OPERATIVE DENTISTRY

may-june 1995 • volume 20 • number 3 • 85-128

(ISSN 0361-7734)

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MAY-JUNE 1995 • VOLUME 20 • NUMBER 3 • 85-128

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.

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Operative Dentistry (ISSN 0361-7734) is published bimonthly for $55.00 per year in the US and Canada (other countries $65.00 per year) by Operative Dentistry, Inc, University of Washington, School of Dentistry,SM-57, Seattle, WA 98195. *Operative Dentistry* is the official journal of the American Academy of Gold Foil Operators, P O Box 57, Industry, TX 78944 and the Academy of Operative Dentistry, P O Box 177, Menomonie, WI 54751.

POSTMASTER: Send address changes to: Operative Dentistry, Inc, The University of Washington, School of Dentistry, SM-57, Seattle, WA 98195.

Subscriptions
Yearly subscription in USA and Canada, $55.00; other countries, $65.00 (sent air mail); dental students, $25.00 in USA and Canada; other countries, $34.00; single copy in USA and Canada, $15.00; other countries, $18.00. 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.

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EDITORIAL

The Board Examination: A True Test or Only a Rite of Passage?

State board examinations have been a fact of life for a very long time.They were originally developed to separate the competent from those with little or no formal training nor even an adequate apprenticeship to perform at a basic level. This historic mechanism became the official way the oral health of the patients in each state or region was to be protected.

These examinations have changed relatively little over the succeeding years, despite the fact that dental education, its accreditation process, and even the way dentistry is practiced have all changed so markedly in the last half-century. The examination process continues as if we were still in the time of apprenticeships and as if the only real test of dental knowledge and skills lies in performing a few common restorative and periodontal procedures under very stressful and artificial conditions.

Our collective thinking seems to be stuck on making small adjustments to the present format rather than "backing off" far enough to determine whether it actually achieves its avowed intention of protecting the public from incompetent practitioners. I assert that it does not! The results from many, if not all, state and regional examinations show that any candidates persistent enough to repeat the examination pass it eventually, despite having had neither time nor opportunity to practice the procedures. The test frequently fails some of the more qualified candidates (as rated by the full- and part-time faculty) and passes others considered to be distinctly less qualified. Some candidates fail simply because patients arrive late or not at all. Since patients may not be from the candidate's own patient pool, this cannot automatically be considered a problem of patient management. Candidates may fail because a cast restoration, made in a hurry under obviously adverse conditions, does not seat. These are not true tests of a candidate's ability to provide high-quality care but a rather perverse test of their ability to work under very high stress!

The results of the regional board examinations for 1994 showed failure rates for regions reaching as high as 40% or more. Results for graduates of certain schools soared as high as 80%. Since the entry-level credentials of the class of 1994 were no different than previous classes, and since most schools have not radically altered their curricula, it is difficult to accept that the graduates were less well qualified than their predecessors. Certainly, current graduates are not different enough from previous ones to warrant a tripling or quadrupling of the failure rate. There is no evidence to explain why the national failure rate should change so dramatically in just one or two years, so a logical assumption is that the examination or the evaluation criteria must have changed significantly. If there has been a significant change, were the public's best interests better served? Did the process really protect the patients from incompetent and/or uncaring young dentists? Or did it merely create a most distressing and expensive, albeit temporary, barrier to these dentists joining their profession? And were those passing the examination the first time better qualified—or were they just more fortunate?

Should the profession do away with the state/regional board examination altogether? Or should it bring together its various components to create an examination format that more accurately separates the competent from the incompetent? To do this requires an end to the unproductive power struggles that have too often characterized the dialogue (or lack thereof) among dental associations, state/regional board examiners, and representatives of the academic community. The profession must join together if it is to truly protect the public while it welcomes qualified new graduates without making them undergo a distressing, very expensive, and, arguably, meaningless process. And we need to put a halt to an attitude that may linger in some areas that a high failure rate is good because it means less competition. Let us not be a profession that ever, even remotely, seems to glory in eating its own young each summer.

As members of the profession, are we willing to surrender our egos and ignore political pressures to make the effort to change the way competency is determined to one that is more valid and less traumatic? Let us hope so. It will not be easy, but it is necessary. And it is time!

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CLINICAL ARTICLE

The Use of Diet Analysis and Advice in the Management of Dental Caries in Adult Patients

EDWINA A M KIDD

INTRODUCTION

In many societies both the prevalence and incidence of caries has fallen dramatically in the last 20 years. For many people dental caries is no longer a problem, but for the unfortunate few the process still leads to clinical cavitation, and dental treatment is required. What does modern dentistry mean by "treatment" of dental caries? GV Black, the father of modern operative dentistry, addressed this point in 1908 when he wrote "the complete divorcement of dental practice from studies of the pathology of dental caries, that existed in the past, is an anomaly in science that should not continue. It has the apparent tendency plainly to make dentists mechanics only." Thus at the beginning of the century this remarkable clinician and scientist set the treatment of dental caries within the science of cariology and was studying the carious process, well aware that operative, mechanical dentistry was not the only treatment required.

The carious process is now known to involve specific groups of microorganisms within the dental plaque (Bowden & Edwardson, 1994) that are capable of fermenting a suitable dietary substrate (particularly sugar) to produce acid. In time this may result in demineralization of a susceptible tooth surface. Fortunately most mouths contain saliva, a natural remineralizing solution, and progress of the carious process to cavitation is not inevitable. Treatment of the carious process, therefore, involves diagnosis of caries risk and preventive management that will include dietary modification, judicious use of fluoride, and improved plaque control. High-quality operative dentistry, including sensible use of fissure sealants, facilitates mechanical plaque control by eliminating stagnation areas.

Thus the modern treatment of dental caries involves more than the traditional surgical model of reparative care. A medical approach (Anderson, Bales & Omnell, 1993) including dietary modification, appropriate fluoride supplementation, and sometimes even chemical plaque control (Kidd, 1991) is an ethical necessity. Without this approach clinicians would indeed be what Black described as "mechanics only," reacting through repair of existing disease rather than accepting a proactive role that attempts to modify the causative and preventive factors to maintain the patient in a state of stable dental health.

Restorative programs should be based on this modern concept of cariology. Preventive treatment should be a recognized part of a treatment plan and therefore worthy of financial reward in the same way as operative treatment.

This paper seeks to revisit the clinical technique of diet analysis and advice. In the 1980s careful research was carried out into the relevance of sugar intake and frequency of ingestion on the dental caries increment in children (Burt & others, 1988). Results showed that in this group of 11-15-year-old children there were no cavitated buccal and lingual smooth surface lesions, but 81% of new lesions were on pit and fissure surfaces. Sugar-eating patterns

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showed little relation to caries increment on these surfaces. However, the consumption of between-meal sugars was related to the approximal caries increment, so that the authors concluded that while sugar-eating frequency might not be relevant to the average teenager, between-meal sugar consumption was still a risk factor for the most caries-susceptible children. It is thus logical to target the technique of diet analysis and advice at those most at risk. For this reason the paper starts by a consideration of the diagnosis of caries risk.

CARIES-RISK ASSESSMENT

The prudent practitioner will make a caries-risk assessment on all patients when they initially present, recording risk as high, low, or intermediate. Caries-risk assessment is a complex topic (Federation Dentaire Internationale, 1988; Johnson, 1991). Table 1 lists some of the many factors to be considered so that, through a careful history, clinical examination, and special tests, this risk assessment may be made.

Social factors will be assessed, often subconsciously, as the patient enters the room. Dress, demeanor, and ethnic background will be apparent for subjective appraisal. Questions on employment and attendance patterns of other family members elicit valuable information. During history taking the patient's dental aspirations become apparent, and relevant treatment planning will encompass these aspirations. Sadly, dental caries is now principally a problem for the socially deprived.

Medical history is always important in dental practice and some illnesses specifically predispose to a high risk of dental caries. The most important of these are medical problems causing xerostomia such as radiotherapy in the region of the salivary glands, Sjögren's syndrome, and long-term use of some medications such as tranquilizers, antihypertensives, and diuretics. Frequent medication may of itself pose a risk if the medication is sugar based.

Dietary habits, and the patient's attitudes to them, are of importance and are the subject of this paper. Diet analysis maybe a useful piece in the information jigsaw. Fluoride history is also of importance, since the fluoride ion delays lesion progression. It is always wise to check if a fluoride toothpaste is used. It is surprising how often the author finds that a patient with multiple carious lesions has selected a particular brand of toothpaste, manufactured for sensitive teeth, which does not contain fluoride.

Clinical examination is the most useful indicator of caries risk (Pienihäkkinen, 1987; Fejerskov & Manji, 1990). A history of repeated restoration and re-restoration, together with multiple new lesions on clinical and/or radiographic examination, is an obvious caries risk. Stagnation areas, such as unsealed deep fissures, multiband orthodontic appliances, partial dentures, and poor restorative dentistry, encourage plaque accumulation and increase caries risk. Plaque control itself is also relevant, and removal of smooth surface plaque may uncover multiple cervical white spot lesions or cavities in caries-prone mouths.

Since saliva is so essential to tooth integrity, its examination is a logical and important step in caries-risk assessment. Stimulated salivary flow rate,

Table 1. Caries-Risk Assessment

HIGH RISK	LOW RISK
SOCIAL HISTORY	
Socially deprived	Middle class
High caries in siblings	Low caries in siblings
Low knowledge of dental disease	Dentally aware
Irregular attender	Regular attender
Ready availability of snacks	Work does not allow regular snacks
Low dental aspirations	High dental aspirations
MEDICAL HISTORY	
Medically compromised	No medical problem
Handicapped	No physical problem
Xerostomia	Normal salivary flow
Long-term cariogenic medicine	No long-term medication
DIETARY HABITS	
Frequent sugar intake	Infrequent sugar intake
FLUORIDE USE	
Nonfluoride area	Fluoridation area
No fluoride supplements	Fluoride supplements used
No fluoride toothpaste	Fluoride toothpaste used
PLAQUE CONTROL	
Infrequent, ineffective cleaning	Frequent, effective cleaning
Poor manual control	Good manual control
SALIVA	
Low flow rate	Normal flow rate
Low buffering capacity	High buffering capacity
High *S mutans* and *lactobacillus* counts	Low *S mutans* and *lactobacillus* counts
CLINICAL EVIDENCE	
New lesions	No new lesions
Premature extractions	No extractions for caries
Anterior caries or restorations	Sound anterior teeth
Multiple restorations	No or few restorations
History of repeated restorations	Restorations inserted years ago
No fissure sealants	Fissure sealed
Multiband orthodontics	No appliances
Partial dentures	

buffering capacity, and counts of *Streptococcus mutans* and *lactobacillus* can all now be carried out at the chairside. While no one factor alone predisposes to caries risk, putting all the information together can build up a valuable picture (Larmas, 1992).

Thus it is suggested that every time a new patient enters the dental office a caries-risk assessment should be made. This assessment will obviously be the best guess possible from the information available. Preventive techniques, such as the one described in this paper, will then be targeted at the high-risk group. At subsequent recall a thorough reassessment and re-evaluation is called for. Dietary analysis may well form a part of such a reassessment to try to check whether messages given at the initial course of treatment were accepted and acted upon. Above all, practitioners should not be lulled into a false sense of security when examining a patient who has been attending the practice for years. A change in the medical or social history can change habits and thus caries risk. For instance, retirement and bereavement are just two of life's vicissitudes that result in altered life style, diet, and dental health.

The remainder of this paper will focus on the clinical technique of diet analysis and advice in the management of dental caries in adult patients.

THE USE OF DIET SHEETS

Many caries-preventive strategies depend on patient cooperation. Dietary modification requires great patient commitment, and the defeatist would suggest that such commitment is rarely forthcoming and thus dietary change is not worth attempting. However, not to explain the cause of caries to a patient seems unethical. If a diet sheet demonstrates an obvious problem, to fail to discuss possible solutions with the patient seems equally unethical, particularly since the patient will be paying directly or indirectly for operative care that may not be successful unless causative factors are altered.

The likelihood of an individual adopting a recommended health action has been discussed in the "Health Belief Model" (Rosenstock, 1966). This model suggests that individuals who are to make a long-term committed change in a behavior that is doing harm must believe they are vulnerable to the disease, believe the disease could have serious consequences, and believe that by engaging in preventive activities they can reduce the likelihood or seriousness of the disease.

Showing patients carious cavities in their mouths and showing them their radiographs can help demonstrate their vulnerability to the carious process. It is important and ethical to explain that, in a high-risk patient, caries cannot be treated away by restorative treatment alone, because new cavities will develop next to the new restorations. The amount of restorative dentistry required, with its time and cost implications, should also be explained so that the patient has an opportunity to evaluate alternative treatment plans, one perhaps based on minimal operative intervention, extractions, and dentures, and the other including prevention of further disease, followed by more complex operative dentistry.

