0.32)	0.27 (0.06)
19	0.37 (0.10)	0.68 (0.18)	0.22 (0.03)	0.32 (0.03)	3.07 (0.28)	0.28 (0.10)
20	0.38 (0.06)	0.68 (0.20)	0.20 (0.00)	0.27 (0.06)	3.07 (0.23)	0.30 (0.13)

*Number of applications

Each specimen was scanned at two separate sites, and the average of the two readings was recorded. Following each successive application of the compound, a measurement of roughness values for each specimen was repeated as described.

After 0, 5, 10, 15, and 20 applications, a polyvinylsiloxane impression (Express, 3M Dental Products, St Paul, MN 55144) of each specimen was made using a light-bodied wash in a heavy-bodied base. The impression was sputter coated with a gold-palladium alloy and examined under a scanning electron microscope at an accelerating voltage of 15 kV. Photomicrographs at X10 were obtained for comparison.

RESULTS

The average roughness values (RA and RQ) recorded on each surface over the course of microabrasion application are summarized in Tables 1 and 2 and graphically depicted in Figures 1 and 2. Data were analyzed by analysis of variance (SuperANOVA, Abacus Concepts, Inc, Berkeley, CA 94704). Scheffé's S tests were used for post-hoc comparison at a significance level of $P < 0.05$. The analysis of variance showed highly significant differences among the means of RA and RQ values, with the material effect being a more significant factor than the number of applications factor. At baseline, i e, before any application of microabrasion compound, both RA and RQ for porcelain, dentin, enamel, and composite were not significantly different; glass ionomer and amalgam were significantly different from the other four materials ($P = 0.0001$). However, after only two applications, with little exception until the end of 20 applications, dentin and glass ionomer became significantly rougher with each application than the rest (Table 3).

In addition to determining RA, the Surfanalyzer provides a hard copy of the surface profile (Figure 3). As can be seen in this figure, the acid-pumice compound had little effect on the surface roughness of enamel, composite, and porcelain. Amalgam showed a decrease in roughness, while dentin and

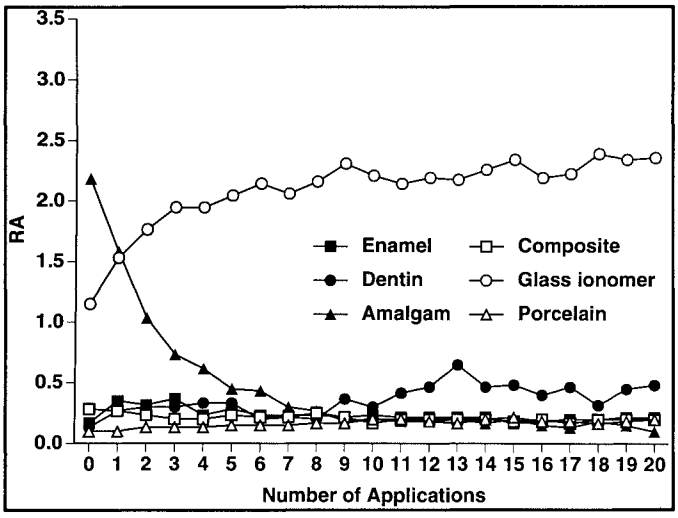

Figure 1. *Graphical representation of RA showing the effect of microabrasion on tooth surface and restorative materials*

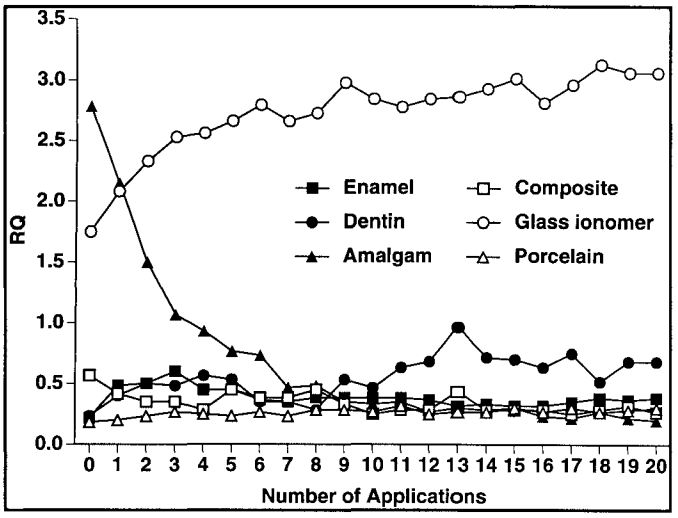

Figure 2. *Graphical representation of RQ showing the effect of microabrasion on tooth surface and restorative materials*

Table 3. Summary of Statistical Analysis for RA Values at Baseline and after 20 Applications

Materials	Mean RA at Baseline	Scheffé's S Post Hoc	Mean RA after 20 Applications	Scheffé's S Post Hoc
Porcelain	0.10	a*	0.20	a
Dentin	0.13	a	0.48	b
Enamel	0.17	a	0.22	a
Composite	0.28	a	0.20	a
Glass Ionomer	1.15	b	2.37	c
Amalgam	2.18	c	0.10	a

*Like letters indicate means in columns are not significantly different.

glass ionomer exhibited an increase in roughness. Porcelain was most resistant to the microabrasion process with no evident loss of material. Other materials, although their RA or RQ values may not be affected, showed various degrees of surface modification perhaps indicative of material loss.

SEM examination of the impression material supports the profilometric data. The increase in roughness of glass ionomer is shown in Figures 4A and 4B. Polishing of the amalgam surface by microabrasion is depicted in Figures 5A and 5B.

DISCUSSION

As indicated in Tables 1 and 2, the values of RQ are greater than those of RA. RA is the arithmetic average height of roughness irregularities from the mean line measured within the sampling length. The root mean square (RQ) is a geometric average height and is therefore more sensitive to occasional peaks and valleys. Yet, the graphic representations of both RA and RQ are very similar (Figures 1 and 2) and therefore only the statistic of RA is presented in Table 3.

It has been previously reported that removal of thin layers of enamel using the microabrasion technique has a polishing effect on the enamel surface as well (Berg & Donly, 1991; Donly, O'Neill & Croll, 1992). However, our surface roughness data and SEM studies do not support this theory. Others also reported that the glossy appearance of the enamel was lost with etching and microabrasion (Tong & others, 1993; Chan & others, 1995). A more granular and irregular architecture of the etching pattern was reported in those studies. Results of this study suggest that it is the physical removal of enamel, rather than an improvement in its optical characteristics, that predominantly accounts for the esthetic results achieved with this technique. The final word is not in yet, as indicated by recent discussions (Chan & García-Godoy, 1995; Croll, 1995; Donly, 1995).

We were unable to quantify the loss of enamel, since the maxillary incisor labial surface has a natural curvature. The loss of dentin estimated from the chart was approximately 50 µm after 20 applications. This number is much smaller than that of enamel previously reported. Waggoner and others (1989) quantified the loss of surface enamel to

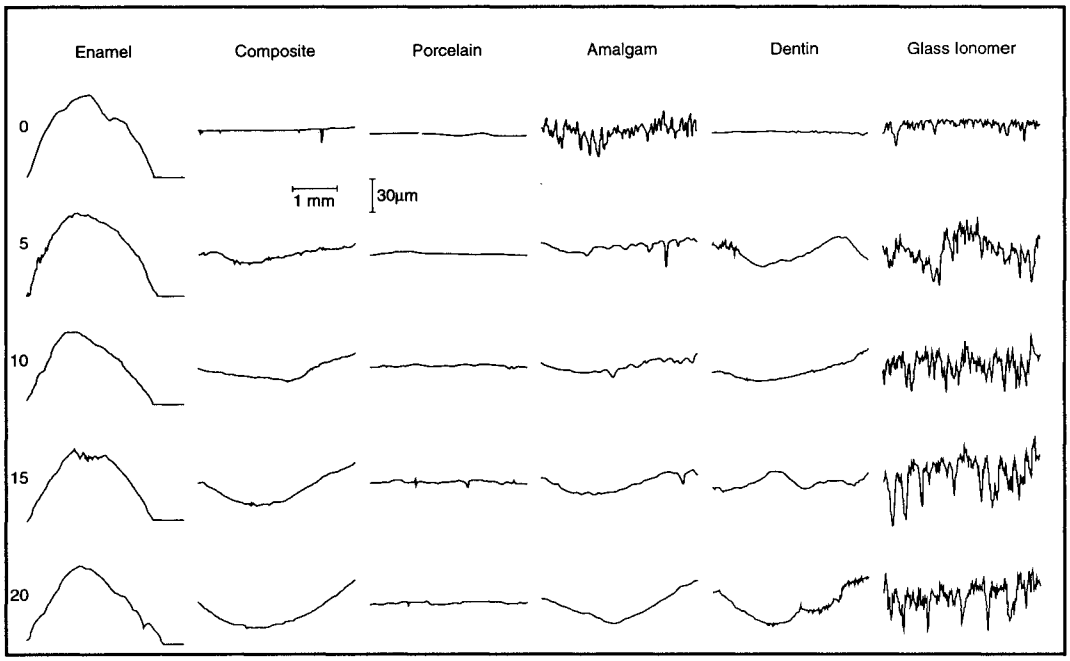

Figure 3. *Profilometric tracings of the materials tested. Scan length was 3.65 mm. 0 = original unabraded surfaces; 5-20 = abraded surfaces at the specified successive applications.*

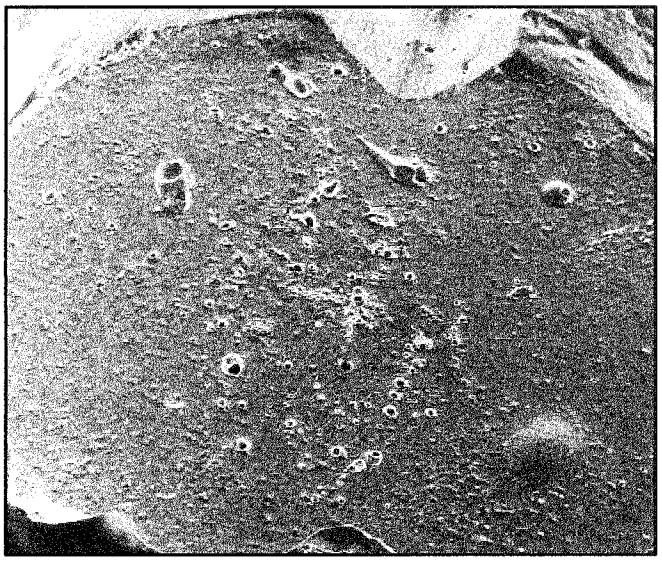

Figure 4A. *SEM image (15 kV, X6.8) of a glass-ionomer specimen before receiving microabrasion application*

