OPERATIVE DENTISTRY

AMERICAN ACADEMY OF GOLD FOIL OPERATORS

ACADEMY OF OPERATIVE DENTISTRY

winter 1989 • volume 14 • number 1 • 1-56

(ISSN 0361-7734)

OPERATIVE DENTISTRY

WINTER 1989 • VOLUME 14 • NUMBER 1 • 1-56

Aim and Scope

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

Publisher

Operative Dentistry is published four times a year: Winter, Spring, Summer, and Autumn, by:

Operative Dentistry, Inc
University of Washington
School of Dentistry, SM-57
Seattle, WA 98195 USA

POSTMASTER: Send address changes to this address. *Operative Dentistry* is the official journal of the American Academy of Gold Foil Operators and the Academy of Operative Dentistry.

Subscriptions

Yearly subscription in USA and Canada, $45.00; other countries, $55.00 (sent air mail); dental students, $25.00 in USA and Canada; other countries, $34.00; single copy in USA and Canada, $13.00; other countries, $16.00. For back-issue prices, write the journal office for quotations. Make remittances payable (in US dollars only) to *Operative Dentistry* and send to the above address.

Contributions

Contributors should study the instructions for their guidance printed inside the back cover and should follow them carefully.

Permission

For permission to reproduce material from *Operative Dentistry* please apply to Operative Dentistry, Inc, at the above address.

Second class postage paid at Seattle, WA.

Editorial Office

University of Washington, School of Dentistry, SM-57, Seattle, WA 98195, USA.

The views expressed in *Operative Dentistry* do not necessarily represent those of the Academies, or of the Editors.

EDITORIAL

Advertising of Dental Products: In Whose Interest?

Advertising is a way of life throughout the world. We are constantly addressed by manufacturers hawking their wares in all types of printed media was well as over the airwaves. Manufacturers try to convince us that their products are the best, most cost-effective, and that none other could possibly satisfy our needs. As dentists, we are deluged with all types of claims about the products we use in the practice of dentistry. Over the past 20 years or so, the amount of advertising of dental products has grown at an alarming rate. We all receive a number of "free" publications, many of which are only product advertisements. The questions that arise concerning these advertisements are: Just how valid are they? Are the products being sold all that the manufacturer claims them to be?

It is true that technology is continuing to change at a pace so rapid that it is almost impossible to keep current with the multitude of products coming on the market or being modified and the new procedures associated with other technological advances. Unfortunately, a very high percentage of dentists rely upon dental advertisements to make their product selections. With all the advertising appearing in reputable journals, such as the *Journal of the American Dental Association*, many dentists are lulled into a false sense of security when they fall for many of the advertising claims made. Many think the American Dental Association only prints advertisements which are factual and true. I find that many also believe that the Council on Materials and Devices regulates the advertising claims made by the manufacturers, which of course is not true. As a result, many dentists rely almost entirely on advertisements and the salesperson representing the products in question. The choices they make are frequently not in their best interests.

Some advertisements are downright misleading! Dentists must constantly be on our guard to ensure that we make prudent choices concerning the materials we use. A good example is a recently promoted base/liner product which is advertised to provide "all the protection of a glass ionomer. 12 times faster." This product is a light-cured-resin and yet I know that many dentists bought the product with the impression that they were buying a glass-ionomer product. What does "all the protection of a glass-ionomer" mean? Shouldn't the manufacturers be required to tell us what they mean? If it provided all the benefits of a glass-ionomer, I would expect that it would have a more durable bond than those achieved with a resin bonding agent, and I would expect the product to release fluoride. It seems to me that such misleading claims should be banned.

Another frustrating problem for the dentist is the large number of products that are modified over a period of time and yet still carry the same trademark. Many products currently on the market are of an entirely different composition or chemistry than the original. It seems logical to me that manufacturers should not be allowed to totally modify a product and still continue to market it as being the same as the original, but improved. It would be preferable to rename the products and be more honest about it.

The time is here for the American Dental Association to take a bold step and establish a Council on Advertising of Dental Materials and Devices. Such a council should have the authority to grant a seal of approval for advertisements which are truthful and not misleading. It would provide untold benefits for those dentists who rely on the advertising claims as a basis for selecting a particular product or device. Comment?

DAVID J BALES, DDS, MSD
University of Washington
School of Dentistry, SM-56
Seattle, WA 98195

©OPERATIVE DENTISTRY, 1989, 14, 2-7

ORIGINAL ARTICLES

Disinfection of Visible-light-curing Devices

G B CAUGHMAN • W F CAUGHMAN
N NAPIER • G S SCHUSTER

Summary

Assays were developed for evaluating disinfection of visible-light-curing devices which were deliberately contaminated with an indicator organism, *Streptococcus mutans*, and devices which were contaminated during routine clinical use. Results indicated that wiping the surface with a substituted phenolic agent followed by wrapping in gauze saturated with the same solution was most effective for disinfecting the device handle and tip surfaces. Longer contact with the disinfectant is recommended to ensure virucidal/sporicidal action.

***Department of Oral Biology/Microbiology
Medical College of Georgia
School of Dentistry
Augusta, GA 30912-0200**

****Departments of Oral Biology/Microbiology and Restorative Dentistry
Medical College of Georgia**

*Gretchen B Caughman, PhD, assistant professor

**W Frank Caughman, DMD, MEd, associate professor

*Nancy Napier, RDH, dental student

**George S Schuster, DDS, MS, PhD, Ione and Arthur Merritt Professor

INTRODUCTION

The exposure of dentists, auxiliaries, and patients to a variety of infectious agents is a danger which was recognized but generally overlooked for many years in clinical practice. The recent emergence of acquired immunodeficiency syndrome (AIDS) and its associated infections has brought the problem to the attention of the profession and led to the development of a variety of infection-control procedures for various aspects of clinical dentistry. Molinari and others (1987) evaluated surface disinfection and found that a number of agents, especially iodophors, were quite useful. For many of the instruments and materials used clinically, such as periodontal probes and surgical instruments, the need for sterilization/disinfection has been long recognized. Until recently, however, other items tended to be overlooked because they either were not obvious sources of infection, presented special problems of disinfection, or were relatively recent additions to our armamentarium. These include dental radiograph units, water lines, dental impressions, and laboratory pumice (White & Glaze, 1979; Scheid & others, 1982; Fitzgibbon & others, 1984; Rowe & Forrest, 1978; Williams & others, 1985; Kelstrup, Funder-Nielsen & Theilade, 1977; Grant & Walsh, 1975; Katberg, 1974; Englehardt, 1986; Borneff, 1986).

Recently we have shown (Caughman & others, 1986) that light-curing devices are a potential source of transmission of infectious diseases due to contamination of the wand, which directly contacts oral structures, and the handles, which become contaminated with saliva from the operator's or assistant's hands or gloves. Although many of the newer designs feature removable, autoclavable wands, the handles still present a disinfection problem since they do not lend themselves readily to such treatment. Furthermore, due to their frequent use in a busy practice, the wands often are not removed and autoclaved, so transmission of infectious agents remains a real possibility. The present study utilized assays which included both deliberately and clinically contaminated devices to evaluate the efficacy of several disinfection procedures.

MATERIALS AND METHODS

Development and assessment of disinfection protocols

The initial laboratory study was designed to evaluate several disinfection agents and their use in preventing the recovery of viable bacteria from deliberately contaminated light-curing device handles and wands. The procedure employed is outlined in the figure. The surfaces of the handles and tips of two pen-type devices (Command, Sybron/Kerr, Romulus, MI 48174) and two pistol-grip devices (Visilux 2, 3M Dental Products, St Paul, MN 55144) were sterilized by UV irradiation using a germicidal lamp for 60 minutes, after which 20 mm^2 sites were inoculated with 2.6 x 10^7 colony-forming units (CFU) of *Streptococcus mutans*, strain 6715, which is resistant to 500 μg/ml streptomycin. This organism was chosen as an indicator organism because its resistance to disinfection procedures is average for bacterial members of the oral flora and because its antibiotic resistance made it readily recoverable. The sites were air-dried for 15 minutes and then subjected to one of several possible disinfection regimens. After completion of the procedure, residual bacteria were recovered by quantitative rinsing in 100 μl of Todd-Hewitt broth containing 500 1g/ml streptomycin, and diluted to 1.0 ml in the same medium. One hundred μl of this dilution was plated onto Todd-Hewitt agar containing streptomycin, then incubated for 24 hours at 37 °C in an atmosphere of 95% N_2 - 5% CO_2. The resulting bacterial growth was quantitated in colony-forming units.

Five disinfection agents were evaluated: a commercial 2% glutaraldehyde solution (Omnicide, Omnitec Medical Corp, Laguna Hills, CA 92653), a commercial substituted phenolic solution (LpH, Vestal Laboratories, St Louis, MO 63110), 70% ethanol, a dishwashing liquid (Ivory Liquid, Procter & Gamble, Cincinnati, OH 45201) made to 1% solution, and distilled water. Agents were applied to the sites as a wipe or as a 10-minute wrap with saturated cotton gauze, as indicated.

Procedure for deliberate contamination/disinfection assay

Sterilize wands and handles by UV irradiation

↓

Inoculate 20 mm^2 sites with 2.6 x 10^7 cfu *S. mutans* (strain 6715)

↓

Air dry for 15 minutes

↓

Disinfect using wipe or wrap or do not treat (control)

↓

Recover residual bacteria in Todd-Hewitt broth with streptomycin

↓

Vortex and plate aliquot onto T-H agar

↓

Incubate for 24 hours at 37 °C in anaerobic atmosphere (95% N_2 - 5% CO_2)

↓

Quantitate in CFU

Recovery and evaluation of microorganisms from devices after clinical use

The efficacy of the disinfection protocols in a clinical setting was tested by assaying light-curing devices after their use in restorative dentistry teaching clinics at the Medical College of Georgia before and after disinfection. To assess the extent of microbial contamination prior to disinfection, selected areas of the handles and wands of units which had been subjected to routine use within the past three hours were cultured by swabbing with sterile, distilled water. The swabs were then submerged in 10 ml of Todd-Hewitt broth (without streptomycin) and agitated on a vortex mixer. From each sample (pre- and postdisinfection) 5 ml of broth was removed and incubated at 37° C under anaerobic conditions (95% N_2 - 5% CO_2); the remainder was incubated at 37° C under aerobic conditions. After 24 hours the tubes were observed for microbial growth and aliquots were streaked onto Todd-Hewitt agar and incubated for 24 hours in either the anaerobic or aerobic atmosphere. All positive cultures were evaluated as to colony morphology and cells from each colony type were examined microscopically after gram staining.

RESULTS

The results of the assays to evaluate disinfection after deliberate microbial contamination are summarized in Table 1. After innoculation and air-drying, viable *S. mutans* was recovered from all control sites which received no further treatment. Both 2% glutaraldehyde and the substituted phenolic solution were effective in eliminating all viable bacteria from the sites when they were used in a 10-minute wrap or a wipe of saturated cotton gauze. A 10-minute wrap using 70% ethanol also appeared to eliminate any viable bacteria from all sites, but when used as a wipe it was not effective in disinfecting the wands, nor were wipes of dishwashing liquid or distilled water reliable. These latter procedures, particularly the distilled water wipe, reduced the contamination (as evidenced by our lack of recovery of organisms from some samples) and thus emphasizes the role, however inadequate, that mechanical removal of microorganisms can play in disinfection.

The results of the inoculation/disinfection assays indicated that for some agents a wipe procedure was sufficient to disinfect the instruments contaminated with *S. mutans*. However, a combined wipe-and-wrap protocol was established for evaluating disinfection of the devices after clinical use, since the combination treatment would provide a more rigorous disinfection of resistant organisms and should lead to less variability in results among different dental personnel while still being easily adapted to a busy dental practice. Eight to nine percent of the wands and handles cultured after clinical use exhibited microbial contamination (Table 2), a result consistent with previous studies indicating that contamination is very common during routine use (Caughman & others, 1986). Most of these samples exhibited microbial growth under anaerobic as well as aerobic conditions. The cultured microorganisms exhibited colony morphology and microscopic characteristics typical of oral and skin flora, predominantly gram-positive cocci and rods and a few gram negative rods.

No microbial growth was observed in any samples from sites treated with the phenolic solution. After 2% glutaraldehyde treatment, one wand site remained positive for both anaerobic and aerobic growth while all handle sites were negative. Disinfection with 70% ethanol was least effective in that two wand sites and one handle site remained positive for growth after treatment.

DISCUSSION

Light-curing devices pose a particular problem in infection control because of the wand's microscopically rough surface, which may contact oral tissues. The current study examined various disinfection agents and techniques for their effectiveness and suitability in disinfecting these units following deliberate contamination with a typical oral microorganism, *S. mutans*. These results then were used to design protocols for testing the efficacy of disinfection procedures on devices contaminated during clinical use. It should be realized that these latter studies were limited in that the only microorganisms detected were those capable of growing on an all-purpose medium under the described conditions. Thus, the efficacy of the protocols against bacteria or other infectious agents which require different cultivation techniques was not determined.

Results of both deliberate-contamination and clinical-use assays indicated that 70% ethanol was not a suitable disinfectant even in a combination wipe-wrap technique, although it did have some efficacy on the monoinfected sites (Table 1) as well as on the clinically contaminated instruments (Table 2). This inconsistency is not surprising, as it is well recognized that 70% ethanol is not a reliable disinfectant (Molinari & others, 1987); however, that fact warrants re-emphasis here since one of the manufacturers of the light-curing devices recommended it be used as a wipe to clean their units. Ethanol apparently did disinfect some of the sites, but the results may be dependent on the degree of contamination and/or the length of time between use and sampling, variables we were unable to control totally in the clinical-use assays. Ethanol's limited disinfection capacity may be incapable of dealing with a large microbial load, especially if the organisms are dried onto a surface.

Both the substituted phenolic solution and 2% glutaraldehyde appeared to prevent recovery of viable *S. mutans* from all sites in the deliberate-contamination assays. However, in the clinical-use assays one wand site remained positive for microbial growth (a gram-positive coccus) after 2% glutaraldehyde treatment. The substituted phenolic solution was effective at all sites cultured in this study. This agent contains a detergent which may improve its cleaning ability and enhance its capacity to reach microorganisms on the microscopically rough wand tips. While in an experimental sense one failure of a recognized good disinfectant may not seem important, it could have clinical significance. A gram-positive coccus such as that isolated from the glutaraldehyde-treated site is not exceptionally resistant to disinfection, and if such labile forms can survive, so can more resistant pathogens. Thus the need for considerable care in disinfecting any surface, even with good disinfectants, is evident.

A wrap technique has been described previously as an effective method for disinfecting

Table 1. Recovery of Inoculated S. mutans *Following Disinfection*

Disinfection Agent	Treatment	Sites Postitive/Total Cultured Wands	Handles
Control	no treatment	4/4	4/4
2% glutaraldehyde	wipe	0/4	0/4
	10-min wrap	0/4	0/4
Substituted phenolic solution	wipe	0/4	0/4
	10-min wrap	0/4	0/4
70% ethanol	wipe	4/4	0/4
	10-min wrap	0/4	0/4
1% dishwashing liquid	wipe	0/4	1/4
Distilled water	wipe	2/4	2/4

Table 2. Recovery of Microorganisms from Light-curing Devices after Clinical Use

Disinfection Agent	Culture Conditions	Sites Positive/Total Sites Cultured: Wands Pre-Disinfection	Wands Post-Disinfection	Handles Pre-Disinfection	Handles Post-Disinfection
70% ethanol	Aerobic	6/6	1/6	6/6	1/6
	Anaerobic	5/6	2/6	6/6	0/6
Substituted phenolic solution	Aerobic	5/6	0/6	5/6	0/6
	Anaerobic	4/6	0/6	3/6	0/6
2% glutaraldehyde	Aerobic	5/6	1/6	5/6	0/6
	Anaerobic	4/6	1/6	2/6	0/6

metal instruments (Christensen, 1977). Using a curved, smooth metal rod as an instrument, she showed that a variety of non-spore-forming organisms were killed after two minutes of contact with a glutaraldehyde disinfectant, while six hours of contact was necessary to destroy spore-forming bacilli. The inactivation of viruses was not specifically addressed in either Christensen's study or our work. Viruses have a broad spectrum of susceptibility to disinfectants; enveloped viruses such as herpes simplex virus and human immunodeficiency virus are generally more susceptible than nonenveloped viruses such as piconaviruses, parvoviruses, and hepatitis B virus. Bond and others (1983) have shown that hepatitis B virus infectivity in dried human plasma was destroyed by 10 minutes of exposure to intermediate-level disinfectants (e g, 70% isopropyl alcohol) and high-level disinfectants (e g, 2% aqueous glutaraldehyde). These results indicated that hepatitis B virus is not as resistant to inactivation as once thought, and certainly is not nearly as resistant as bacterial spores. This study supports the current assumption that disinfection methods which have proven sporicidal activity should have adequate virucidal activity as well.

Although Christensen's study dealt only with disinfection of smooth surfaces, she recognized that surface roughness might present additional disinfection problems by providing a shelter for microorganisms.

CONCLUSION

Our results emphasize that microroughness of the wand tips is a factor in the ease of disinfection, and for this reason a combination of mechanical cleaning followed by disinfection or sterilization is advisable. With these considerations in mind, the following procedures are recommended:

Both the handles and wands of all light-curing units should be disinfected after each use.

Autoclavable wands should be removed and sterilized.

The handles and nonautoclavable wands should be wiped and then wrapped for at least 10 minutes with a high-level disinfectant such as the substituted phenolic or 2% glutaraldehyde agents used in this study.

The wraps should remain in place until the unit's next use, at which time the wand should be unwrapped and wiped with distilled water to remove any disinfectant residue.

Disposable protective coverings could be used on the handles providing they do not interfere with the unit's cooling mechanism.

ACKNOWLEDGMENTS: This study was supported in part by NIH 5-T35-DEO7143.

(Received 5 August 1987)

References

BOND, W W, FAVERO, M S, PETERSEN, N J & EBERT, J W (1983) Inactivation of hepatitis B virus by intermediate-to-high-level disinfectant chemicals *Journal of Clinical Microbiology* **18** 535-538.

BORNEFF, M (1986) Hygiene-problems in dental practice focused on dental units *Zentralblatt für Bakteriologie Mikrobiologie und Hygiene* B **183** 130-152.

CAUGHMAN, W F, O'CONNOR, R P, VOLKMANN, K R, SCHUSTER, G S & CAUGHMAN, G B (1986) Visible-light-curing devices: a potential source of disease transmission *Operative Dentistry* **12** 10-14.

CHRISTENSEN, R P (1977) Effectiveness of glutaraldehyde as a chemosterilizer used in a wrapping technique on simulated metal instruments *Journal of Dental Research* **56** 822-826.

ENGELHARDT, J P (1986) Prosthetic appliance and dental impression taking viewed from a hygienic standpoint *Zentralblatt für Bakteriologie Mikrobiologie und Hygiene* B **183** 179-195.

FITZGIBBON, E J, BARTZOKAS, C A, MARTIN, M V, GIBSON, M F & GRAHAM, R (1984) The source frequency and extent of bacterial contamination of dental unit water systems *British Dental Journal* **157** 98-101.

GRANT, A A & WALSH, J F (1975) Reducing cross-contamination in prosthodontics *Journal of Prosthetic Dentistry* **34** 324-328.

KATBERG, J W (1974) Cross-contamination via the prosthodontic laboratory *Journal of Prosthetic Dentistry* **32** 412-419.

KELSTRUP, J, FUNDER-NIELSEN, T D & THEILADE, J (1977) Microbial aggregate contamination of water lines in dental equipment and its control *Acta Pathologica Microbiologica Scandinavia B* **85** 177-183.

MOLINARI, J A, GLEASON, M J, COTTONE, J A & BARRETT, E D (1987) Comparison of dental surface disinfectants *General Dentistry* **7** 171-175.

ROWE, A H R & FORREST, J O (1978) Dental impressions: the probability of contamination and a method of disinfection *British Dental Journal* **145** 184-186.

SCHEID, R C, KIM, C K, BRIGHT, J S, WHITELY, M S & ROSEN, S (1982) Reduction of microbes in handpieces by flushing before use *Journal of the American Dental Association* **105** 658-660.

WHITE, S C & GLAZE, S (1979) Interpatient microbiological cross-contamination after dental radiographic examination *Journal of the American Dental Association* **96** 801-804.

WILLIAMS, H, FALKLER, W Jr, HASLER, J & ROMBERG, E (1985) The persistence of contaminant bacteria in dental laboratory pumice *Journal of Dental Research* **64** *Abstracts of Papers* p 258 Abstract 752.

 ©OPERATIVE DENTISTRY, 1989, 14, 8-11

The Status of a Chemomechanical Caries Removal System in Dental Education

JON G SCRABECK • GLORIA M LIST

Summary

A survey on the status of a chemomechanical caries removal system was mailed to the operative dentistry departments of each dental school in the United States and Canada. Eighty-eight percent of the respondents reported they were not presently teaching this technique. The most frequent reasons given for noninclusion in their curriculum were a lack of available clinical data and a variety of specific objections primarily related to limited applicability. Very few schools presently anticipate teaching this technique in the near future, and those that do are basing their final decision upon outcomes of further research. Consensus opinion indicated that additional studies and more definitive information would be required before final judgement could be made regarding the clinical value of this modality.