At this stage patients should be encouraged to

Diet Analysis

	THURSDAY		FRIDAY		SATURDAY		SUNDAY	
	Time	Item	Time	Item	Time	Item	Time	Item
BEFORE BREAKFAST								
Breakfast								
MORNING								
Mid-day meal								
AFTERNOON								
Evening meal								
EVENING & NIGHT								

Figure 1. *A diet sheet on which the patient should record everything taken by mouth (food, drink, medicines) together with the time*

consider how serious the consequence of tooth loss is to them. Only their efforts will make preventive treatments work, and for some people loss of teeth and dentures is not serious and preferable to time and money spent in dental care. However, many patients are anxious to save their teeth and ask what can be done, which gives the dentist the opportunity to explain the importance of finding the cause of the decay. At this point it can be explained that decay is caused by what we eat and drink, and thus a detective job is required to identify the cause in that individual.

The dentist may now give the patient a diet sheet (Figure 1) and ask that a 4-day record of all food and drink consumed should be kept. The sheet includes 2 weekdays and a weekend, because diet can change according to whether the patient is at work or at home. The dentist should ask the patient to record all food and drink taken and any medication, together with a note of the time. The patient should be advised that this will be a nuisance, but worth the effort. The sheet should be kept in the pocket with a pencil so that food and drink is written down as it is consumed, otherwise things will be forgotten. Finally, it should be stressed that nothing should be changed because a record is being kept. Dentist and patient are partners in the investigation, and the object of the exercise is to help, not to condemn.

Although this strategy is useful for many patients, it may be inappropriate for others. Scientifically it seems unlikely that this simple 4-day approach should ever work. A careful history and examination allow the dentist a snapshot of a lifetime's caries experience. Can this ever be explained on the basis of a single 4-day record? The author finds it remarkable how often patients with multiple active carious lesions present a diet sheet loaded with frequent sugar attacks.

Sometimes variable dietary habits will mean that the 4-day record is inappropriate or even misleading. Shift workers may have different dietary habits from week to week, as may those whose work necessitates frequent trips abroad. "Bingers" are likely to be unwilling to commit their usual dietary pattern to paper. A medical history may reveal unstable health conditions such as intermittent ulcer problems, and again a 4-day record may be inappropriate. However, if the patients understand the purpose of the record, they may suggest how best it is kept. For instance, the shift worker may record 2 days on duty and 2 days off. Those with a medical history may record typical days when they are well and other days when they are ill. Finally it must be appreciated that a patient may not always tell the truth, although if the patient knows what to lie about, progress has been made!

RECEIVING THE DIET SHEET; LOOKING FOR FREQUENCY OF SUGAR INTAKE

Once the patient returns the completed diet sheet, dentist and patient can begin to look at it together. A highlighter pen is useful to mark items containing sugar. If the dentist encourages the patient to identify these, it will become apparent whether the patient realizes which items are sweet.

The relevance of sugar and the role of bacterial plaque should be explained, and then the number of sugar attacks can be counted and this number recorded at the top of each day. This gives the dentist the opportunity to explain the relevance of frequency of sugar attacks. The amount of time the plaque remains acid and capable of causing demineralization varies depending on such factors as the consistency of the food, salivary flow, salivary clearance rates, and the activity of the carious lesion (Dawes, 1989; Nyvad & Fejerskov, 1994).

However, these complex and important scientific deliberations will be lost on the patient who needs a simple (but scientifically simplistic) message. It would not be unreasonable to suggest that after a sugar attack the plaque is likely to remain acid for 1 hour, thus eight attacks would equal 8 hours of acid plaque.

Cariogenic snacks and drinks before bedtime are particularly important, because salivary flow is reduced at night and plaque may thus remain acid for many hours.

The diet sheet has been designed to highlight the between-meal snacks and drinks. These should be examined for their cariogenicity and consistency, since sticky snacks take longer to clear from the mouth (Gustafsson & others, 1954). Any medication that is either syrupy or likely to cause dry mouth or thirst should also be noted. Finally, the adequacy of main meals should be assessed, because if meals are light, the patient may need to snack between meals.

DIETARY CHANGE

Involved patients who understand the relevance of frequency of sugar attack can now be encouraged to suggest their own dietary changes, but patients should be encouraged to set realistic goals that they consider to be achievable. The dentist may be tempted to try to impose a "sensible diet" on the patient. However, such an approach will not work, because dietary change is difficult to achieve, and imposed foods, that the patient may not like, will be not be accepted.

It is both impractical and unnecessary to cut sugar out of the diet, but keeping sugar to mealtimes, and thus reducing sugar attacks to two or three per day, may be possible.

The adequacy of main meals should be checked, because this may reduce the need to snack. Ideally three meals a day should be eaten, with at least two of them containing protein, green vegetables, salad, fruit, or cheese. Sugary snacks and drinks between meals should be discouraged. If the patient is hungry or thirsty between meals, a safe snack should be chosen. It is helpful to have a list of safe snacks (Table 2), so patients can pick out snacks acceptable to them. In addition, care should be taken not to substitute a high-fat and -salt diet for a high-sugar diet. With socially deprived families the dentist should also be sensitive to the cost of dietary change. It will not be reasonable to suggest expensive foods to poor patients in large families. Again, listening to patients' suggestions may be relevant, since they are unlikely to choose a food they cannot afford.

With adults a sweet drink, frequently consumed, is often of particular importance. Sweetened tea and coffee are of great relevance here, and the habit is difficult to break. Some patients are helped by substituting artificial sweeteners for sugar. Unfortunately some of these products are expensive, and cost may preclude their use in poor families. It may be helpful to keep various sweeteners (Table 2) in the surgery and make patients their drinks with the sweetener instead of sugar. It is the author's subjective impression that the sweeteners vary in taste and that patients will not agree on which is the best substitute. Thus, making several cups of tea/coffee, sweetened with different products, may be helpful. It is also useful to warn patients that while these products impart sweetness, they do not give the "body" to a drink in the same way as multiple heaped spoons of sugar. Finally, a common misconception is that reducing the amount of sugar in a drink will suffice. Sadly this is not the case and considerable effort will have been made to no avail.

Table 2. Sugar-free Snacks and Drinks (Barker, 1994)

Drinks
Water
Tea and coffee without sugar
Milk
Diet drinks sweetened with artificial sweeteners aspartame, saccharin, Acesulfame-K

Snacks
Toast
Rolls
Sandwiches (e g, meat, cheese, salad, egg, fish, marmite)
Pita bread
French bread
Cheese scones
Some wafers and crackers (check label)

Raw Fruit and Vegetables
Fruit is not sugar-free but is a good alternative to cakes and biscuits, which are high in sugar.
NB: Dried fruit (raisins, sultanas) is high in sugar and not a safe snack. Similarly, muesli bars are high in dried fruits, honey, glucose syrup, and sugar.

Yogurts
Those sweetened with aspartame and Acesulfame-K

Sweets (often sweetened with xylitol or sorbitol)
Sugar-free chewing gums
Sugar-free mints

Alternative Sweeteners for Drinks (in tablet or granule form)
Aspartame
Saccharin
Acesulfame-K

Artificial sweeteners are also used in the manufacture of several drinks, and from a caries point of view, substitution of the artificially sweetened beverage may be helpful. However, it must be remembered that such drinks, although not cariogenic, are very acidic and may cause erosion if frequently consumed.

Sometimes medications, frequently consumed, have a syrup base, but the patient's doctor may be able to substitute a similar sugar-free product. Other medications cause thirst or dry mouth, and plain water is the safe remedy here. In addition, where some salivary gland tissue remains, salivary flow may be stimulated by chewing a sugar-free gum. Indeed these gums have been shown to raise salivary pH after a sugar attack. Chewing gums containing xylitol (a sugar alcohol) are of particular interest. Xylitol cannot be metabolized to acid by dental plaque and can therefore be considered noncariogenic. Indeed, it has also been claimed to be anticariogenic (Scheinin & Makinen, 1975). This may be due to its nonfermentability in plaque, its saliva-stimulating effect, and a possible antimicrobial effect. In addition some food, such as cheese and nuts, have been shown to raise plaque pH. Cheese is a useful end to a meal in this respect (Rugg-Gunn, 1993).

RECORDING SUGGESTED MODIFICATIONS

It is important that both dentist and patient have a written record of any changes in diet that the patient agrees to attempt. The next visit should then begin with some specific inquiries as to progress. It is not easy to change habits, and plenty of encouragement is called for.

The first diet sheet should be followed up with a subsequent one after a few weeks, and here some misconceptions may be spotted. For instance substituting honey for sugar, when both are equally cariogenic.

CASE REPORTS

Case 1 is a 24-year-old mechanical engineer referred by his general practitioner to a consultant because of a high caries rate. The practitioner had restored open cavities, given oral hygiene instruction, and advised the patient to use a daily fluoride mouthrinse in addition to his fluoride toothpaste. Diet had been discussed and was described by the dentist as "low sugar," but no diet sheet had been kept. The patient was sent a diet sheet with his first appointment with the consultant, together with a letter of explanation as to why the written record was necessary.

The patient was an intelligent young man apparently concerned for his teeth and most grateful for all his dentist was doing for him. The mouth was clean and well restored, but white spot lesions were developing around the margins of restorations, and the dentist's radiographs, taken at yearly intervals, showed new lesions developing.

Figure 2 shows one day of the diet sheet the patient produced. Sugar intakes were highlighted and showed 10 separate sugar attacks, including a sugary drink just before bed. In addition the patient ate frequently and used the term "grazing" to describe his eating habits. All drinks were cariogenic, and main meals were inadequate, because he ate as he worked.

After discussion a list of possible dietary changes was agreed on (Figure 3) and a review appointment made. Figure 4 shows 1 day in the diet sheet brought by the patient at this visit. If this is a true record, this patient has done all that was asked and his dental health will reflect this.

SUGGESTIONS

1. Aim for 2-3 sugar attacks a day.
2. Never have sugar before bed.
3. Coffee and tea--try no sugar.
4. If Coke, use diet variety.
5. Water is safe (patient hates milk).
6. Try savory roll to eat at work.
7. Try to eat more lunch and reduce "grazing."
8. Eat lots in evening.
9. Beer is not cariogenic!

Figure 3. *The written suggestions for dietary change given to the patient. Each suggestion has been discussed with the patient and he has agreed they are worth trying.*

Case 2 is a 50-year-old secretary referred by a consultant in oral medicine. The patient had suffered from Sjögren's syndrome for 10 years, and some advice on preventing caries was now deemed appropriate.

The patient was an intelligent lady. She came to the appointment with an adult daughter who was also concerned for her mother's teeth. The mouth was very clean and all teeth were crowned. Secondary caries was obvious at the margins of several crowns. While the mouth was dry, it was not totally devoid of saliva. Although the patient had tried a saliva substitute, she found these distasteful, "as if someone has spat into my mouth" and preferred to use frequent sips of water to moisten the mucosa.

Diet Analysis

	Time	Item (10 attacks, 1 pre-bed)
BEFORE BREAKFAST	7:15	1 pint skimmed milk milk shake
Breakfast	8:30	black coffee & sugar
MORNING	10:00	white coffee & sugar, 2 cheese rolls, bag crisps, cake
	12:00	Twix, white coffee & sugar
Mid-day meal	13:30	2 cheese rolls, cake, 1 mint, apple
AFTERNOON	15:30	white coffee & sugar
	17:00	tea & sugar, 4 biscuits
Evening meal	19:30	pizza, Ribena, ice cream
EVENING	21:30	glass of Coke
	22:30	glass of Coke

Figure 2. *One day in the initial diet sheet of a 24-year-old mechanical engineer*

Diet Analysis

	THURSDAY	
	Time	Item (2 attacks)
BEFORE BREAKFAST	7:30	white coffee
Breakfast		
MORNING	10:00	2 cheese & salad rolls, crisps, cake, white coffee
Mid-day meal	13:00	2 cheese & salad rolls, apple
AFTERNOON	15:30	glass of orange
	17:00	cup of tea
Evening meal	18:00	pizza, garlic bread, salad
EVENING	21:00	diet Coke
	23:00	beer

Figure 4. *One day in the second diet sheet produced by the same young man following consultation*

Figure 5 shows 1 day from this lady's diet sheet, and it is apparent that tea with sugar is consumed regularly to moisten the mouth. Three separate cups of tea were made for this lady, sweetened with saccharin (Hermasetas granulated sweetener), aspartame (Canderel spoonful), and aspartame with acesulfame-K (Hermesetas New Taste tablets) respectively. Of the three, this patient identified an aspartame product (Canderel spoonful) as closest to sugar and promised to try this as a sugar substitute. Safe snacks were discussed, because reducing the sugar intake could leave her hungry. Many of these snacks were not liked by the patient, and others were difficult to eat with a dry mouth. However, cheese and brown bread and meat sandwich were identified by the patient as possible acceptable snacks.