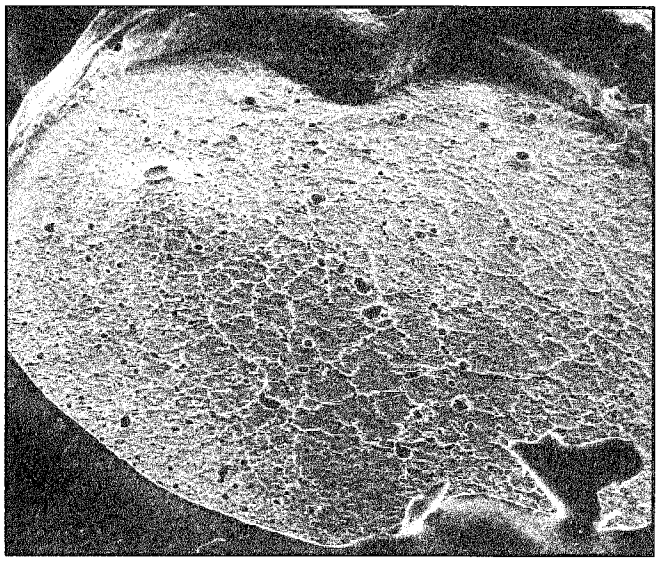

Figure 4B. *Micrograph of the same specimen after 20 5-second applications of the acid-pumice mixture shows a roughened surface.*

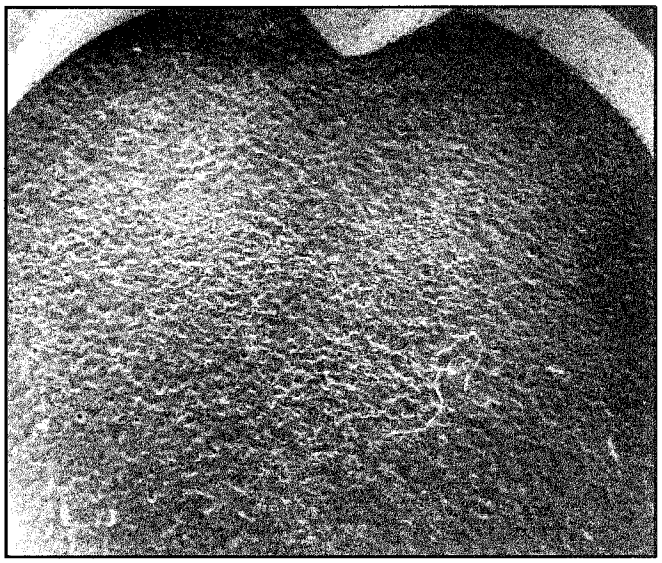

Figure 5A. *SEM image (15 kV, X6.8) of an amalgam specimen before receiving microabrasion application*

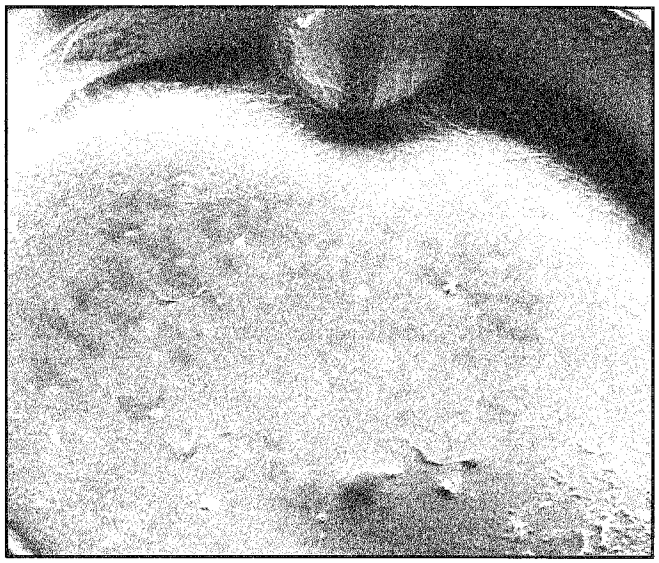

Figure 5B. *Micrograph of the same specimen after 20 5-second applications of the acid-pumice mixture shows a polished surface.*

average 26 µm per manual application and the removal of up to 25% of the labial enamel. Tong and others (1993) reported that 18% hydrochloric acid combined with pumice and rotary prophy cup removed up to 360 µm of enamel, and the effect was time dependent. Chan and others (1995) compared manual and mechanical methods of microabrasion and reported no difference between the two techniques: both techniques removed up to 300 µm of enamel after 20 applications. It must be noted that the loss of dentin in this study is estimated from the peaks and valleys scanned with no arbitrary baseline. It is very possible that the amount of enamel and dentin lost is even significantly higher than that evidenced from the scan.

Amalgam displayed a decrease in RA and RQ such that it was basically polished. From a clinical and visual standpoint, this would not contraindicate the use of the microabrasion technique in the presence of amalgam restorations and could be considered a desirable result. However, further study is necessary to determine the extent of amalgam removal and, more importantly, its effect on the integrity of the margins of amalgam restorations.

Dentin and glass ionomer exhibited increases in surface roughness such that their presence may

contraindicate the technique. The dentin of exposed root surfaces in older and periodontally involved patients is susceptible to caries, even with the root surface intact; thus, disturbing the integrity of this surface might not be a desirable result.

Glass ionomer and composite resin are usually the restorative materials of choice for lesions on the facial surface of anterior teeth. The ability to polish composite resin to a high luster is one reason it is preferred in this area of the mouth. These same teeth, however, are often the primary candidates for the microabrasion technique. Roughening the glass ionomer surface would undo the esthetic advantage provided by this material in restoring anterior teeth. Therefore, it follows that the abrasion-erosion process might compromise the integrity of glass-ionomer/tooth margins, a hypothesis that merits further investigation.

The results of this study should instill caution in the clinician seeking to provide esthetic improvement for patients with either root exposure or glass-ionomer restorations present in their mouths. Judicious use of the microabrasion technique in all cases is therefore advised.

CONCLUSIONS

1. Enamel surface roughness did not improve using Prema microabrasion compound as previously reported, suggesting that changes in optical characteristics may not be as important as removal of enamel in obtaining smoother enamel surfaces.
2. Dentin and glass ionomer exhibited an increase in roughness, which contraindicates use of the technique. Amalgam was essentially polished. Porcelain was most resistant to the effects of microabrasion.

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Sealing Capacity of a Resin-modified Glass-Ionomer and Resin Composite Placed in Vivo in Class 5 Restorations

M FERRARI • C L DAVIDSON

Clinical Relevance
A resin-modified glass-ionomer cement performed as well as a hybrid composite resin when placed in class 5 preparations in vivo.

SUMMARY

A 2% methylene blue dye was used to assess the leakage resistance of class 5 resin-modified glass-ionomer and resin composite restorations placed in 17 adults. The teeth were extracted 75 to 90 days after placement of the restorations and immersed for 24 hours in the dye solution. Within 7 days after extraction the teeth were sectioned inciso-apically through the center of the restoration and inspected under a stereomicroscope at X20 to determine the depth of dye penetration. No significant differences between the resin-modified glass-ionomer and resin composite restorations at the incisal or cervical margins were found. Although no more than 30% of the restorations of either group exhibited microleakage, neither of the restorative systems was able to completely prevent leakage at either incisal or cervical margins.

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INTRODUCTION

A major advancement in the current practice of dentistry is the restoration of class 5 cavities with tooth-colored, adhesive materials. The aesthetic qualities of such restorations and the appropriate ease of placement are such that the results are most satisfactory both for the practitioner and the patient. A major problem associated with restoring class 5 cavities with these materials has been in preventing marginal leakage (Taylor & Lynch, 1992). Recent developments, however, have led to the use of systems that create marginal seals without microleakage (Nakabayashi, Nakamura & Yasuda, 1991; Gwinnett & Kanca, 1992). Unfortunately such systems are very technique sensitive and demand much time and clinical skill. Two different systems are at our disposal: the resin composite materials' bond to dentin that relies upon hybridization of the substrate and direct bonding by resin-modified glass-ionomer cements. Often a combination of these two is used, with the glass ionomer serving as a liner or base under the resin composite restoration. In vitro and in vivo studies have shown that microleakage can be eliminated with these materials even after load cycling (Mason & Ferrari, 1994; Davidson & Abdalla, 1994).

The objective of this study was to evaluate the marginal seal of class 5 restorations placed in vivo, made with a resin-modified glass ionomer and with a resin bonding agent used in conjunction with a resin composite.

METHODS AND MATERIALS

For this in vivo trial, 17 volunteer patients participated in the study. Each of these patients was required to have one, two, or three severely compromised periodontally involved anterior teeth (four maxillary canines, four maxillary incisors, eight mandibular incisors, and four mandibular canines) that were scheduled for extraction. The patients' average age was 57. All of the teeth were free of caries and restorations, and the patients agreed to have their extraction(s) postponed for about 3 months to facilitate the study.

In each tooth, one 3 mm-wide V-shaped cavity with a maximum depth of 2 mm and a cavosurface angle of 120°-140° was prepared on the labial surface crossing the cementoenamel junction. The preparations were cut with new medium-grain diamond points mounted in an air-turbine handpiece. The experimental cavity was located at the cementoenamel junction with half of the cavity margin in enamel and half in root cementum. Immediately after the preparation, a rubber dam was applied, and the restorations were placed at random with resin-modified light-curing glass-ionomer cement or with the adhesive resin/composite combination. Following this protocol, the samples were divided in two groups of 10 class 5 restorations each.

Table 1 identifies the restorative materials used in this trial. Manufacturers' instructions were strictly followed for use of all materials.

Table 1. Adhesive Systems Used

Components	Batch	Manufacturer
Scotchbond Multi-Purpose Z 100		3M Dental Products, St Paul, MN 55144
etchant	#2AC	
primer	#2AB	
adhesive	#2AB	
composite (Z 100)	#92108A(A3)	
Fuji II LC		GC International Corp, Tokyo, Japan
dentin conditioner	#020631	
glass ionomer (powder)	#090521	
glass ionomer (liquid)	#020421	

Glass-Ionomer Cement Group

After having been conditioned with polyacrylic acid for 30 seconds, the cavity walls were washed and gently dried. The powder and liquid were dispensed according to manufacturer's instructions and mixed for 10 seconds. The material was divided into two increments. After each increment was placed in the cavity preparation, it was light cured for 20 seconds. Before the activation of the final increment, a transparent matrix was placed over the restoration to obtain a smooth surface. Immediately after curing, the restorations were finished and polished with dry Sof-Lex disks (3M).

Composite Group

A Scotchbond Multi-Purpose conditioning gel was applied for 30 seconds to remove the smear layer and to modify the enamel and dentin substrates. Then the cavity was rinsed with water spray for 30 seconds and dried gently. The primer was applied with a soaked cotton pellet for approximately 30 seconds to the whole cavity wall, followed by gentle air drying. The bonding resin was then applied and light cured for 20 seconds. The resin composite was inserted in three increments, which were each separately light activated for 40 seconds. Before the activation of the final increment, a transparent matrix was placed to contour the restoration and to serve as a barrier against oxygen contamination, which otherwise might have inhibited the polymerization of the free surface of the resin. Immediately after curing, the restorations were finished with Sof-Lex disks.