Marquette University, School of Dentistry, Department of Operative Dentistry, 604 North Sixteenth Street, Milwaukee, WI 53233

Jon G Scrabeck, DDS, MA, associate professor and chairman

Gloria M List, DDS, MA, associate professor

Introduction

With the rapid development of new methods and materials in dentistry today, practitioners are continually asked to decide if, when, and how such methods and materials will become part of their armamentarium. Products often receive minimal clinical testing, particularly of the long-term variety, and commercial evaluation methods do not always consider all that is important in clinical practice. Marketing techniques frequently tend to emphasize patient acceptability, ease of manipulation, and relative cost, while less commercial factors are given little or no attention.

Techniques and materials are judged to a considerable extent by whether or not they are taught in schools of dentistry (Herrin, Harrison & von der Lehr, 1987; Clark & Smith, 1984; Lambert, 1980). Dental school curricula generally reflect the basic policies of the American Dental Association and governmental agencies charged with jurisdiction over such matters. From the medicolegal standpoint, the expression "standard of care" is usually defined in part by those methods and techniques being taught in regional dental schools.

In this context, an effort was made to determine the status of a relatively new chemomechanical caries removal device, Caridex (National Patent Dental Products, Co, Inc, New Brunswick, NJ 08901) in dental schools in the United States and Canada.

Method

In July 1987 an eight-item survey (see figure) was mailed to each department of operative dentistry in the United States and Canada, asking them if they were currently teaching the Caridex technique in their school. Respondents who answered yes were asked about specifics of its presentation in their curriculum. Those who answered no were asked the reasons for noninclusion, and questioned regarding plans for teaching it in the near future. General comments were encouraged from all respondents. Some schools replied to individual questions with multiple answers. Results shown in the sample survey are a summary of those answers.

Results

Sixty-one replies were received from a total of 67 requests, a 91% response rate. A significant number (88%) of schools responding were not currently teaching the Caridex technique. Of those 54 schools, only four had any plans for teaching it in the near future. Two of these schools said it would be taught only as a didactic subject for informational purposes, or presented on an elective basis. The remaining two indicated it would be taught contingent upon future research

1. Is the Caridex System currently being taught in your school?

Yes ___ No ___

If your answer was Yes, please respond to Questions #2-6.
If your answer was No, please respond to Questions #7-8.
GENERAL COMMENTS are requested from all respondents.

2. How long has your school been teaching this technique?

___ years

3. In which year is it introduced in the curriculum?

Fr ___ Soph ___ Jr ___ Sr ___

4. By whom is it taught?

___ Operative Dentistry
___ Pediatric Dentistry
___ Clinical Sciences
___ Other: ___

5. How much curriculum time is devoted to it?

___ hours

6. Where is it taught?

___ Clinic only
___ Precinic only
___ Combination preclinic and clinic
___ Elective courses
___ Other: ___

7. If your school is not teaching this treatment, what is/are the principle reasons?

___ Curriculum time not available
___ Acceptance/approval status with ADA
___ Not enough clinical data currently available
___ Other, please explain: ___

8. Based upon current information, do you anticipate your school will be teaching this method in the near future?

Yes ___ No ___

Please explain: ___

GENERAL COMMENTS: ___

and long-term results. Among schools in this category, the most frequent reasons given for not teaching it were "not enough clinical data currently available" and "other," including a variety of reasons to be noted in the Discussion section. In addition, many respondents also considered the acceptance/approval status of Caridex with the American Dental Association as being a reason for not teaching it. The ADA Council on Dental Materials, Instruments, and Equipment has not granted formal acceptance or approval status to this technique, but rather have put it in a separate "recognized" category.

Schools who were teaching the technique at the time of the survey had been doing so for as many as three years in one case, to "just starting" in two others. The majority of schools in this category reported that they introduce Caridex in the third year, and all but one school teaches it in operative dentistry. Curriculum time devoted to this subject ranges from 12 hours to less than one hour, and it is most often presented in an elective-course format. Among the seven schools which indicated they were currently teaching the technique, four of them said it was being presented on a limited basis until more complete information becomes available.

Discussion

The Caridex system is described as a process by which carious material is selectively dissolved away from unaffected tooth structure (Katz, 1987). The procedure is accomplished by directing a solution of N-monochloro-DL-2-aminobutyric acid directly at the carious site, accompanied by mechanical action with an applicator tip.

Advocates of this technique claim it has several advantages, including conservation of tooth structure and a reduced need for anesthesia and the use of conventional instrumentation (Gross & Malcmacher, 1986); however, these same authors and others (McNierney & Petruzillo, 1986) report certain limitations with the system. These include the need for direct access to lesions for effectiveness, required verification of remaining caries and final preparation by conventional methods, increased length of treatment time, objectionable taste of solution, and apparent contraindication for incipient lesions (McCune, 1986).

Results of this survey indicate the technique has not been widely accepted by dental educators at the present time. As described in the classic literature (Black, 1936), slow-speed rotary instrumentation and spoon excavation were still considered by the vast majority of respondents as being the most effective method for caries removal. Such opinion was expressed by one chairman as follows: "...it is still expected that current methods of caries removal and its recognition are basic to operative procedures." In this regard, several respondents identified what appeared to be a significant point in this discussion. The fact that Caridex theoretically removes only decayed tooth structure is one consideration; however, complete caries removal is still left to the judgment of and verification by the operator through conventional methods. A serious problem becomes obvious for operators who think the system is a fail-safe method for caries removal and become lulled into a false sense of security in this regard. Visual and/or tactile examination still remain the only conclusive methods for verification of caries removal.

In addition to the caries verification issue, consensus among respondents not presently teaching the procedure indicated that they felt it did not adequately reduce the need for conventional instrumentation to justify its use. Others were more critical in their opinions, stating that the technique was virtually useless, and that it appeared to be little more than a gadget, or an expensive gimmick. Still others thought it required an unnecessary amount of time to use and reported it did not eliminate the need for local anesthesia in moderate-to-advanced lesions.

Those respondents who were currently teaching the procedure considered it a worthwhile adjunct, although a majority of them also thought it had certain limitations. Some were less enthusiastic and committed in their positions, and at least three of the seven schools in this category said they were presenting it on a trial or an "ad lib" basis.

Conclusion

A reasonable conclusion suggested by this study is that caution should be exercised relative to the expectations and clinical performance of this modality. Until more favorable information becomes available and limitations are clearly understood, it appears that the clinical value of this procedure will remain highly questionable in the minds of most academicians.

(Received 25 August 1987)

References

BLACK, G V (1936) Revised by Black, *A D G V Black's Work on Operative Dentistry*, 7th edition. Chicago: Medico-Dental.

CLARK, N P & SMITH, G E (1984) Teaching gold castings in North American dental schools *Operative Dentistry* **9** 26-31.

GROSS, J S & MALCMACHER, L J (1986) Caries removal system update *Dentistry Today* **5(6)** 25-27.

HERRIN, H K, HARRISON, J L & von der LEHR, W (1987) The status of posterior composites in the dental curriculum *Journal of Dental Education* **51** 252-253.

KATZ, E (1987) A comparison of the efficacy of Caridex caries removal system and conventional drills in complete caries removal *Journal of Dental Research* **66** *Abstracts of Papers* p 123 Abstract 134.

LAMBERT, R L (1980) A survey of the teaching of compacted gold *Operative Dentistry* **5** 20-23.

McCUNE, R J (1986) Report on a symposium on chemomechanical caries removal: a multicenter study *The Compendium of Continuing Education in Dentistry* **7** 151-160.

McNIERNEY, H D & PETRUZILLO, M A (1986) A gentle approach to operative dentistry: the Caridex caries removal system *General Dentistry* **34** 282-284.

©OPERATIVE DENTISTRY, 1989, **14**, 12-19

Evaluation of Hand Instruments Used in Operative Dentistry: Hardness and Sharpness

GREGORY E SMITH • NEREYDA P CLARK

Summary

Four brands of dental instruments were evaluated for Knoop hardness in this study. Enamel hatchets and hoes made from two brands of carbon steel and two brands of stainless steel were tested as received and after 10, 30, and 50 cycles of dry heat or steam autoclave sterilization. Results indicated an initial reduction in hardness in the carbon steels after 10 cycles, then no further hardness deterioration. Both of the stainless steels tested were significantly softer than the two carbon steels before and after sterilization. SEM evaluation of two brands of carbon-steel enamel hatchets and two brands of stainless-steel enamel hatchets before and after planing enamel revealed more rapid dulling of blade edges on the stainless-steel instruments than on the carbon-steel instruments.

University of Florida, College of Dentistry, Department of Operative Dentistry, Box J-415, JHMHC, Gainesville, FL 32610

Gregory E Smith, DDS, MSD, professor

Nereyda P Clark, DMD, assistant professor

INTRODUCTION

Stainless-steel and carbon-steel hand instruments are available for use in refining dental cavity preparations. Some types of steel deteriorate during sterilization procedures, and some types of steel may deteriorate more rapidly than others during cavity preparation procedures. This study was in two parts. The purpose of the first part was to evaluate the effects of two sterilization procedures on the hardness of stainless-steel and carbon-steel enamel hatchets and hoes. The purpose of the second part was to observe the changes in sharpness of enamel hatchets used to plane enamel.

In the first part of this investigation carbon-steel and stainless-steel instruments were subjected to two methods of sterilization commonly used in dental offices: steam autoclaving and dry-heat sterilization. Autoclaving is a cost-effective and rapid method for instrument sterilization; however, it is corrosive to carbon-steel instruments (Foster, LeMay & Johnson, 1945; Nolte & Arnim, 1955; Haberman, 1962; Cluster & Addington, 1965; Bertolotti & Hurst, 1978). Dry-heat sterilization is often used clinically; however, Nolte & Arnim (1955) and Cluster & Coyle (1970) report that dry heat decreased the hardness of carbon-steel instruments by 3%, and stainless-steel instruments by 2%.

In the second part of this investigation sharpness deterioration was studied on enamel hatchet blades made from four commercially available brands of steel. Photomicrographs were made on the scanning electron microscope (SEM) for study of changes in blade edges after use.

MATERIALS AND METHODS

Hardness testing

Four types of steel were evaluated:

1. Carbon steel (American Dental Mfg Co, Missoula, MT 59806),
2. Carbon steel (Suter Dental Co, Chico, CA 95927),
3. A high-carbon stainless steel (American Dental Mfg Co), and
4. Immunity stainless steel (Hu-Friedy Co, Chicago, IL 60690).

Thirty enamel hatchet blades and 30 hoe blades of each of the four steels were tested. Ten of each type were randomly selected as received from the manufacturer and tested for Knoop hardness. Ten of each were subjected to autoclave sterilization at 121° C and 15 psi for 15 minutes, and 10 of each were subjected to dry-heat sterilization at 170° C for one hour. Each set of 10 blades was sterilized for 10, 30, and 50 cycles and cooled for at least 20 minutes between cycles.

Prior to hardness testing, instrument blades were broken from their shanks and mounted in resin (Bakelite, Buehler Co, Evanston IL 60201). Samples were ground with 600-grit silicon-carbide polishing paper and polished for four hours with 1.0 μm alumina (Vibromet, Buehler Co). Polishing was necessary because accurate measurements were otherwise impaired by the surface finish of instruments as they were received from the manufacturer.

Three Knoop hardness determinations (Tukon Micro-Hardness Tester, Paige-Wilson Corp, Bridgeport, CT 06601) were recorded for each of the samples prior to sterilization, and following each of the sterilization cycles. Measurements were made with the Knoop indentor under a 1000-gram load. The first series of indentations was placed 0.5 mm from the cutting edge of each instrument. The second, third, and fourth series of indentations were placed 0.2 mm from the previous indentations.

Means and standard deviations were calculated for each of the groups. Analysis of variance with Tukeys multiple range procedures determined the statistical significance ($P = 0.05$).

Sharpness testing (SEM evaluation)

The same four brands of enamel hatchets (two carbon steels and two high-carbon stainless steels) were studied for edge deterioration before and after use. Enamel hatchet blades were evaluated as received and after 5, 30, and 55 planing strokes on the approximal enamel walls of class 2 cavity preparations cut in extracted teeth. Sequential impressions were taken (Mirror 3 Wash, Kerr Mfg Co/Sybron, Romulus, MI 48174), and replicas made of blades (Araldite 502 Resin, E F Fullam, Inc, Schenectady, NY 12301) as received, and after 5, 30, and 55 planing strokes on tooth enamel. Several actual blades were also evaluated directly under the SEM to validate use of replicas for sequential study. SEM photographs were made (JEOL JS7-35C, JEOL LTD, Tokyo, Japan) and blade-edge sharpness evaluated before and after use (Fig 1). Instruments evaluated for sharpness in the SEM examination

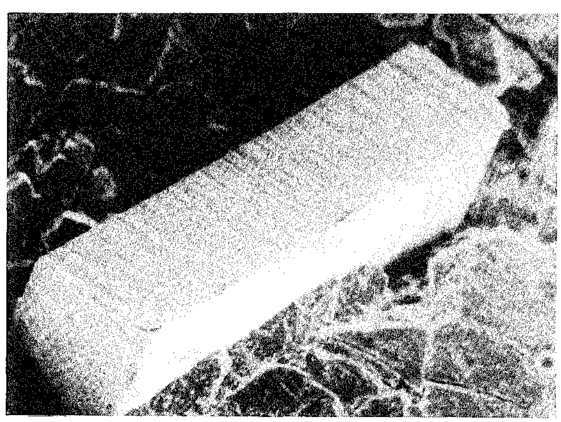


FIG 1. *Enamel hatchet blade mounted for SEM study*

Table 1. Mean Knoop Hardness Measurements, Standard Deviation, and Percent Change of Dental Instruments after Autoclave Sterilization

Instrument Brand	As Received	SD	AC-10	SD	%Δ	AC-30	SD	%Δ	AC-50	SD	%Δ	Over All %Δ
Suter carbon steel	806	26	785	25	-3*	768	19	-2	769	35	0	-5
American carbon steel	816	39	790	36	-3*	778	38	-2	782	33	+1	-4
American stainless steel	574	28	581	35	+1	575	32	-1	572	10	0	0
Hu-Friedy stainless steel	651	11	648	14	0	648	17	0	644	19	-1	-1

* - Significant differences are marked with an asterisk.

Δ - Change

Table 2. Mean Knoop Hardness Measurements, Standard Deviation, and Percent Change of Dental Instruments after Dry-heat Sterilization

Instrument Brand	As Received	SD	DH-10	SD	%Δ	DH-30	SD	%Δ	DH-50	SD	%Δ	Over All %Δ
Suter carbon steel	806	26	741	27	-8*	743	34	0	745	27	0	-5
American carbon steel	816	39	729	16	-11*	726	11	0	723	13	+1	-4
American stainless steel	574	28	571	33	-1	582	28	+2	574	17	0	0
Hu-Friedy stainless steel	651	11	61	23	-5*	619	18	0	622	11	-1	-1

* - Significant differences are marked with an asterisk.

Δ - Change

were not subjected to any sterilization procedures before or during use on extracted teeth.

RESULTS

Hardness testing

Knoop hardness tests revealed the carbon-steel instruments were significantly harder than stainless-steel instruments both before and after they were sterilized (Tables 1 and 2). There was no significant difference among the carbon steel brands; however, the Hu-Friedy Immunity steel was harder than the American stainless steel evaluated.

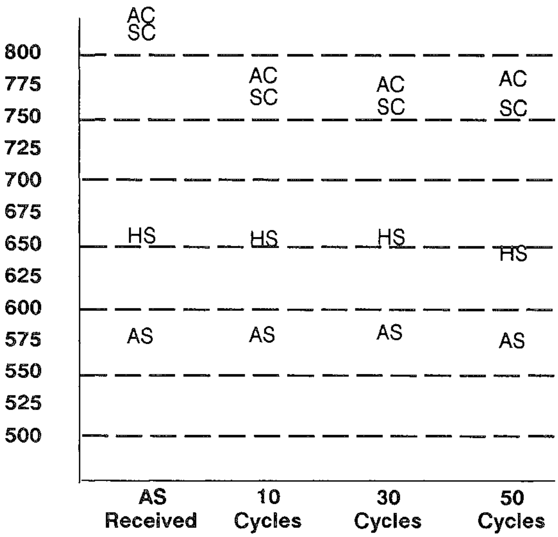
Autoclave sterilization caused rust on all carbon-steel instruments, but rust was not observed on the stainless-steel instruments.

AUTOCLAVE AND DRY-HEAT STERILIZATION

Carbon steel (American and Suter):

1. Autoclave sterilization caused a statistically

Table 3. Autoclave Sterilization Plot of Mean Hardness by Brand



significant 3% decrease in hardness after 10 cycles (Tables 1 & 3). There was no significant hardness decrease thereafter.

2. Dry-heat sterilization also resulted in a significant decrease in hardness after 10 cycles. This initial decrease was 11% for American carbon steel and 8% for Suter after 10 cycles (Tables 2 & 4), with no significant decrease thereafter.

High-carbon stainless steel (American):

Neither of the sterilization methods had a statistical effect on the hardness of the American high-carbon stainless-steel instruments regardless of the number of sterilization cycles employed (Tables 1 - 4).

Immunity stainless steel (Hu-Friedy):

1. Autoclave sterilization did not significantly alter the hardness of these stainless-steel instruments (Tables 1 & 3).

2. Dry-heat sterilization significantly decreased the hardness of these instruments by 5% after 10 cycles (Tables 2 & 4). There was no significant hardness decrease thereafter.

Sharpness testing (SEM evaluation)

Photomicrographs taken of replicas of instruments in the condition in which they were received revealed the width of the cutting edges to be in the range of 2-10 μm in each of the steels evaluated (Fig 2). Blade cutting edges widened with use to 30-50 μm, thereby appreciably decreasing instrument sharpness.

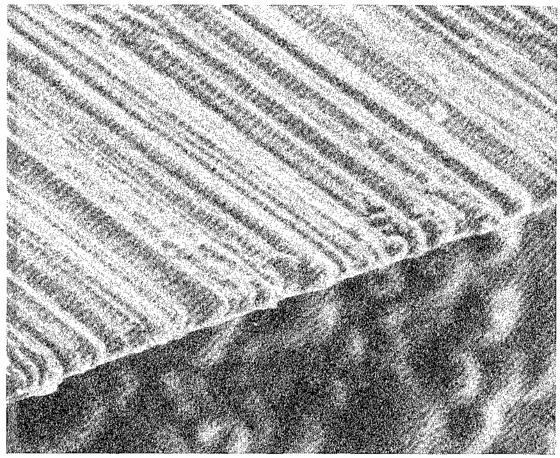
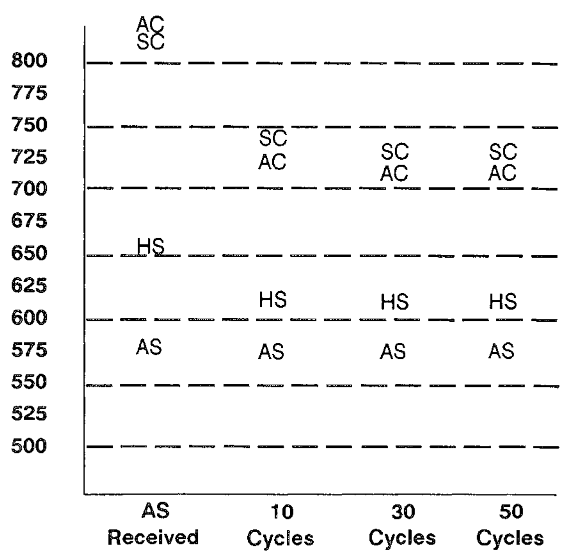


FIG 2. *Replica of blade edge of stainless-steel enamel hatchet (X240).*

Table 4. Dry-heat Sterilization Plot of Mean Hardness by Brand



EDGE DULLING

Carbon steel: Slight blade-edge deformation or buckling was seen on carbon-steel instruments after five planing strokes on enamel (Figs 3a,3b); however, although isolated dull areas were seen at this stage, an extensive widening of the blade edges was rare in either of the carbon steels after only five planing strokes. High magnification of actual blades after five strokes showed an initial deformation of the blade edges (Fig 4). The sharpness of both carbon steels decreased further after 25-50 additional planing strokes (Figs 3c,3d), and some isolated bending of blade-edge steel occurred.