As this lady left the surgery she commented it had been important to drink tea within the surgery and realize that a sugar substitute could actually simulate the real thing surprisingly well. It seems a pity that this lady was not given a diet sheet when Sjögren's syndrome was first diagnosed. On review it appeared she bought the artificial sweetener on the way home and was using it routinely. The suggested snacks had proved acceptable, and the patient was also buying cottage cheese, which she found sustaining and easy to swallow.

Diet Analysis

	THURSDAY	
	Time	Item (10 attacks)
BEFORE BREAKFAST	6:00	tea & sugar
Breakfast	7:00	banana, tea & sugar
MORNING	9:30	tea & sugar
	11:00	tea & sugar
Mid-day meal	13:00	prawn, avocado sandwich, 2 bananas, tea & sugar
AFTERNOON	15:30	tea & sugar
	17:30	tea & sugar
	19:30	tea & sugar
Evening meal	20:15	baked potato, vegetable curry, banana, custard
EVENING	21:30	tea & sugar
	22:30	2 sherries, small lager

Figure 5. *One day in the diet sheet of a 50-year-old secretary with Sjögren's syndrome. Note frequent intake of tea with sugar.*

CONCLUSION

It is remarkable how often diet analysis appears to reveal a frequent intake of sugar in a caries-prone adult. Whether a patient can modify this is another matter, because changing habits is notoriously difficult. However, the diet sheet provides a basis for patient education so that informed patients can suggest solutions acceptable to them. Advice should be personalized and realistic. Reinforcement of advice and long-term follow up are essential, but it is not impossible to alter eating habits for the better.

(Received 17 November 1993)

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ORIGINAL ARTICLES

Influence of Different Etchants and Etching Times on Shear Bond Strength

J R HOLTAN • G P NYSTROM • R A PHELPS
T B ANDERSON • W S BECKER

Clinical Relevance
When applied to an enamel surface for 15 seconds, 10% maleic acid appears to be an effective etchant when used with the Scotchbond Multi-Purpose system.

SUMMARY

This study compared the shear bond strength to enamel of Scotchbond Multi-Purpose Dental Adhesive System's bonding resin following etching of enamel with 10% maleic, 1.6% oxalic, 10% phosphoric, and 35% phosphoric acids for 15, 30, and 60 seconds. Three hundred and sixty human molar teeth were used to create 12 groups of 30 enamel specimens per group (n = 30). Flattened enamel surfaces were treated with the different etchants for the time periods indicated, the surfaces primed, and adhesive resin applied according to the manufacturer's recommendations. The specimens were completed with Silux Plus resin and subjected to 1000 thermocycles (5-55 °C) followed by shear stress in an Instron Testing Machine to failure within a 24-hour period. A two-way ANOVA revealed significant differences for shear bond strength values by type of etchant (10% phosphoric, 35% phosphoric > 10% maleic > 1.6% oxalic acid) ($P < 0.005$) and by length of application time ($P < 0.005$). The interaction term for these two treatments was statistically significant ($P < 0.005$).

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INTRODUCTION

Currently available dentin and enamel bonding systems use an acid conditioner/etchant to remove or alter the dentin smear layer and simultaneously etch enamel (Barkmeier & Cooley, 1992). Following suggestions made in several recently published articles (Shaffer, Barkmeier & Kelsey 1987; Bastos & others, 1988; Blosser, 1990), some manufacturers are now using weaker acids for these conditioners/etchants with recommended short application times. The Scotchbond Multi-Purpose Dental Adhesive System (3M Dental Products, St Paul, MN 55144) uses 10% maleic acid (a weak organic acid) with a recommended 15-second application time to simultaneously condition/etch both dentin and enamel. However, several recent conflicting reports raise the question of whether weaker acids used for shorter periods of time create an etched enamel surface that will allow the production of adequate bond strength for a

bonding resin (Triolo, Mudgil & Levine, 1993; Cloe & Swift 1993; Aasen & Ario, 1993). The purpose of this study was to evaluate the effectiveness of 10% maleic, 10% phosphoric, 1.6% oxalic, and 35% phosphoric acid as etchants with varying application times in terms of shear bond strength to enamel of Scotchbond Multi-Purpose Dental Adhesive System's bonding resin.

METHODS AND MATERIALS

Study Design

Three hundred and sixty human molar teeth were obtained for this study from the School of Dentistry's Oral Surgery clinic and several local oral surgery offices. The teeth (representative of a cross section of the population in terms of age and sex) were randomly divided into 12 groups (n = 30). These groups were used to evaluate the effects of variations in the type of etchant/length of application time used with the Scotchbond Multi-Purpose dental adhesive system on the shear bond strength to enamel of its bonding resin. A two-way ANOVA was used to statistically examine the results.

Enamel Specimen Preparation

All teeth obtained for this study were stored in distilled water at room temperature and used within 2 months of collection for specimen preparation. After mechanical debridement of their surfaces, the teeth were cleaned with a pumice water slurry. The buccal surface of each tooth was held against the face of a water-lubricated 400-grit diamond wheel to create a flat enamel surface sufficient to allow the inclusion of a 4-mm-in-diameter circle. The root structure was removed and each tooth sectioned through the crown in a mesiodistal direction (with the lingual half discarded) to create a test specimen. The flattened buccal enamel surface was then positioned against a Teflon disk bored with a 4-mm-in-diameter opening at its center and tacked in place with sticky wax. The disk with its attached enamel specimen was then placed in the end of an aluminum mounting cylinder (Figure 1). The cylinder was inverted and filled with orthodontic resin (Caulk/Dentsply, Milford, DE 19963). Following setting, the resin-encased enamel specimen was removed from the aluminum cylinder, inspected, cleaned of any flash, and returned to the cylinder. The specimen was secured in position using a recessed locking screw with its surface protruding slightly beyond the end of the cylinder. This assembly was mounted in a jig attached to a modified lathe with an end-cutting, water-lubricated 3-inch-in-diameter 400-grit diamond wheel. The specimens under constant water irrigation were moved

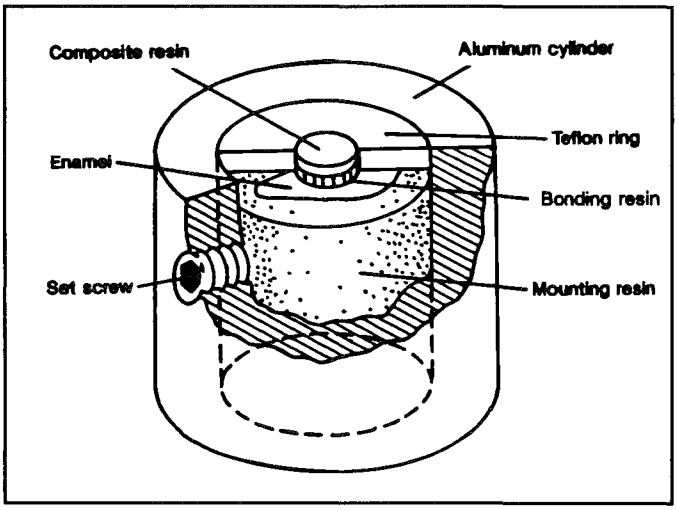

Figure 1. *Aluminum cylinder and resin-encased enamel specimen with the split Teflon ring in position and the bonding/composite resin button completed*

orthogonally against and across the diamond wheel to obtain a flat and uniformly smooth test surface. The resin-encased specimens were removed from the aluminum cylinders, wrapped in gauze moistened with water, and stored in a closed container prior to completion of the restorative procedure.

Restorative Procedures

Individual specimens were removed from their respective containers. Depending on the group to which they were assigned, the flattened enamel surfaces were etched with either a 35% phosphoric acid semi-gel (Ultra-Etch, Ultradent Products Inc, South Jordan, UT 84095), a 10% phosphoric acid semi-gel (All-Bond 2 All-Etch, Bisco, Inc, Itasca, IL 60143), a 10% maleic acid semi-gel (Scotchbond Multi-Purpose Etchant, 3M) or an aqueous solution of 1.6% oxalic acid (Gluma Conditioner, Miles Inc, Dental Products, South Bend, IN 46614) for 15, 30, or 60 seconds and then rinsed for 15 seconds (Bates & others, 1982) and dried. The etchants were placed on the enamel surface and left undisturbed for the time specified with the exception of the aqueous solution of 1.6% oxalic acid (Gluma Conditioner, Miles Inc), which was used with a slight dabbing motion according to the manufacturer's instructions. All drying procedures in this study were accomplished using a contaminant-free air source, PerfectData II, (Perfect Data Corporation, Simi Valley, CA 93063).

After completion of the etching procedure, the resin-encased specimens were returned to the aluminum cylinders and secured in direct apposition to a split Teflon disk bored with a 4 mm-in-diameter cylindrical opening and positioned flush with the face of the cylinder. A cavity preparation 4 mm in diameter and 3 mm deep was thus formed by the

enamel surface and the internal cylindrical surface of the disk. With the exception of the variations made in the choice of etching agents/etching times, all other instructions provided in the Scotchbond Multi-Purpose dental ahesive system kit (for placement of the primer and bonding resin) were followed precisely. Following completion of placement of the bonding resin, the remainder of the cavity was filled in two increments with Silux Plus resin (3M). Each increment was cured for 60 seconds.

A new Visilux Visible Light Curing Unit (3M) that was designed to produce light in the 440 to 470 nm range was used throughout this study. The unit was calibrated at the beginning, during, and at the end of the project using a Demetron Curing Radiometer (Demetron Research Corporation, Danbury, CT 06810). Power output remained at or in excess of 500 mw/cm^2, well above the manufacturer's stated power level that would require additional curing time (300 mw/cm^2).

Following completion of the restorative procedure, the set screw was released and the resin-encased enamel specimen with the split Teflon ring still in position removed from the aluminum cylinder (Figure 1). The split Teflon ring was separated and any bonding resin that may have escaped containment of the Teflon ring at the enamel interface was carefully removed from the base of the newly completed composite resin button. Four power binocular loupes and a new Number 25 surgical blade were used for this purpose. Failure to remove such flash if it were present would result in a larger than anticipated bonding area and potentially erroneous bond strength values. Completed specimens were subjected to 1000 thermocycles (5-55 °C). All specimens were wrapped in moistened gauze and stored in closed containers prior to shear bond strength testing.

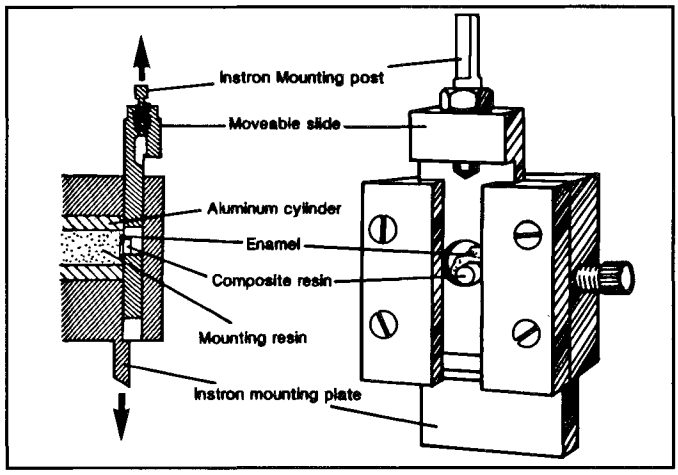

Figure 2. *The aluminum cylinder with its included bonding/composite resin button bonded to enamel and positioned in a guillotine-type jig (design developed by Dr O Zidan) prior to the button being subjected to shear-type forces*

Shear Bond Strength Testing

Shear bond strength testing was done 24 hours after completion of the specimens and subsequent thermocycling procedures. Individual specimens were taken from their containers, the gauze wrapping removed, and the specimen locked in position in an aluminum mounting cylinder (Figure 2). The enamel surface was positioned flush with the face of the ring with the composite resin button projecting above that plane. The aluminum mounting cylinder with its included specimen was positioned in a guillotine-type jig in an Instron Testing Machine (Model 4204, Instron Corporation, Canton, MA 02021) configured with a crosshead speed of 0.5 mm/minute. Shear forces were applied to the composite resin button by a movable slide contained within the jig. Peak break points (kg) were recorded for each specimen by the machine and reported to three decimal points.