Following a period of clinical service between 75 to 90 days, the teeth were extracted, taking care to avoid any stresses that might have compromised the seal between the restoration and the cavity preparation. The extracted teeth were then washed under tap water and stored at room temperature in 1% chloramine solution for no more than 7 days before immersion in a 2% methylene blue dye solution for 24 hours. Prior to sectioning with a low-speed diamond blade saw through the centers of the restorations in an inciso-apical direction, the teeth were thoroughly washed with water and embedded in slow-curing epoxy resin. Each section was inspected under a stereomicroscope at X20. The deepest dye penetration at the cavity-restoration interfaces, both incisally and apically, was registered for both pairs of sections, according to a three-score system: 0 = no penetration; 1 = penetration was not deeper than half the length of the cavity wall between cavosurface margin and axial wall; 2 = penetration was deeper than halfway to the axial wall. The data were statistically analyzed by using the Kruskal-Wallis one-way ANOVA ranks and Neuman-Keuls multiple comparison test performed at a 0.05 level of significance.

RESULTS

Table 2 summarizes the frequency of dye penetration depths in terms of materials and sites. Dye penetration was registered for both the enamel and cementum margins. A statistical analysis of the leakage data showed no significant differences between resin-modified glass-ionomer and composite restorations at the incisal and cervical margins. Although neither of the systems was able to completely eliminate microleakage, no more than 30% of the restorations of either group exhibited microleakage.

Table 2. Leakage Scores

Degree of Leakage	Glass Ionomer 0	1	2	Resin Composite 0	1	2
Occlusal Margins	7	3	0	9	1	0
Cervical Margins	7	2	1	7	3	0

No statistically significant differences between the two groups were found at $P < 0.05$ level (n=10). Dye penetration: 0 = no penetration; 1 = ≤ one-half distance to axial wall; 2 = ≥ one-half distance to axial wall.

DISCUSSION

Much research has been carried out to evaluate the bonding and sealing capability of glass ionomers and resin composite systems (Powell, Gordon & Johnson, 1992; Mount, Papageogiou & Makinson, 1992; Sidhu & Henderson, 1992; Douglas & Fundingsland, 1992; Chohayeb, 1992). Recent literature reports only a few studies that have compared in vivo and in vitro restorations. Some of these studies evaluated the cervical leakage of class 5 cavities filled with a glass ionomer used as a liner in the sandwich technique (Mason & Ferrari, 1994) or with composite resin restorations (Barnes & others, 1993; Ferrari & others, 1993). For both groups of materials no statistically significant differences were found between the restorations placed in vital teeth and those placed under laboratory conditions. For both restorative techniques, satisfactory sealing was reported when the latest-generation materials were used. The clinical performance of these materials can be explained by the hydrophilic nature of glass ionomers and the new bonding agents.

The presence of tubular fluid of vital dentin can reduce dehydration of glass-ionomer materials during the setting period. It may also improve the hydrated gel phase during solidification and allow a self-repairing process (Davidson, Leloup & DeGee, 1994). According to the above theory, the glass ionomer forms internal microcracks as compensation for the shrinkage in order to maintain the bulk volume. After water sorption and consequential swelling, the cracks close and, due to the continuing chemical reaction, the partially lost cohesive strength is repaired. Thus, the important role of water for glass ionomers during this phase is in the maintenance of dimensional stability. On the other hand, the in vivo performances of resin composite adhesive systems can, besides the presence of hydrophilic groups within the primers, be related to the strong and reliable micromechanical bond of resin that has impregnated the demineralized surface dentin (Van Meerbeek & others, 1992).

From the experimental in vivo results, it can be concluded that the performance of Fuji II LC and Scotchbond Multi-Purpose Z 100 were similar in marginal sealing of class 5 restorations. The mechanism responsible for the quality of new resin bonding systems has been described extensively in the literature (Suh, 1991; Nakabayashi & others, 1991; Gwinnett, 1992; Erickson, 1992; Pashley & others, 1993). In fact, in in vitro studies perfect adaptations have been reported (Abdalla & Davidson, 1993). Less literature is available on the performance of glass ionomers, although this material is widely used for class 5 restorations (Hallet & García-Godoy, 1993). With the introduction of the resin-modified version of glass-ionomer cements, many disadvantages of the traditional products are being overcome. Practitioners now have a material at their disposal that is easier to handle than traditional glass ionomers or resin composites, yet still offers similar results. The relatively good performance of glass-ionomer materials in vivo is due to its ease of use and bonding to dentin via the development of ionic cross-links at the tooth/restorative interface (Wilson & others, 1983). Besides adaptation, there are several other reasons why one would prefer resin-modified glass-ionomer cements to resin composites for restoration of class 5 cavities. A primary reason is for its fluoride release. As was demonstrated in this study, one can never be sure that leakage has been completely prevented. If not, further insurance via a cariostatic agent at the existing margins is desired. Another reason for preferring resin-modified glass ionomers deals with the ease of handling and the direct bonding of the cement to the dentin. Disadvantages of resin-modified glass ionomers might be found in discoloration of the material, abrasive wear, and a possible inconsistency in the physical properties of the set material produced by individual hand proportioning and mixing the powder and liquid.

CONCLUSIONS

From the results of this investigation, the following conclusions can be drawn:

1. The resin-modified glass-ionomer cement (Fuji II LC) and the dentin bonding agent (Scotchbond Multi-Purpose) combined with a hybrid composite resin (Z 100) showed no statistical differences in microleakage at cervical or incisal margins of clinically performed class 5 restorations; and
2. Neither of the restorative systems was able to completely prevent microleakage of the class 5 restorations, although no more than 30% of the specimens exhibited microleakage.

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Opacity and Color Changes of Tooth-colored Restorative Materials

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Clinical Relevance
Light-cured composites are much more color stable than chemically cured composites. Resin-modified glass-ionomer cements showed marked darkening and increase of translucency initially.

SUMMARY

Internal opacity and color changes of several esthetic direct restorative materials were determined using an accelerated test proposed by Asmussen (1981). Five chemically cured composites, seven light-cured composites, and three resin-modified glass-ionomer cements were placed in acrylic rings. After curing, they were left at 37 °C for 1 week before baseline measurement, and then stored in 60 °C distilled water up to 4 weeks. Color change was determined by a color analyzer, and contrast ratio representing opacity was calculated. All chemically cured composites tested discolored to dark yellow or dark brown after 4 weeks. Opacity decreased for two macrofilled composites. Light-cured composites discolored slightly, but their opacity change was negligible. All resin-modified glass-ionomer cements tested showed an abrupt decrease of opacity at the initial stage, with accompanying darkening of the materials. Opacity decrease was found to be a factor of discoloration for some tooth-colored restorative materials, and might be caused by a refractive index change of the matrix phase of the materials.

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INTRODUCTION

Discoloration is a major esthetic failure of direct tooth-colored restorations. It results from surface staining, marginal staining due to microleakage, changes in surface morphology by wear, and internal material deterioration. Although extrinsic surface and marginal staining are minimized by regular tooth cleaning and by the use of a good adhesive resin system, intrinsic discoloration is material-dependent and difficult to control by the clinical dentist. Several in vitro accelerated tests for color stability have been developed to predict clinical performance of tooth-colored restorative materials (Council on Dental Materials and Devices, 1977; Powers, Fan & Raptis, 1980; Asmussen, 1981; Burrow & Makinson, 1991; Davis, Friedl & Powers, 1994), but little is known about opacity change of the materials (Powers & others, 1980) and its possible relationship

to color change. The aim of the present study was to determine intrinsic opacity and color changes for three kinds of direct tooth-colored restorative materials using an accelerated test proposed by Asmussen (1981).

METHODS AND MATERIALS

Sample Preparation and Accelerated Test

Five chemically cured composites, seven light-cured composites, and three resin-modified glass-ionomer cements were used, and the most popular shades were selected. They were placed in acrylic rings (inside diameter of 6.0 mm and a thickness of 1.0 mm) on a glass slide, and then covered by another glass slide (Table 1, Figure 1). All materials were used according to the manufacturers' instructions. Five samples were prepared for each material. Light-cured materials were polymerized by 30 seconds of irradiation to both sides of the samples through the glass. As for the resin-modified glass-ionomer cements, the samples were removed from the glass immediately after light curing, and then entirely coated with a thin film of a light-cured unfilled resin (Surface Brightener, Kanebo, Tokyo, Japan), after which the samples were placed between two new glass slides, in order to prevent the specimen surface from deterioration during water storage at 60 °C. The unfilled resin film was light cured for 30 seconds from both sides of the disks through the glass.

After curing, all samples were left at 37 °C for 1 week and held between two glass slides before removal. One week of storage at 37 °C was performed in order to obtain sufficient polymerization of the materials, because a pilot study showed that self-cured composites put in 60 °C water 24 hours after the start of mixing displayed surface roughening, which was shown to increase random surface reflection at the sample surface and to prevent accurate measurements of opacity and internal discoloration. Although resin-modified glass-ionomer cement samples contained water, holding the samples coated with unfilled resin between two glass slides sufficiently prevented dehydration of the samples during storage.

Baseline measurement was performed as described below immediately after removal from the glass slides without polishing the sample surfaces, and then stored in 60 °C distilled water for up to 4 weeks. During sample preparation and measurement, special care was taken not to contaminate the sample surface with direct finger contact and debris, because opacity is very sensitive to surface reflectance, and can easily change by placing a fingerprint on the sample surface with only a light touch.

Color Measurement

Color and opacity measurements were performed weekly on a filter-type photoelectric colorimeter

Table 1. Materials Used

Material	Product Name	Batch #	Manufacturer
Chemically cured composites (shade = U)	Clearfil F	CC-2433 CU-2344	Kuraray, Osaka, Japan
	Clearfil FII	FC-1345 FU-1444	Kuraray
	Concise	2HH2R 2HL2	3M Dental Products, St Paul, MN 55144
	Microrest AP	100831 100831	GC, Tokyo, Japan
	Silar	2EP2 1EP1	3M
Visible-light-cured composites (shade = A2 or U)	APX	135	Kuraray
	Charisma	A20054 Kulzer	
	Estio LC	NT-107-3	GC
	Herculite XR	8 2162	Kerr Mfg Co, Glendora, CA 91740
	Palfique Estelite	467	Tokuyama, Tokuyama, Japan
	Silux Plus	3BK	3M
	Z100	2AG	3M
Resin-modified glass-ionomer cements (shade = A3)	Fuji II LC	L:091211 P:251212	GC
	Fuji II LC (capsule type)		GC
	Vitremer	L:315 P:39	3M