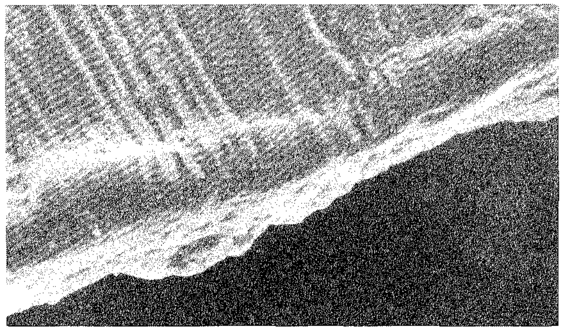
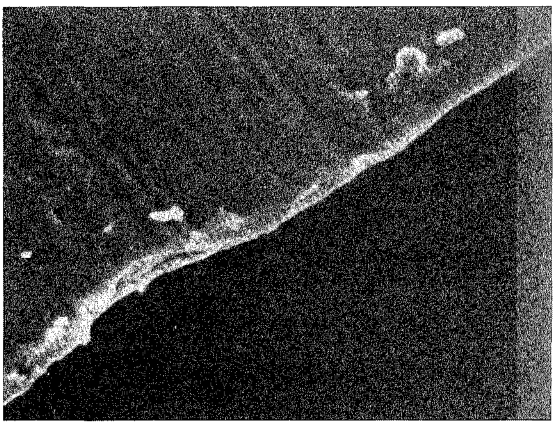
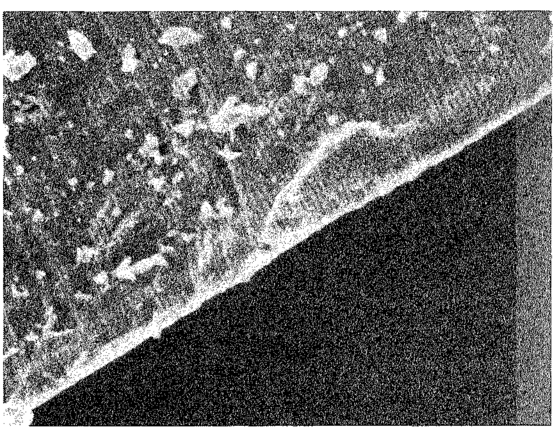


FIG 4. *High magnification (X800) of actual carbon-steel blade after five planing strokes on enamel. Note initial deformation on buckling of blade edge brought about by force of enamel against cutting edge.*

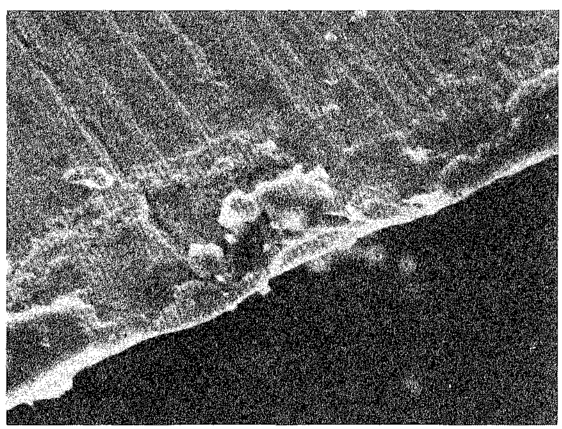


a. *Blade as received*

b. *Blade after five strokes on enamel. Some deformation of blade edge is evident.*



c. *Blade after 30 strokes on enamel. Additional dulling seen as blade widens to approximately 30 μm in isolated areas.*



d. *Blade after 55 planing strokes. No additional dulling evident.*

FIG 3. *Replica of carbon-steel enamel hatchet (X240).*

Stainless steel: Planing of enamel with the stainless-steel instruments caused immediate dulling along the entire cutting edge (Figs 5a,5b) as blade edges widened to 30-50 μm after five planing strokes on enamel. Additional planing of enamel further dulled the instruments (Figs 5c,5d), resulting in generalized edge widening and bending.

DISCUSSION

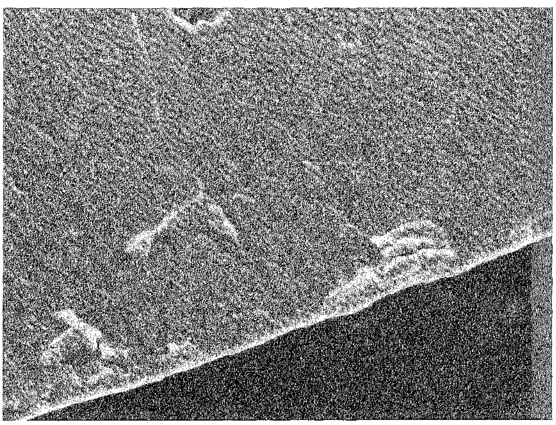
Hardness testing

Hardness is but one measure of durability. Knoop hardness tests in this study indicate that the carbon-steel instruments are significantly harder than stainless-steel instruments both before and after sterilization procedures are employed.

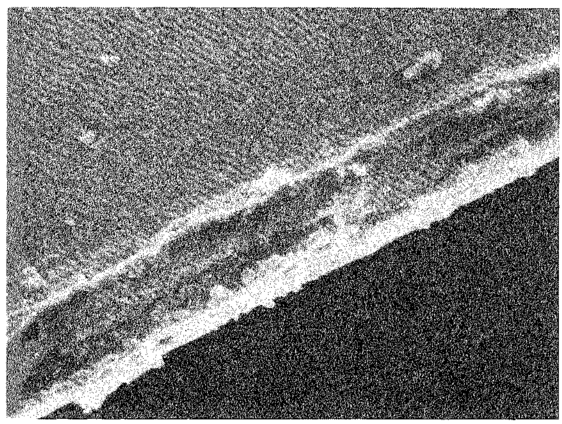
Dry-heat sterilization affects the hardness of carbon-steel and Immunity stainless-steel instruments to a greater degree than autoclave sterilization. When a decrease in hardness occurs, it is evident after 10 sterilization cycles. Mean Knoop hardness values did not decrease significantly after additional sterilization cycles in any of the four steels subjected to evaluation.

Sharpness testing

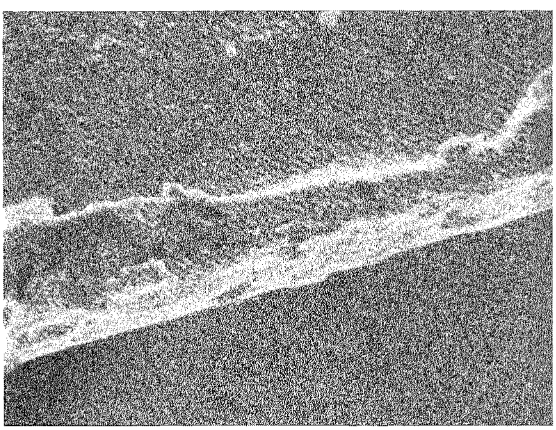
Analysis of SEM photographs indicates that



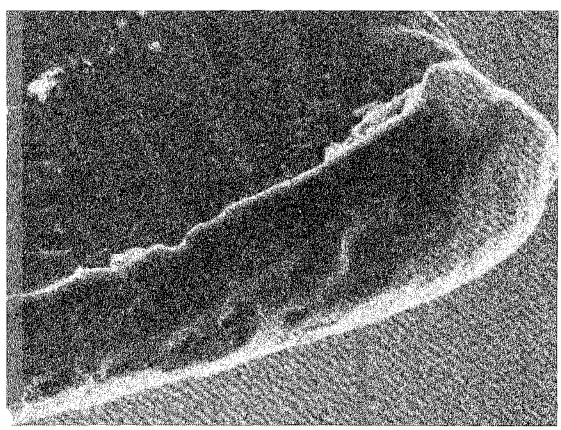
a. *Blade as received*



b. *Blade after five strokes on enamel. Extensive dulling has occurred as edge width has widened.*



c. *Blade after 30 strokes on enamel*



d. *Blade edge after 55 planing strokes on enamel*

FIG 5. *Replicas of stainless-steel enamel hatchet blades (X240).*

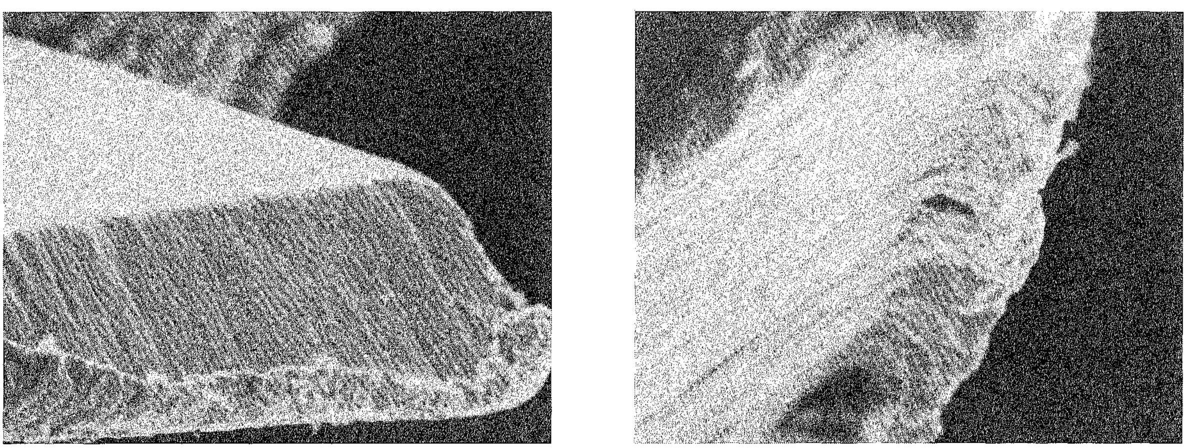
the sharpness of stainless-steel enamel hatchets deteriorates more rapidly than the sharpness of carbon-steel instruments when used to plane enamel. As dulling occurs, the cutting edges bend (Figs 6a,6b). Stainless-steel instruments appear to dull extensively along the entire cutting edge after only a few strokes on enamel. Carbon-steel instruments dull with use also; however, initial use produces less extensive damage to their cutting edges and edge sharpness deteriorates, but more slowly than in the stainless steels studied.

CONCLUSIONS

1. The hardness of carbon-steel dental instruments decreases with 10 cycles of steam-autoclave or dry-heat sterilization. No significant further reduction in hardness of carbon steel occurs with either sterilization method.
2. Steam autoclaving causes rust on carbon steel but not on the stainless-steel instruments evaluated.
3. Dry-heat sterilization causes a more severe hardness reduction of carbon-steel instruments than steam-autoclave sterilization after 10 cycles. Additional sterilization cycles (dry-heat or autoclave) fail to further reduce hardness in carbon-steel instruments.
4. The hardness of the American stainless instruments evaluated is not affected significantly by either of the sterilization methods employed.
5. Carbon-steel instruments remain significantly harder than the stainless instruments after any cycles of sterilization.
6. Stainless-steel instrument blades dull rapidly as they widen from the 2-10 μm original edge widths to 30-50 μm after five planing strokes on enamel. Edge deterioration also occurs on carbon-steel instruments, but progresses more slowly, requiring 25-50 strokes on enamel to produce significant edge change. Based upon this study, stainless-steel instruments should be sharpened more frequently than carbon-steel instruments to maintain a sharp cutting edge.

(Received 8 September 1987)

ACKNOWLEDGMENT: The authors wish to thank Dr David Sarrett, associate professor at the University of Florida College of Dentistry, for the statistical analysis in this study.



a. *Blade edge deformation evident in frontal view*

b. *Side view shows bending and deterioration of cutting*

FIG 6. *Low magnification of stainless-steel blade after 30 planing strokes on enamel (X130)*

References

BERTOLOTTI, R L & HURST, V (1978) Inhibition of corrosion during autoclave sterilization of carbon steel dental instruments *Journal of the American Dental Association* **97** 628-632.

CLUSTER, F & ADDINGTON, L (1965) Physical changes of instruments during sterilization *Journal of Periodontology* **36** 34-38.

CLUSTER, F & COYLE, T (1970) Instrument changes during sterilization *Journal of Dental Research* **498** 487-495.

FOSTER, J, LEMAY, C H & JOHNSON, K L (1945) The corrosion of sharp-edged opthalmic instruments *Proceedings of the Royal Society of Medicine* **38** 465-469.

HABERMAN, S (1962) Some comparative studies between a chemical vapor sterilizer and a conventional steam autoclave on various bacteria and viruses *Journal of the Southern California Dental Association* **30** 163-172.

NOLTE, W A & ARNIM, S S (1955) Sterilization lubrication and rust-proofing of dental instruments and handpieces with a water-oil emulsion: laboratory and clinical study *Journal of the American Dental Association* **50** 133-146.

©OPERATIVE DENTISTRY, 1989, **14**, 20-27

Pulpal Effects of Composite Resin Restorations

EDWARD J SWIFT, JR

Summary

This article reviews the literature concerning the pulpal effects of composite resin restorations. A number of aspects are addressed, including the composite resin materials themselves, bacterial leakage, acid-etch technique, and dentin bonding procedures. Guidelines for pulpal protection are discussed.

Introduction

A primary objective in the restoration of any vital tooth is the prevention of pulpal injury. With regard to composite resin restorations, the pulpal effects of materials and procedures have become a relatively minor concern for many practitioners. However, the increasing use of posterior composite resins has provoked a renewed interest, as post-operative sensitivity and loss of vitality associated with these resins has been reported (Bales, 1987; Council on Dental Materials, Instruments and Equipment, 1986; O'Hara, Reeves & Quiroz, 1988).

Disregarding cavity preparation, adverse pulpal effects associated with composite resins could be initiated by any or all of three discrete sources. First are the composite resin materials themselves. These materials have been examined to determine whether they possess any inherent toxicity. Also, microleakage and bacterial penetration around resin restorations have been studied.

Secondly, the effects of the acid-etch technique have been studied. Direct effects of the acid, as well as indirect effects (i e, increased dentin permeability and bacterial ingress), have been considered.

Finally, various aspects of dentin bonding have been examined, including the smear layer, pretreatments of dentin, and the biocompatibility of dentin bonding materials.

The purpose of this paper is to review the literature in each of these areas, thereby providing a better understanding of how composite resin

University of Iowa, Department of Operative Dentistry, Iowa City, IA 52242

Edward J Swift, Jr, DMD, clinical instructor

restorations can affect the pulp. Furthermore, a number of guidelines for pulpal protection based on this literature are discussed.

EFFECTS OF COMPOSITE RESINS

Several main areas of interest can be identified in research concerning the effects of composite resins on the pulp. Some studies have focused on the relative severity of pulpal responses to different materials. Others have compared methods of preventing undesirable pulpal effects. Finally, a number have been concerned with identification of etiologic factors. Inherent chemical toxicity of the materials and bacterial penetration around the margins of restorations have been proposed as possible causes of pulpal response.

Even before the advent of composite resins, other resin materials were used to restore anterior teeth. However, these materials caused pathologic pulpal changes which could lead to chronic irreversible pulpitis (Nygaard-Ostby, 1955). These changes were generally believed to be the result of chemical irritation. However, Zander (1951, 1959) proposed that bacterial ingrowth was the primary cause.

When composite resins were introduced during the 1960s, their potential for toxic pulpal effects was a major concern. Langeland and others (1966) found that the new composite resins caused a pulp reaction similar to that of their unfilled predecessors. The degree of pulpal response was determined primarily by the thickness of the remaining dentin (Stanley, Swerdlow & Buonocore, 1967). Lining of cavities with calcium hydroxide was proposed as a means of providing adequate pulpal protection (Baume & Fiore-Donno, 1968).

Concerns about the pulpal effects of composite resins remained as new materials were developed during the late1960s and 1970s. A number of histologic studies were carried out on human and animal (monkey, dog, rat) teeth.

Pulpal response was shown to vary among different materials (Sayegh & Reed, 1969). As before, remaining dentinal thickness and adequate lining were considered critical factors in reduction of pulpal response (Goto & Jordan, 1972a; Tobias & others, 1973). The effectiveness of liners was generally attributed to their role as a physical barrier against chemical irritants.

Materials were developed to reduce the potential for chemical irritation. Specifically, methacrylic acid was removed from resin formulations and a neutral pH was achieved. However, one study showed that these changes did not prevent pulpal reactions in deep, unlined cavities. Again, adequate dentinal thickness and calcium hydroxide liners were cited as important factors in pulpal protection (Stanley, Going & Chauncey, 1975).

Brännström and Nyborg (1972) found a high frequency of bacteria beneath unlined composite resin restorations. These bacteria and their products could diffuse through dentinal tubules to cause the pulpal inflammation associated with unlined cavities. Therefore, poor marginal adaptation of a restoration (allowing bacterial ingress) was proposed as a more significant factor than chemical irritation in producing pulpal response.

Brännström's hypothesis has been supported by studies relating pulpal inflammation and numbers of bacteria with the contraction gaps which form around resin restorations (Qvist, 1975; Bergenholtz and others, 1982). Unacceptable pulpal responses have been correlated with a higher frequency of bacteria under the restoration (Skogedal & Eriksen, 1976).

Later research substantiated the importance of bacterial ingress in eliciting pulpal inflammation. Undiluted composite resin ingredients were placed in cavities and sealed to prevent bacterial penetration. None of the components caused significant pulpal irritation, possibly due to the failure of microorganisms to invade and thrive under these conditions. Apparently, chemical toxicity was not a factor (Stanley, Bowen & Folio, 1979; Nordenvall, Brännström & Torstenson, 1979).

While all of the resins mentioned to this point were of the auto-polymerizing variety, the pulpal effects of the light-curing materials have also been studied. Research with an early ultraviolet light-cured resin showed a more persistent and intense pulpal response than that associated with a self-curing resin (Stanley & others, 1972). Later ultraviolet materials produced minimal pulpal irritation, perhaps due to a more complete polymerization of the resin (Heys & others, 1977).

The ultraviolet-cured resins have been superseded by visible-light-cured materials. The early materials caused pulpal irritation greater than that produced by zinc oxide/eugenol. Placement of a calcium hydroxide liner reduced this irritation to acceptable levels (Bloch & others, 1977).

In addition to the changes in polymerization methods, the composite resins themselves have changed in composition. For example, the microfilled resins available today contain much smaller filler particles and a lower filler content than the conventional composites (Leinfelder, 1985). These changes in composition have definite effects on the physical properties of the materials and hence a potential effect on their biological properties.

Microfills allow a greater amount of microleakage (and theoretically, at least, more bacterial penetration) than conventional composites (Hembree, 1983). Therefore, a more severe pulpal response would be anticipated. However, one study showed that there was no significant difference (Heys, Heys & Fitzgerald, 1985).

Another study found an unacceptable pulpal response to microfilled resins, a response that could be reduced by lining with calcium hydroxide. The importance of the liner was not as pronounced with restorations in place for longer periods of time. The researchers attributed this difference not only to the healing potential of the pulp, but also to improved operative procedures, e g, acid-etching and incremental placement (Hörsted, Simonsen & Larsen, 1986).

Brännström has commented on the importance of the cervical gaps which form when a composite resin is placed with a margin on dentin or cementum. As the material polymerizes, it pulls away from dentin, resulting in a gap which allows bacterial penetration. Subsequent hygroscopic expansion of the resin may compensate somewhat for this shrinkage. However, Brännström recommends that these gaps should be occluded by application of an unfilled resin after a restoration is placed. Cervical gaps may be a greater problem in terms of pulpal irritation and post-operative sensitivity with some of the newer materials (specifically, posterior composite resins) which undergo little or no hygroscopic expansion (Brännström 1984a; Brännström, 1986).

The controversy over whether chemical toxicity or bacterial penetration is the primary cause of pulpal irritation has not yet been resolved. However, a study addressing this matter has recently been reported by Cox and others (1987). Several commonly used dental materials, including a composite resin, were placed in direct contact with the pulp. All were well-tolerated if adequately sealed; however, severe inflammation occurred when bacteria were present. These results indicate that bacterial penetration was the more significant factor in determining pulpal response to the composite resin.

EFFECTS OF ACID-ETCHING

The phosphoric acid component of silicate cement was frequently cited as the cause of pulpal inflammation associated with these materials (Johnson & others, 1970). Therefore, when the acid-etch technique for increasing adhesion of composite resins (Buonocore, 1955) was introduced into clinical use, there was much concern about the effects of this technique on the pulp-dentin complex.

Early studies showed that phosphoric acid did not penetrate into dentin (Lee & others, 1973) and caused no significant pulpal response in dogs (Goto & Jordan, 1972b). However, later research indicated that acid-etching did cause significant pulpal inflammation and enhanced the irritation associated with composite resins. Calcium hydroxide liners and adequate dentinal thickness were cited as protective factors (Retief, Austin & Fatti, 1974; Eriksen, 1974; Stanley & others, 1975; Eriksen, 1976).

The specific etiology of pulpal inflammation is the subject of debate. It is known that etching with phosphoric acid causes opening and widening of dentinal tubules (Brännström & Johnson, 1974; Meryon, Tobias & Jakeman, 1987). The protective diffusion barrier of the smear layer (to be discussed in greater detail in the following section) is removed and dentin permeability is increased (Pashley, Michelich, & Kehl, 1981; Pashley & others, 1983). This could increase the concentration of bacterial products which reach the pulp and cause inflammation (Pashley, 1984).

Some research has indicated that pulpal inflammation in etched cavities is indeed related to bacterial growth. Bacterial invasion of tubules opened by acid caused more severe pulpal responses then that associated with unetched cavities (Vojinović, Nyborg & Brännström, 1973). Brännström and Nordenvall (1978) showed that inflammation was correlated with bacterial growth, regardless of remaining dentinal thickness, presence of a liner, or non-bacterial leakage. No direct response to the acid was seen.

Bacteria responsible for pulpal inflammation may arise from three sources: the smear layer on the dentin surface, contamination after cavity cleaning, and microleakage (Torstenson, Nordenvall, & Brännström, 1982). The latter is a particular concern, especially when a margin is on dentin (Mejàre, Mejàre & Edwardsson, 1987).

Despite the concern about bacteria, some research has demonstrated a moderate pulpal response to phosphoric acid even with no bacteria present in the tubules or on cavity walls. This finding suggests that acids should not be used on exposed, unprotected dentin (Macko, Rutberg & Langeland, 1978).

Regardless of the actual cause of pulpal response to acid etching, this is a problem which should not be overlooked. Post-operative sensitivity and possible loss of vitality have been attributed to the acid-etch technique (Liatukas, 1985). The use of protective liners has been recommended (Macko & others, 1978; Brännström & Nordenvall, 1978). The resistance of calcium hydroxide liners to acid is somewhat unpredictable (de Freitas, 1984). Therefore, glass-ionomer cements have been recommended for use with the acid-etch technique (McLean, Prosser, & Wilson, 1985). Also, oxalate crystals are being studied as a means of closing dentinal tubules after etching (Pashley & Galloway, 1985).