Postfracture Specimen Interface and Etched Enamel Surface Evaluation

A light stereomicroscope (Zeiss, Oberkochen, Germany) was used to examine all specimens after failure in the Instron Testing Machine at the bonding resin/enamel interface. In addition, analysis of enamel surfaces treated with the different etchants and etching times evaluated in this study was carried out using a Stereoscan 120 scanning electron microscope (SEM) (Cambridge Instruments Ltd, Cambridge, England). Flattened enamel surfaces were prepared using the same water-lubricated 3-inch-in-diameter 400-grit diamond wheel associated with the technique for specimen preparation just described. Each surface was steam cleaned to remove any retained debris, dried, and the specimen attached to an aluminum mounting post with conductive tape. The specimens were then gold sputter coated using an E5200 Auto Sputter Coater (BIO-RAD, Polaron Equipment Ltd, Watford Hertfordshire, England) in preparation for SEM examination.

Statistical Analysis

A two-way analysis of variance (ANOVA) procedure was used to compare and evaluate the bond strength data generated for each of the 12 groups (table), n = 30.

RESULTS

Shear bond strength values (kg/cm^2) were calculated from peak break points as the load to produce failure (kg) divided by the area (cm^2, which was

Mean Bond Strength Values for Scotchbond Multi-Purpose Dental Adhesive System Bonding Resin to Human Tooth Enamel Based on the Type of Etchant Used and Its Time of Application

		10% Phosphoric	35% Phosphoric	10% Maleic	1.6% Oxalic
	n	Mean ± s d	Mean ± s d	Mean ± s d	Mean ± s d
15 seconds	30	14.8 ± 5.7 MPa	15.3 ± 5.5 MPa	15.8 ± 5.9 MPa	4.9 ± 1.8 MPa
30 seconds	30	19.3 ± 6.1 MPa	17.6 ± 5.4 MPa	14.5 ± 4.2 MPa	8.1 ± 3.7 MPa
60 seconds	30	15.4 ± 3.7 MPa	18.4 ± 6.8 MPa	13.4 ± 4.2 MPa	8.4 ± 2.5 MPa

assumed to be a constant) of the bonding agent. These values were then converted to MPa. Mean shear bond strength comparisons for the different types of etchants/etching times used with the Scotchbond Multi-Purpose dental adhesive system are shown in the table.

A two-way ANOVA revealed that significant differences exist for shear bond strength values by type of etchant (10% phosphoric, 35% phosphoric > 10% maleic > 1.6% oxalic acid) ($P < 0.005$) and by length of application time ($P < 0.005$). The interaction term for these two treatments was statistically significant ($P < 0.005$), indicating that a change in one factor (etchant time) produced a change in bond strength by type of etchant. Further analysis revealed that the bond strength values for three etchants increased as the application time increased from 15 to 30 seconds (Figure 3). Bond strength values for the etchants used in this experiment either decreased or did not significantly improve as the application time increased from 30 to 60 seconds. The greatest mean bond strength value obtained was achieved using 10% phosphoric acid applied for 30 seconds.

Light stereomicroscopy of the postfracture specimens revealed that 80% of the specimens produced with the use of phosphoric and maleic acid failed cohesively (i e, within the bonding/composite resin), while 70% of those produced with oxalic acid failed adhesively (i e, at the bonding resin/enamel interface). In addition, SEM analysis of enamel surfaces treated with the different etchants and etching times evaluated in this study demonstrated that the degree of surface etching provided by oxalic acid was generally less than that observed for the other etchants (Figure 4).

DISCUSSION

Current conditioner/etchants used in conjunction with enamel and dentin adhesive systems (compared to those previously used) tend to be weaker acids with recommended short application times and are used to treat dentin and enamel simultaneously. This is in response to recent reports that have advocated the use of weaker acids/shorter application times (Shaffer & others, 1987; Bastos & others, 1988; Blosser, 1990). This use helps prevent loss of fluoride-rich surface enamel and unnecessary contamination and shortens clinical procedure times. It also decreases the acidic challenge to vital dentin (less pulpal irritation) and may play a role in preventing excess demineralization of the dentinal surface with subsequent loss of adhesion (Pashley, Horner & Brewer, 1992; Nakabayashi, 1989).

Conflicting reports have recently appeared that raise the question of whether these reduced strength conditioner/etchants with short application times are capable of providing sufficient etching of enamel such that an adequate micromechanical bond with a low-viscosity bonding resin can be formed. Triolo and others (1993) found that bond strengths acquired with 10% maleic acid at the manufacturer's recommended 15-second application time were significantly lower than those obtained when longer application times were used. They were also lower than those obtained when 35% phosphoric acid was applied for 15- or 30-second intervals. Bond strengths

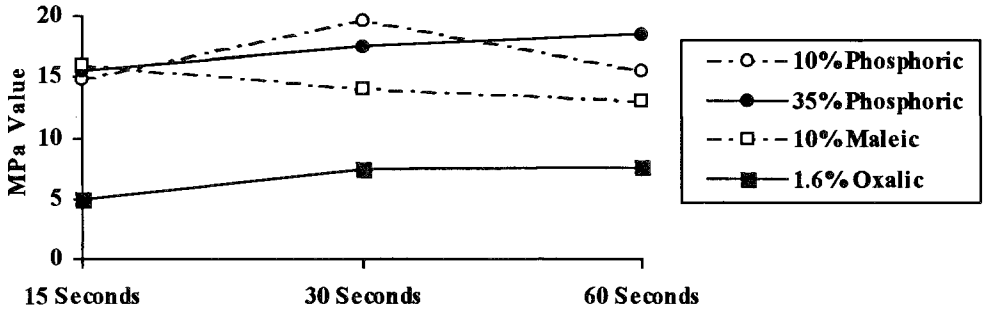

Figure 3. *Graphic representation of the change in bond strength values for Scotchbond Multi-Purpose Dental Adhesive System's bonding resin to human tooth enamel by type of etchant and application time*

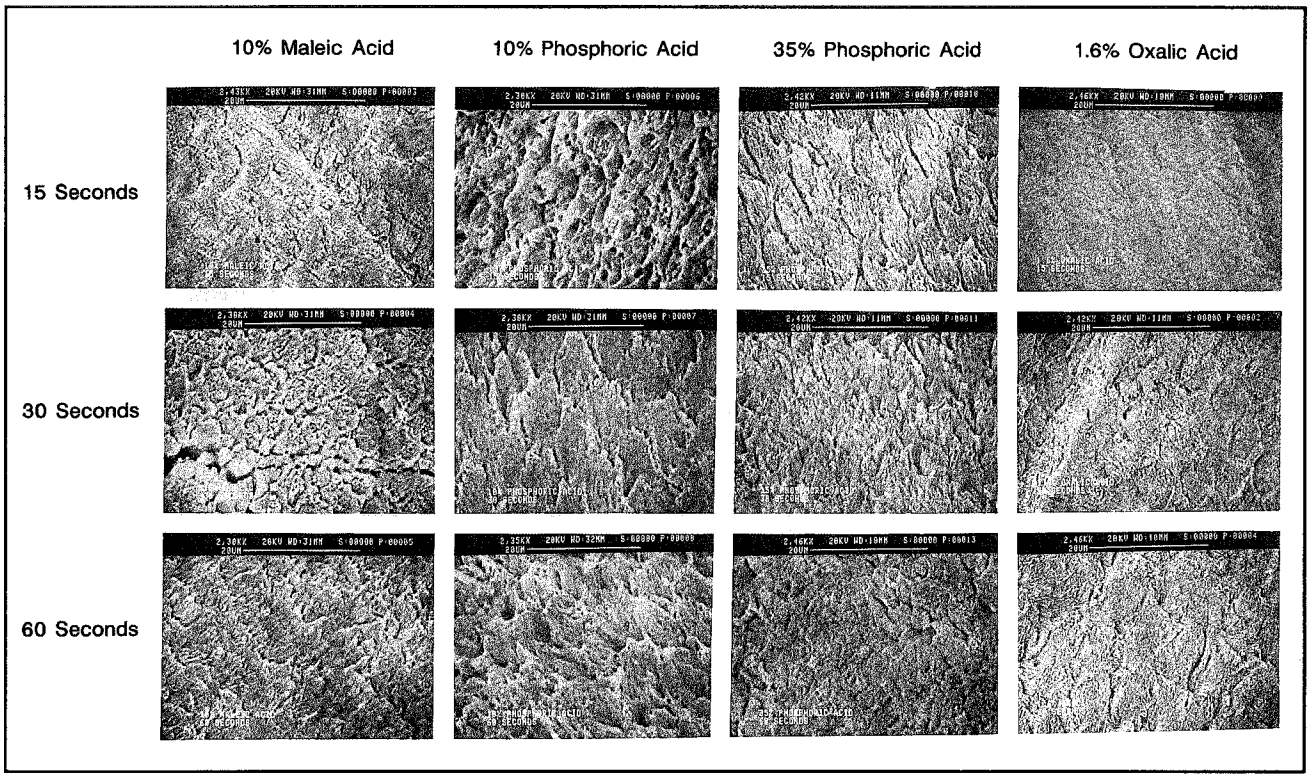

Figure 4. *SEM analysis of etched human tooth enamel by type of etchant and application time (magnification approximately X2400)*

reported for 1.6% oxalic acid at 15- or 30-second intervals were lower than those reported for similar periods for either 10% maleic or 35% phosphoric acids. They also reported somewhat higher bond strengths when a primer was not used. A recent article has suggested reduced bond strength will result if enamel is accidentally contacted by a dentin primer (Hadavi & others, 1993) as used in current dentin and enamel adhesive systems. In any event, an experienced clinician will know that it is virtually impossible to prevent such an occurrence under most clinical circumstances. Even if one wanted to remove the primer from enamel, at some point water would have to be used to flush the area. The primer could be rinsed off the adjacent dentinal surface, the wettability of the dentinal surface impaired, and bond strength significantly reduced (Erickson, 1992). Cloe and Swift (1993) found that etching with 35% phosphoric acid for 15 seconds gave significantly higher bond strengths for a bonding resin to an unprimed enamel surface than 10% phosphoric, 10% maleic, or 1.6% oxalic acid (the oxalic acid application time was 30 seconds, as recommended by the manufacturer). Aasen and Ario (1993), however, reported that for the acid concentrations and application times studied, maleic and phosphoric acids produced equivalent bond strengths for an adhesive resin to primed enamel surfaces.

This study evaluated the effectiveness of three reduced-strength acids (10% maleic, 10% phosphoric, and 1.6% oxalic) and 35% phosphoric acid as etchants on enamel when applied for different periods of time. This was done in terms of shear bond strength of a bonding resin to enamel when used in the context of the Scotchbond Multi-Purpose dental adhesive system (i e, when the primer and bonding resin were applied according to the manufacturer's recommendations). Significant differences for shear bond strength values by type of etchant and length of application time were noted. However, there were no significant differences in resultant bond strengths between 35% phosphoric, 10% phosphoric, and 10% maleic acid when applied as etchants for 15 seconds. The 35% phosphoric acid produced steadily improving bond strengths as the application time increased from 15 to 30 to 60 seconds. The 10% phosphoric acid produced improved bond strengths at 30 seconds (highest recorded in the study) but not at 60 seconds. Maleic acid bond strengths decreased as the length of application time increased. Bond strengths produced with 1.6% oxalic acid (i e, for 15-, 30-, and 60-second application times) did not approach those recorded for the other etchants. This observation is supported by the fact that 80% or more of all specimens produced with the use of phosphoric and maleic acids failed cohesively (i e,

within the bonding/composite resin), while 70% of those produced with oxalic acid failed adhesively (i e, at the bonding resin/enamel interface). Light microscopy was used to examine all specimens after failure at the bonding resin/enamel interface. In addition, SEM analysis of prepared specimens showed that the degree of surface etching provided by oxalic acid was generally less than that observed for the other etchants. This was particularly noticeable for the 15-second application time (Figure 4).

Shear bond strength values associated with two of the three reduced-strength acids evaluated in the present study (i e, 10% phosphoric and 10% maleic acid when either was applied for 15 seconds) approach those seen when other conditioners/etchants/etching times are used (Barkmeier, Shaffer & Gwinnett, 1986; Craig, 1989; Barkmeier & Cooley, 1992; Burgess, Alvarez & Stattmiller, 1993). It should also be noted that microleakage was not observed in a previous study by the authors at the enamel/resin interface of class 5 cavity preparations restored with composite resin when either of these etchants were used with an adhesive system (Holtan & others, 1994).

CONCLUSIONS

The 1.6% oxalic acid did not appear to be an effective etchant for any application time in terms of shear bond strength developed on enamel with Scotchbond Multi-Purpose dental adhesive system bonding resin. The 10% maleic acid when applied to an enamel surface for 15 seconds produced bond strength values most closely approximating those reported for other conditioners/etchants/etching times and would appear to be an effective etchant when used with the Multi-Purpose system. The use of a strong acid (in this case, 35% phosphoric acid) with the Scotchbond Multi-Purpose dental adhesive system for a 15-, 30-, or 60-second application time is not indicated. Clinicians considering the use of an adhesive system that includes a reduced strength conditioner/etchant with a suggested short etching time should ask to see supportive evidence of that product's efficacy with respect to bond strength and microleakage performance.