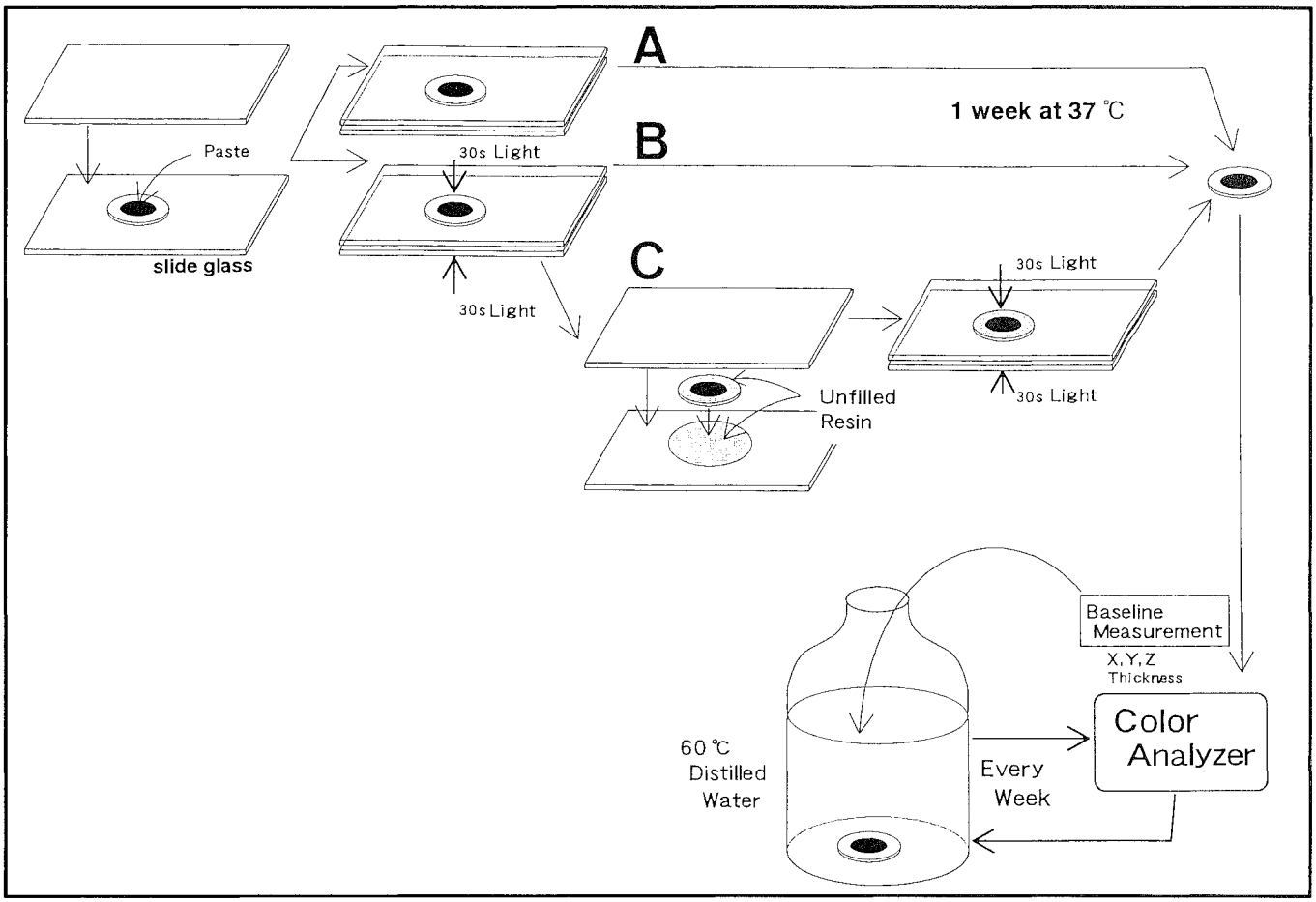

Figure 1. *Schematic illustration of the experimental procedure. A = chemically cured composites; B = light-cured composites; C = resin-modified glass-ionomer cements.*

(CD-270, Murakami Color Research Laboratory, Tokyo, Japan); the calibration for zero and 95.31% reflectance was carried out using a black cavity (X = 0, Y = 0, Z = 0) and a white standard (X = 93.39, Y = 95.31, Z = 112.46) respectively. The colorimeter was equipped with CIE (Commission Internationale de l'Éclairage) standard illuminant C (Judd & Wyszecki, 1975), and the sample port was 6.0 mm in diameter. The samples were illuminated by light beams at an angle of 45 degrees from the normal to the sample surface, and a photoelectric sensor was positioned perpendicularly to the sample surface. The tristimulus values (X,Y,Z) of the samples backed by a black cavity were obtained and transformed to CIELAB values (L*a*b*) (Judd & Wyszecki, 1975).

The L*a*b* color system is a three-dimensional color space, and a given color is expressed as a point in space, which has the coordinates (L*,a*,b*) (Figure 2). Color difference values (ΔE*ab) between baseline measurement and measurements after i week(s) were expressed as a distance between two points in space and calculated as below.

$$\Delta E_i^*ab = [(L^*_i - L^*_0)^2 + (a^*_i - a^*_0)^2 + (b^*_i - b^*_0)^2]^{1/2},$$

where (L^*_0, a^*_0, b^*_0) is the CIELAB value at baseline measurement, (L^*_i, a^*_i, b^*_i) is the CIELAB value at **i** week(s), and *i = 1, 2, 3, or 4.*

The amount of discoloration after a given period was represented by the color difference value (ΔE*ab).

Opacity Measurement

Opacity of the samples was represented by the contrast ratio, which is the ratio of the reflectance of a specimen disk (1.0 ± 0.05 mm thick) when backed by a black standard to that when backed by a white standard of a known reflectance (Council on Dental Materials and Devices, 1977; Craig, 1985) (Figure 3). The contrast ratio (C_R) is defined as $\mathbf{C_R = R_b/R_w}$, where $\mathbf{C_R}$ is the contrast ratio of the sample related to the white background of which reflectance is **R**, $\mathbf{R_b}$ is the reflectance of the sample on the black background, and $\mathbf{R_w}$ is the reflectance of the sample on the white background.

Since the luminous reflectance of the specimen is identical to the tristimulus value Y, the value Y of

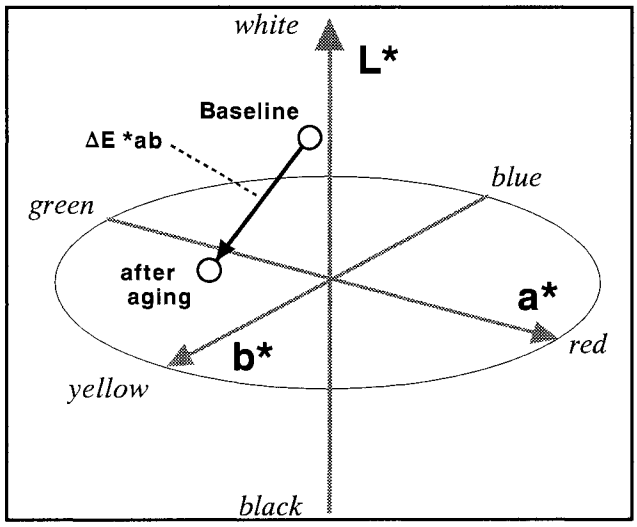

Figure 2. *CIELAB color system: The system is a three-dimensional color space, similar to the Munsell color system. L* represents lightness similar to the Munsell value, and a* and b* are chromatic axes expressing both hue and chroma. Higher L* value means a much lighter shade, higher a* value means more red, and higher b* means a more yellow shade. A color difference between two colors is expressed by the distance between two points in space.*

the sample disks was determined backed with the black cavity and the white standard. The reflectance of the white standard was 0.95. The contrast ratio at the reflectance of the white standard 0.95 (abbreviated as $C_{0.95}$) was calculated as $C_{0.95} = Y_b/Y_w$, where Y_b is the tristimulus value Y of the sample on the black background and Y_w is the tristimulus value Y of the sample on the white background. The contrast ratio represents the hiding power of translucent materials, and takes a value between 0 and 1. The higher the opacity of materials, the higher the contrast ratio.

Since opacity is sensitive to specimen thickness (Powers, Dennison & Lepeak, 1978; Crisp, Abel & Wilson, 1979), and a specimen with a thickness of exactly 1.0 mm is difficult to obtain, a correction for specimen thickness must be made. The thickness of the disks was measured with a micrometer (Mitsutoyo, Tokyo, Japan) to an accuracy of 1 μm, and the contrast ratio at 1.0 mm is estimated by $C_{0.95} = 1-(1-Y_b/Y_w)^{1/L}$, where L is the thickness of the sample in millimeters (Inokoshi & others, 1995).

Statistics

Statistical analysis of the results was performed using parametric one-way ANOVA and Fisher's PLSD test. Correlation between opacity changes and color changes were analyzed by correlation coefficient.

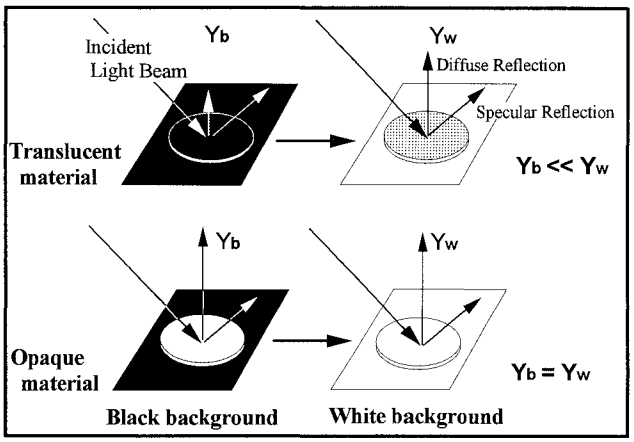

Figure 3. *Schematic illustration of determination of contrast ratio. The contrast ratio is the ratio of reflectance backed by black and white standards. The incident light beam to a sample disk on a black background is partly reflected, and the rest is transmitted and absorbed in the black background. The reflected light consists of specular and diffuse reflections; the latter is determined by a colorimeter as luminous reflectance (Y_b) of the sample with the black background. With the identical sample backed by a white background, the transmitted light is reflected at the white backing and is added to the diffuse reflection from the sample. The increased diffuse reflection is determined as luminous reflectance (Y_w) of the sample backed by the white background. The greater the transparency of the sample disk, the greater the increase of diffuse reflection at the white background: contrast ratio (Y_b/Y_w) takes a smaller value. A complete opaque material hides both the white and black backgrounds, resulting in $Y_b=Y_w$; the contrast ratio = 1.*

RESULTS

Color Changes

Although all materials showed statistically significant color changes after 4 weeks' storage in 60 °C water compared to baseline data ($P < 0.01$), the magnitude was different depending on the products ($P < 0.01$). Light-cured composites showed negligible discoloration even after 4 weeks ($\Delta E^*ab = 0.8 \sim 3.3$) (Figure 4), which was hardly recognized by visual inspection. Almost all chemically cured composites tested discolored gradually to dark yellow or dark brown ($\Delta E^*ab = 8 \sim 10$), which could clearly be recognized, even by visual inspection. Concise showed exceptionally smaller discoloration similar to light-cured composites. Resin-modified glass-ionomer cements showed an abrupt change of color (darkening) at the initial stage, which was also apparent by visual inspection. From 2 to 4 weeks, color difference values increased slightly for Vitremer ($P < 0.01$), and slightly decreased for Fuji II LC (hand-mixed and capsulated) ($P < 0.01$). Statistical comparison of ΔE*ab after 4 weeks among

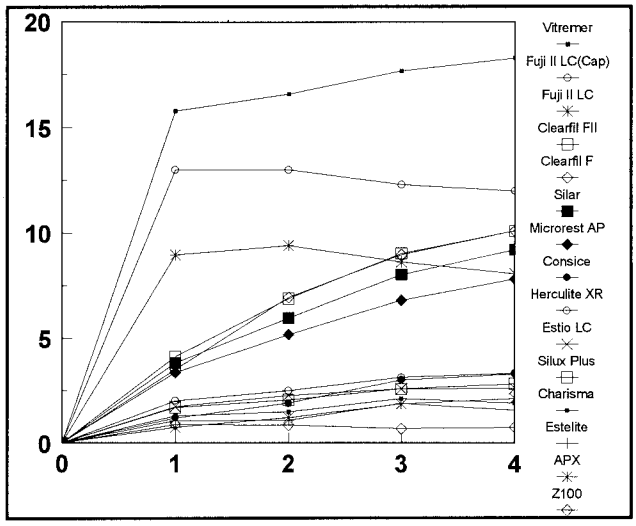

Figure 4. *Color difference values (ΔE*ab) of tooth-colored restorative materials stored in 60 °C water. Resin-modified glass-ionomer cements showed abrupt changes at the first week, whereas chemically cured composites exhibited gradual increases of color. Light-cured composites showed the least color changes.*

products is given in Table 2.