In addition, some manufacturers have advocated the use of dentin bonding agents to protect dentin from acid. Results of research have been mixed. While some studies showed that dentin bonding agents reduce acid penetration (Chan & Jensen, 1986) and pulpal response (Van Leeuwen, Dogon & Heeley, 1986), one found that these agents, particularly the phosphate ester type, are removed by acid. Polyurethane adhesives are apparently more effective in maintaining a seal of the dentin (Eick & Welch, 1986).

To this point in the discussion, only the potentially injurious effects of acid-etching have been mentioned. However, it must be noted that some Japanese researchers have proposed that etching of dentin is desirable and should be performed routinely as a pulpal protective measure. They state that etching creates sites (i e, open dentinal tubules and a porous intertubular layer) to which a chemically-adhesive resin can bond. They believe that the adhesion of resin to these etched bonding sites prevents separation of the resin from dentin. A tight marginal seal which prevents bacterial ingress and subsequent pulpal irritation is supposedly formed (Fusayama, 1987). Etching of dentin is not considered an acceptable procedure in the United States at this time.

DENTIN BONDING

The Smear Layer

Various types of dentin bonding agents have been introduced or are being developed. With each of these, some consideration must be given to the smear layer which forms on dentin after any cutting procedure. The smear layer consists of a roughened, smeared surface with obliteration of tubule orifices, as well as debris -- blood, saliva, bacteria, enamel, and dentin particles (Eick & others, 1970; Brännström & Johnson, 1974; Brännström, Glantz & Nordenvall, 1979; Duke, Phillips & Blumershine, 1985).

A number of agents have been evaluated for their effect on the smear layer. Demineralizing agents such as phosphoric acid, citric acid, and EDTA completely remove the smear layer and open the dentinal tubules (Brännström & Johnson, 1974; Meryon, Tobias & Jakeman, 1987). Polyacrylic acid removes only the superficial smear layer, leaving the orifices closed. Pumice slurry and prophylaxis paste are also somewhat effective in removing the smear layer. Other agents, e g, hydrogen peroxide and cavity cleaners, have no effect (Duke & others, 1985).

There are two widely divergent opinions regarding treatment of the smear layer. Some believe that the smear layer acts as an effective, natural cavity liner that seals the dentinal tubules and reduces permeability. At the other extreme are those who contend that the smear layer interferes with adhesion of materials, serves as a depot of bacteria and bacterial toxins, and should be removed. Pashley (1984) states that the latter perspective may become more appropriate when dentin bonding agents which effectively reduce microleakage are available.

Bergenholtz (1982) and Brännström (1984b) have suggested that only the superficial smear layer be removed, and the remaining smear "plugs" treated with an antiseptic. They believe that improved adhesion and reduced risk of bacterial penetration result.

Treatment of the smear layer is an important consideration in each of the dentin bonding systems recently introduced on the American market. The first of these, called Tenure (Den-Mat Corporation, Santa Maria, CA 93456), is based on a method developed by Bowen and Cobb (1983) and Bowen, Cobb, and Rapson (1982). In this bonding system, aluminum oxalate (ferric oxalate in Bowen's original formula), an acidic mordant, reacts with the smear layer to form insoluble calcium salts. Resin monomers are bound chemically to the altered surface (Strassler & Weiner, 1988).

Another new system, Scotchbond 2 (3M Dental Products Division, St Paul, MN 55144), involves pretreatment with a maleic acid primer. This removes the superficial smear layer and creates a surface to which the resin adhesive bonds through mechanical interlocking (Creo & Steen, 1987).

Finally, GLUMA (Columbus Dental, St Louis, MO 63188), a product developed in Europe (Munksgaard & Asmussen, 1984) has a pretreatment of buffered EDTA (Columbus Dental, 1987).

DENTIN BONDING AGENTS

Obviously, the debate concerning the biocompatibility of the smear layer will continue as newer adhesives and pretreatment methods are developed. The biocompatibility of the dentin bonding agents themselves has been and continues to be the subject of research.

The halophosphorus esters of Bis-GMA, while shown to be cytotoxic in one study (Wiseman, Stangel & Germinario, 1985), have produced little or no pulpal response in most cases (Van Leeuwen & others, 1982; Van Leeuwen, Dogon & Heeley, 1985). Some researchers have stated that a liner is not necessary unless very little dentin thickness remains (Pameijer, Stanley & Dickinson, 1986).

Biocompatibility studies have been performed on the dentin bonding system developed by Bowen and Cobb (1983). Results indicate that the system causes no cytotoxic effect or significant pulpal response (Stanley, Bowen & Cobb, 1985; Chohayeb & others, 1985; Sydiskis & Dumsha, 1985; Dumsha & Beckerman, 1986).

The apparent biocompatibility of the dentin bonding agents suggests that future research may be more concerned with smear layer treatment, permeability, and microleakage effects.

CONCLUSIONS

In summary, a variety of factors may contribute to the pulpal irritation associated with composite resin restorations. Chemical toxicity, bacterial penetration, and the complications of acid-etch and dentin-bonding techniques must be considered.

Controversy remains concerning the relative effects of these factors; however, the clinical dentist must realize that pulpal irritation is a possibility and must strive to prevent it. Unfortunately, because of conflicts and confusion in the literature, absolute rules for pulpal protection are not possible with regard to composite resin restorations.

Nevertheless, some strong recommendations can be made. Although this paper is not concerned with the effects of cavity preparation, this is an area which must not be overlooked. The basis for successful prevention of pulp irritation must always be proper preparation technique. Preparations should be as conservative as possible, exposing the minimum number of dentinal tubules. Furthermore, copious water lavage should be used to prevent dehydration and heating of the tooth (Seltzer & Bender, 1984).

Pulpal irritation associated with composite resins themselves has generally been attributed to either of two possible causes--toxicity of the material or bacterial leakage around margins (Brännström, 1986). However, most evidence indicates that bacterial ingress is the more significant factor, particularly with the more recently developed composite resins (Brännström, 1984a; Brännström, 1986). These materials would probably not cause pulpal damage if leakage were eliminated (Spangberg, 1982).

Prevention of bacterial ingress and growth is vitally important to pulpal health. Careful removal of all infected dentin is essential. Antimicrobial cleansing of cavities, while not widely practiced in the United States, might be considered. Any and all techniques which help prevent the ingress of bacteria around restoration margins must be followed. Acid-etching and dentin bonding techniques should be used. The development of dentin bonding agents which adhere strongly to dentin and eliminate microleakage would provide significant improvement in this area.

Use of a material with a coefficient of thermal expansion close to that of tooth structure is beneficial in preventing microleakage (Leinfelder, 1985). Finally, incremental placement techniques may help reduce leakage (Donovan, 1985; Leclaire & others, 1988).

There is some controversy regarding the role of acid-etch technique as a contributing factor in pulpal irritation. Phosphoric acid can hardly be considered an innocuous substance when applied to living tissue (Macko & others, 1978). However, the enlargement of dentinal tubules by acid, allowing greater penetration by bacterial toxins, is the likely cause of pulpal irritation (Pashley & others, 1983).

The role of dentin bonding procedures in pulpal irritation has not been fully elucidated. In particular, treatment of the smear layer remains a highly controversial subject. Certainly, deliberate etching of the dentin cannot be considered acceptable at this point. With many currently-available bonding agents, particularly the phosphate esters, adhesion to dentin is very weak and incapable of preventing marginal gaps (Crim & Chapman, 1986). Therefore, the smear layer must be retained as a permeability barrier. At best, only the superficial smear should be removed, maintaining plugs in the tubular orifices. Some of the newer dentin bonding technology (e g, Tenure; GLUMA; Scotchbond 2) involves chemical alteration of the smear layer to form a bonding substrate.

Adequate liners should be used. Glass-ionomer liners, which adhere to dentin, release fluoride, and resist acid, have been recommended by McLean and others (1985). While a liner is not essential for all restorations (Pameijer & others, 1986), it might be placed to protect the dentinal tubules while etching, and then removed if desired.

(Received 28 September 1987)

References

BALES, D J (1987) Posterior composites: for routine use in today's practice? *Operative Dentistry* **12** 41.

BAUME, L J & FIORE-DONNO, G (1968) Response of the human pulp to a new restorative material *Journal of the American Dental Association* **76** 1016-1022.

BERGENHOLTZ, G (1982) Relationship between bacterial contamination of dentin and restorative success *Proceedings of Symposium on Dental Pulp* University of Michigan 93-107.

BERGENHOLTZ, G, COX, CF, LOESCHE, WJ & SYED, SA (1982) Bacterial leakage around dental restorations: its effect on the dental pulp *Journal of Oral Pathology* **11** 439-450.

BLOCH, W W, AUSTIN, J C, CLEATON-JONES, P E, WILTON-COX, H & FATTI, L P (1977) Pulpal response to a new visible light-cured composite restorative material: Fotofil *Journal of Oral Pathology* **6** 278-287.

BOWEN, R L & COBB, E N (1983) A method for bonding to dentin and enamel *Journal of the American Dental Association* **107** 734-736.

BOWEN, RL, COBB, EN & RAPSON, JE (1982) Adhesive bonding of various materials to hard tooth tissues: improvement in bond strength to dentin *Journal of Dental Research* **61** 1070-1076.

BRÄNNSTRÖM, M (1984a) Communication between the oral cavity and dental pulp associated with restorative treatment *Operative Dentistry* **9** 57-68.

BRÄNNSTRÖM, M (1984b) Smear layer: pathological and treatment considerations *Operative Dentistry* **Supplement 3** 35-42.

BRÄNNSTRÖM, M (1986) The cause of postrestorative sensitivity and its prevention *Journal of Endodontics* **12** 475-481.

BRÄNNSTRÖM, M, GLANTZ, P O & NORDENVALL, K-J (1979) The effect of some cleaning solutions on the morphology of dentin prepared in different ways: an in vivo study *Journal of Dentistry for Children* **46** 291-295.

BRÄNNSTRÖM, M J & JOHNSON, G (1974) Effects of various conditioners and cleaning agents on prepared dentin surfaces: a scanning electron microscopic investigation *Journal of Prosthetic Dentistry* **31** 422-430.

BRÄNNSTRÖM, M & NORDENVALL, K-J (1978) Bacterial penetration, pulpal reaction and the inner surface of Concise enamel bond. Composite fillings in etched and unetched cavities *Journal of Dental Research* **57** 3-10.

BRÄNNSTRÖM, M & NYBORG, H (1972) Pulpal reaction to composite resin restorations *Journal of Prosthetic Dentistry* **27** 181-189.

BUONOCORE, M G (1955) A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces *Journal of Dental Research* **34** 849-853.

CHAN, D C N & JENSEN, M E (1986) Dentin permeability to phosphoric acid: effect of treatment with bonding resin *Dental Materials* **2** 251-256.

CHOHAYEB, A A, BOWEN, R L, RUPP, N W & ADRIAN, J (1985) Pulpal response to a new dentin and enamel system *Journal of Dental Research* **64** *Abstracts of Papers* p 222 Abstract 428.

COLUMBUS DENTAL (1987) Gluma Bonding System product information. St Louis.

COUNCIL ON DENTAL MATERIALS, INSTRUMENTS AND EQUIPMENT (1986) Posterior composite resins *Journal of the American Dental Association* **112** 707-709.

COX, C F, KEALL, C L, KEALL, H J, OSTRO, E & BERGENHOLTZ, G (1987) Biocompatibility of surface-sealed dental materials against exposed pulps *Journal of Prosthetic Dentistry* **57** 1-8.

CREO, A L & STEEN, D L (1987) Scotchbond 2 dental adhesive system product profile. 3M Dental Products Division, St Paul, MN.

CRIM, G A & CHAPMAN, K W (1986) Prevention of marginal leakage by four dentinal adhesives *General Dentistry* **34** 235-236.

De FREITAS, J F (1984) Resistance of calcium hydroxide materials to phosphoric acid *Australian Dental Journal* **29** 389-393.

DONOVAN, T E (1985) Adhesive restorative dentistry: a conservative perspective *Journal of the California Dental Association* **12** 13-17.

DUKE, E S, PHILLIPS, R W & BLUMERSHINE, R (1985) Effects of various agents in cleaning cut dentine *Journal of Oral Rehabilitation* **12** 295-302.

DUMSHA, T C & BECKERMAN, T (1986) Pulp response to a dentin bonding system in miniature swine *Dental Materials* **2** 156-158.

EICK, J D & WELCH, F H (1986) Dentin adhesives -- do they protect the dentin from acid etching? *Quintessence International* **17** 533-544.

EICK, J D, WILKO, R A, ANDERSON, C H & SORENSEN, S E (1970) Scanning electron microscopy of cut tooth surfaces and identification of debris by use of the electron microprobe *Journal of Dental Research* **49** 1359-1368.

ERIKSEN, H M (1974) Pulpal response of monkeys to a composite resin cement *Journal of Dental Research* **53** 565-570.

ERIKSEN, H M (1976) Protection against harmful effects of a restorative procedure using an acidic cavity cleanser *Journal of Dental Research* **55** 281-284.

FUSAYAMA, T (1987) Factors and prevention of pulp irritation by adhesive composite resin restorations *Quintessence International* **18** 633-641.

GOTO, G & JORDAN, R E (1972a) Pulpal response to composite-resin materials *Journal of Prosthetic Dentistry* **28** 601-606.

GOTO, G & JORDAN, R E (1972b) The pulpal effects of 50 per cent phosphoric acid *Journal of the Canadian Dental Association* **38** 248.

HEMBREE, J H Jr (1983) Marginal leakage of microfilled composite resin restorations *Journal of Prosthetic Dentistry* **50** 632-635.

HEYS, R J, HEYS, D R, COX, C F & AVERY, J K (1977) Histopathologic evaluation of three ultraviolet-activated composite resins on monkey pulps *Journal of Oral Pathology* **6** 317-330.

HEYS, R J, HEYS, D R & FITZGERALD, M (1985) Histological evaluation of microfilled and conventional composite resins on monkey dental pulps *International Endodontic Journal* **18** 260-266.

HÖRSTED, P B, SIMONSEN, A-M & LARSEN, M J (1986) Monkey pulp reactions to restorative materials *Scandinavian Journal of Dental Research* **94** 154-163.

JOHNSON, R H, CHRISTENSEN, G J, STIGERS, R W & LASWELL, H R (1970) Pulpal irritation due to the phosphoric acid component of silicate cement *Oral Surgery, Oral Medicine, and Oral Pathology* **29** 447-454.

LANGELAND, L K, GUTTUSO, J, JEROME, D R & LANGELAND, K (1966) Histologic and clinical comparison of Addent with silicate cements and cold-curing materials *Journal of the American Dental Association* **72** 373-385.

LECLAIRE, C C, BLANK, L W, HARGRAVE, J W & PELLEU, G B, Jr (1988) Use of a two-stage composite resin fill to reduce microleakage below the cementoenamel junction *Operative Dentistry* **13** 20-23.

LEE, H L Jr, ORLOWSKI, J A, SCHEIDT, G C & LEE, J R (1973) Effects of acid etchants on dentin *Journal of Dental Research* **52** 1228-1233.

LEINFELDER, K F (1985) Composite resins *Dental Clinics of North America* **29** 359-371.

LEINFELDER, K F, RUSSELL, C M, THORNTON, R J, COWEN, R G & WALKER, C K (1986) Efficacy of the dentin bonding agents. Part II *Journal of the Alabama Dental Association* **70** 15-22.

LIATUKAS, E L (1985) An in vivo survey of pulp response to acid-etch technique *Journal of Dental Research* **64** *Abstracts of Papers* p 222 Abstract 427.

MACKO, D J, RUTBERG, M & LANGELAND, K (1978) Pulpal response to the application of phosphoric acid to dentin *Oral Surgery, Oral Medicine, and Oral Pathology* **45** 930-946.

McLEAN, J W, PROSSER, H J & WILSON, A D (1985) The use of glass ionomer cements in bonding composite resins to dentine *British Dental Journal* **158** 410-414.

MEJÀRE, B, MEJÀRE, I & EDWARDSSON, S (1987) Acid etching and composite resin restorations. A culturing and histologic study on bacterial penetration *Endodontics and Dental Traumatology* **3** 1-5.

MERYON, S D, TOBIAS, R S & JAKEMAN, K J (1987) Smear removal agents: a quantitative study in vivo and in vitro *Journal of Prosthetic Dentistry* **57** 174-179.

MUNKSGAARD, E C & ASMUSSEN, E (1984) Bond strength between dentin and restorative resins mediated by mixtures of HEMA and glutaraldehyde *Journal of Dental*

Research **63** 1087-1089.

NORDENVALL, K-J, BRÄNNSTRÖM, M & TORSTENSON, B (1979) Pulp reactions and microorganisms under ASPA and Concise composite fillings *Journal of Dentistry for Children* **46** 449-453.

NYGAARD-OSTBY, B (1955) Pulp reactions to direct filling resins *Journal of the American Dental Association* **50** 7-13.

O'HARA, J W, REEVES, G W & QUIROZ, L (1988) Posterior composites: a review of current clinical concepts *General Dentistry* **36** 207-209.

PAMEIJER, C H, STANLEY, H R & DICKINSON, A (1986) Histological evaluation of a dentin adhesive *Journal of Dental Research* **65** *Abstracts of Papers* p 251 Abstract 734.

PASHLEY, D H (1984) Smear layer: physiological considerations *Operative Dentistry* **Supplement 3** 13-29.

PASHLEY, D H & GALLOWAY, S E (1985) The effects of oxalate on smear layers permeability and resistance to acid *Journal of Dental Research* **64** *Abstracts of Papers* p 238 Abstract 570.

PASHLEY, D H, KEPLER, E E, WILLIAMS, E C & OKABE, A (1983) The effects of acid etching on the in vivo permeability of dentine in the dog *Archives of Oral Biology* **28** 555-559.

PASHLEY, D H, MICHELICH, V & KEHL, T (1981) Dentin permeability: effects of smear layer removal *Journal of Prosthetic Dentistry* **46** 531-537.

QVIST, V (1975) Pulp reactions in human teeth to tooth colored filling materials *Scandinavian Journal of Dental Research* **83** 54-66.

RETIEF, D H, AUSTIN, J C & FATTI, L P (1974) Pulpal response to phosphoric acid *Journal of Oral Pathology* **3** 114-122.

SAYEGH, F S & REED, A J (1969) Tissue reactions to a new restorative material *Journal of Prosthetic Dentistry* **22** 468-478.

SELTZER, S & BENDER, IB (1984) *The Dental Pulp* pp 195-206. Philadelphia: J B Lippincott.

SKOGEDAL, O & ERIKSEN, H M (1976) Pulpal reactions to surface-sealed silicate cement and composite resin restorations *Scandinavian Journal of Dental Research* **84** 381-385.

SPANGBERG, L S W (1982) Biocompatibility of restorative materials *Proceedings of Symposium on Dental Pulp* University of Michigan 53-89.

STANLEY, H R, BOWEN, R L & COBB, E N (1985) Pulp responses to experimental treatments of dentin for bonding composites *Journal of Dental Research* **64** *Abstracts of Papers* p 222 Abstract 423.

STANLEY, H R, BOWEN, R L & FOLIO, J (1979) Compatibility of various materials with oral tissues: II. Pulp responses to composite ingredients *Journal of Dental Research* **58** 1507-1517.

STANLEY, H R, GOING, R E & CHAUNCEY, H H (1975) Human pulp response to acid pretreatment of dentin and to composite restoration *Journal of the American Dental Association* **91** 817-825.

STANLEY, H R, MYERS, C L, HEYDE, J B & CHAMBERLAIN, J (1972) Primate pulp response to an ultraviolet light cured restorative material *Journal of Oral Pathology* **1** 108-114.

STANLEY, H R, SWERDLOW, H & BUONOCORE, M G (1967) Pulp reactions to anterior restorative materials *Journal of the American Dental Association* **75** 132-141.

STRASSLER, H E & WEINER, S (1988) Oxalate dentin bonding *Compendium of Continuing Education in Dentistry* **9** 98-108.

SYDISKIS, R J & DUMSHA, T C (1985) Cytotoxicity testing of a dentin bonding system *Journal of Dental Research* **64** *Abstracts of Papers* p 338 Abstract 1468.

TOBIAS, M, CATALDO, E, SHIERE, F R & CLARK, R E (1973) Pulp reaction to a resin-bonded quartz composite material *Journal of Dental Research* **52** 1281-1286.

TORSTENSON, B, NORDENVALL, K-J & BRÄNNSTRÖM, M (1982) Pulpal reaction and microorganisms under Clearfil composite resin in deep cavities with acid etched dentin *Swedish Dental Journal* **6** 167-176.

VAN LEEUWEN, M J, DOGON, I L, NORRIS, D & HEELEY, J (1982) A histological evaluation of two dentin bonding agents *Journal of Dental Research* **61** *Program and Abstracts of Papers* p 268 Abstract 804.

VAN LEEUWEN, M J, DOGON, I L & HEELEY, J (1985) A histological study of two visible light curved esters of Bis-GMA *Journal of Dental Research* **64** *Abstracts of Papers* p 222 Abstract 425.

VAN LEEUWEN, M J, DOGON, I L & HEELEY, J (1986) A study of the protective properties of light cured Scotch Bond *Journal of Dental Research* **65** *Abstracts of Papers* p 251 Abstract 732.

VOJINOVIĆ, O, NYBORG, H & BRÄNNSTRÖM, M (1973) Acid treatment of cavities under resin fillings: bacterial growth in dentinal tubules and pulpal reactions *Journal of Dental Research* **52** 1189-1193.

WISEMAN, M A, STANGEL, I & GERMINARIO, R J (1985) Cytotoxicity of Scotchbond assessed by a modified chromium-51 release method *Journal of Dental Research* **64** *Abstracts of Papers* p 318 Abstract 1292.