(Received 11 April 1994)

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Microleakage in Class 2 Composite Resin Restorations

K DERHAMI • P COLI • M BRÄNNSTRÖM

Clinical Relevance
Neither of the two bonding systems tested could totally prevent cervical gap formation.

SUMMARY

Using the dye penetration method, the effect on the microleakage of class 2 resin restorations of two dentin bonding systems that use 10% citric acid-containing dentin conditioners was studied. These results were then compared to the results obtained when the manufacturer's conditioner was replaced by a mild surface-active detergent containing 0.2% EDTA and 1% NaF. The cavities that were treated with the 0.2% EDTA-containing conditioner in place of the manufacturer's conditioner showed similar results: Neither of the two bonding systems could totally prevent cervical gap formation.

INTRODUCTION

In recent years many new bonding systems have been developed to promote adhesion between composite resin and dentin. Of special concern is the seal at the cementum/dentin-composite resin interface, since numerous microleakage studies have demonstrated that it is more difficult to seal the cervical margins (Ehrnford & Dérand, 1984; Gross, Retief & Bradly, 1985; Fayyad & Shortall, 1987; Sparrius & Grossman, 1989). At the cervical wall the dentinal tubules' configuration is parallel, oblique, or crosscut. This may play a role in dentin bonding at these particular margins. During polymerization the composite resin shrinks towards the enamel margins, forming a gap at the cementum/dentin-composite interface.

It has been suggested that successful dentin bonding can be achieved using weak acid solutions that cause only a superficial demineralization of dentinal surfaces (Nakabayashi, Ashizawa & Nakamura, 1992). For example, Superbond D-liner system (Sun Medical Co, Ltd, Kyoto, Japan) uses a 10% citric acid and a 3% ferric chloride solution (10-3 solution) as the surface conditioner. It is claimed (Nakabayashi & others, 1992) that the bonding mechanism is generated by monomer impregnation of the exposed collagen of the demineralized superficial dentin, the monomer polymerizing in situ to create a hybrid layer—a transitional zone of resin on an unaltered dentinal substrate. According to Nakabayashi, formation of the hybrid layer is essential to the high bonding strength and resin tags formation (previously considered crucial for good resin adhesion to dentin), contributing only minimally to the overall dentin bond strength (Nakabayashi, Nakamura & Yasuda, 1991).

According to Pashley, Horner, and Brewer (1992) and Brännström (1982), the adverse effects of acidic conditioners on the pulp seem to be minimal if the combination of the bonding agent and resin composite restoration can truly seal dentin and prevent microleakage. If microleakage cannot be totally prevented, the open dentinal tubules created by the acidic surface conditioner provide easy access

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for bacteria and their toxins to damage pulp tissue. It is therefore desirable to use dentin conditioners that remove the smear layer but leave and reinforce the smear plugs to cover the tubule openings in dentin (Brännström, 1982).

A surface-active solution containing 0.2% EDTA and 1% NaF (Tubulicid Red Label, Dental Therapeutics AB, Nacka, Sweden) is claimed to remove only the smear layer, leaving the tubule plugs undisturbed (Brännström, 1982). Theoretically, this solution could be used in combination with dentin bonding systems that bond micromechanically to intertubular dentin (such as those used in the present study). The bonding agent could adhere to intertubular dentin while the dentinal orifices remain closed by fluoridated smear plugs and thus possibly prevent the influx of irritants to the pulp in case of an eventual microleakage around the filling.

The purpose of the present study was to:

1. Compare the efficiency of the two dentinal bonding systems (Superbond D-liner and Clearfil Liner Bond System, Kuraray Co, Ltd, Osaka, Japan) that use a 10% citric acid conditioner in preventing cervical microleakage in class 2 composite resin restorations,
2. Investigate cervical microleakage in similar restorations using a 0.2% EDTA-containing solution (Tubulicid Red Label) in place of the dentinal pretreatments used in the two dentin bonding systems, and
3. Study, by scanning electron microscopy (SEM), the surface morphology of the cervical dentinal wall after treatment of the cavities with the three dentinal conditioners used in this study.

METHODS AND MATERIALS

Cavity Preparation

The materials comprised intact premolar teeth extracted for orthodontic reasons and frozen until use. This procedure is known to be preferable to chemical preservation of extracted teeth (Brännström, Coli & Brixt, 1992). Sixty class 2 cavities were prepared with both approximal surfaces of each tooth being restored. Each approximal box was 3.0-4.0 mm wide and 1.5-2.0 mm deep. The cervical wall was located just below the cementoenamel junction. The cavity was prepared with a fissure bur at high speed under water coolant. A thin fissure bur at high speed was used to cut retention grooves at the axioproximal line angles. In a recent study by Shahani and Menzes (1992), it was shown that these retention grooves reduce microleakage associated with class 2 composite resin restorations. To minimize the effect of mechanical stress and counteract contraction forces, double retention grooves were made with a notched chisel (Dental Therapeutics AB) at the cervical wall (Coli, Blixt & Brännström, 1993). The enamel on the lateral and occlusal walls was bevelled with a diamond point at high speed. A polystyrene liner (Tubilitec, Dental Therapeutics) was applied to the surfaces outside and around the cavity in order to facilitate the removal of excess composite.

Cavity Treatment

The teeth were divided into four groups, each group comprising 15 similarly treated cavities. In the first group, 15 cavities were treated according to Superbond D-liner's manufacturer's instructions as follows. The 10-3 conditioner was applied to exposed dentin and enamel using a soaked sponge. It was left undisturbed for 30 seconds, washed with water spray for 10 seconds, followed by 10 seconds' drying by air jet. The primer was applied to dentin surfaces and gently blown with air for 20 seconds. Two drops of bonding liquid and one drop of catalyst were mixed and brushed onto the dentin and enamel in a thin layer and gently air blown. The light cure composite resin Palfique (Tokuyama Soda Co, Ltd, Tokyo, Japan) was applied to one-third of the cavity height using a metal matrix band to facilitate condensation. The first composite increment was light cured (Visilux, Model 5520 AH, 3M Dental Products, St Paul, MN 55144) for 40 seconds, followed by the second increment, which was light cured for 80 seconds. The excess of composite resin was removed from around the cavity walls using a hand instrument.

A second group consisting of 15 cavities was treated as instructed by the Clearfil Liner Bond system's instruction manual. Using a small brush, the dentin conditioner (10-20 solution) was applied over the entire cavity surface. After 40 seconds the cavity was thoroughly washed with water spray for 10 seconds and dried with air jet for 10 seconds. The primer was applied to all cavity walls using a sponge and was evaporated by mildly blowing air over the cavity for 10 seconds. One drop of universal liquid was added to one drop of catalyst and mixed. The mix was applied to the entire surface and gently air streamed for 5 seconds. The bonding agent and the Protect Liner (Kuraray) were both light cured simultaneously for 20 seconds. The composite resin restorations were done similarly to the composite resin restorations in the first group.

The third group, also containing 15 cavities, was treated with the 0.2% EDTA solution (Tubulicid Red Label). First, a sponge was used to rub the solution onto the whole cavity for 5 seconds, and the cervical wall was rubbed with the same sponge using the notched chisel to clean the cervical grooves for another 5 seconds. The 0.2% EDTA solution was

then left undisturbed for 20 seconds. This was followed by 10 seconds of water spray and 10 seconds of air jet. All enamel walls were etched carefully for 20 seconds by a 36% phosphoric acid gel (Dentsply Limited, Weybridge, Surrey, England), taking care not to cover dentinal surfaces with this etchant. The cavity was washed with water spray for 10 seconds and dried with an air stream for 10 seconds. The remaining steps were performed in the same manner as in the first group with omission of the step involving the application of the Superbond D-liner's 10-3 solution as the dentinal pretreatment.

All 15 cavities in the last group were treated with the 0.2% EDTA solution, and the enamel walls were etched with 36% phosphoric acid gel, in a similar manner to the third group. The remaining steps followed the instructions used by the Clearfil Liner Bond System except for the steps involving the application of the 10-20 solution and the primer, which were replaced by the 0.2% EDTA conditioner.

In order to avoid leakage from the apex, the apical part of the root was removed with a diamond disk under water coolant, and a cavity was prepared. The deepest part was filled with Coltosol temporary cement (Coltene AG, Altstätten, Switzerland), over which Tokuso Light Bond (Tokuyama Soda Co) and Palfique were applied and cured for 40 seconds. Finally, two layers of nail varnish were brushed onto the entire tooth surface, except for a 1 mm area nearest the composite resin filling. The teeth were then immersed in a dye solution of 0.5% toluidine blue for 20-22 hours at 37 °C.

Light Microscopy

The teeth were sectioned mesiodistally using an Exakt Cutting Grinding System (Histolab, Göteborg, Sweden). In order to have more than only two longitudinal sections for microleakage control, two representative sections were selected from the lingual half of the tooth, while the buccal hemisection remained as a whole. The two lingual sections were then mounted on a glass plate using Tokuso Light Bond and cured for 2 minutes. The lingual sections were then ground to a thickness of 0.3-0.4 mm in an Exakt grinding machine (Histolab) using water-proof SiC papers (800-1200 grit). The buccal hemisections were manually polished on the same SiC papers. The specimens were observed and photographed under UV-light in a light microscope (E Leitz Orthoplan microscope, GmbH, Wetzlar, Germany) at magnifications X4 and X10.

SEM Procedures

To study the effect of the three conditioners used in this study on the cervical dentin wall with SEM, six additional class 2 cavities were prepared in three teeth in the same manner as described above. Two cavities were treated with 10-3 solution for 30 seconds and rinsed with water spray for 10 seconds. Two cavities were treated with 10-20 solution and after 40 seconds they were washed off with water spray. In two other cavities the 0.2% EDTA conditioner was applied for a total time of 30 seconds using the same application steps as described for groups three and four, including the step involving the enamel etching with the 36% phosphoric acid. After cutting the apical half of the roots and the coronal half of the crowns, all pulp tissue was dissected and the teeth were fixed for 24 hours in a mixture of 4% paraformaldehyde and 2.5% glutaraldehyde in PBS buffer, pH 7.4. They were then rinsed carefully with nonionized water and

Number of Cervical Dye Penetrations and Dye Penetration into Dentinal Tubules

Bonding Agent	Dentin Pretreatment	Cervical Dye Penetration Extension		Dye Penetration in Dentinal Tubules	Total # of Restorations, # of Failures & Significance		
		I*	II**		Total	# Fail	Sig
Superbond	[10-3]	1	2	1	15	3	$P = 1.00$ NS***
	0.2% EDTA	0	4	1	15	4	
Clearfil	[10-20]	5	0	1	15	5	$P = 0.39$ NS***
	0.2% EDTA	2	0	0	15	2	

*Extension I = dye penetration did not reach the first cervical retention groove (> 1 mm).
**Extension II = dye penetration reached the first cervical retention groove (= 1 mm).
***P = two-tailed P value; NS = no significant difference ($P < 0.05$) between the two groups, as shown by the chi-square test.

left to be air dried overnight. Finally, they were attached to aluminum specimen holders and coated with Au-Pd alloy using the sputter technique. The specimens were examined and photographed in a JEOL JSM 820 scanning electron microscope (Phillips Electronics, Eindhoven, Netherlands) at an accelerating voltage of 15 KV at magnification X1000, X4500, and X10,000.

Statistical Procedures

A GraphPad InStat software (GraphPad Software, San Diego, CA 92121) was used to perform a chi-square analysis of the significance of dentinal pretreatment on the microleakage results ($P < 0.05$).

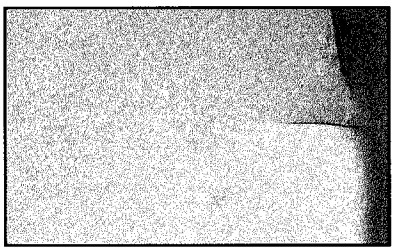
RESULTS

The table shows the number of cervical and dentinal tubule dye penetrations. Microleakage was observed in all experimental groups. The extension of the dye penetrations into the cervical gaps were similar in all restorations that exhibited such a defect. In none of the four groups did the cervical dye penetrations extend beyond the first cervical retention groove (1 mm into the cervical region); however, in order to make a distinction between dye penetration depths, two types of cervical dye penetrations were recognized. The first type was called "Extension I," not reaching the first cervical retention groove, and the second type, "Extension II," reaching to the first cervical retention groove but not extending beyond this point (Figures 1A and 1B). Only one restoration in each of the first three groups showed evidence of dye penetration into dentinal tubules (Figure 2). All cervical microleakage at any extension or depth or dye penetrations into dentinal tubules were considered as failures. The results of the chi-square analysis suggest that cavities treated with 0.2% EDTA solution do not show a significant difference in cervical microleakage as compared to cavities treated by manufacturers' dentin conditioners ($P < 0.05$).