Color changes of all materials generally comprised a decrease of the L* value, slight increase of a* value, and slight to moderate increase of b* value, indicating a similar tendency to discolor to dark yellow or dark brown (Figure 5). The main component of discoloration was a decrease of value (whiteness) in resin-modified glass-ionomer cements, and both darkening and yellowing in chemically cured composites. Light-cured composite showed only a minute increase of yellow and/or decrease of whiteness.

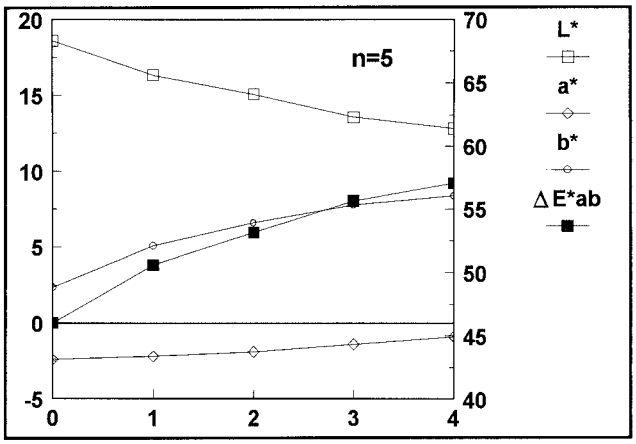

Figure 5. *A representative color change of a tooth-colored restorative. A microfilled chemically cured composite, Silar, displayed gradual increase of discoloration (ΔE*ab), comprising a decrease of L*, slight increase of a*, and increase of b*. Standard deviations of L*, a*, b*, and ΔE*ab were around 0.4, 0.1, 0.4, and 0.1 respectively.*

Table 2. Statistical Comparison of Maximum Color and Opacity Changes after 4 Weeks

Product	ΔE*ab	$\Delta C_{0.95}$	$\Delta C_{0.95}$
Vitremer	18.3	-0.22	
Fuji II LC (capsule type)	13.0*	-0.16*	
Clearfil F	10.1	-0.13	
Clearfil F2	10.1	-0.12	
Silar	9.2		+0.01
Fuji II LC	9.0*	-0.11*	
Microrest AP	7.8		-0.02
Herculite XR	3.3		+0.02
Concise	3.1		-0.01
Silux Plus	2.8		-0.02
Estio LC	2.6		-0.01
APX	2.1		-0.01
Charisma	1.9		-0.01
Palfique Estelite	1.6		-0.01
Z100	0.8		-0.02

Vertical bar indicates no significant difference ($P > 0.05$); * stands for maximum change after 1 week.

Opacity Changes

Light-cured composites showed negligible opacity change even after 4 weeks (Figure 6). Opacity gradually decreased for two macrofilled composites ($\Delta C_{0.95} = -0.12 \sim -0.13$) ($P < 0.01$), but did not for one macrofilled and two microfilled resins (Figure 7). All resin-modified glass-ionomer cements tested showed an abrupt decrease of opacity at the initial stage ($\Delta C_{0.95} = -0.11 \sim -0.20$) (Figure 8) ($P < 0.01$). From 2 to 4 weeks, opacity slightly decreased for Vitremer ($P < 0.01$), but slightly increased for Fuji II LC (hand-mixed and capsulated) ($P < 0.01$). After 4 weeks' storage, surface coatings of the samples remained intact in Vitremer, and the sample's surfaces remained glossy, but almost all the coating was lost in Fuji II LC (hand-mixed and capsulated), with the

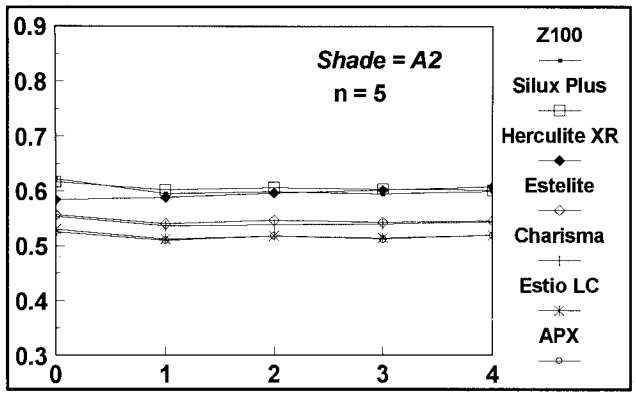

Figure 6. *Opacity changes of light-cured composites. The light-cured composites showed negligible opacity changes. Standard deviations were around 0.01.*

sample surfaces becoming slightly matte in appearance.

For the three resin-modified glass-ionomer cements and Clearfil F and FII, the correlation between opacity decrease and L* decrease was highly significant ($r^2 = 0.999$, $P < 0.001$).

DISCUSSION

Color stability of direct tooth-colored restorative materials has been evaluated using several accelerated tests. Powers and others (1980) reported gradual discoloration and an increase of opacity for resin composites stored at 43 °C and 90% relative humidity. Davis and others (1994) reported a high degree of discoloration of resin-modified glass-ionomer cements in an artificial aging chamber. We measured internal opacity and color changes of three kinds of tooth-colored restorative materials using the accelerated test proposed by Asmussen (1981), storing samples in 60 °C water for 4 weeks. This test was reported to simulate discoloration after 1 year of clinical service, and the requirements for the laboratory apparatus are relatively simple. Asmussen stated that samples were stored in 37 °C water for 24 hours and then polished before being placed in 60 °C water. Although we modified the technique by putting the samples in 60 °C water after 1 week of storage in 37 °C air without surface polishing, the findings on discoloration of chemically cured and light-cured materials coincided well with this previous report (Asmussen, 1981).

A color-difference value (ΔE*ab) less than 3.3 is considered to be clinically insignificant (Ruyter, Nilner & Moller, 1987). Chemically cured composites showed a gradual increase of color difference value, being finally 8 to 10 after 4 weeks, the color changes of which could be clearly recognized by the naked eye; whereas light-cured composites displayed values of less than 4 even after 4 weeks of storage. A new restorative material, resin-modified glass-ionomer cement, showed abrupt discoloration initially and then remained constant afterward, but the magnitude of discoloration was much greater than those of the conventional chemically cured composites tested in the present study.

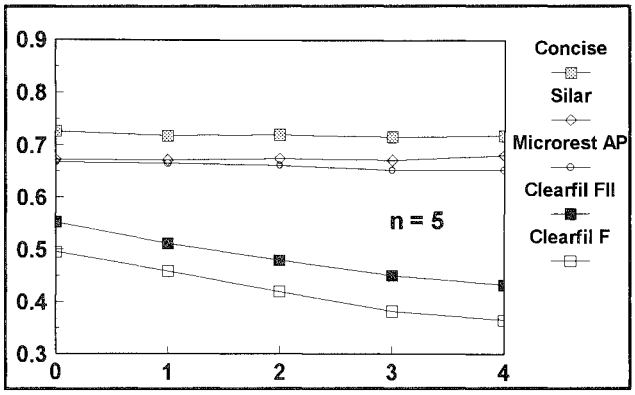

Figure 7. *Opacity changes of chemically cured composites. Two macrofilled composites showed gradual decreases of opacity, whereas the other products displayed minimal changes. Standard deviations were around 0.01.*

All tooth-colored restorative materials tested in the present study showed a similar tendency to become dark yellow or dark brown, the magnitudes of which depended on the product used.

Discoloration of the chemically cured restorative composites must be dependent on composition of the matrix phase, especially the composition of the activator system (Bowen & Argentar, 1971). Concise and Silar are BIS-GMA-based chemically cured restorative composites from the same manufacturer. However, macrofilled Concise showed much less discoloration compared with the microfilled Silar, and the least discoloration among the five chemically cured composites. This is partly due to the smaller matrix content of Concise compared with Silar

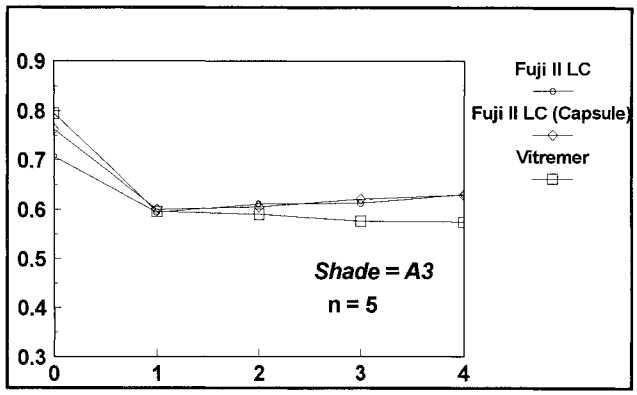

Figure 8. *Opacity changes of resin-modified glass-ionomer cements. Resin-modified glass-ionomer cements showed abrupt decreases of opacity, indicating the tendency to become much more translucent. Standard deviations were around 0.04.*

(Doray, 1994). It is assumed that the resin component is the source of discoloration and that higher volume fractions of this resin result in a greater appearance of discoloration. Another reason might be due to the difference in composition of the activator system between the two products, according to the manufacturer's information.

The opacity of translucent materials is very sensitive to surface roughness, because a roughened surface increases random reflection at the surface, leading to an increase of opacity. The aim of the present study was to determine internal opacity and color changes of tooth-colored restorative materials, so great effort was made to keep the sample surfaces as smooth as possible. For this purpose, the sample surfaces were prepared using clean glass slides

without sample surface polishing, the samples were stored in 37 °C air for 1 week while held between two glass slides to obtain a higher degree of polymerization, and the sample surfaces of the resin-modified glass-ionomer cements were coated with an unfilled light-cured resin to prevent deterioration by water. In spite of these precautions, Fuji II LC showed exfoliation of the surface coating and slight surface deterioration during the 4 weeks of storage in 60 °C water. This surface roughening seems to be the cause of a slight increase of opacity and decrease of color difference value after 2 weeks.