ZANDER, H A (1951) Effect of self-curing resins on the dental pulp *Oral Surgery, Oral Medicine, and Oral Pathology* **4** 1563-1567.

ZANDER, H A (1959) Pulp response to restorative materials *Journal of the American Dental Association* **59** 911-915.

 © OPERATIVE DENTISTRY, 1989, 14, 28-32

Coronal Fractures in Posterior Teeth

P LAGOUVARDOS • P SOURAI • G DOUVITSAS

Summary

Coronal fractures of posterior teeth are not rare in clinical practice. Most of the time they constitute a restorational problem for the clinician, since they usually end below the free gingival crest. Two hundred coronal fractures of posterior teeth were examined in this study, with respect to several factors. Some of the factors were the sex and age of the patient, type and location of the tooth, and vitality of the pulp.

The results showed that frequency of fractures is not influenced by the sex or age of the patient, the type or location of the tooth, or the vitality of the pulp. Factors that significantly affect the appearance of a fracture include caries, restored surfaces, and tooth morphology. Lingual cusps fracture more often than buccal cusps, fractures ended more frequently above or at the gingival crest in teeth with vital pulps, and in nonvital teeth fractures ended more frequently below the crest. Conservative cavity designs for tooth restorations and conservative access to the root canals for endodontic treatment will decrease the frequency of tooth or restoration fracture.

University of Athens, Dental School, Operative Dentistry Department, 2 Thivon St, Goudi, 115 27 Athens, Greece

P Lagouvardos, DDS, lecturer

P Sourai, DDS, lecturer

G Douvitsas, DDS, assistant professor

Introduction

Clinical studies have shown that tooth fractures are the main reason for replacing 11-13% of amalgam restorations (Mjör, 1981; Charbeneau & Klausner, 1984; Charbeneau, Klausner & Green, 1986; Lioumi & others, 1987) and constitute 5% of the restorations placed in posterior teeth (Lioumi & others, 1987). Posterior teeth with fractured cusps frequently present a difficult restorative problem because the fracture very often ends below the free gingival crest.

The incidence of tooth fracture has been shown to be higher in first molars, especially the mandibular ones, possibly because of their susceptibility to caries and therefore the frequent restoration of these teeth (Cavel, Kelsey & Blankenau, 1985).

Tooth preparation has a significant effect on the incidence of fractures since prepared teeth are not so resistant to fractures as unprepared teeth (Mondelli & others, 1980); the wider the occlusal preparation the higher the frequency of fractures (Larson, Douglas & Geistfeld, 1981). Tooth fractures are also more frequent in teeth which have been restored in more than two surfaces than they are in teeth which have been restored in two surfaces only (Cavel & others, 1985).

The incidence of fractures does not appear to be related to upper or lower dental arch (Cavel & others, 1985), or to the sex of the patient (Eakle, Maxwell & Braly, 1986). The higher percentage of fractures seems to occur in patients less than 40 years old, and most of the fractures end above the cementoenamel junction (Eakle & others, 1986).

The results of previous studies present some factors that clearly may affect fractures in posterior teeth, but the results are not entirely clear for other factors. Fractures, for instance, appear to be related to functional cusps in one study (Pietrokovski & Lantzman, 1973), while in another they appear to be related to nonfunctional cusps (Eakle & others, 1986). Therefore, does cusp location influence the frequency of fractures? Does pulp vitality, or lack of it, have an effect on where the fracture-line ends? Do dental arches or the restorative material used have an effect on the incidence of fractures?

The purpose of this study was to evaluate some of the factors involved in fractures of posterior teeth, particularly the age of the patient, the vitality of the pulp, and the location or end of the fractures.

Methods

Posterior-tooth fractures observed in patients under treatment at the Operative Dentistry department of the University of Athens Dental School during the years 1986-1987 were the subject of this study. These fractures had occurred during mastication and were examined by the authors during student clinical training. A specially-designed questionnaire was completed immediately after the examination.

The questionnaires included information about the sex and age of the patient, type of tooth, location of fracture (bucally or lingually), direction of fracture (gingivally, supragingivally or subgingivally) and distance of fracture-end from the gingival crest, in cases of supra or subgingival fractures. Information about the vitality of the pulp, presence of caries or restorations, existence of opposing teeth, buccolingual width of occlusal preparations, material of the restorations, and whether the teeth had been endodontically treated or not were also included.

For purposes of the questionnaire, "horizontal" indicated fractures where the beginning and end of the fracture-line were on the same level, "oblique" where the end of the fracture was lower or higher than the beginning, and "vertical" where the end of the fracture was lost well below the gingival margin.

Pulp-vitality evaluation was in most cases based on clinical examination, radiographic examination, and diagnostic cavity preparation. Additional diagnostic tests, such as electric pulp tests, were rarely needed because in most cases the fractured tooth had been immediately restored.

The buccolingual width of the occlusal restoration was classified in two broad categories to facilitate recording. The first category included fractured teeth in which the buccolingual width of the restoration was less or equal to 1/4 the intercuspal distance; the second category included all the other cases. Fractures of third molars or fractures in which the occurrence of fracture during mastication was doubted were excluded from the study.

Results and Discussion

Of the 200 fractures recorded, 87 were observed in men (43.5%) and 113 in women (56.5%) (Table 1). These percentages are close to the percentages (39.7% and 60.3%) of men and

Table 1. Tooth Fractures within Sexes and Age Groups

AGE	MALES	FEMALES	TOTAL
-24	14	25	39
25-48	59	67	126
49+	14	21	35
TOTAL	87	113	200

women who usually come to the operative dentistry clinic for placement or replacement of restorations (Lioumi & others, 1987). Consequently the coronal fractures of posterior teeth do not appear to be affected by the sex of the patient.

A large percentage, 82.5%, of the fractures occurred in patients younger than 49 years of age, which is close to the 78.5% that was reported by Eakle & others (1986). This percentage should not be attributed to the influence of age on the incidence of tooth fractures, however, since 79% of all the restorations are placed in patients younger than 49 years old, according to the results of Lioumi and others (1987).

Table 2 contains the tooth fractures in the four quadrants. As we can see in this table, the frequency of fractures is the same in all quadrants, arches, or sides. The highest frequency, 43.5%, was observed in the first molars, followed by 23% in the second molars, 20% in the second premolars and 13.5% in the first premolars. Statistical analysis by the chi-square test of independence revealed that teeth and quadrants are independent variables ($v^2 = 67.51$, $P < 0.00$ 1), which means that fractures occur in different frequencies between quadrants. Fracture incidence in molar teeth is higher in the lower than in the upper arch, in contrast to that in premolar teeth which is higher in the maxilla. This is the same order of fracture frequency as that reported by Eakle & others (1986) and is probably related to the incidence of caries and restorations in these teeth, since the frequency of restoration placement in posterior teeth follows the same order as in the study done by Lioumi and others (1987).

In the study done by Lioumi and others, the frequency of restorations placed in upper premolars was the same as that in lower premolars; the frequency of fractures in upper premolars found in our study was 5.7 times the frequency of lower premolars. We can therefore assume that, in addition to restorative procedures, tooth morphology also affects the incidence of fractures in posterior teeth.

The locations of tooth fracture are presented in Table 3, which shows that lingual cusps demonstrate coronal fracture most often (64.5%) in posterior teeth in all quadrants. Further analysis of the data related to fracture location and pulp vitality (Table 4) showed that lingual-cusp fractures occur more often than buccal-cusp fractures in teeth with either vital or nonvital pulp. The ratio of buccal-cusp fractures to lingual-cusp fractures ranges from 1.3% to 1.4% in teeth with vital pulp, but in teeth with nonvital pulp the range is much higher, 2.1% to 3.6%.

The frequency of fractures does not appear to be related to functional or nonfunctional cusps or to teeth with vital or nonvital pulp. Tooth preparation for restoration placement may be the most influential factor. The fact that lingual-cusp fractures occur more often than buccal-cusp fractures may be ascribed to tooth weakening during cavity preparations because of the

Table 2. Coronal Fractures within Teeth

QUADRANT	FIRST PREMOLAR	SECOND PREMOLAR	FIRST MOLAR	SECOND MOLAR	TOTAL
1	18	17	10	7	52
2	8	14	17	6	45
3	-	4	38	15	57
4	1	5	22	18	46
TOTAL	27	40	87	46	200

Table 3. Fracture Location

	QUADRANT 1		QUADRANT 2		QUADRANT 3		QUARDRANT 4	
	BUCCAL	LINGUAL	BUCCAL	LINGUAL	BUCCAL	LINGUAL	BUCCAL	LINGUAL
First premolar	9	9	4	4	-	-	1	-
Second premolar	6	11	5	9	1	3	1	4
First molar	3	7	2	15	11	27	8	14
Second molar	3	4	3	3	7	8	7	11
TOTAL	21	31	14	31	19	38	17	29

Table 4. Fracture Location and State of Pulp

	UPPER		LOWER	
PULP	BUCCAL	LINGUAL	BUCCAL	LINGUAL
Vital	18	26	27	34
Nonvital	4	3	-	1
End treated	13	33	9	32
TOTAL	35	62	36	67

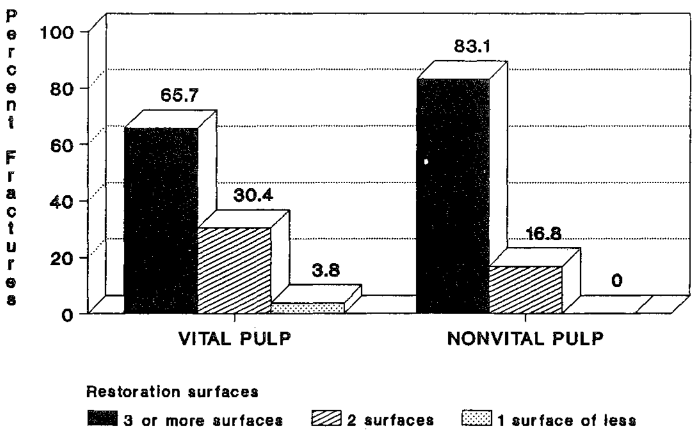


FIG 1. *Nonintact surfaces in fractured posterior teeth with vital and nonvital pulps*

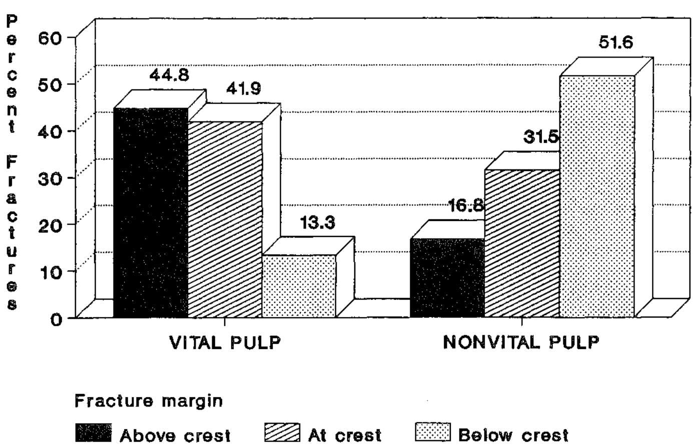


FIG 2. *End of fracture line in fractured posterior teeth with vital and nonvital pulp*

inclination of the tooth and/or the location of the central fossa, which is usually closer to the lingual wall. Root-canal preparation for endodontic treatment may also cause tooth weakening.

Nearly half, 47.5%, of the fractured teeth were found to have nonvital pulps, 91.6% of which had received endodontic treatment. Pulp vitality, therefore, does not seem to be directly related to the incidence of fractures.

Most of the fractured teeth, 74%, were restored in more than two of their surfaces (Fig 1). This percentage is much higher than the percentage of teeth that are usually restored in three or more of their surfaces (25.3%), according to Lioumi & others (1987). Consequently cavity preparation and the restoration of tooth surfaces has a significant influence on the frequency of fractures.

The influence of the restorative material upon the frequency of tooth fractures was not evaluated, because amalgam was the restorative material in all cases. The influence of the buccolingual width of restorations upon the frequency of fractures also was not evaluated because the width in each case was greater than 1/4 the intercuspal distance.

Analysis of the data concerning the end of the fracture-line revealed that fractures end with almost the same frequency at, below, or above the gingival crest (37%, 31.5%, 31%). The location of the fracture-line end seemed to be related to pulp vitality. In teeth with vital pulp, most of the fractures ended supragingivally, in contrast to teeth with nonvital pulp, where in the greater percentage the fractures ended subgingivally (Fig 2). Statistical analysis of the data (test of independence) showed that the two variables were not independent ($v^2 = 36.9$, $P < 0.01$). This probably is due to the fact that endodontic treatment destroys the pulpal wall, permitting the fracture line to extend below the gingival crest.

The direction of the fracture was oblique in 60.5% of the cases, horizontal in 36%, and vertical in 3.5%.

The opposing teeth were part of a natural dentition in almost all cases except one, where the opposing teeth were part of a partial denture.

The above results clearly indicate the necessity for protecting teeth against fractures when restorative procedures are planned. They also indicate the need for more conservative techniques within our restorative curriculum. Protecting teeth against fractures is not only needed for endodontically treated teeth but also for vital teeth with wide isthmuses and restorations. Cusp protection is often necessary and can be accomplished with amalgam or selected indirect materials. The use of resin sealants, glass ionomer, cermet/amalgam, and glass-ionomer/composite-resin restorations should be a part of all curricula.

Conclusions

The following conclusions can be drawn from this study:

1. Sex, age, arch, side, quadrant, or tooth type alone do not affect the incidence of tooth fractures more than they affect the placement of restorations in these teeth. No special precautions need to be taken for these factors when we evaluate the need to protect posterior teeth against coronal fractures.
2. The morphology of posterior teeth and the number of decayed or restored surfaces are two very strong factors that affect the incidence of fractures. The use of materials and methods necessary for a more conservative restoration will undoubtly eliminate the risk of fracture.
3. Lingual-cusp fractures in posterior teeth occur more often than buccal-cusp fractures, especially in second premolars and first molars. More attention must be given to limiting lingual extention of the occlusal preparation in order to preserve the strength of the tooth.
4. Although pulp vitality does not appear to be directly related to the frequency of fractures, it does affect the line of fracture; therefore, in teeth with nonvital pulp, we must prepare a more conservative access to the root canals and protect the cusp with a cusp-covering restoration, because subgingival fractures occur quite often.

(Received 14 October 1987)

References

CAVEL, W T, KELSEY, P W & BLANKENAU, R J (1985) An in vivo study of cuspal fracture *Journal of Prosthetic Dentistry* **53** 38-42.

CHARBENEAU, G T & KLAUSNER, L H (1984) Amalgam restorations. A cross-sectional survey of placement and replacement *Journal of Dental Research* **63** *Abstracts of Papers* p 260 Abstract 808.

CHARBENEAU, G T, KLAUSNER, L H & GREEN, T G (1986) The placement and replacement of amalgam restorations: a national survey *Journal of Dental Research* **65** *Abstracts of Papers* p 219 Abstract 449.

EAKLE, W S, MAXWELL, E H & BRALY, B V (1986) Fractures of posterior teeth in adults *Journal of the American Dental Association* **112** 215-218.

LARSON, T D, DOUGLAS, W H & GEISTFELD, R E (1981) Effect of prepared cavities on the strength of teeth *Operative Dentistry* **6** 2-6.

LIOUMI, E, PAXIMADA, KARAGIORGOU, M, LAGOUVARDOS, P & DOUVITSAS, G (1987) Clinical study of the reasons for placement and replacement of restorations 5th Hellenic Odontostamotologic Congress, Athens.

MJÖR, I A (1981) Placement and replacement of restorations *Operative Dentistry* **6** 49-54.

MONDELLI, C D, STEAGALL, L, ISHIKIRIAMA, A, NAVARRO, M F de L & SOARES, F B (1980) Fracture strength of human teeth with cavity preparations *Journal of Prosthetic Dentistry* **43** 419-422.

PIETROKOVSKI, J & LANTZMAN, E (1973) Complicated crown fractures in adults *Journal of Prosthetic Dentistry* **30** 801-807.

©OPERATIVE DENTISTRY, 1989, **14**, 33-39

Linings and Caries in Retrieved Permanent Teeth with Amalgam Restorations

DONNA NOVICKAS • VINCENT L FIOCCA • RAFAEL GRAJOWER

Summary

Possible correlations between the presence or position of cavity linings and the incidence of caries were studied in a sample of 57 extracted permanent teeth with amalgam fillings. Linings could be detected if their thickness was greater than approximately 20 μm, and if they were observed on 74% of the teeth. On 53% of the teeth caries were found adjacent to the restorations, and on 11% not adjacent to the restorations. The incidence of adjacent caries on the teeth with lined cavities was not lower than on the unlined ones.

In 36% of the teeth with linings, evidence was found for washout of linings which had been present at the cavosurface margin. These teeth showed a significantly higher incidence of adjacent caries than the unlined ones. Carious sites associated with washout of linings were found in 31% of the lined specimens.

Department of Operative Dentistry, College of Dentistry, University of Illinois, Chicago, IL 60612

Donna Novickas, DDS, assistant professor

Vincent L Fiocca, DDS, professor and chairman

Rafael Grajower, PhD, visiting professor from The Hebrew University--Hadassah School of Dental Medicine, Jerusalem, Israel

Introduction

Cavity bases should have sufficient strength to withstand the forces of amalgam condensation and those transmitted through the filling during mastication (Farah & others, 1981). Studies in vitro demonstrated that amalgam condensation in class 2 cavities does not cause significant displacement of the calcium hydroxide liner (Dycal, L D Caulk Co, Milford, DE 19963) when applied in thin (Fuks, Grajower & Knoll, 1975), thick (Chong, Swartz & Phillips, 1967) and multiple (Shorer, Hirschfeld & Grajower, 1984) layers. A study of retrieved, exfoliated deciduous teeth, however, demonstrated that Dycal linings are frequently misplaced and displaced during preparation of the restorations (Grajower, Bielak & Eidelman, 1984). The study showed that linings which are present at the cavosurface angle can be washed out and may be a factor causing recurrent caries. The object of the present study was to examine possible correlations between caries and the presence or position of linings in extracted permanent teeth with amalgam fillings.

Methods and Materials

Fifty-seven human premolars and molars with amalgam restorations were collected from clinics in the Chicago area and stored in water for up to two weeks. No selection was made among the collected teeth and no information about their treatment was available. Twenty-one teeth had been restored with class 1 fillings, of which four had facial or lingual extensions. Thirty-six teeth had class 2 restorations, eight of which were MODs. At least nine of the teeth had coverage of a cusp; on additional teeth cuspal coverage may have remained undetected due to fracture of the cusps.

The teeth were examined for caries and amalgam overhang with an explorer, as customary in clinical practice (Sturdevant & others, 1985). Most teeth were embedded in epoxy or acrylic resin to prevent dislodgement of the restoration during subsequent manipulation. Sections were prepared using an Isomet saw (Buehler Ltd, Evanston, IL 60204) parallel to the tooth axis in the faciolingual as well as the mesiodistal directions, and examined with a microscope (X-Tr zoom, Olympus, Tokyo, Japan, X6-X40 magnification). It was estimated that the presence of liners thicker than 20 μm could be detected on the sections with the microscope.

The shape and position of the lining with respect to tooth tissue and amalgam were noted. From these observations inferences were made regarding the position of the lining upon completion of the restoration and regarding changes occurring during service of the restoration in the mouth. Gaps between amalgam and hard dentin were considered evidence for partial washout of the lining if they were adjacent to lining material and to the cavosurface margin. This inference stands to reason, since gaps of similar shapes were not found remote from linings. Similarly, a highly irregular shape of the lining cross-section was considered an indication for displacement of the lining during amalgam condensation. No other manipulation could be thought of which would result in these shapes.

Statistical differences were evaluated with the Fischer's exact probability test for small samples ($N < 20$ in 2x2 tables) and by the chi-square test with Yates correction for larger samples.

Results

A summary of the results is given in Tables 1 and 2. The statistical analysis of differences between some groups of results is given in Table 3. Linings of various thicknesses were detected on 74% of the restorations (Fig 1). This proportion was similar on class 1 and class 2 restorations. The sections of most of these restorations indicated that extensive displacement of the lining had occurred during amalgam condensation (Fig 2). A third of the lined specimens showed gaps, or areas with only crumbs of linings, between dentin and amalgam adjacent to the margin (Fig 3). These phenomena were considered evidence for the presence of linings at the margin after preparation of the restorations and subsequent washout of the lining in vivo.

Forty-eight percent of the class 1 specimens and 72% of the class 2 specimens were affected by caries. The carious lesions were adjacent to restorations in all affected class 2 specimens and in 40% of the affected class 1 specimens. Sixty percent of the carious lesions in class 1 specimens were approximal and remote from the restorations. The majority of class 2 restorations showed amalgam overhang.

Washout of the linings which had been present at the cavosurface (Fig 3) was associated with all cases of adjacent caries in the class 1 specimens. Washout was also observed for 43% of the lined class 2 specimens with caries. The difference in incidence of adjacent caries between lined restorations (45%) and unlined ones (33%) was not statistically significant; however, a significantly greater caries incidence was found for the specimens with washout of linings than for the unlined ones.