In spite of the relatively small sample size used in each group, it can be stated that:

1. None of the four treatment forms could totally prevent cervical microleakage, and
2. All four groups showed similar results.

SEM photographs revealed a smooth intertubular dentin surface with open dentinal tubules where Superbond D-liner's 10-3 conditioner was used (Figure 3A). The cavities treated with Clearfil Liner



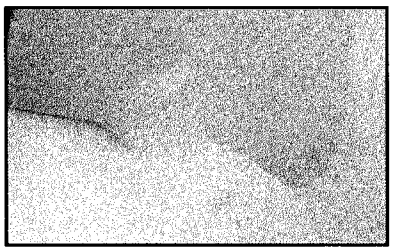


Figure 1. *UV-light microscopic photographs taken at the profile of the cervical wall showing examples of cervical dye penetrations and their extension. Dye penetration did not extend beyond first retention groove (magnification X2.28)* ***A****. Extension I penetration: dye penetration has not reached the first cervical retention groove* ***B****. Extension II penetration: dye penetration to the first cervical retention groove*

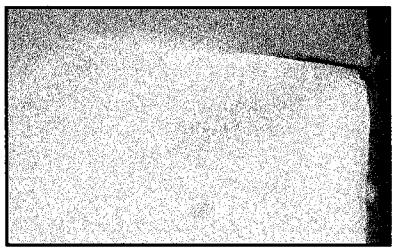
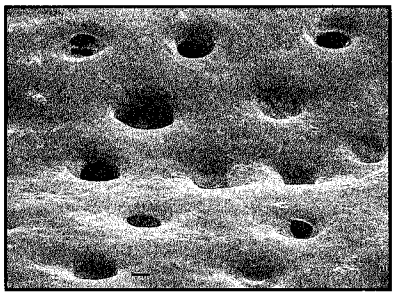
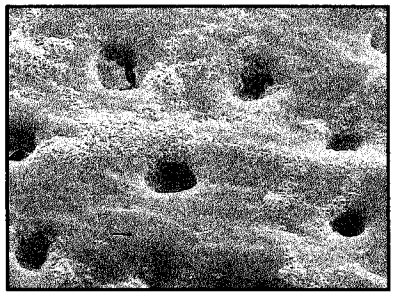


Figure 2. *Dye penetration into dentinal tubules (magnification X5.7)*





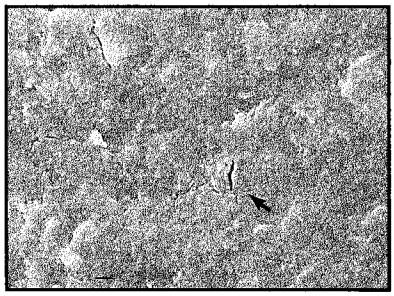


Figure 3. *SEM photographs taken at the peripheral surface of the first retention groove on the cervical wall* ***A****. Dentin treated with Superbond D-liner's surface contitioner for 30 seconds* ***B****. Dentin treated with Clearfil Liner Bond system's surface conditioner for 40 seconds. Note the granulated precipitant (possibly calcium chloride) on the dentinal surfaces.* ***C****. Dentin treated with the 0.2% EDTA solution for 30 seconds. Cracks indicate the position of dentinal plugs. (magnification X2565 x bar = 1 μm)*

Bond's 10-20 solution exhibited similar features, but the smooth dentinal surface was covered with a granulated structure (Figure 3B). The dentinal surfaces cleaned with the 0.2% EDTA conditioner appeared to have fairly intact dentin, and in general the tubule orifices were plugged with debris showing crack-artifacts on the surface (Figure 3C).

DISCUSSION

Pretreatment of dentinal surfaces is considered to be a crucial step in dentin bonding procedures. Proper dentinal conditioning seems to be particularly essential for both the bonding systems used in this study, assuring the formation of the resin-impregnated zone. Despite this fact, the performance of Superbond D-liner was not drastically altered when the dentin conditioner supplied with the system was replaced by 0.2% EDTA solution. Unlike the 10-3 or 10-20 acidic solutions used by the two systems, the 0.2% EDTA conditioner appears to leave dentinal surfaces intact, generally leaving the smear plugs in the dentinal tubules. This can be confirmed by the SEM photographs (Figure 3C). The 10-3 solution leaves a very smooth dentinal surface, removing all smear layer and smear plugs. The surface treated with 10-20 solution also shows a smooth dentinal surface; however, it is covered by a granulated structure, possibly calcium chloride. This high concentration of calcium chloride may decrease the extent of demineralization of hydroxyapatite as suggested by Pashley and others (1992), but it may also mechanically prevent bonding between the adhesive resin and dentinal surfaces.

The present findings imply that a relatively good marginal seal of class 2 composite resin restorations can be achieved using the two dentin bonding systems, even when the manufacturers' dentin conditioner is replaced by the 0.2% EDTA solution. However, removal of smear plugs by acidic surface treatment such as 10-3 or 10-20 solutions or even high concentrations of EDTA may leave dentinal tubules open for bacterial toxins and facilitates hydrodynamic movement of dentinal fluids, increasing the risk for postoperative tooth sensitivity. It may therefore be advantageous to leave the smear plugs undisturbed in order to keep dentin less permeable to bacterial toxins (Brännström, Nordenvall & Glantz, 1980). In a recent in vitro study by Haller and others (1992), it was shown that the permeability of dentin treated with the 0.2% EDTA conditioner (Tubulicid Red Label) for 30 seconds was reduced by 20% as compared to untreated dentin. This might be due to CaF_2 precipitation reinforcing the dentinal plugs. Preservation and reinforcement of dentinal plugs is particularly important in deep dentin, where the smear plugs may be longer due to the greater diameter of the tubules (Pashley, 1991) and the much shorter distance to the pulp.

Another potential disadvantage with using acidic conditioners is the possibility of adhesive resin not deeply penetrating into the demineralized zone made by the acidic conditioner. It has been suggested by Eick (1992) that this could create a weak zone and a possible site along which bond failure may occur. In a study by Nakabayashi (1989), dentin bonding in surfaces conditioned with EDTA 3-2 (0.3 M sodium EDTA and 0.2 M ferric EDTA) showed not only higher tensile strength but also increased durability in water over a period of several years as compared to dentin treated with 10-3 solution. This could be due to the fact that treatment with EDTA 3-2 creates a less deep demineralized zone than the acid 10-3 treatment, thus not leaving any exposed collagen to be hydrolyzed. Weak EDTA solutions may therefore demineralize dentinal surfaces and/or dentinal plugs to a degree that may explain why 0.2% EDTA-treated cavities exhibited similiar microleakage results as cavities treated with 10% citric acid conditioners.

To obtain more definite results, studies with larger sample sizes, also including other bonding systems with similar bonding mechanisms, are needed to confirm the outcome of the present investigation. As in most in vitro experiments, these findings should not be extrapolated directly to in vivo conditions. For example, the outward fluid flow in dentinal tubules can impair bonding in vivo (Mitchem, Terkla & Gronas, 1988). In addition, such factors as nonvitality of the teeth, mechanical stress, and thermocycling have been excluded in the present study. It should also be pointed out that failure to randomize the treatment sequence in the experimental groups may have affected the results of the present study. To minimize the effect of mechanical stress, cervical retention grooves are recommended (Coli, Blixt & Brännström, 1993) and were therefore used in this study. These may reduce the effect of occlusal trauma, counteract effects of flexibility, "flow and creep," and be helpful in the retention of the composite in resisting the contraction forces. This is particularly important when polymerization is initiated at the cervical wall as in techniques introduced by Lutz, Krejci, and Oldenburg (1986).

CONCLUSION

All treatment forms showed similar results and none of the forms could completely prevent cervical microleakage in class 2 composite resin restorations.

Acknowledgments

To Dr Karl-Johan Nordenvall, for his valuable contributions to the study, to Dr Joan Bevenius and

Dr John Francis Wolfaardt for editorial assistance during the preparation of the manuscript. Special thanks to Kjell Hiltenby of the Clinical Research Centre at Huddinge Hospital for assisting with scanning electron microscopy.

(Received 8 November 1993)

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Surface Roughness of Opalescent Porcelains after Polishing

M T WARD • W H TATE • J M POWERS

Clinical Relevance
Various commercial intraoral finishing and polishing kits produced smoother porcelain surfaces compared to self-glazing and overglazing of three opalescent porcelains.

SUMMARY

Intraoral porcelain polishing is an important consideration in many restorative and esthetic procedures. Several porcelain polishing systems as well as improved ceramics are now commercially available. This study evaluated the efficacy of eight different intraoral polishing techniques on three opalescent porcelains. The surface roughness (Ra) of the opalescent porcelains were measured before and after the polishing procedures with a profilometer. These results were then compared to self-glazed and overglazed control groups. Five of the techniques tested produced surfaces smoother than glazing. The use of a 30-fluted carbide bur before diamond polishing paste produced the smoothest surfaces.

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INTRODUCTION

Recent advances in both restorative materials and dentin/enamel bonding systems have provided the dental practitioner with many new and exciting techniques in esthetic dentistry. Patients themselves are also becoming more sophisticated in their knowledge and desire for esthetic dentistry.

Opalescent porcelain is one of the latest advances in ceramic technology (Yamamoto, 1989). With this development ceramists can now create more naturally esthetic porcelain dental restorations. Using conventional ceramic technology, the natural translucency and brightness of teeth are difficult to duplicate. With the opal ceramic, the presence of microparticles to scatter incident light has overcome many of these problems.

With the increase in use of these materials, one must pay careful attention to the role that finishing and polishing plays in the long-term success of the porcelain restoration. As with any dental restorative material, the biologic effects on the gingival tissues must be appreciated (Klausner, Cartwright & Charbeneau, 1982). Proper finishing and polishing assure harmony between the restoration and the gingival tissues. Further, the surface finish of restorative materials can disturb the natural wear process of opposing teeth. A definite correlation has been observed between the surface finish of porcelain and the resultant rate of tooth wear (Monasky & Taylor, 1971). Often, extraoral porcelain polishing is

Table 1. Opalescent Porcelain Materials Tested

Code	Product	Batch Number	Manufacturer
C	Ceramco II Opal Incisal Orange	93030512	Ceramco Inc Burlington, NJ 08016
V	Vintage/Opal 58	930204	3M Dental Products St Paul, MN 55144
D	Duceram-LFC	073 500	Ducera Dental, Gmbh Rosbach, Germany

either contraindicated, as in the placement of ceramic veneers and bonded all-porcelain restorations, or impossible, as in the case of a break in the glazed surface of a cemented porcelain-fused-to-metal crown (PFM) (Newitter, Schlissel & Wolff, 1982). It becomes readily apparent that an efficient, effective technique for intraoral porcelain polishing would be especially applicable for these situations. Haywood (Haywood & others, 1988; Haywood, Heymann & Scurria, 1989) concluded that intraoral polishing of porcelain can equal or surpass the smoothness of glazed porcelain.

The purpose of this study was to determine the surface roughness (Ra) of three different brands of opalescent porcelain polished by eight different intraoral porcelain polishing techniques as compared to glazed control groups.

METHODS AND MATERIALS

Codes, products, batch numbers, and manufacturers of the three opalescent porcelains and surface treatments (T1-T10) are listed in Tables 1 and 2. Porcelain disks (10 mm in diameter and 3 mm thick) were prepared according to the manufacturers' firing instructions using a porcelain oven (Phoenix Vacuum Firing Porcelain Furnace, Ceramco, Inc, Burlington, NJ 08016), embedded in resin (except samples for treatments T1 & T2), and abraded with 240-grit silicon carbide paper (Buehler Ltd, Lake Bluff, IL 60044). Four disks were made per treatment condition yielding 40 disks per porcelain product (120 disks total).