In clinical situations, restorative materials are usually finished and exposed to oral fluids immediately after restoration. If the samples were put in water immediately after curing, discoloration might be much greater than the present results, because of a lower degree of polymerization and greater degree of surface deterioration (Doray, 1994). However, this condition led to surface roughening for some restorative materials, making determination of internal opacity and discoloration difficult. Powers and others (1980) reported increases of opacity of restorative composites stored in a weathering chamber. Since they simulated in vivo discoloration caused by the formation of colored degradation products, and by changes of surface morphology because of wear, increases of opacity seem to be due to surface roughening during the storage in the weathering chamber.

Opacity decreased gradually for the two macrofilled chemically cured composites and abruptly for all the resin-modified glass-ionomer cements tested in this study. Since it corresponded to decrease of lightness, darkening of the materials is caused not only by colored degradation products, but also by a decrease of opacity. Opacity decreases of Clearfil F and FII coincide well with clinical experiences for both materials that showed a gradual darkening and increase of translucency. Conn, Lane, and Duke (1994) reported the darkening of resin-modified glass-ionomer cement restorations during the first 6 months of clinical service, which corresponds to the findings of the present study. Mount (1993) stated that translucency of conventional and resin-modified glass-ionomer cement restorations will improve because the materials continue to mature. Since these materials were composed of numerous inorganic particles and a surrounding matrix phase, the higher the refractive index difference between the two phases, the greater the opacity of the materials, due to multiple reflection and refraction at the matrix-particle interfaces (Figure 9). Opacity decrease might be caused by a change of refractive index of the matrix phase of the materials, leading to a decrease in the refractive index difference between the particles and the matrix. Although the exact mechanism is still not known, the composition of the matrix phase, including the activator system, might be responsible for the changes observed in Clearfil F and FII. The abrupt decrease of opacity and color change of the resin-modified glass-ionomer cements might be due to the accelerated acid-base reaction between the glass particles and polyalkenoic acid, and accelerated free-radical polymerization in 60 °C water. This might result in an increase of refractive index of the matrix, leading to a lessened refractive index difference between the particles and matrix. Color and opacity of resin-modified glass-ionomer cements were stable after the initial change if surface deterioration did not occur. This suggests that resin-modified glass-ionomer cements might be chemically stable after sufficient maturation has taken place.

Light-cured composites were found to be the most color-stable direct restorative material, and their color and opacity stability seems to indicate matrix resin stability of the composites.

CONCLUSIONS

Clinical discoloration is affected by many parameters, including type of restorative materials, clinical manipulation of the material, and diet and oral hygiene of patients. It is also a mixture of extrinsic staining and intrinsic discoloration. The present study suggests that opacity decrease is a factor of intrinsic discoloration in resin-modified glass-iono-

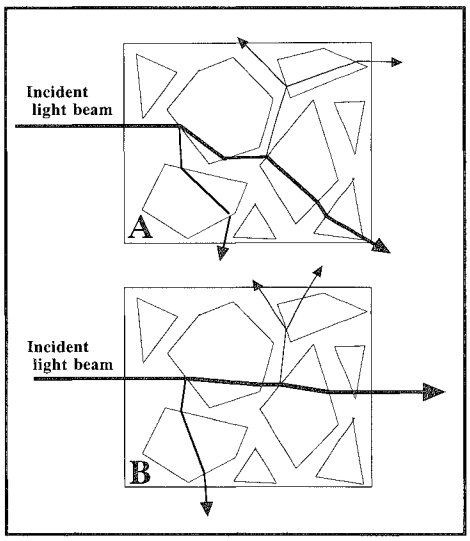

Figure 9. *Possible explanation of opacity change of resin-modified glass-ionomer cements and macrofilled composites. A: Higher refractive index difference between particles and matrix results in severe bending of the light-ray at the particle/matrix interface, which reduces light transmittance. B: Low refractive index difference between particles and matrix allows incident light passing through the material with little interference by the interface between particles and matrix.*

mer cements and some chemically cured composites. During the last decade, chemically cured restorative composites have been replaced by light-cured composites, which are highly color stable. Recently, resin-modified glass-ionomer cements have been introduced. These materials are not a simple hybrid of light-cured composites and conventional glass ionomers, but a new class of materials with different compositions (Doray, 1994). Opacity decrease and darkening of the resin-modified glass-ionomer cements could lead to a clinical suggestion that dentists should select a shade that is lighter than the original tooth color. However, a well-controlled clinical study and a colorimetric discoloration test in 37 °C water are required to decide proper shade selection for the resin-modified glass-ionomer cements to obtain better color match after sufficient maturation of the restorative materials. Further study is also required to examine those parameters that can affect the internal and external discoloration of resin-modified glass-ionomer cements, such as water sorption, degree of conversion, and surface finishing techniques.

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DEPARTMENTS

ABSTRACTS

The editor wishes to thank the second-year Comprehensive Dentistry Residents at the Naval Dental School in Bethesda, MD, for their assistance in the preparation of these abstracts.

Core build-ups and posts. *ADEPT Institute (1993) *ADEPT Report* 4 (4)25-36.

(**ADEPT Report*, Post Office Box 5433, Santa Rosa, CA 95402-5433)

When significant amounts of tooth structure have been lost through caries, fracture, and/or endodontic access, a core or post and core build-up is needed to retain and/or restore the coronal superstructure for crown placement. This article is a literature review of materials and techniques used in core/post and core build-ups. The major topics include: post systems, core materials, fabrication and cementation of cast post and cores, and guidelines for post system selection. Each section includes a discussion on the advantages and disadvantages of the system or material. Instructions on preparation and restoration are also given. Greatest emphasis is given to cast post and cores, and information on achieving a ferrule effect to distribute occlusal forces is included. Very detailed instructions are given from preparation to cementation, and rationale is provided for each step. The article is a wealth of information for the restorative dentist and a good "decision tree." The article's specific recommendations: 1) The single cast post and core with a 360° ferrule is the most advantageous; 2) Duralay, a self-curing acrylic, is best for pattern fabrication; and 3) Composite resin cements such as Panavia 21 should be used for post cementation.

Effect of cavity form on the durability of glass ionomer cement restorations in primary teeth: A three-year clinical evaluation. *Andersson-Wenckert IE & Van Dijken S (1995) *Journal of Dentistry for Children* May-June 197-200.

(*Umeå University, Department of Pedodontics, Cariology and Public Dental Health Service, Umeå, Sweden)

This research study investigated the durability of class 2 glass-ionomer cement restorations in primary molars, with two types of cavity design: a) a tissue-saving approximal microcavity and b) a slightly modified Black's class 2 cavity. Twenty-five children who had approximal carious lesions in at least one primary molar participated. Each patient received at least one preparation of each type, in order to evaluate the cavity types.

Restorations were assessed and scored for quality according to USPHS criteria at baseline (directly after finishing), at 6, 12, 24, and 36 months, or until exfoliation or failure. Caries, anatomical form, marginal adaptation, color match, marginal discoloration, and surface roughness were evaluated. Scores of A (Alpha) or B (Bravo) were considered acceptable, with scores of C (Charlie) or D (Delta) considered unacceptable.

Thirty-eight of the 56 restorations could be evaluated at the 24-month recall and 21 at the 36-month recall. Twenty-three teeth were exfoliated during the 3-year evaluation period. Unacceptable restorations included three that were totally lost. Of the durability and quality of the restorations in the intraindividual comparison, no significant difference was found at either the 24- or the 36-month evaluation.

Results indicated that the extension of the cavity form to create a bulk of restorative material is not of major importance in durability of class 2 restorations in primary molars with well-rounded outer and inner angles. When possible, the saucer-shaped preparation is preferred, resulting in conservation of tooth structure and reduced risk of pulpal exposure.

Fluoride retention of incipient enamel lesions after treatment with a calcium fluoride varnish in vivo. *Attin T, Hartmann O, Hilgers RD & Hellwig E (1995) *Archives of Oral Biology* 40(3) 169-174.

(*University Clinic of Dentistry, Department of Operative Dentistry, D-79106 Freiberg, Germany)

Cariostatic effects of fluoride varnishes have been proven in many clinical studies. Their highest efficacy is on approximal surfaces, but the cariostatic mechanism is unknown.

The purpose of this study was to determine the fluoride retention in plaque-covered and clean incipient enamel lesions after topical application of Bifluorid 12, a CaF_2/NaF (6% calcium fluoride and 6% sodium fluoride) varnish.

Fifty specimens of 3 mm-in-diameter enamel

cylinders were made from extracted bovine incisors, ground flat, and polished. Incipient carious lesions were produced with acidic hydroxyethyl cellulose (pH 4.8 for 3 days). Bifluorid 12 was applied to the flattened surface, and fluoride levels were determined immediately and at intervals of 1 day, 3 days, and 5 days.

Immediately after fluoridation, a considerable amount of KOH-soluble fluoride was bound, but after 5 days 80% was lost. A significant increase of structurally bound fluoride was found in both the plaque-covered and clean enamel. The structurally bound fluoride amount decreased continually from the outermost to the deeper layers, which agrees with previous studies.

The conclusion is that the addition of calcium fluoride to a sodium fluoride varnish leads to an appreciable amount of initially deposited KOH-soluble fluoride on demineralized enamel, but this does not result in improved retention of the KOH-soluble and structurally bound fluoride. Bifluorid 12 (CaF_2/NaF) varnish deposits more KOH-soluble fluoride on the surface of demineralized enamel than other varnishes, but after 5 days fluoride retention is similar to other varnishes.

A structural analysis of approximal enamel caries lesions and subjacent dentin reactions. *Bjorndal L & Thylstrup A (1995) *European Journal of Oral Science* 103(1) 25-31

(*University of Copenhagen, School of Dentistry, Faculty of Health Sciences, Department of Cariology and Endodontics, 20 Norre Alle, DK-2200 Copenhagen N, Denmark)

This article examines the relationship between carious lesions in enamel and their effect on underlying dentin in approximal tooth surfaces ranging in size from enamel lesions to cavitations without dentin exposure. Using quantitative imbibition technique, three new caries lesion characteristics were identified: (1) The highest degree of porosity was always found corresponding to a line from the surface along the enamel rods to the deepest point of penetration or to the apex of the conical lesion; (2) Surface zone thickness (performed on this line paralleling the rods) increased with lesion progression; and (3) The thickness of the central surface zone was significantly greater than in the periphery of the same lesion. Histological examination showed that when lesions contacted the DEJ, discoloration of dentin never exceeded the contact area between the enamel lesion and the DEJ. Consequently, dentin demineralization and translucent dentin reactivity followed dentinal tubules, forming a truncated cone-shaped lesion with the base toward the DEJ. This experiment thus does not support the opinion that caries spreads laterally once in contact with the DEJ. Rather, progression of dentin caries is generated by stimuli transmitted along enamel rods at the periphery of the lesion. These findings indicate that further study is needed into reevaluating what stage of approximal caries development is the appropriate one for restoring these lesions as seen in bite-wing radiographs. Additional study may also be needed concerning handling small, interproximal lesions with methods other than restorations if the decay has not spread as far laterally along the DEJ as previously believed.