Table 1. Fractions of Specimens with Class 1 Restorations Showing Various Characteristics

Characteristic	**# of specimens**		**% of specimens**	
	yes	**no**	**yes**	**no**
Caries present	10	11	48	52
Caries adjacent to restoration	4	6	40	60
Lining applied	15	6	71	29
Washout of lining	5	10	33	67
Adjacent caries in specimens without lining	0	6	0	100
Adjacent caries in specimens with lining	4	15	27	73
Adjacent caries in lined specimens with washout	4	0	80	20
Adjacent caries in lined specimens without washout	0	10	0	100

Table 2. Fractions of Samples with Class 2 Restorations Showing Various Characteristics

Characteristic	**# of specimens**		**% of specimens**	
	yes	**no**	**yes**	**no**
Caries present	26	10	72	28
Lining applied	27	9	75	25
Washout of lining	10	17	37	63
Caries in specimens without linings	5	4	56	44
Caries in specimens with linings	21	6	28	22
Caries in lined specimens with washout	9	1	90	10
Caries in lined specimens without washout	12	5	71	29
Overhang of amalgam	21	14	60	40
Caries in specimens without overhang	9	5	69	29
Caries in specimens with overhang	16	5	76	24

Table 3. Statistical Evaluation of Results

Difference in frequency of lining application between class 1 and class 2 restorations: NS (not significant)

Difference in incidence of adjacent caries between class 1 and class 2 restorations: $P < 0.01$

Difference in incidence of caries adjacent to cavities between lined and unlined restorations:

class 1	NS
class 2	NS
class 1&2	NS

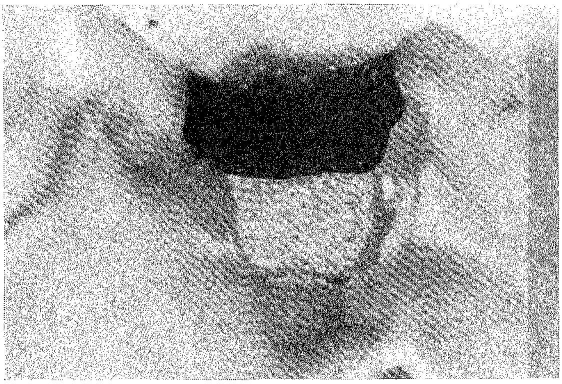
Difference in incidence of caries adjacent to cavities which had been lined between the restorations showing evidence of washout of linings and the restorations which don't indicate washout of linings:

class 1	$P < 0.01$
class 2	NS
class 1&2	$P < 0.01$

Difference in incidence of caries adjacent to cavities between the restorations showing evidence of washout of linings and the restorations without linings:

class 1	$P < 0.01$
class 2	$P < 0.12$
class 1&2	$P < 0.001$

Difference in incidence of caries adjacent to class 2 restorations between restorations with amalgam overhang and without: NS



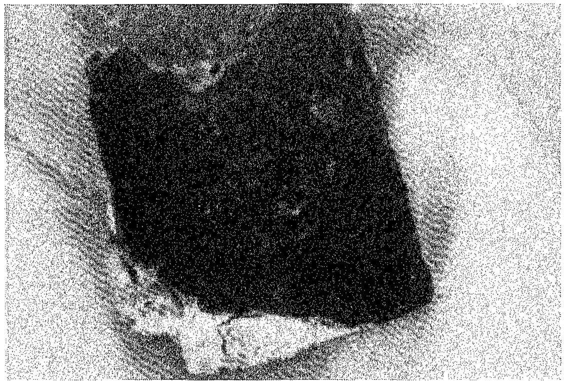


FIG 1. *Thickness of lining. a-b: Two cavities of similar depth with linings of very different thicknesses*

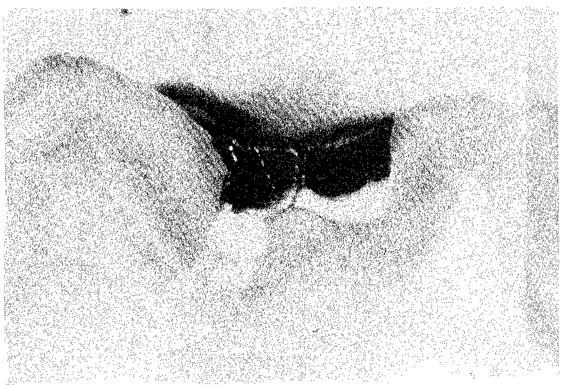
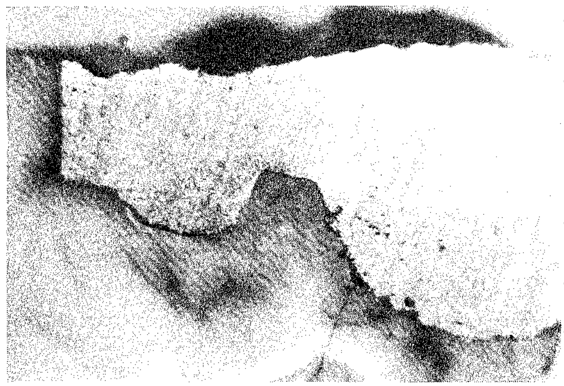


Fig 1c: *Thick lining in cavity which was confined to enamel*



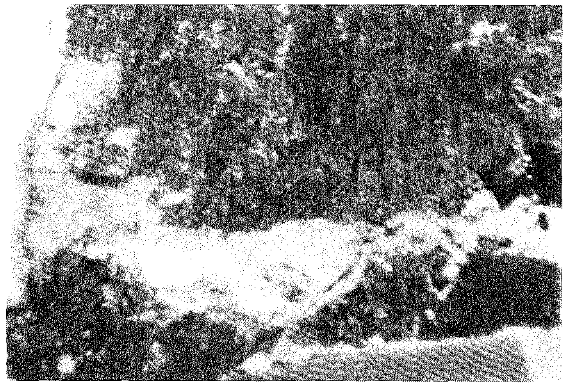
d: *No lining in deep cavity*

Discussion

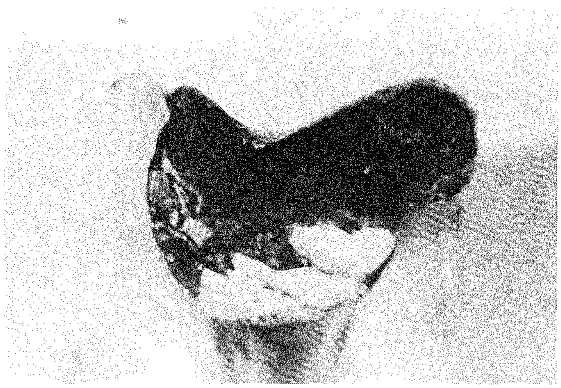
The investigated sample included a large percentage of teeth which were extracted due to caries associated with amalgam restorations. Teeth with defective amalgam restorations are frequently restored before they need to be extracted. Amalgam overhang did not affect the caries incidence significantly. The overhang on the investigated tooth sample did not necessarily correlate to the secondary caries on an "average" sample in a mouth having a much lower incidence of caries. Therefore, the investigated sample cannot be considered to be characteristic of amalgam restorations of the general population. One may expect, however, that similar types of flaws are made in the preparation of amalgam fillings in all groups of patients, although the incidence of these flaws may be different.

Mjör (1985) observed that the approximal and cervical area of teeth with amalgam restorations were more susceptible to recurrent decay than the occlusal surface. The former showed a recurrent decay rate of 97% and the latter of 7%. In agreement with these observations, the present study showed that the incidence of adjacent decay for class 1 restorations (19%) was much lower than for class 2 restorations (72%). Caries were found more often remote from the restoration than adjacent to it, but the difference was not significant. In 35% of the class 2 specimens, caries were found as well as indications for washout of liner. The results show that the caries incidence of specimens having washout of liners is greater than that for unlined specimens, but no

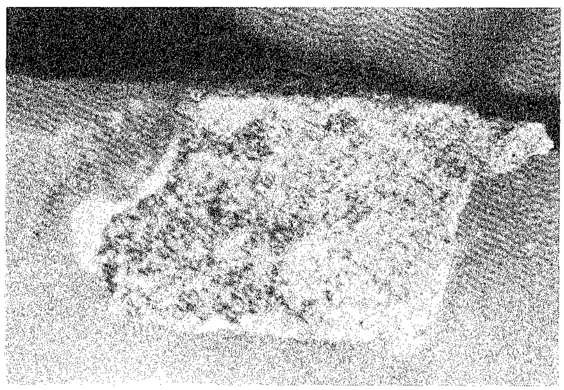
a: *Slight displacement on cavity floor*



b: *Amalgam was condensed through the soft lining onto the cavity floor*



c: *Lumps of lining on the cavity floor. The lining was either placed after setting or it was broken and displaced during condensation.*

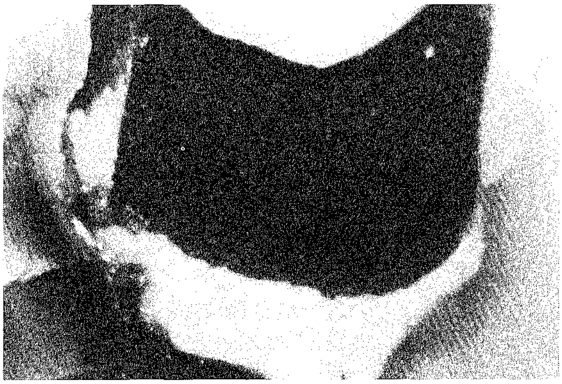


d: *The lining was displaced onto the facial cavity wall during condensation.*

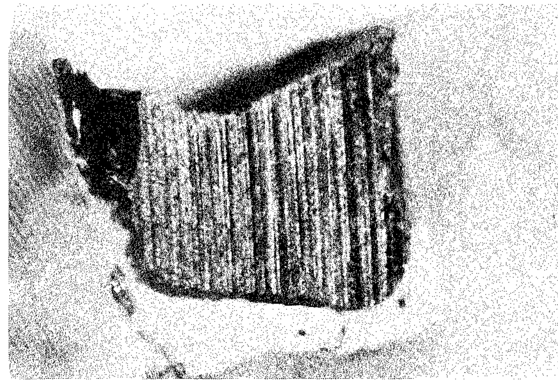
e: *The filling fell out during sectioning, but part of the lining remained, adhering to the lingual wall.*

f: *A thin layer of lining was condensed between amalgam and enamel. The marginal part of this layer was washed out.*

Fig 2. *Indications for misplacement or displacement of linings*



a: *The straight facial wall of the amalgam restoration suggests that a thin layer of lining on this wall was made smooth, rather than removed before condensation.*



b: *The irregular shape of the filling suggests that the lining was extruded onto the occlusal surface during condensation. The indentation made with a probe before sectioning can be seen at the buccal wall of this upper tooth.*

c: *Marginal decay is seen to follow the contour of the restoration on the tooth section. This suggests that washout of the lining rather than amalgam overhang is the main reason for decay.*

d: *The lining was displaced from the pulpal floor during condensation. Some liner material was deposited on the cervical floor, resulting in washout and caries.*

Fig 3. *Decay related to washout of lining*

proof was found that the presence of liners in general affects the incidence of adjacent caries.

The results are in agreement with a previous study of exfoliated primary teeth, which showed that linings are frequently misplaced and displaced during preparation of the restoration (Grajower & others, 1984). Chong and others (1967) concluded from a study in vitro that linings with a compressive strength of more than 170 psi can support amalgam condensation. They determined that the lining Cavitec has a compressive strength of 400 psi and withstands condensation. Fuks and others (1975) found, however, that Cavitec is extensively displaced during condensation. The displacement of bases with high final strength during amalgam packing is also possible if insufficient time is allowed for curing or excessive stresses are applied to the lining at the axial wall. Chong and others (1967) and Draheim, Titus and Murrey (1986) showed that the strength of zinc phosphate and of several other bases is very low, seven minutes after mixing.

Indications were found for the following flaws in the preparation of the fillings:

1. careless placement of the liner in the cavity, resulting in irregular thickness of the lining,
2. nonremoval of lining from enamel and cavosurface areas,
3. insufficient setting of the liner before amalgam condensation, and
4. application of excessive pressure on the lining at the pulpo-axial wall of class 2 restorations during condensation.

It is well known that these flaws can cause defective restorations. Hampson (1980) mentions in his textbook that cement which is washed away from the margin could invite caries to return at the resulting gap. The major finding of the present study is that washout of linings from cavosurface margins occurs quite frequently and is almost invariably associated with decay.

In view of this observation it is surprising that some of these factors are not adequately addressed in textbooks. Most of the examined books state that bases should not be placed at margins or that cleaning of excess liner is essential (Gilmore & others, 1977; Baum & others, 1985; Marzouk, Simonton & Gross, 1985; Sturdevant & others, 1985), but in other less recent books, these issues were not found (Schultz & others, 1966; Bell & Grainger, 1971). None of the textbooks mentioned above states that care should be taken to allow the lining to set before amalgam condensation and to condense in such a manner that excessive stresses on the liner are avoided. The authors may have considered these points self-evident. The results of this study suggest, however, that quite a few dentists are not sufficiently aware of the possibility that liner displacement can occur and that it may have a detrimental effect on the quality of the restoration.

Conclusions

Washout of linings at the cavosurface margin was found in 24% of the investigated extracted teeth with class 1 amalgam restorations and in 28% of the teeth with class 2 restorations. The caries incidence adjacent to restorations in teeth with washout was greater than in teeth with unlined restorations.

(Received 23 November 1987)

References

BAUM, L, PHILLIPS, R W & LUND, M R (1985) *Textbook of Operative Dentistry* 2nd edition, p 149. Philadelphia:W B Saunders.

BELL, B H & GRAINGER, D A (1971) *Basic Operative Dentistry Procedures* 2nd edition, pp 215-226. Philadelphia:Lea & Febiger.

CHONG, W F, SWARTZ, M L & PHILLIPS, R W (1967) Displacement of cement bases by amalgam condensation *Journal of the American Dental Association* **74** 97-102.

DRAHEIM, R N, TITUS, H W & MURREY, A J (1986) Compressive strength of six cavity base materials *Journal of Dental Research* **65** *Abstracts of Papers* p 175 Abstract 52.

FARAH, J W, CLARK, A E, THOMAS, P A & BORKOW, I (1981) Cement bases under amalgam restorations: effect of thickness *Operative Dentistry* **6** 82-89.

FUKS, A, GRAJOWER, R & KNOLL, C H (1975) Resistance to displacement of two cavity liners under amalgam condensation. In *Proceedings of the Fifth Congress of the International Association of Dentistry for Children*, Herzeliya, Israel F8 3.

GILMORE, H W, LUND, M R , BALES, D J & VERNETTI, J (1977) *Operative Dentistry* 3rd edition, p 93. St Louis:C V Mosby.

GRAJOWER, R, BIELAK, S & EIDELMAN, E (1984) Observations on a calcium hydroxide lining in retrieved deciduous teeth, with proximal amalgam fillings *Journal of Oral Rehabilitation* **11** 561-569.

HAMPSON, E L (1980) *A Textbook of Operative Dentistry* 4th edition, pp 48-49. London:William Heinemann Medical Books Ltd.

MARZOUK, M A, SIMONTON, A L & GROSS, R D (1985) *Operative Dentistry: Modern Theory and Practice* pp 268-269. St Louis:Ishiyaku EuroAmerica.

MJÖR, I A (1985) Frequency of secondary caries at various anatomical locations *Operative Dentistry* **10** 88-92.

SCHULTZ, L C, CHARBENEAU, G T, DOERR, R E, CARTWRIGHT, C B, COMSTOCK, F W, KAHLER, F W Jr, MARGESON, R D, HELLMAN, D L & SNYDER, D T (1966) *Operative Dentistry* p 77. Philadelphia:Lea & Febiger.

SHORER, V, HIRSCHFELD, Z & GRAJOWER, R (1984) Dycal: physical properties and resistance to amalgam condensation *Journal of Prosthetic Dentistry* **51** 358-363.

STURDEVANT, C M, BARTON, R E, SOCKWELL, C L & STRICKLAND, W D (1985) *The Art and Science of Operative Dentistry* 2nd edition, pp 67-72, 101-104, 197. St Louis:C V Mosby.

© OPERATIVE DENTISTRY, 1989, 14, 40-43

Effects of Glass Ionomers on Recurrent Caries

EDWARD J SWIFT, JR

Summary

Glass-ionomer cements slowly and continuously release fluoride ions. The studies described in this article have shown that glass ionomers can therefore reduce the incidence and severity of recurrent caries.

Introduction

There are a number of reasons for the replacement of dental restorations. For amalgam, the primary reasons include recurrent caries, poor marginal adaptation, and fracture of the restoration or tooth. The main reasons for replacement of composite resin restorations are discoloration, secondary caries, and poor anatomic form (Elderton, 1976; Mjör, 1981; Mjör, 1985).

University of Iowa, Department of Operative Dentistry, Iowa City, IA 52242

Edward J Swift, Jr, DMD, clinical instructor

Several factors interact to determine the longevity of a restoration. These include the oral hygiene of the patient, the skill of the operator, and inherent properties of the restorative material. One property which can enhance longevity, insofar as it relates to recurrent caries, is fluoride released from the restorative material.

The silicate cements, used for many years as an anterior restorative, are a classic example of a fluoride-releasing material. Fluoride incorporated into silicates during manufacture is released from the material and taken up by adjacent tooth structure. Enamel solubility is decreased, reducing the incidence and severity of recurrent caries (Paffenbarger, Nelsen & Sweeney, 1953; Norman, Phillips & Swartz, 1960; Hals & Nordenval, 1973; Hals, 1975a; Hals, 1975b).

Today, much interest is centered on a related class of fluoride-releasing materials, the glass-ionomer cements. These materials have many limitations, including relatively poor mechanical strength and susceptibility to moisture and dehydration; however, they can be very useful in selected situations.

This report provides (1) a brief background on the glass ionomers, (2) information concerning the production of secondary caries-like lesions in vitro, and (3) a review of research concerning the effect of glass ionomers on the development of recurrent caries.

Glass-ionomer cements

Glass-ionomer cements were introduced during the early 1970s (Wilson & Kent, 1972). They have since been used for a variety of clinical applications, including restoration of cervical lesions, core build-ups, cavity lining, and crown cementation (Mount, 1982).

Glass ionomers are formed by the reaction of polymers and co-polymers of acrylic acid with an ion-leachable calcium aluminosilicate glass powder prepared at high temperature in a fluoride flux (Wilson & Kent, 1972; Walls, 1986). The set cement consists of unreacted glass particles coated with silica gel and embedded in a matrix of calcium and aluminum "polysalts" (Crisp & Wilson, 1974; Walls, 1986).

Fluoride ions are released slowly from the material over an extended period of time (Forsten, 1977; Maldonado, Swartz & Phillips, 1978; Swartz, Phillips & Clark, 1984). Fluoride is taken up by tooth structure not only adjacent to a restoration, but even at a substantial distance away (Wesenberg & Hals, 1980; Retief & others, 1984).

Recurrent caries in vitro

Acidified gels are used to produce caries-like lesions in vitro which are indistinguishable from naturally-occurring caries when examined with microradiography or polarized-light microscopy (Silverstone, 1967). Recurrent caries around silicate cements, composite resins, and amalgam have been studied using this method (Hals, 1975a; Hals, 1975b; Hals & Kvinnsland, 1974; Hals & Nernaes, 1971).

The lesions actually consist of two parts--the outer and wall lesions. The outer lesion is caused by a direct acid challenge to the tooth surface and resembles primary caries. The wall lesion is adjacent to the restoration/cavity wall interface and is caused by hydrogen-ion diffusion from the medium through a microspace along this interface (Hals & Nernaes, 1971; Hals, 1975a; Hals, 1975b; Hicks, 1986; Hicks, Flaitz & Silverstone, 1986).

Fluoride-releasing restorative materials can exert an inhibitory effect on the development of these lesions. For example, the frequency and severity of outer lesions is generally reduced. This effect may result from diffusion of fluoride ions through the artificial caries medium (Hals, 1975a). In addition, if a wall lesion is present, its depth (measured perpendicular to the cavity wall) is decreased. This depth is used as an indication of the cariostatic influence of a given material (Hicks, 1986; Hicks & others, 1986).

Review of research studies

An early study concerning the effects of glass ionomers on recurrent caries was reported by Kidd (1978). Cavities were prepared in the crowns of extracted permanent teeth, then restored with either glass-ionomer cement or composite resin. After suspension of the teeth in acidified gel for 10 weeks, ground sections were made and examined using polarized-light microscopy.

Outer lesions around glass-ionomer restorations were less severe (in terms of depth) than those around composite resins. Also, lesions did not form directly adjacent to cavity walls. Finally, a wide negatively birefringent (mineralized) zone was usually present on the surface. Each of these observations indicates that a cariostatic effect was rendered by the glass-ionomer material.

Because of their ability to adhere to tooth structure, there has been much interest in glass ionomers as restorations for root-caries lesions (Walls, 1986). Wesenberg and Hals (1980) showed that the cariostatic benefit was not as great for radicular as for coronal surfaces. Still, secondary lesions were surrounded by a zone of increased radiopacity representative of hypermineralization.

Derand and Johansson (1984) compared the effects of various materials on the development of recurrent root caries in vitro. Lesions around glass-ionomer cements were consistently the smallest after different intervals in an acidified gel system. In addition, radiopaque areas were found to be associated with the glass ionomers. Wall lesions developed when restorations were inadequately sealed.

Later, Hicks (1986) examined adaptation of glass-ionomer restoratives to cavity walls as well as their effect on recurrent caries formation in roots. Class 5 cavity preparations were restored with either a conventional glass-ionomer restorative material or one reinforced with silver particles (McLean & Gasser, 1985). The teeth were suspended in acidified gel for 10 weeks. Artificial lesions were also created in sound teeth to serve as controls.