Samples were abraded with a 60-μm diamond by a single operator in one direction in a sweeping motion to simulate an intraoral adjustment. Four samples of

Table 2. Surface Treatment Materials

Code	Product	Batch Number	Manufacturer
Control	60-μm diamond (263.8F)	03	Premier Dental Products Co, Norristown, PA 19404
T1	Self-glazing		
T2	Overglazing		
	Synspar, clear	L2021H, B2334H	Jeneric/Pentron, Wallingford, CT 06492
T3	E T diamonds		Brasseler USA, Savannah, GA 31419
	135F 30 μm	014	
	135 EF 15 μm	314	
	135 UF 8 μm	314	
	TruLuster 2.5 μm	D39300	Brasseler
T4	Treatment T3 + 30-fluted carbide bur ET UF9	014 073093	Brasseler
T5	Enhance Finishing & Polishing System		LD Caulk/Dentsply, Milford, DE 19963
	Enhance Points 100 μm		
	Prisma Gloss		
	fine 1 μm	930719	
	extra fine 0.3 μm	9307121	
T6	FlexiDisc System	9322, 1992	Cosmedent Inc, Chicago, IL 60640
	Porcelize 3 μm, 1 μm		
	Enamelize 0.3 μm		
T7	Intraoral Porcelain Polishing Kit	042193	Den-Mat Corp, Santa Maria, CA 93456
T8	Two-Striper MFS diamonds		Premier
	MF1 45 μm	17	
	MF2 25 μm	20	
	MF3 10 μm	18	
	Two-Striper MPS Diamond Polishing System		Premier
	MP1 4 μm	19131	
	MP2 1 μm	19152	
T9	Treatment T8 + 30-fluted carbide bur ET UF9	014 073093	Brasseler
T10	Porcelain Laminate Polishing Kit + white stone	079141	Shofu Dental, Menlo Park, CA 94025
	Ultra II + super-snap	5970	

Table 3. Surface Roughnness (μm) of Three Opalescent Porcelains after 10 Surface Treatments Compared to a Control

	Control	T1	T2	T3	T4	T5
C	3.18 [0.55]*	0.52 [0.10]	0.39 [0.11]	0.19 [0.04]	0.07 [0.02]	0.70 [0.13]
V	2.96 [0.52]	0.43 [0.08]	0.44 [0.09]	0.14 [0.05]	0.07 [0.02]	0.60 [0.14]
D	2.60 [0.60]	0.44 [0.09]	0.37 [0.10]	0.05 [0.02]	0.05 [0.02]	0.06 [0.10]
	T6	**T7**	**T8**	**T9**	**T10**	
C	0.10 [0.04]	0.79 [0.12]	0.14 [0.04]	0.06 [0.02]	0.44 [0.10]	
V	0.09 [0.05]	0.77 [0.16]	0.10 [0.04]	0.05 [0.02]	0.37 [0.08]	
D	0.06 [0.03]	0.78 [0.10]	0.11 [0.04]	0.07 [0.03]	0.38 [0.11]	

*Means (SD) of Ra (μm) of five replications for each of four samples. Tukey intervals determined from ANOVA at the 0.05 significance for comparisons among three porcelains and among 10 polishing treatments were 0.02 and 0.05 μm. The diamond-abraded controls were not included in the statistical analysis.

each porcelain were selected as the diamond-abraded controls. Five roughness measurements (Ra, μm) were performed on each disk using a profilometer (Taylor-Hobson Talysurf-10, Rank Taylor Hobson Limited, Leicester, England) with a cutoff value of 0.25 mm.

Samples were then randomly assigned to one of ten treatment groups (T1-T10) as listed in Table 2. Groups T1 and T2 were adjusted flat with a green stone (Shofu Dura-Green wheel, WH6, silicone carbide grit 75 μm) and sandblasted with 27-μm aluminum oxide powder (0.48 MPa pressure) using a sandblasting device (Micro-Etcher, Danville Engineering, San Ramon, CA 94583) before glazing. Self-glazing at 918 °C and overglazing at 899 °C followed manufacturers' instructions. All polishing materials were used according to manufacturers' recommendations. Finishing burs and polishing materials were used by a single operator with uniform pressure and uniform application time for each surface treatment. The treated surfaces were measured again with the profilometer.

Examples of smooth and rough porcelain surfaces, as identified by profilometer tracings, were then examined by scanning electron microscopy (SEM) at X500 (JOEL USA, Inc, Peabody, MA 01960).

Means and standard deviations of surface roughness were determined. Data were analyzed by analysis of variance (SuperANOVA, Abacus Concepts, Inc, Berkeley, CA 94704). Tukey intervals (Tukey's Multiple Comparison Test) (Zar, 1984) were calculated from analysis of variance at the 0.05 significance level for comparisons of means among three porcelains and 10 treatments.

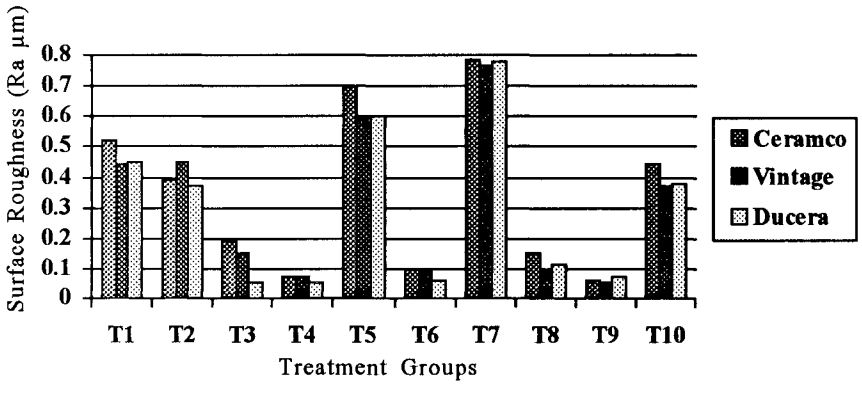

Figure 1. *Comparison of surface roughness of three opalescent porcelains*

RESULTS

Means and standard deviations of surface roughness (Ra) for the three porcelains and 10 polishing treatments are listed in Table 3 and shown in Figure 1. The analysis of variance showed highly significant differences among the means, with the polishing treatment being a more significant factor than the brand of porcelain. Tukey intervals determined from the analysis of variance at the 0.05 significance level for comparisons among three porcelains and 10 polishing treatments were 0.02 and 0.05 μm respectively.

In general, porcelain C was found to be slightly rougher than porcelain V or porcelain D. Polishing treatments T3, T4, T6, T8, and T9 produced smoother surfaces than self-glazing or overglazing. Treatment T10 produced a smoother surface than self-glazing and overglazing for porcelain V. Treatments T5 and T7 produced rougher surfaces compared to either glazing procedure. The smoothest surfaces (Ra < 0.10 μm) were produced by T4, T6, T9, and by T3 with porcelain D. The diamond-abraded controls (Table 1) were much rougher than the 10 polishing treatments and were excluded from the statistical analysis.

DISCUSSION

Haywood (Haywood & others, 1988) also found that the best technique for intraoral polishing involved a

sequence of micron finishing diamonds and a 30-fluted carbide bur followed by a diamond polishing paste. A systematic reduction in diamond particle size of the instruments and paste appears to be the most effective porcelain polishing technique. Further, Haywood found that finishing with diamond instruments and air/water spray produced a smoother surface than did dry finishing. However, when using the 30-fluted carbide bur, dry finishing produced the smoothest surface (Haywood & others, 1989). Still, another group (Scurria & Powers, 1994) found that the use of the 30-fluted carbide bur did not improve smoothness. Instead, they simply used micron finishing diamonds followed by micron diamond paste to produce the smoothest surface. Two of the systems, T4 and T9, tested in the present study utilized a sequence of progressively finer diamond grits followed by a diamond polishing paste. A 30-fluted carbide bur was also used before polishing with the diamond paste. The Cosmedent disk system followed by their polishing paste (T6), produced a smooth surface on all porcelains without the use of a 30-fluted bur. Clinically, however, posterior teeth are difficult to access with disks, making this system somewhat cumbersome in these areas. Research appears to be equivocal on the use of the 30-fluted carbide bur for polishing porcelain.

Another group has theorized that some profilometer readings of porcelain surfaces may be misleading (Bessing & Wiktorsson, 1983). They suggest that autoglazed porcelain exhibits both roughness and waviness and that a filtration must be made by the surface roughness recorder in order to separate shape from roughness. This, they argue, coupled with the presence of irregularities and voids on a porcelain surface makes measuring surface roughness of this material difficult. In the present study, a cutoff of 0.25 mm was used to increase filtration, thereby minimizing the influence of waviness.

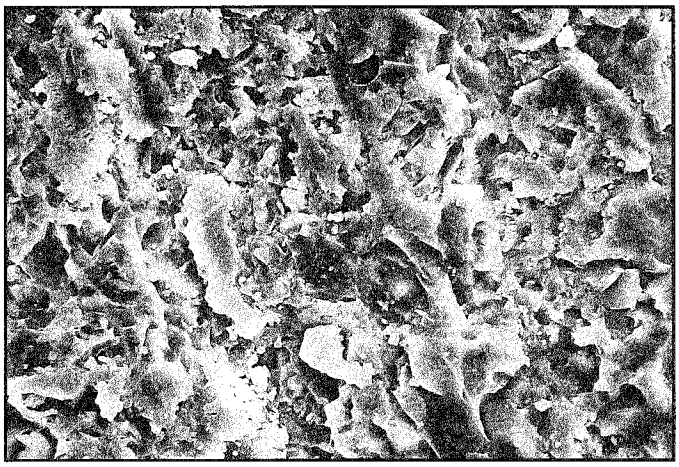

Figure 2. *Scanning electron photomicrograph of the self-glazed porcelain V surface (X350)*

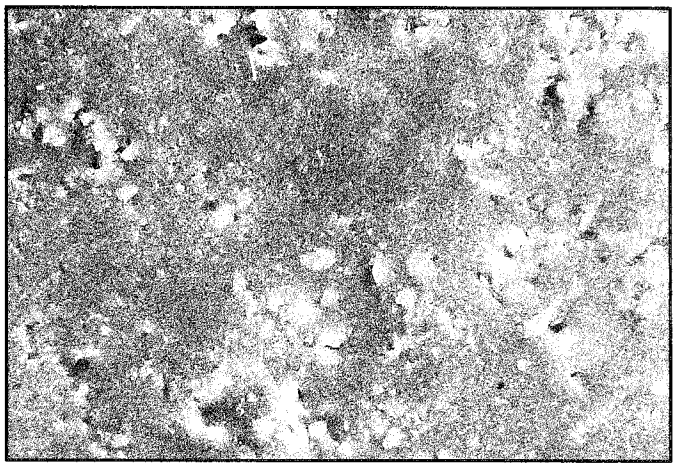

Figure 3. *Scanning electron photomicrograph of the over-glazed porcelain V surface (X350)*

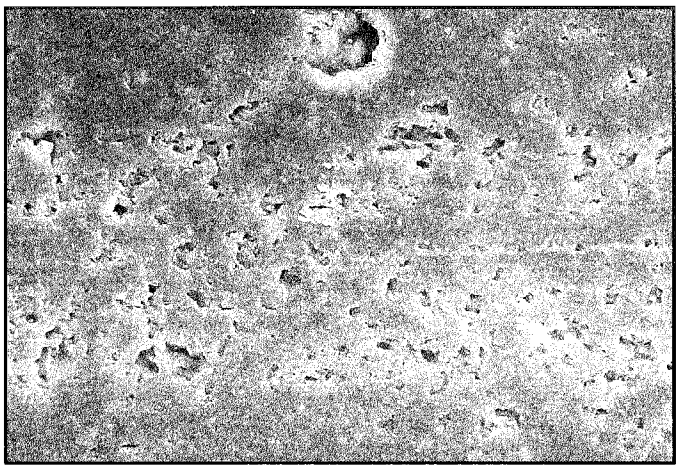

Figure 4. *Scanning electron photomicrograph of the porcelain V surface after polishing treatment 7 (X350)*

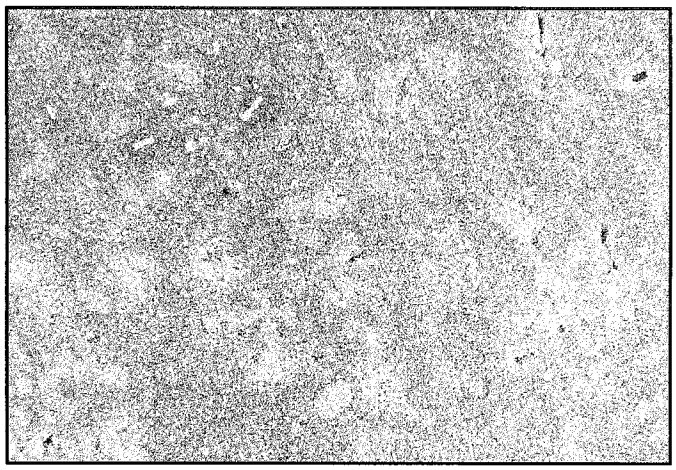

Figure 5. *Scanning electron photomicrograph of the porcelain C surface after polishing treatment 9 (X350)*

SEM evaluation of porcelain V revealed noticeable surface irregularities after both glazing procedures, especially the self-glaze (Figures 2 and 3). Statistically, the mean roughness values of the self-glazed and overglazed surfaces were similar, 0.43 μm and 0.44 μm respectively. Waviness cannot be evaluated effectively by SEM; however, profilometer data suggest that the visibly rough self-glazed surface (Figure 2) has a low waviness component, while the smoother-looking overglazed surface (Figure 3) is more wavy. SEM analysis further revealed a rough, striated, pitted surface produced with the Den-Mat polishing kit (T7) (Figure 4). All data suggest that this was the roughest and the most wavy surface analyzed. The Premier polishing system plus the 30-fluted bur (T9) produced the smoothest surface (Figure 5).