Topical fluoride and glass ionomer microhardness. *Diaz-Arnold AM (1995) *American Journal of Dentistry* 8(3) 134-136.

(*University of Iowa College of Dentistry, Department of Family Dentistry, Iowa City, IA 52242)

The purpose of this study was to determine the effect of topical fluoride gels on the microhardness of Ketac-Silver, Photac-Fil, and Fuji II LC. These glass-ionomer materials are frequently utilized in caries-susceptible patients, due to their ability to release fluoride. As high-caries patients are frequently prescribed fluoride supplements ranging from acidic (pH 2.5) to neutral, it is possible that chronic fluoride exposure could contribute to surface disintegration of glass-ionomer restorations in these patients. Fifty samples of each of the restorative materials were prepared per the manufacturer's directions, placed in Teflon cylinders, and stored in distilled water at 37 °C for 48 hours. Ten samples of each material were stored at 37 °C for 36 hours in the following media: NaF (pH 6.7), APF (pH 5.2), SnF (pH 2.4), water (pH 6.7), and lactic acid (a plaque metabolite with pH 2.7). Following storage, a Knoop Hardness Number was obtained via a Micromet II microhardness tester. Analysis of the data indicated that there is no significant difference in the microhardness of Ketac Silver when stored in the five solutions. Exposure of Photac-Fil to APF caused a decrease in surface hardness. A significant decrease in the surface hardness of Fuji II LC occurred when it was exposed to NaF, APF, and lactic acid. This decrease could be correlated to surface degradation, and a degraded surface could retain more plaque and possibly cause problems with the cariostatic effects of fluoride release by the glass-ionomer material.

A combined porcelain onlay/amalgam restoration for an endodontically treated posterior tooth. *Fuhrer N & Helft E (1995) *Practical Periodontics and Aesthetic Dentistry* 7(5) 13-20.

(*Tel Aviv University, The Maurice and Gabriela Goldschleger School of Dental Medicine, Department of Oral Rehabilitation, Tel Aviv, Israel)

This article describes a method of fabricating an esthetic restoration for endodontically treated posterior teeth. Amalgam is utilized as the build-up material, and a porcelain onlay is then fabricated to provide an esthetic final restoration. This technique conserves tooth structure that would normally be removed in preparation for a conventional full crown restoration, and maintains all onlay margins supragingivally.

Upon completion of endodontic therapy all unsupported tooth structure is removed. Gutta-percha from the canal orifices is removed to a depth of 3 mm. Amalgam is condensed into the canals, pulp chamber, and coronal areas after placement of a Toffelmire matrix. Occlusion is verified and the patient is seen again after 24 hours.

The entire occlusal surface is reduced by 2 mm. The amalgam is reduced an additional 1 mm, creating a step between tooth and amalgam and removing the interproximal contact. The occluso-axial line angle is then rounded to create an internal bevel. Porcelain retention holes, 1 mm deep and 2 mm in diameter, are placed in the occlusal surface of the amalgam.

A PVS impression is made, and a provisional restoration placed. The onlay is fabricated incorporating opaque porcelain to prevent amalgam show-through.

The onlay is fitted and the contacts verified. The amalgam is air-abraded, the enamel etched with 37% phosphoric acid for 30 seconds, and the internal surface of the onlay etched with 9% hydrofluoric acid for 4 minutes. 4-META/MMA-TBB is placed on the amalgam, silane on the etched porcelain surface, and the onlay cemented with a dual-cure resin cement.

Fracture toughness testing of visible light- and chemical-initiated provisional restoration resins. *Gegauff AG & Wilkerson JJ (1995) *International Journal of Prosthodontics* 8(1) 62-68.

(*The Ohio State University, College of Dentistry, Section of Restorative and Prosthetic Dentistry, Columbus, OH 43210)

Fracture failure of interim fixed partial dentures is a common clinical problem. Availability of light-initiated resin formulations might offer improved fracture resistance. This in vitro study evaluated the wet and dry fracture toughness of four light- and chemical-initiated resins used for interim fixed partial dentures. The four resins included Triad brand urethane dimethacrylate, Jet polymethyl methacrylate, Trim polyethyl methacrylate, and Unifast LC light-initiated polyethyl methacrylate. The light-cure resins were subdivided into direct and indirect fabrication methods to yield six sample groups. The six sample groups were then divided into wet and dry test environments, creating a total of 12 experimental groups, each group with seven samples. The samples were subjected to wet and dry fracture toughness tests. Fracture toughness was utilized for the study and was felt to produce more clinically relevant results than tensile strength from three-point flexure testing. The Triad material was significantly stronger than the other materials. The wet test environment did not significantly change fracture toughness.

Some physical and biological properties of glass ionomer cement. *Mount GJ (1995) *International Dental Journal* 45(2) 135-140.

(*13 MacKinnon Parade, North Adelaide, 5006 South Australia)

The apparent biological advantages presented by glass-ionomer cements are now being harnessed into a complete review of restorative dentistry and are leading to a very conservative approach in dealing with carious lesions. Studies indicate that components of the cement before and after mixing suggests that both the glass powder and polykenoic acid resist the build up of *Streptococcus mutans*. The cement itself is so highly biocompatible that there is no need to place a sub-lining under a glass-ionomer restoration. The adhesion between tooth structure and cement also results in almost complete prevention of the bacterial microleakage. The ion-exchange layer will develop best if the tooth surface has been cleared of debris, and this can be achieved with a brief application of a 10% solution of polyacrylic acid. It will reduce the surface energy of the tooth, thus encouraging the adaptation of the cement to the cavity walls. Recent studies have shown clearly that the cement can take up fluoride again when the ambient concentration is higher around a restoration than within. Bacterial flora will not thrive on a fluoride-rich surface. Newer versions of glass ionomer have been developed with higher physical properties, and these are expected to be able to withstand occlusal stress for a reasonable period of time. Glass-ionomer cements are the materials of choice for a patient with a high caries rate and for any restoration that is subgingival. They have taken the place of zinc oxide and eugenol as the material of choice.

Influence of toothbrushing, eating and smoking on Dentocult SM Strip mutans test scores. *Schlagenhauf U, Pommerenke K & Weiger R (1995) *Oral Microbiology and Immunology* 10 98-101.

(*University of Tübingen, School of Dental Medicine, Department of Conservative Dentistry, Tübingen, Germany)

The effects of toothbrushing, eating, and smoking on the reproducibility of test scores of a commercially available test system for the quantification of salivary *Streptococci mutans* were evaluated. Thirty subjects participated. For standardization, none received antibiotics within 4 weeks, were told not to perform oral hygiene during the test, and instructed to refrain from eating or smoking in the morning before the experiments.

All evaluated parameters reduce salivary counts. The observation that eating had a stronger effect on the D-SM scores and D-SM colony-forming units per cm^2 than toothbrushing did can be related to the fact that the tongue was not cleaned during the oral hygiene procedures. The decrease after eating is most likely due to a tongue-cleaning effect by ingested food. Smoking induced shifts comparable to those observed after toothbrushing, with the mechanism probably related to the bacteriocidal substances in the smoke.

The test is based on the observation that the number of salivary MS found on the surface of the tongue reflects the number on the tooth surfaces. Due to the principles of the D-SM test (measuring the bandwidths of bacterial counts rather than exact numbers), only the decrease after experimental breakfast was enough to shift the frequency distribution of the D-SM scores. The conclusion is made that eating should be avoided prior to performance of a D-SM test.

Marginal ridge strength of teeth with tunnel preparations. *Strand GV, Tveit AB, Gjerdet NR & Eide GE (1995) *International Dental Journal* 45 117-123.

(*University of Bergen, School of Dentistry, Department of Cariology and Endodontics, Aarstadveien 17, N-5009 Bergen, Norway)

This study investigated how tunnel preparations with different buccolingual dimensions and distances from the marginal ridge affect the strength of the ridge and if a glass-ionomer restoration would also affect strength. Nine groups of 14 extracted maxillary premolars were prepared with a 009 high-speed round bur in a direction perpendicular to the long axis of the tooth, 2 mm below the marginal ridge. The bur was angled approximately 45° in the buccal and in the lingual direction to create a cavity, then mounted at 1 mm below the cementoenamel junction in a block of acrylic resin. The block was mounted in a standardized vise and handpiece setup to drill the preparations with different buccolingual occlusal opening dimensions, 1.5 mm and 2.5 mm, and different distances to the marginal ridge, 0.5 mm and 2.0 mm. Four groups were left unfilled and four corresponding groups were filled with a glass-ionomer cement according to the manufacturer's instruction and stored for 1 week prior to testing. Teeth in the ninth group were not prepared and were the control group. The strength of the marginal ridges was tested in a servo-hydraulic mechanical testing machine using a stepwise, dynamic loading procedure. The results showed that the distance from the marginal ridge is more important with regards to marginal strength than the extension of the opening in a buccolingual direction. The tunnel preparation 2 mm from the marginal ridge does not significantly weaken an otherwise intact tooth.

BOOK REVIEWS

ORAL MANIFESTATIONS OF HIV INFECTION

John S Greenspan, Deborah Greenspan, Editors

Published by Quintessence Publishing Co, Inc, Chicago, 1995. 381 pages, 100 illustrations, $64.00 softbound.

John and Deborah Greenspan have edited an outstanding text based on the proceedings of the Second International Workshop on the Oral Manifestations of HIV Infection, held in San Francisco, California, 31 January through 3 February, 1993. This workshop was dedicated to the significant advances in the field and to the growing recognition by the health professions of the significance of oral HIV-related disease. The workshop also identified areas where more work is urgently needed. This monograph includes most of the papers presented during the oral session of the workshop as well as

three papers added during the preparation of this text.

This text is composed of 51 papers from 124 authors. The authors are world-renowned experts in the area of HIV. Both John and Deborah Greenspan are well recognized and published experts in this area and are an excellent choice to edit this monograph. Chapters are grouped into sections of similar topics. Each topic is covered by one to nine research papers and include the following topics: epidemiology of oral lesions; candidiasis; HIV, saliva, and salivary glands; Epstein-Barr virus and hairy leukoplakia; Kaposi's sarcoma; oral ulcers; HIV in children; periodontal disease; occupational issues; provision of care to the HIV-positive population; and treatment of HIV-associated oral diseases.

This text can be of use to both the specialist who is well versed in the field of HIV disease and to the informed general dentist who wants an in-depth reference. For the specialist, the papers offer complete documentation of the research and a complete bibliography. The depth of the coverage of each topic will satisfy even a highly knowledgeable clinician. The general dentist will find that the organization of the sections allows easy access to the specific area of interest.

I do not recommend this text for an initial review of the oral manifestations of HIV infection. It can only be fully appreciated if the reader has a solid knowledge base on the topic. This text then can provide a thorough supplement to that base. It gives the reader an understanding of the current research as well of the limitations to our knowledge. The topics are thoroughly covered and provide a snapshot of knowledge at this time. Discussion of treatment for the common oral lesions of HIV is summarized. This text is written for those professionals who want a current review of the research in the area of the oral manifestation of HIV disease and not merely a review of the clinical management of lesions.