Longitudinal sections were ground, imbibed in water, and examined using polarized-light microscopy. Photomicrographs were made and projected on a digitizer to measure lesion depths. The mean depths of surface lesions were 338 μm for controls, 279 μm for silver-glass-ionomer restorations, and 227 μm for conventional glass-ionomer restorations. Only the difference between controls and conventional glass ionomers was statistically significant.

No wall lesions were present in association with either type of glass-ionomer restoration. Typical outer lesions were separated by a positively birefringent band from both the underlying dentin and a zone of apparently less-affected dentin bordering the cavity walls. The major difference between the two types of restoration was the greater lesion depth of the silver-reinforced restoration as compared to the conventional glass ionomer. In addition, a larger microspace was present at the cavity-wall/restoration interface of the silver-glass-ionomer restoration.

A similar study using the same materials in enamel cavities has been reported by Hicks & others (1986). Again, no wall lesions were observed with either restorative material. Mean depths of outer lesions were smaller than those discussed above; however, the relative differences were similar, i e, mean depths were greatest for control lesions and least for conventional glass ionomers. The difference between control-lesion depth and the depth of both treatment groups was statistically significant, as was the difference between the two glass-ionomer groups.

Histopathologically, control lesions consisted of a negatively birefringent surface zone overlying a positively birefringent area representing a pore volume greater than 5%. Lesions associated with silver-reinforced glass ionomers contained pseudoisotropic areas (indicating a pore volume of exactly 5%) as well as positively birefringent areas. Those lesions adjacent to conventional glass ionomers consisted of loosely-associated pseudoisotropic areas. The negative birefringence of the surface zones in both types was similar to that of sound enamel. Finally, as in the previous study, a wider microspace was associated with the silver-glass ionomers. Similar results, in terms of mean lesion depth and absence of wall lesions, have been observed with glass ionomers used to restore overdenture abutments (Kambhu, Ettinger & Wefel, 1987).

Discussion

Because of their relatively poor physical properties, the glass-ionomer cements cannot be considered a universal restorative material. Because of their proven ability to release fluoride and reduce the incidence and severity of recurrent caries, however, they do have some useful applications.

Glass ionomers should be considered as a restorative material whenever recurrent caries is likely and maximum strength is not required. Obvious indications are root caries or class 5 lesions on patients with poor oral hygiene or high caries index.

Conclusions

Recurrent caries represents a significant problem in restorative dentistry. One method of reducing this problem may be the use of fluoride-containing materials such as glass-ionomer cements. Several studies in vitro have shown that glass ionomers do indeed reduce the incidence and severity of recurrent caries.

(Received 14 October 1987)

References

CRISP, S & WILSON, A D (1974) Reactions in glass ionomer cements: III The precipitation reaction *Journal of Dental Research* **53** 1420-1424.

DERAND, T & JOHANSSON, B (1984) Experimental secondary caries around restorations in roots *Caries Research* **18** 548-554.

ELDERTON, R J (1976) The causes of failure of restorations: a literature review *Journal of Dentistry* **4** 257-262.

FORSTEN, L (1977) Fluoride release from a glass ionomer cement *Scandinavian Journal of Dental Research* **85** 503-504.

HALS, E (1975a) The structure of experimental in vitro lesions around silicate fillings in human teeth *Archives of Oral Biology* **20** 283-289.

HALS, E (1975b) Histology of natural secondary caries associated with silicate cement restorations in human teeth *Archives of Oral Biology* **20** 291-296.

HALS, E & KVINNSLAND, I (1974) Structure of experimental in vitro and in vivo lesions around composite (Addent XV) fillings *Scandinavian Journal of Dental Research* **82** 517-526.

HALS, E & NERNAES, A (1971) Histopathology of in vitro caries developing around silver amalgam fillings *Caries Research* **5** 58-77.

HALS, E & NORDENVAL, I-T (1973) Histopathology of experimental in vivo caries around silicate fillings *Acta Odontologica Scandinavica* **31** 357-367.

HICKS, M J (1986) Artificial lesion formation around glass ionomer restorations in root surfaces: a histologic study *Gerodontics* **2** 108-114.

HICKS, M J, FLAITZ, C M & SILVERSTONE, L M (1986) Secondary caries formation in vitro around glass ionomer restorations *Quintessence International* **17** 527-532.

KAMBHU, P P, ETTINGER, R L & WEFEL, J S (1987) In vitro evaluation of lesions adjacent to overdenture abutment restorations *Journal of Dental Research* **66** *Abstracts of Papers* p 124 Abstract 139.

KIDD, E A M (1978) Cavity sealing ability of composite and glass ionomer cement restorations. An assessment in vitro *British Dental Journal* **144** 139-142.

MALDONADO, A, SWARTZ, M L & PHILLIPS, R W (1978) An in vitro study of certain properties of a glass ionomer cement *Journal of the American Dental Association* **96** 785-791.

MCLEAN, J W & GASSER, O (1985) Glass-cermet cements *Quintessence International* **16** 333-343.

MJÖR, I A (1981) Placement and replacement of restorations *Operative Dentistry* **6** 49-54.

MJÖR, I A (1985) Frequency of secondary caries at various anatomical locations *Operative Dentistry* **10** 88-92.

MOUNT, G J (1982) The use of glass ionomer cements in clinical practice *Dental Outlook* **8** 37-44.

NORMAN, R D, PHILLIPS, R W & SWARTZ, M L (1960) Fluoride uptake by enamel from certain dental materials *Journal of Dental Research* **39** 11-16.

PAFFENBARGER, G C, NELSEN, R J & SWEENEY, W T (1953) Direct and indirect filling resins: a review of some physical and chemical properties *Journal of the American Dental Association* **47** 516-524.

RETIEF, D H, BRADLEY, E L, DENTON, J C & SWITZER, P (1984) Enamel and cementum fluoride uptake from a glass ionomer cement *Caries Research* **18** 250-257.

SILVERSTONE, L M (1967) Observations on the dark zone in early enamel caries and artificial caries-like lesions *Caries Research* **1** 261-274.

SWARTZ, M L, PHILLIPS, R W & CLARK, H E (1984) Long-term F release from glass ionomer cements *Journal of Dental Research* **63** 158-160.

WALLS, A W (1986) Glass polyalkenoate (glass-ionomer) cements: a review *Journal of Dentistry* **14** 231-246.

WESENBERG, G & HALS, E (1980) The in vitro effect of a glass ionomer cement on dentine and enamel walls *Journal of Oral Rehabilitation* **7** 35-42.

WILSON, A D & KENT, B E (1972) A new translucent cement for dentistry. The glass ionomer cement *British Dental Journal* **132** 133-135.

©OPERATIVE DENTISTRY, 1989, 14, 44-45

POINT OF VIEW

Contributions always welcome

Reflections on Effective Teaching of Operative Dentistry

JOSÉ E MEDINA

Teaching a clinical discipline is indeed a challenge and a rewarding experience. The challenge is even more demanding when the clinical discipline encompasses not only sound, basic scientific knowledge but also the application of surgical and restorative skills. Such is the case in the teaching of operative dentistry, a discipline based upon sound biological sciences which must be understood fully and then applied clinically to fulfill the preservation and restoration of the human dentition to physiological form and function.

Teachers of this clinical discipline must possess a comprehensive knowledge not only of all basic biological sciences including gross anatomy, physiology, immunology, microbiology, pathology, biochemistry, microscopic anatomy, and pharmacology, but also a knowledge of materials science, including metallurgy, polymer science, physical chemistry, physics, and engineering principles. They must also be knowledgeable in the biological behavior of all dental biomaterials in order to determine the success or failure of a restorative dental service and its compatibility to the oral tissues.

Knowledge and understanding of biological and physical principles are essential ingredients for effective teaching in operative dentistry; however, the resources needed for clinical teachers to be effective are much broader. They must also possess the psychomotor skills required to apply the knowledge in the performance and delivery of restorative services for patients. Surgical and restorative skills must be developed in order to ensure a lasting service of uncompromised quality. Effective teachers must possess those skills and be able to apply them and demonstrate to students the proper utilization of knowledge and the application of clinical skills in a given restorative service.

The acquisition of knowledge and the development of superior clinical skills are still insufficient

University of Florida, College of Dentistry
Department of Operative Dentistry
Box J-415, J Hillis Miller Health Center
Gainesville, FL 32610

José E Medina, DDS, professor emeritus

resources for becoming effective clinical teachers. There is also the need to develop a keen clinical judgment in order to know when and why a specific restorative service is indicated or contraindicated. The development of clinical judgment is a slow process and evolves gradually from experience, primarily from close observation of successes and failures of services rendered. Failures can provide a tremendous wealth of information for the development of clinical judgment, particularly when one analyzes in depth the reasons for their occurrence.

Perhaps the most important ingredient for effective clinical teaching is the personal philosophy and behavior of the teacher. Teachers must be motivated with a philosophy of excellence of service, always striving to achieve perfection, to enhance their understanding of basic sciences, to continually improve their skills and to utilize clinical judgment based upon what restorative treatments would best meet the needs of the patients. Such a philosophy of dedication and motivation to excel must be shown, demonstrated, and expressed to the students so that they in turn will begin to develop the desire and motivation to excel through continued learning.

Communication skills, therefore, are critical for clinical teachers to become effective academicians. They must be enthusiastic about their field, enjoy their role as teacher, and be able to communicate and transfer their knowledge, skills, judgment, and philosophy of practice to the students under their tutelage. Effective clinical teachers in operative dentistry are, therefore, motivators, mentors, sharers of information, facilitators, correlators and, above all, role models for their students to emulate.

Highly motivated clinical teachers who are enthusiastic about their discipline, who greatly enjoy teaching, and who possess the basic knowledge, skills, and judgment in their chosen discipline can become outstanding and effective clinical teachers. When such an attitude is developed, then both teaching and learning are enjoyable and the educational process is enhanced and quite effective.

©OPERATIVE DENTISTRY, 1989, 14, 46-47

Distinguished Member Award

Ian Fleming created James Bond. On the other hand, Mrs Hamilton created Ian Hamilton. Ian is a famous name, more so because of Ian Hamilton. His birth in 1915 took Canada's attention away from World War I. Then, at the age of three, when the armistice was signed, he vowed to become a dentist, bringing great cheer to his dentist father from that moment on.

Who would have thought then that the little toddler would later write for the journal *Science* or Gegenbauer's *Morphologisches Jahrbuch,* that he would work with titanium implants in the seventies, or that he would write with Karagianes and others in 1981? If Ian's mother had known that the little fellow would become the champion pole-vaulter of all Canada, she probably would have changed the height of his playpen.

Ian went on not only to achieve, but to give back to his profession a full measure of his time and ability. His honors include a master's degree in economics, a fellowship from Claremont Men's College, and a doctorate in anatomy achieved after six years of work at the University of London.

From our dental standpoint, his literally creating our *Operative Dentistry* journal and securing its place among scholarly journals was a major triumph. As its editor for 10 years, he brought it to a level where it is now used routinely as a reference in other professional journals.

A Ian Hamilton

Ian has demonstrated gold foil techniques in England at the Royal Dental Hospital, at the University of Washington, and for years as a study club member in Seattle.

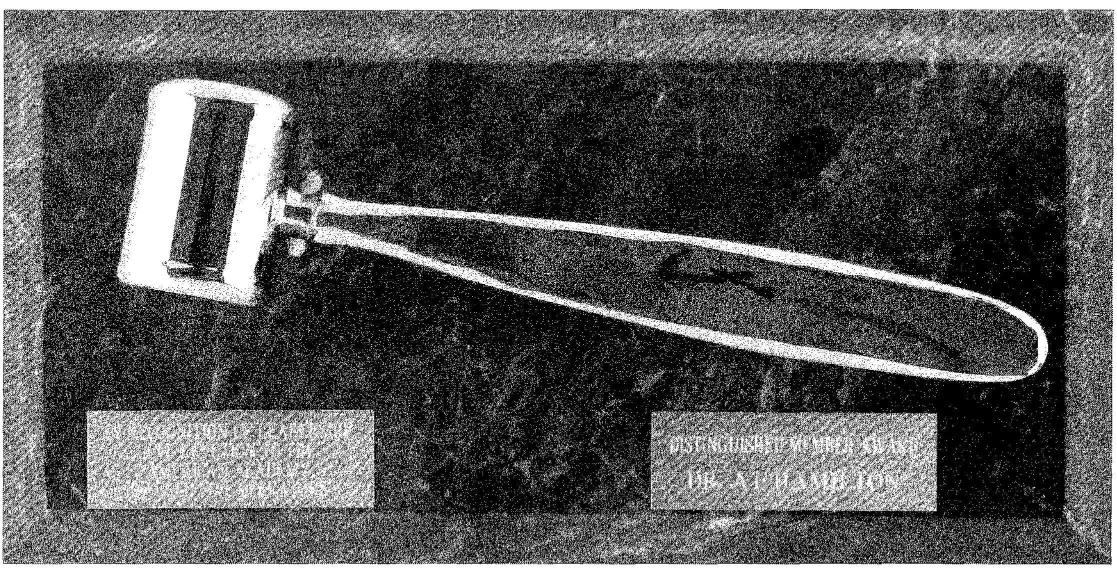
Those who know his character well are delighted by his Irish wit and pixielike sense of humor. It has been said that a small turf fire burns in his heart. Of course, without his wife Mary's wonderful understanding and support, he could have ended up chirping in a tree instead of flying with eagles. She stood by him through primate lab experiments (where even monkeys hate to lose their teeth), CAIC membership, and American Academy of Restorative Dentistry meetings, and she even puts up with his passion for Dixieland music.

All in all, Ian has been blessed, but he has returned a blessing to this Academy and to dentistry far beyond the average.

Many people through the years have contributed greatly to our Academy's unique and superior operating standards, but none has contributed more than Ian.

It is a sincere pleasure to extend to Ian Hamilton the Academy's Distinguished Member Award.

BRUCE B SMITH



Distinguished Member Award for 1988

DEPARTMENTS

Press Digest

Accuracy of elastomeric impressions disinfected by immersion. Johnson, G H, Drennon, D G & Powell, G L (1988) ***Journal of the American Dental Association*** **116 525-530.**

This study evaluated the effects of six representative disinfectants on the accuracy and surface quality of stone dies recovered from three different elastomeric impression materials. The three elastomeric impression materials were polyether, polysulfide and addition silicone. The accuracy of the impression materials was assessed by measuring locations on type IV stone casts obtained from impressions of a stainless steel master model. Impressions were placed in each disinfectant at room temperature for the allotted time suggested by the manufacturer. Compared to the controls, all disinfectants, except for neutral glutaraldehyde, had negligible effect on the polysulfide and addition silicone impression materials. The disinfectants uniformly had a deleterious effect on the stone dies recovered from polyether impressions. The surface quality of the stone dies was acceptable with all disinfectants and demonstrated improved quality with the acid potentiated glutaraldehyde. Results of this study indicate that the selection of the elastomeric impression material is more important that selection of the disinfectant.

Responses to periodontal injury in the dog: Removal of gingival attachment and supracrestal placement of amalgam restorations. Tal, H, Soldinger, M, Dreiangel, A & Pitaru, S (1988) ***International Journal of Periodontics and Restorative Dentistry*** **3 45-55.**

The distance between the bottom of the gingival sulcus and the alveolar bone crest averages 2.07 mm and is referred to as the biological width. The purpose of this study was to investigate the effect of violating the biologic width by positioning well-filled amalgam restoration margins at the level of the alveolar bone crest. Class 5 restorations were placed on the buccal surfaces of selected teeth in female beagle dogs who had clinically healthy periodontium. Evaluations were made at 12 and 24 weeks postoperatively. In comparison to the controls, the experimental sites exhibited more pronounced gingival recession, varying between 1 and 3 mm. At 12 weeks the experimental sites had edematous gingiva that bled with delicate probing. Histologic sections showed moderate bone loss and moderate to severe gingival inflammation. The epithelium lining against the root surface and the restoration was atrophic, ulcerated and severely infiltrated by inflammatory cells. The epithelium migrated beyond the apical margins of the restorations in all specimens. The subgingival placement of amalgam restorations resulted in periodontal pathology consistent with acute gingivitis and active periodontitis.

An evaluation of finishing instruments for an anterior and a posterior composite. Pratten, D H & Johnson, G H (1988) ***Journal of Prosthetic Dentistry*** **60 154-158.**

The purpose of this study was to evaluate the surface finish produced by 18 different finishing instruments on both a posterior and anterior composite restoration. BISFIL-I and BISFIL-M were cured in acrylic blocks, prepared in a specified manner and polished with one of the following: #15 scalpel blade, Midwest #7406 (12 fluted) carbide bur, Brasseler ET (12 fluted) carbide OSI bur, Brasseler fine and x-fine ET diamond burs at both high and low speed, 3M Soflex disk series, Shofu Rainbow disk series, white stone, Shofu Quasite rubber point, and Kerr Luster polishing paste. Five specimens, with a mylar strip finish only, served as controls. The difference in surface roughness, as measured with a surface profile analyzer, was significantly different between instruments. Mylar strips yielded the smoothest surface which appeared, on SEM, to be resin rich. Shofu disks and the Luster paste were next in smoothness and Shofu was slightly better than the Soflex disks. The fine diamond yielded the roughest surface, while the x-fine diamond performed better than the white stone or fine diamond. Diamonds were generally smoother at slow than high speed. Scalpel blades, often used in the interproximals, were not statistically different from the Brasseler carbide burs, x-fine diamonds or rubber points, all of which were intermediate in their polishing effectiveness. White stones appeared to result in a smear layer of resin, and were poor composite polishers. The rubber points left a smooth undulating surface with some grooving.

Effects of four lubricants used during incremental insertion of two types of visible light-activated composites. Tjan, A H L, & Glancy, J F (1988) *Journal of Prosthetic Dentistry* 60 189-194.

Incremental insertion of visible-light-cured resin requires manipulation of material with composite instruments. To prevent material from sticking to instruments, lubrication with alcohol or bonding agents has been recommended. This study evaluated the effects of four lubricants on the adhesive bond between layers of composite. Two visible-light-activated posterior composites were used: Herculite and Heliomolar. Five groups for each composite were evaluated: 1) no lubricant (control), 2) 70% EtOH, 3) 70% isopropanol, 4) bonding resin, and 5) dentin adhesive. An adhesive layer was bonded to a substrate layer, then specimens were tested by axial loading. Peak strengths were recorded as tensile bond strengths. There were no statistically significant differences between the Herculite groups. Adhesive failures were observed in all of the Heliomolar ethanol and dentin adhesive specimens and in 40% of the isopropanol specimens. No difference was found between the Heliomolar bonding resin and control groups.

A comparison of different treatments for nocturnal bruxism. Pierce, C J & Gale, E N (1988) *Journal of Dental Research* 67 597-601.

The purpose of this study was to compare the electromyographic (EMG) activity of four bruxism treatments for short- and long-term effectiveness. One hundred selected bruxers were equally divided into four experimental treatment groups consisting of diurnal biofeedback (relaxation), nocturnal biofeedback, massed negative practice, splint therapy, and a control group. EMG frequencies and durations per hour were measured for four time periods: two weeks pretreatment baseline, two weeks post-treatment and two weeks of follow-up six months later. Only the nocturnal biofeedback and flat plane occlusal splint therapy treatment groups were associated with significant decreases in EMG-measured bruxing activity from baseline to treatment times, and generally significant increases in bruxing activity to baseline levels when treatment was withdrawn. These results support previous findings with regard to nocturnal biofeedback and splint therapy, including the effects of short-term intervention on long-term bruxing activity. Contrary to the literature, massed negative practice was not found to have a significant treatment effect.

Osseointegrated oral implants - A Swedish multi-centered study of 8139 consecutively inserted Nobelpharma implants. Albrektsson, T, & others (1988) *Journal of Periodontology* 59 287-296.

The purpose of this retrospective, multiclinic study was to give a complete report of all inserted Nobelpharma implants by 14 Swedish teams. Each team consisted of an oral surgeon and prosthodontist. The teams had participated in a detailed Branemark training course prior to the insertion of any implants and each member had a minimum of three years of experience. The total number of consecutively inserted implants at the 14 clinics was 8139. The outcome of every implant was reported and all failures published. The success criteria included absence of radiolucent zones on radiographs, an annual bone loss of less than 0.2mm after the first year, and the absence of mobility. Of the 334 mandibular implants followed for five to eight years, there were three failures, for a success rate of 99.1%. In the maxilla 106 implants were followed for five to seven years, with a success rate of 84.9%. The overall success rate of 4907 mandibular implants was 98.94% compared to a 92.95% rate for 3089 maxillary implants. Of the mandibular failures, 78.8% occurred in the first year of implantation and 13.5% in the second year. In comparison, 82.9% of all maxillary failures occurred in the first year and 14.5% in the second year. It was concluded that the osseointegrated implant, if inserted according to the guidelines of Branemark, results in a very high degree of clinical success.

The periodontal ligament injection: A comparison of 2% lidocaine, 3% mepivicaine, and 1:100,000 epinephrine to 2% lidocaine with 1:100,000 epinephrine in human premolars. Schleter, J R, Reader A, Beck, M, & Meyers, W M (1988) *Journal of Endodontics* 14 397-404.

The purpose of this study was to evaluate the anesthetic efficacy of the periodontal ligament injection with different solutions. The mandibular first premolars of 75 healthy students were tested with one side serving as the control and the other as the test tooth. An Analytic Technology pulp tester was used to determine the level of pulpal anesthesia at 2, 4, 10, 20, 30, and 45 minutes. Two percent lidocaine with 1:100,000 epinephrine was compared with 2% lidocaine, 3% mepivicaine, and 1:100,000 epinephrine. Two percent lidocaine with 1:100,000 epinephrine anesthetized 87% of tested teeth and pulpal anesthesia lasted approximately 20 minutes. This was significantly better than other solutions. Three percent mepivacaine anesthetized 42% of tested teeth for a duration of 4 minutes. Two percent lidocaine anesthetized 14% of tested teeth and lasted 2-4 minutes. Epinephrine alone did not anesthetize any teeth. Teeth adjacent to the injected teeth were also anesthetized; 45% on the mesial and 78% on the distal of teeth injected with 2% lidocaine with 1:100,000 epinephrine and less with the other solutions. Post injection discomfort was reported by 88% of the subjects and 49% reported feeling the tested teeth were high in occlusion. At four weeks post injection no clinically observable pulpal or peridontal damage was seen.

A quantitative study of finishing and polishing techniques for a composite. Chen, C S, Chan, D C, & Chan, K C (1988) *Journal of Prosthetic Dentistry* 59 292-297.

This study compared six finishing/polishing techniques for effectiveness on Silux, a microfilled composite resin. Class 5 preparations were filled with Silux on both the buccal and lingual surfaces of 15 extracted molars. The samples were grossly finished with a 12-fluted carbide finishing bur and then randomly assigned to one of the following groups: I, dry Soflex disks of medium, fine, and superfine grits in descending order of coarseness; II, dry Vivadent polishing point; III, wet Den-Mat polishing paste with rubber cup; IV, wet Densco finishing (40 micron) and polishing (15 micron) diamond burs; and V, same as IV followed by Den-Mat polishing paste. The restorations were evaluated by measuring the relative reflectance with a video image analysis system in addition to examination under a scanning electron microscope. The results were, in order of decreasing effectiveness: I and V > II > and IV > III. The Soflex disk system (I), used in proper sequence, produced the smoothest polished surface. The wet finishing and polishing diamonds/polishing point technique (V) was not statistically different, however, and should be considered for use in areas inaccessible to disks.

Nabers, C, Stalker, W, Esparza, D, Naylor, B & Canales, S (1988) Tooth loss in 1535 treated periodontal patients *Journal of Periodontology* 59 297-300.

Of 1535 periodontally treated recall patients observed for an average time of 12.9 years since treatment was completed, 1371 retained all treated teeth. The total number of teeth lost was 444 by 164 patients, with the average tooth loss for the 1535 patients being 0.29. Patients with poorly controlled diabetes, poor oral hygiene, noncompliance with periodontal maintenance, or full arch splinting demonstrated much higher average tooth loss. Of the patients treated, 73.5% required various surgical procedures while 26.5% were treated nonsurgically. No attempt was made to compare treatment modalities. Of the 1535 patients, many of whom developed recurrent periodontal problems, 15.9% required surgical retreatment. Teeth with an original doubtful prognosis were often responsible for recurrent problems that sometimes necessitated extraction. Motivated patients, pocket elimination, excellent plaque control, and an effective three- to six- month maintenance recall program all appear to be factors in the low tooth-loss rate.

The sealing properties of temporary filling materials. Pashley, E L, Tao, L, & Pashley, D H (1988) *Journal of Prosthetic Dentistry* 60 292-296.

It has been suggested that reduced pulpal response under IRM and ZOE restorations may be due to their antimicrobial and anodyne properties instead of their sealing qualities. The purpose of this study was to quantitatively evaluate the sealing properties of five temporary filling materials. Sixty-six extracted human third molars were sectioned horizontally at the CEJ and the coronal section mounted in a fluid filtration apparatus which measured dentin permeability. Class 1 cavity preparations were made, the dentin etched with 6% citric acid and the teeth restored. All restorative materials, except Gutta Percha and Cavit-G, were mixed with the following powder to liquid ratios (P/L); ZOE (2, 4, 6), IRM (2, 4, 6, 7), and Durelon cement (2, 4). Measurements of microleakage were made at various times after insertion, with thermocycling of the specimens between measurements. The results suggest that the best seals were with Cavit-G cement and Durelon cements, at a P/L ratio of 2. The worst seal was found with Gutta Percha. The worst P/L ratio for IRM was 7, which reduced microleakage only 27.6% at 60 minutes. IRM and ZOE mixes of high P/L ratios had good initial sealing qualities but, with time, resulted in microleakage 40-50% as great as the unrestored cavity. This data supports other studies that claim the clinical success of these materials may be a result of the antimicrobial or anodyne properties of the materials instead of their sealing qualities.

Book Reviews

PRINCIPLES AND PRACTICE OF OPERATIVE DENTISTRY
Third Edition

Gerald T Charbeneau, DDS, MS, Editor

Published by Lea & Febiger, Philadelphia, 1988. 496 pages, illustrated, $45.00.

If this book contained a "Dedication," it would surely honor dental students for it is virtually a complete guide to learning basic operative dentistry. As in previous editions, a strong emphasis is placed upon occlusion, periodontal considerations, and the biologic basis for restoring teeth. This edition is made current by the expansion of sections regarding direct esthetic restorations, cariology, biologic considerations, and esthetic crowns. A new and useful chapter is devoted to diagnosing and treating odontalgia and related complications in operative dentistry.

Unique to this textbook is the self-evaluation and quality evaluation systems which students and teachers should find invaluable.

The book has numerous minor improvements which range from illustrations to organization of subject matter. Techniques to deal with badly broken-down teeth and defective restorations receive limited coverage but may be beyond the scope of this book.

This is surely one of the finest texts ever on operative dentistry principles.

Glenn E Gordon, DDS, MS
Department of Restorative Dentistry, SM-56
School of Dentistry
University of Washington
Seattle, WA 98195

DENTAL OFFICE HAZARD COMMUNICATION KIT

Diane Miller, Bud Miller, Peter Harnack

Published by HASCOM, INC, Lake Oswego, OR, 1988. 75 pages. $95.00.

The purpose of this excellent publication is to assure that an office can and will comply with all relevant regulations and safe practices concerning hazardous substances. Specifically, it shows each user how to comply with the Occupational Safety and Health Administration requirements that each employer create a Hazard Communication Program, evaluate hazards, maintain inventories of hazardous chemicals, appropriately label each container, maintain files of Material Safety Data Sheets, and provide each employee with appropriate information and training. This list is, regrettably, only a brief and incomplete summary.

Increasing formality of office policies and procedures is a characteristic of our times. It is essential to have procedures manuals for many activities. In the case of hazardous chemicals, each practitioner must also keep records of staff training sessions, and maintain a large file of information. This kit facilitates these tasks. It includes brief reviews of Federal regulations, defines a dental office Hazard Communication Plan, provides an inventory form with many useful examples, provides samples of appropriate labels, and even includes some sample Material Safety Data Sheets. Although this information could be collected by persons in a dental office, it is much easier, and surely less costly, to purchase and use the kit.

The section titled, "Employee Information and Training," is terse but sufficient for several productive staff meetings. There are even a few suggested test questions, and a lot of spaces for information to be added for each individual office. Creating procedures manuals is an arduous task. The time and effort required is always larger than expected, and outside help is often cost-effective. This kit will eliminate much (though not all) of the work associated with developing a sound office hazard program. It will be very helpful to every practitioner using it.

Dan Middaugh, DDS, MPS
Assistant Dean for Continuing Dental Ed
School of Dentistry, SB-27
University of Washington
Seattle, WA 98195

AN ATLAS OF REMOVABLE PARTIAL DENTURE DESIGN

R J Stratton and F J Wiebel

Published by Quintessence Publishing Co, Inc, 1988. 336 pages, 800 illustrations. $48.00.

The intent of this book is to decrease the frustration for the dentist in partial denture design and to aid in dentist/laboratory communications.

Emphasis is on design, with a marvelous atlas of 151 reference cases. The authors discuss fundamentals of design concepts and mouth preparation. Discussion is limited to conventional extracoronal designs with broad stress distribution and to minimal tooth and tissue coverage.

The authors get to the point and address the most commonly encountered clinical situations in a very understandable format. Concepts are well-illustrated with drawings.

This atlas is recommended for the dentist desiring to gain a thorough understanding of partial denture design.

Diantha J Berg, DDS
17220-140th Ave SE, Suite C
Renton, WA 98058

CONTEMPORARY FIXED PROSTHODONTICS

Stephen F Rosensteil, BDS, DDS, Martin F Land, DDS, MSD, and Junhei Fujimoto, DDS, MSD, DDSc

Published by The C V Mosby Company, St Louis, 1988. 528 pages, 2127 illustrations. $44.95.

The authors intended to provide a well-organized and clearly illustrated text addressing quality comprehensive fixed prosthodontics for the dental student, educator, clinician, and researcher. This was successfully achieved by presenting four structured sections: planning, clinical procedures, laboratory procedures, and delivery. Each area is generously illustrated with black and white photographs, line drawings, and descriptive shaded drawings.

The first five chapters provide an overview of occlusal therapy, periodontal considerations, and pretreatment mouth preparation as basic background information. The second section describes tooth preparation techniques for complete and partial veneer preparations. The authors have limited the use of this text in educational programs that favor the beveled-shoulder preparation by emphasizing the utilization of the chamfer finish-line design. The preparation chapters and those describing the laboratory techniques succinctly present a volume of information for all of the intended readers. The chapter explaining dental laboratory communication is especially useful. The final section describes the steps necessary for delivering the restoration to the patient. The subject of assessment and fitting of the finished restoration is discussed in detail, an area that is too often inadequately covered in texts. It is a welcome addition to a comprehensive textbook. There is an appendix which includes the brand names and the manufacturers' addresses.

An attempt to cover the considerable amount of material involved with a subject as large as contemporary fixed prosthodontics allows only a general coverage of each area, which has been accomplished quite well by these authors. For additional information they have provided references for each chapter. This text would be a good source book for any of the intended readers.

DAVID G DRENNON, DDS, MS
Department of Restorative Dentistry
School of Dentistry, SM-56
University of Washington
Seattle, WA 98195

ESTHETIC COMPOSITE BONDING
Techniques and Materials
Revised Reprint

Ronald Jordan

Published by B C Decker, Inc, Philadelphia, 1988. Distributed by C V Mosby, St Louis, 376 pages, hundreds of color photographs, indexed. $119.00.

The revisions in this reprint edition of Dr Jordan's textbook on composite materials are largely related to the color photography; the color photographs are printed larger, and the color is significantly improved. One may wonder whether the reprint was necessary simply for improvement of the photography. For certain, the reprint edition more clearly demonstrates the subtleties of cosmetic dentistry, particularly in cases dealing with slight changes in shading such as is found in tooth bleaching.

The text is without much change. There are two sections added to the chapter on posterior composites, one dealing with direct hybrid composite inlays, the other with porcelain inlays. The product information lists at the end of each chapter have also been updated.

This textbook on composite techniques was excellent to begin with (original review Autumn 1986); now it is without a doubt the most comprehensive book of its field. It includes chapters on all aspects of esthetic dentistry from simple bonding techniques to more complicated procedures such as bleaching, veneers, and acid-etch bridges. The revised reprint edition has added significantly to the clarity of instruction. This book is again highly recommended for dentists who want to improve or extend the use of composite resin in their practice and also for students who want an introduction to the various uses of composite resins.

L VIRGINIA POWELL, DMD
Department of Restorative Dentistry
School of Dentistry, SM-56
University of Washington
Seattle, WA 98195

Letters

Periodontal Considerations of Operative Dentistry

Dr Ramfjord's comments in his Buonocore Memorial Lecture about subgingival electrosurgery emphasize the cliché that there are two sides to every coin. His observations about the results of electrosurgery provide a unique example of the diversity of the two sides, namely, the esoteric, scientific aspects versus the practical, clinical results of subgingival electrosurgery.

He focused unabashedly on the scientific, and almost cavalierly dismissed the practical, clinical usefulness of subgingival electrosurgery with the statements, "The use of electrosurgery for 'troughing' of the gingival sulcus is, in spite of all the testimonial assurances to the contrary, hazardous to the attachment level," and, "A confusing aspect of these (troughing) procedures and of electrosurgery is that the clinical gingival response may be beautiful, except for some recession, but what has happened to the attachment level and the junctional epithelium is not observable clinically." These comments bear closer scrutiny and evaluation. First, the reference to gingival recession. When the electrosurgical modality and clinical operative technique are properly utilized, the tissues do not recede as they heal; rather, they tend to regenerate to or toward their original level. Moreover, his comment about the need for brief contact between the activated electrode with metal restorations is misleading. Need for very brief activated electrode contact is by no means limited to metal restorations. It is imperative that contact should be limited at all times to a maximum of two seconds during which the electrode must be kept in rapid motion and followed by a 10-second rest interval to prevent destructive cumulative heat retention in the tissues. Furthermore, when metallic contact cannot be avoided, the restoration should be coated with vaseline to minimize the risk of thermal pulp irritation.

The serial, step-by-step illustrations in the chapters on operative dentistry, fixed prosthodontics, and periodontal therapy of the Oringer text, *Color Atlas of Oral Electrosurgery* (Quintessence, 1985), attest incontrovertibly in living color that when gingival and subgingival electrosurgery is performed properly and skillfully, the esthetic and functional results exceed by far those attained by other methods of instrumentation.

Dr Ramfjord's plaintive, "but what has happened to the attachment level and the junctional epithelium is not observable clinically," is factually irrelevant. In the final analysis, if the end result of therapy is healthy gingival and subgingival tissues, normal investing alveolar bone, unimpaired tooth vitality, and circumferentially intact gingival attachment devoid of periodontal pockets, what difference does the level of attachment and junctional epithelium make, since they cannot be determined clinically, but would require block dissection of gingival and subgingival tissues, alveolar bone, and perhaps even extraction of the teeth to make the determination?

It is regrettable that many research-oriented periodontists ignore the need for unbiased, balanced consideration of the realistic, clinical aspects as well as the esoteric, scientific aspects of dental electrosurgery. One cannot help but wonder what it will take to put to rest their exaggerated fears of, and shopworn admonitions to avoid subgingival use of, a modality that has contributed so greatly to the improvement and simplification of clinical dentistry?

MAURICE J ORINGER, DDS
15 W 81st St
New York, NY 10024

RESPONSE

Dentistry is going through a stage of adaptation to scientific methodology from the traditional clinical empiricism. In this process, some old dogmas have been proven wrong (for example, in periodontics) and the required changes in thinking and procedures are hard to take for clinicians who have been proud and confident of their subjective good results.

I gave in my article scientific evidence for what I wrote, and statements in the letter such as, "The esthetic and functional results exceed by far those attained by other methods of instrumentation," are nice but completely valueless without scientifically acceptable testing with measurements and statistics.

In our research we also found that electrosurgery could be harmless if done within the epithelial attachment to enamel, but as soon as the epithelial attachment extended apically to the C-E junction, harmful effect had a distinct tendency to occur. Clinically, dentistry does not need such a hazardous procedure to produce optimal results. As a periodontist, I happen to believe that the level of connective tissue attachment is extremely precious and important to maintain as far coronally as possible.

SIGURD P RAMFJORD
Professor Emeritus
School of Dentistry
The University of Michigan
Ann Arbor, MI 48109-1078

Announcements

NEWS OF THE ACADEMIES

American Academy of Gold Foil Operators

The 38th annual meeting was held 5-7 October 1988 at Georgetown University School of Dentistry and the Key Bridge Marriott, Arlington, Virginia. The Board of Directors meeting was held on Wednesday afternoon followed by a no-host cocktail "Welcome Party" in the hospitality suite. On Thursday morning, clinical demonstrations were given, with 17 clinicians presenting a variety of class 2, 3, 4 and 5 procedures to an enthusiastic group. Dr Chester Gibson was commended for volunteering to do a class 4 direct gold restoration when the operator scheduled to accomplish the restoration was unable to attend.

During the afternoon, members and guests enjoyed an afternoon cruise to Mount Vernon. The day concluded with a reception and banquet at the Key Bridge Marriott featuring entertainment by "The Docs of Dixieland." Dr Paul A Moore, the longest original member of the group and a Life Member of the Academy, was the Master of Ceremonies. The evening concluded with the presentation of the Distinguished Member Award for 1988 to A Ian Hamilton of Seattle, Washington. Dr Hamilton was this Journal's first editor, a position he held for 10 years.

Friday morning found the participants listening to a number of exceptional papers given by Ted Ramage, Chester Gibson, Richard D Tucker, Clyde Ingersoll, Matt Panar and Josef Schmidseder.

The officers of the Academy for the forthcoming year are: president, Richard V Tucker; immediate past president, Allan G Osborn; president-elect, William H Harris; vice-president, Michael A Cochran; secretary-treasurer, Nelson W Rupp; and councillors, Alfred C Heston, Richard J Hoard, and Ralph L Lambert.

Next year's annual meeting will be held in Seattle, Washington with clinical demonstrations at the University of Washington School of Dentistry, 1-3 November, 1989.

It is not too early to make plans to attend what promises to be another outstanding meeting in Seattle. Plan on joining us there.

American Board of Operative Dentistry

The American Board of Operative Dentistry is pleased to announce that three more distinguished members of the profession have successfully completed all phases of the board's certifying examination. They are: Drs Maxwell H Anderson of Olney, Maryland; R Craig Bridgeman of Boone, North Carolina; and Joel M Wagoner of Beckley, West Virginia. They completed the final phases of the examination process by completing the oral and clinical phase of the examination given at the University of Maryland School of Dentistry, Baltimore, Maryland, this past August and will be inducted as certified members of the board at its annual meeting in Chicago.

The Board wishes to express its thanks and appreciation to Dr Erroll L Reese, Dean of the University of Maryland School of Dentistry and Dr George Buchness, Chairman of Restorative Dentistry for their assistance in making the clinical and oral examinations run so smoothly. These two gentlemen were professionals of the first order.

DIRECT FILLING GOLD COURSE

On 31 October and 1 November, 1988, Dr Lloyd Baum gave a course in Direct Filling Gold at the Southerland Clinic, University of British Columbia, Canada. The hands on participation course was attended by an enthusiastic group of dentists from the Vancouver area. This was the first course generally open to dentists in this area in the last 10 years.

Manuscript Submissions

Authors are encouraged to read the revised *Instructions to Authors* found on the inside back cover of the journal. For more than a year, we have been "reading" accepted manuscripts with an "optical scanner" which directly translates the typed page into our computer's word processing program. We need to inform you that type sizes on the printed page need to be consistent, preferrably at 10- or 12-point size. **Do not use a variety of type sizes**, as this only confuses the computer.

We now are requesting that authors who prepare their manuscript on an IBM-compatible word processor submit their manuscript on a floppy disk, in addition to the usual 2 copies of written text.

If you are submitting a manuscript prepared on an IBM or compatible, your submission of the floppy disk should identify the name of the word processor used to prepare the written text. This will allow us to serve you better and be more cost-effective at the same time.

Your assistance in this regard is appreciated.

THE EDITOR

International Meeting of the American Academy of Gold Foil Operators
Goettingen, West Germany
8-9 June, 1989

This two-day meeting is being arranged and organized by Drs Allan G Osborn of Winnipeg, Canada, and A Motsch and Josef Schmidseder of West Germany. It will include lectures and clinical demonstrations in much the same pattern as the annual meeting of American Academy of Gold Foil Operators. The meeting is programmed to be helpful to the dental practitioners of Europe who may have an interest in direct filling gold.

The following members of the AAGFO are scheduled to be participants in the program: J Schmidseder, R Kinzer, L Baum, A Osborn, H Schnepper, M Lund, R Hoard, J Gourley, A Motsch, R Harris, R Tucker, and L Beamish.

During recent years, there have been several areas of Europe that have shown interest in this restorative procedure. Since the utilization of direct gold in North America seems at a constant level, it is novel to have requests for knowledge of this material arise from other geographical locations. Should North Americans wish to attend this meeting, they would be welcome. For information, please contact Dr Allan G Osborn, 406 Medical Arts, 233 Kennedy, Winnipeg, Manitoba, Canada.

Melvin R Lund, DMD, MS
Department of Operative Dentistry
School of Dentistry
Indiana University
1121 West Michigan Street
Indianapolis, IN 46202

DIRECT GOLD COURSE CANCELED

The direct gold course for educators and practitioners, scheduled to be held at Indiana University, will not be held in 1989 due to the commitment of faculty to the international direct gold course mentioned above.

NOTICE OF MEETINGS

Academy of Operative Dentistry

Annual Meeting:
15-16 February 1989
Westin Hotel
Chicago, Illinois

American Academy of Gold Foil Operators

Annual Meeting:
1-3 November 1989
University of Washington
Seattle, Washington

American Board of Operative Dentistry

Annual Meeting:
14 February 1989
Westin Hotel
Chicago, Illinois

Wit and Wisdom

My candle burns at both ends;
It will not last the night;
But ah, my foes, and oh my friends--
It gives a lovely light!
--Edna St Vincent Millay (1892-1950)

"There is always room at the top." (When advised not to become a lawyer as the profession was overcrowded)
--Daniel Webster (1782-1852)

New occasions teach new duties: Time makes ancient good uncouth;
They must upward still, and onward, who would keep abreast of truth.
--James Russell Lowell (1819-1891)

INSTRUCTIONS TO CONTRIBUTORS

Correspondence

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

Exclusive Publication

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

Manuscripts

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

Tables

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

Illustrations

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

References

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

Reprints

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

OPERATIVE DENTISTRY

WINTER 1989 • VOLUME 14 • NUMBER 1 • 1-56

EDITORIAL

ORIGINAL ARTICLES

POINT OF VIEW

DISTINGUISHED MEMBER AWARD

DEPARTMENTS

University of Washington
School of Dentistry, SM-57
Seattle, WA 98195 USA