The section on provisions of care to the HIV-positive population explores the concerns many have in managing this population. This section reviews the costs, risks of exposure to the provider, and the ability of the general dentist to treat these patients. These chapters were particularly interesting because they discussed both sides of the informed-consent issue; i e, providers must inform patients of their HIV status but patients do not have to disclose their status. The argument of dedicated dental clinics for the management of HIV-positive patients is also discussed.

The significance of managing the HIV-infected patient population is an important concern to all dental professionals. This text will add significantly to the recognition and understanding of the management of the oral manifestation of HIV disease.

I very strongly recommend this text for the specialist and those general dentists interested in research in HIV-related oral manifestations. With this understanding, information is easily found. This is not an entry-level text to this topic and was not designed as such. It accomplishes its goal of being an accurate review of the proceedings of the Second International Workshop on the Oral Manifestations of HIV Infection.

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QUINTESSENCE OF DENTAL TECHNOLOGY 1995

John A Sorensen, DMD, Editor

Published by Quintessence Publishing Co, Inc, St Louis, 1995. 217 pages, 400+ illustrations, $56.00 softbound.

Quintessence of Dental Technology (QDT), is published annually by Quintessence Publishing Company. The editor for this 18th volume is John Sorensen, the chairman of fixed prosthodontics at the University of Oregon. The book is similar in design to a monthly dental journal in that it is a collection of articles, each written by a different author. Some of the articles are scientific in nature and others are more technique oriented. The intention is to increase the readers' knowledge and use of state-of-the-art materials and techniques in dental restorative technology.

The book deals specifically with fixed and removable restorations. Much like a monthly journal, articles of similar content are grouped together. Sections include new technology, implantology, removable prosthodontics, ceramics, research, and technical tips. The book offers an international perspective, presenting articles submitted from the United States, Europe, Canada, and Japan.

In typical Quintessence fashion, the book is also a photodocumentation of excellent dentistry. It contains over 400 color photographs or illustrations to compliment 19 articles. The articles are well written, understandable, and easy to read. There is a superbly illustrated article on removable partial denture design; however, it contains no references.

Most, but not all, of the other articles are well referenced. Surprisingly, a few errors in the text and photographs were noticed throughout the book.

This text is a must for dental laboratories and restorative specialists. It presents current topics to keep both dentists and laboratory technicians aware of developments in restorative dentistry. It can easily be scanned for articles of interest or pertinence. Some articles will stimulate thought and generate enthusiasm, while other articles may be skipped altogether, depending on the reader's interests and scope of practice. The book serves as an excellent reference for new techniques and is invaluable as a vehicle for improving communication between the dentist and the laboratory technician.

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IMPLANT-SUPPORTED PROSTHESES: OCCLUSION, CLINICAL CASES AND LABORATORY PROCEDURES

Vincente Jiménez-López

Published by Quintessence Publishing Co, Inc, Chicago, 1995. 256 pages, 679 illustrations. $140.00.

This book is written in easy-to-read large type with the chapters laid out in outline form. The color illustrations meet the high standards typical of Quintessence publications.

The subject of occlusion as applied to the variety of patient presentations in which implant therapy is part of the treatment plan is a daunting topic that needs to be explored, and Dr Jiménez-López is to be congratulated for his effort in summarizing his personal philosophies and their clinical application. Despite his courage in presenting his beliefs, however, there are several reasons to exercise caution in accepting many of the statements and techniques demonstrated in this book.

First and foremost, the reader would benefit from end-of-chapter references, especially in Chapters 1-5. Occlusion is a subject beset with a variety of sometimes conflicting theories and philosophy. All who practice restorative dentistry have the responsibility to justify their personal philosophy of occlusion. Authors of textbooks who champion specific philosophies must justify their conclusions. Additionally a text purporting to present a given subject should also be responsible to indicate ongoing debate and opposing philosophies. This book fails to provide either.

Much of the book is anecdotal in presenting a number of the author's personal treatment cases. These cases are demonstrative but not all inclusive of the subject of occlusion in implant-supported prostheses. Some of the material is very confusing, such as the author's use of tripod occlusion as opposed to cusp tip-to-fossa occlusion utilizing semiadjustable articulators and then relying on intraoral adjustments to achieve the final result. Other clinical treatment presentations are both frustrating and potentially misleading. Most frustrating is that the implicit subject of the book, the occlusion on the implants and how it was planned, justified, and achieved, is not addressed. The author fails to present long-term results or the maintenance of the final occlusal schemes. Cases that employ precision attachments connecting natural teeth to anterior and posterior implant-supported restorations are highly controversial. The author should at least discuss the controversy and perhaps discuss alternative and perhaps more-accepted treatment modalities.

That occlusion in dentistry, let alone as applied to implant-supported restorations, is the focus of immense unresolved controversy and ongoing debate is an understatement. While there are numerous occlusal philosophies that enjoy various degrees of advocacy and apparent success when applied to specific clinical situations, there is no conclusive scientific evidence to support the claims of any of them.

Restorative dentists need a reliable, periodically updated overview text that deals comprehensively and candidly with current philosophies of occlusion and their application in concert with implant therapy. Unfortunately this book cannot be recommended in this respect for either general dentists or prosthodontists.

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CLINICAL MANAGEMENT OF TEMPOROMANDIBULAR DISORDERS AND OROFACIAL PAIN

Richard A Pertes and Sheldon G Gross

Quintessence Publishing Company, Inc. Chicago, 1995, 368 pages, 280 illustrations, $58.00.

Although there has been some abatement in the fervent nature of the diagnosis and treatment of disorders associated with the temporomandibular

joint, those conditions continue to be an important consideration in dental practice. Drs Pertes and Gross have compiled an impressive and moderately priced text that addresses many of the concerns associated with temporomandibular disorders.

The text is divided into four sections: "Diagnostic Foundations," "Temporomandibular Disorders," "Management of Temporomandibular Disorders," and "Orofacial Pain of Non-Masticatory Origin." Each section contains four to six chapters by various contributors on specific topics. The chapter contributors represent a broad range of practitioners, from physical therapists to dentists to physicians. In general, the various chapters appear to be consistent and referenced with current literature and accepted scientific knowledge regarding TMD. This soft-bound book is produced in black and white, without the impressive color illustrations that we have come to expect from Quintessence, but it is also very competitively priced at $58.00. The illustrations, which include both photographs and line drawings, are well-produced and support and expand the written material.

The initial section on diagnosis contains monographs on anatomical considerations for both the TMJ and the cervical spine and general concepts of pain and pain management. Possibly the most valuable chapter for practitioners dealing with TMD is the description of pain patients in general. There is a very good depiction of pain behavior and the pain-prone personality and a brief discussion of clinical screening for psychological dysfunction.

In the second section, specific disorders of the temporomandibular region are described in conjunction with various imaging techniques for the joint. Although there is a chapter on muscle disorders, the predominant emphasis is placed upon afflictions of the joint itself. The management section includes nonsurgical regimens such as occlusal appliances, pharmacotherapy, and physical therapy along with behavioral therapy. TMJ surgery is discussed in one chapter, and the authors correctly point out that such surgery is indicated only in specifically defined cases. The chapter on long-term management contains a series of case studies that demonstrate restorative and orthodontic treatment to stabilize the occlusion following other therapy such as disk repositioning. The final section contains information on pain disorders of the head and neck unrelated to the TMJ and is quite helpful in differentiating other conditions from those associated with TMD.

In the preface, the authors ask, Why another text on temporomandibular disorders? This is a reasonable question, as there are many such texts on the shelf. They state that their goal is to address only those concepts and treatment methods supported by current scientific documentation. In general, they have succeeded in that quest. Many of the fringe and unsupported elements of TMD therapy are not discussed or only briefly touched upon. This is a good text for both clinicians and students, requiring reasonably well-balanced information on these specific topics.

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COMPLETE DENTAL BLEACHING

Ronald E Goldstein and David A Garber

Published by Quintessence Publishing Co, Inc, Chicago, 1995. 176 pages, 202 illustrations. $68.00.

This book is a valuable contribution to the dental profession and lives up to its title, *Complete Dental Bleaching*. It is indeed the most comprehensive text on those matters related to bleaching of teeth with vital pulps and those which are pulpless. It puts into perspective the role of bleaching in today's dental practice.

The section on the chemistry of bleaching is much more than it sounds, providing not only the chemistry involved when we bleach teeth but also defining those changes in the tooth structure resulting from bleaching. It also presents excellent information on the effects of "overbleaching," that is, the use of the bleaching compounds beyond the time it takes to obtain maximum whiteness. Both nightguard and in-office vital bleaching are presented in a logical, straightforward, and informative manner. The book also has a complete section on the bleaching of pulpless teeth.

References are provided at the conclusion of each of the seven chapters, and there is an excellent index. The color plates are excellent, which is typical of this publisher.

From my perspective, all dentists currently providing bleaching services, as well as any who may be contemplating such treatment, should have this book in their libraries.

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CORRECTION

An incorrect reference was published in the article found in Volume 20(6), Pages 241-245, entitled "Mechanical Properties and Clinical Performance of a Gallium Restorative Material" by J W Osborne and J B Summitt. The incorrect reference is on Page 245, and should read as follows:

MASH LK, MILLER BH, NAKAJIMA H, COLLARD SM, GUO IY & OKABE T (1993) Handling characteristics of gallium alloy for dental restoration *Journal of Dentistry* **21** 350-354.

We regret the error.

ANNOUNCEMENT

GOLD FOIL COURSE

There will be a practical Gold Foil course at the University of Washington on 16-20 September 1996. The participation is limited to 12 people. For more information, please contact either:

Dr Warren K Johnson
3107 W McGraw
Seattle, WA 98199
(206) 282-2416

or

Dr Bruce Walter
1306 N 175th Street
Seattle, WA 98133
(206) 546-2322

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Manuscripts

Submit the original manuscript and one copy; authors should keep another copy for reference. Type double spaced, including references, and leave margins of at least 3 cm (1 inch). Supply a short title for running headlines and a FAX number for the corresponding author. Spelling should conform to *American Heritage Dictionary of the English Language,* 3rd ed, 1992. Nomenclature used in descriptive human anatomy should conform to *Nomina Anatomica,* 6th ed, 1989; the terms *canine* and *premolar* are preferred. The terms *vestibular*, *buccal*, *facial*, and *lingual* are all acceptable. SI (Système International) units are preferred for scientific measurement, but traditional units are acceptable. Proprietary names of equipment, instruments, and materials should be followed in parentheses by the name and address, including ZIP code, of the source or manufacturer. The editor reserves the right to make literary corrections. Research (original) papers must include a one-sentence **Clinical Relevance** statement, as well as **Summary**, **Introduction**, **Methods and Materials**, **Results**, **Discussion**, and **Conclusion** sections. Clinical papers should contain at least the following: **Purpose**, **Description of Technique** or **Solution** along with materials and potential problems, and a **Brief Summary** outlining advantages and disadvantages.

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

References

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EDITORIAL

CLINICAL ARTICLES

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