In this study and others (Haywood & others, 1988), SEM and profilometer data confirm that a finish equal or superior in smoothness to glazed porcelain can be achieved through these polishing methods, although none of the studies has proven definitively that all steps are necessary clinically. How smooth a restoration needs to be to prevent detrimental occlusal wear or gingival irritation is not known. Further, this study analyzed overall outcome efficiency of the various surface treatments and did not take into account cost effectiveness. Numerous polishing steps can become time-consuming and costly to the dentist and still may not produce either functional or optimal results. By considering the data and rationale behind the finishing and polishing procedures presented, practitioners can choose or develop a system that meets their individual needs.

CONCLUSION

Most of the commercial intraoral polishing kits tested produced surfaces smoother than either self-glazing or overglazing of three commercial opalescent porcelains. The use of a 30-fluted carbide bur with the Brasseler and Premier systems before the diamond polishing paste step produced the smoothest surfaces analyzed.

Acknowledgments

The authors wish to thank G D Ladd for his technical assistance, the manufacturers for supplying commercial products, and Mr Udayan Parikh for his technical assistance with the SEM. This research was supported in part by Ducera Dental and 3M Dental Products.

(Received 13 May 1994)

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Monkey Pulpal Response to Adhesively Luted Indirect Resin Composite Inlays

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M MORIGAMI • T TAKATSU

Clinical Relevance
Initial pulpal responses to adhesively luted inlays subsided if a tight marginal seal was secured by final cementation of the inlay.

SUMMARY

Monkey pulpal responses to resin-bonded indirect resin composite inlays were histopathologically evaluated by placing them in either etched-enamel, total-etched, or adhesive-resin-lined cavities. Initial pulpal responses caused by re-exposure of the cut dentin surfaces and luting procedure subsided if a tight marginal seal was secured by final cementation of the inlay. The adhesive resin coating of freshly cut dentinal walls/floors seems to provide a new technique to protect the dentin and pulp in indirect restorations requiring temporary sealing.

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INTRODUCTION

Pulp irritation caused by restorative composites is a common concern of clinical dentists. Histopathological responses of the dental pulp to direct restorative composites have been evaluated extensively using human and animal teeth (Langeland & others, 1966; Stanley, Swerdlow & Buonocore, 1967; Brännström & Nyborg, 1973; Inokoshi, Iwaku & Fusayama, 1982; Fujitani, 1986; Cox, 1992; Fujitani, Inokoshi & Hosoda, 1992). However, little information is available with regard to pulpal responses to indirect inlay restorations luted with adhesive resin composites. Although some luting adhesive resins were tested as a direct restorative material by placing them in cavities prepared on monkey teeth immediately after preparation (Inokoshi, Fujitani & Hosoda, 1986), various clinical procedures of the indirect method requiring two appointments might complicate pulpal reactions. Temporary sealing of freshly cut dentin surfaces is a source that may threaten pulp protection. Poor sealing might result in bacterial contamination of the cavity, possibly leading to pulp damage. Removal of the temporary sealant, re-exposure of prepared dentin surfaces, and positive pressure during inlay insertion frequently induces discomfort in patients. Although excellent adhesive qualities to dentin have been reported for several luting composites (Nikaido & others, 1992; Maseki & Katsuyama, 1993), temporary sealing material was reported to remain on the prepared surface (Terata, 1993) and to affect the marginal seal of resin composite inlay restorations (Woody & Davis, 1992).

Recent advances in dentin adhesives enable us to

cover prepared cavity surfaces with a tight sealing film of adhesive resin and a low-viscosity resin composite immediately after preparation (Otsuki & others, 1993). This protective film might minimize further pulp irritation from mechanical, thermal, and bacterial insults during impression taking, temporary restoration wearing, and final cementation. It might also serve as a direct pulp capping agent (Kashiwada & Takagi, 1991; Masaka & others, 1991; Cox,1992; Onoe, 1994).

The aim of the present study was to evaluate pulpal responses to indirect resin composite inlay restorations luted with an adhesive composite in three different kinds of cavities, namely: etched-enamel, total-etched, or adhesive-resin-lined cavities.

METHODS AND MATERIALS

The restorative materials employed are listed in Table 1. Two monkeys were placed under general anesthesia by intramuscular injection of 20 mg/kg ketamine (Ketaral, Sankyo Co, Tokyo, Japan) and intravenous injection of 10 mg/kg pentobarbital sodium (Nembutal Sodium Solution, Abbott Laboratories, Abbott Park, IL 60064). One animal was assigned to the short-term group, and the other to the long-term group. Class 5 cavities were prepared on the facial surfaces of 56 teeth using a high-speed tapered diamond bur (ISO #170, G-C Corp, Tokyo, Japan) under water-spray coolant. For the mandibular first molar, two cavities were prepared for each tooth. These were divided into three groups: enamel etching (**EE group**) (n=10x2), total etching (**TE group**) (n=10x2), and adhesive resin lining (**AdL group**) (n=10x2) (Figure 1). The three experimental groups were randomly assigned to each animal. For each animal, 28 teeth were divided into six groups comprising two anterior parts (from canine to canine) and four posterior parts (from first premolar to second molar). Then cavity preparation, impression taking, and temporary sealing were performed for each group. The time between cavity preparation and temporary sealing varied from 10 to 20 minutes. Rubber dam and local anesthesia were not used during the experiment.

For the AdL group, the cavity walls were covered with an adhesive resin (Tokuso Lite Bond, Tokuyama Corp, Tokuyama, Japan) and a low-viscosity composite (Palfique Clear, Tokuyama Corp) immediately after the preparation was completed as described below. The cavity, including the dentin walls/floor, was etched with 37% phosphoric acid gel for 40 seconds, spray washed for 10 seconds and air dried with oil-free compressed air. A primer (35% HEMA in

Table 1. Restorative Materials Employed

Material	Brand Name	Content	Batch	Manufacturer
Adhesive resin for restorative composite	Tokuso Lite Bond	Etching gel	#989	Tokuyama Corp, Tokuyama, Japan
		Primer	#20	
		Bonding resin	#20	
Low-viscosity restorative composite	Palfique Clear	Homogeneously submicro-filled light-cured composite	#262	Tokuyama Corp
Resin composite inlay	Palfique Inlay	Heavily-filled light-cured composite	#451	Tokuyama Corp
Dual-cured luting composite	Bistite Resin Cement	Conditioner	#001	
		Primer A	#001	Tokuyama Corp
		Primer B	#001	
		Paste A	#101	
		Paste B	#801	
Temporary sealing material	Cavit-G	Zinc sulfate, Zinc oxide Polyvinyl acetate, etc	#0102	ESPE, Seefeld/Oberbay, Germany

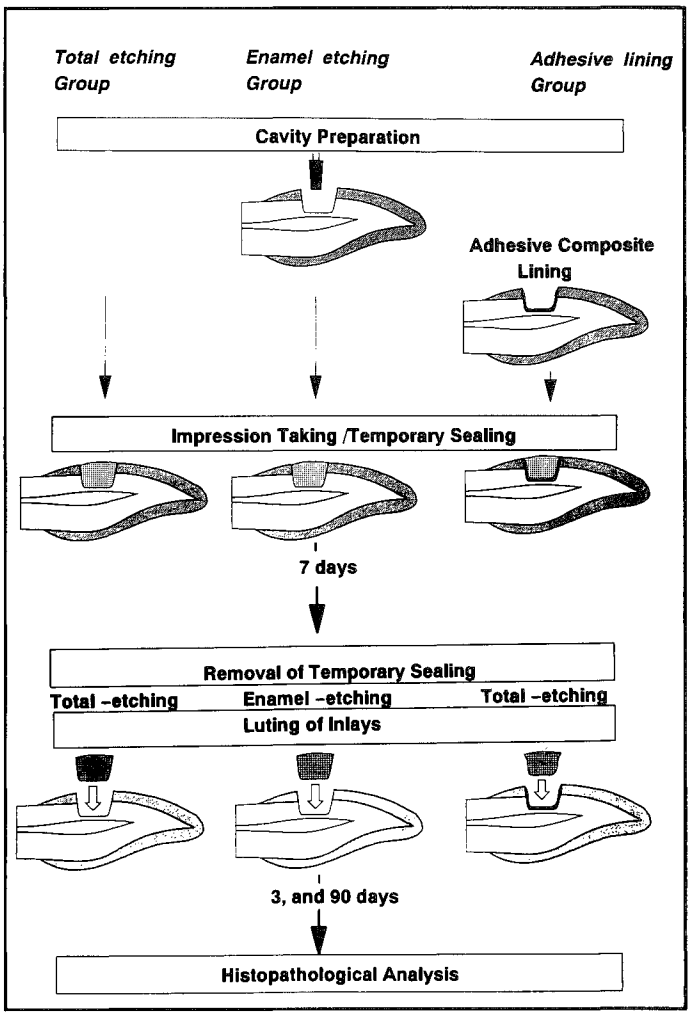

Figure 1. *Experimental procedure of three groups*

water) was applied for 30 seconds, gently air-dried, and then a one-liquid-type dentin adhesive (BIS-GMA-type bonding resin with MAC 10, 11-methacryloxy-1 1-undecadicarboxylic acid) was applied, air thinned, and light cured for 10 seconds. All the dentinal walls/floor were then covered with a thin layer of the low-viscosity light-cured composite, and light cured for 30 seconds. Cavity preparations and lining for this group was performed first prior to cavity preparations for Groups TE and EE to avoid inadvertent etching of open cavities of the other groups.

Impressions were then taken of the preparations of all groups using a combination of injection and putty-type, addition-cured silicone impression material (Hydrophilic Exaflex, G-C Corp). All preparations were temporarily sealed with Cavit-G (ESPE, Seefeld/Oberbay, Germany) because of its better sealing and biological qualities (Widerman, Eames & Serene, 1971; Provant & Adrian, 1978; Turner & others, 1990). Nikaido and others (1993) reported that Cavit-G significantly increased bond strength of a luting composite to an adhesive cavity lining composite. Stone (Tokuso Rock One, Tokuyama Corp) working models were poured and then used to construct the resin composite inlays (Palfique Inlay, Tokuyama Corp) according to the manufacturer's instructions. For ease of handling during the try-in and luting procedure, a small projection 2 mm long was added to the facial surface of each inlay.

At 7 days after cavity preparation, the monkeys were again anesthetized. The temporary sealing material was thoroughly removed with a sharp explorer and the preparations cleaned with a water spray. The resin composite inlays were tested for fit in the prepared teeth, and then luted with a dual-cure adhesive resin composite (Bistite Resin Cement, Tokuyama Corp) as described below. The conditioner gel (10% citric acid gel containing 3% $FeCl_3$) was applied with a small pointed brush to confine it to only the enamel walls for Group EE, and the whole cavity for Groups TE and AdL for 40 seconds. The cavities were washed and air dried. A two-liquid-type primer (MAC 10 and catalyst) was mixed, applied for 30 seconds, and gently air dried. Equal amounts of universal and catalyst pastes of the resin cement were mixed for 10 seconds, placed in the cavities, and light cured for 20 seconds after insertion of the inlays. The resin cement flash and small projections from the inlays were removed with a high-speed superfine diamond bur (V16ff, G-C Corp) under water-spray coolant.

At 3 and 90 days after placement of the inlays, the monkeys were sacrificed by intravenous injection of 250 mg/kg thiopental sodium (Ravonal, Tanabe Pharmaceutical Co, Osaka, Japan). The teeth were extracted and immersed in a 10% neutral buffered formalin solution for 1 week. Before immersion, the mesial and distal approximal surfaces of the teeth were reduced with a high-speed diamond stone under spray coolant until the pulp became almost visible through the remaining dentin to facilitate the penetration of the fixing solution. The teeth were embedded in paraffin after application of Plank-Rychro's decalcifying solution at 4 °C for 5 days. Histopathological serial sections 5 μm thick through the cavities and pulp were prepared, obtaining approximately 50 to 60 sections per cavity. These were stained with hematoxylin and eosin for routine histological evaluation and with Taylor's modification of Gram's staining technique for microorganisms (Taylor, 1966).

The remaining dentin thickness was measured parallel to the dentinal tubules and was represented by the shortest floor-to-pulp distance of each section. Among the 50 to 60 serial sections per cavity, one section of the thinnest remaining dentin thickness was selected for assessment as a representative

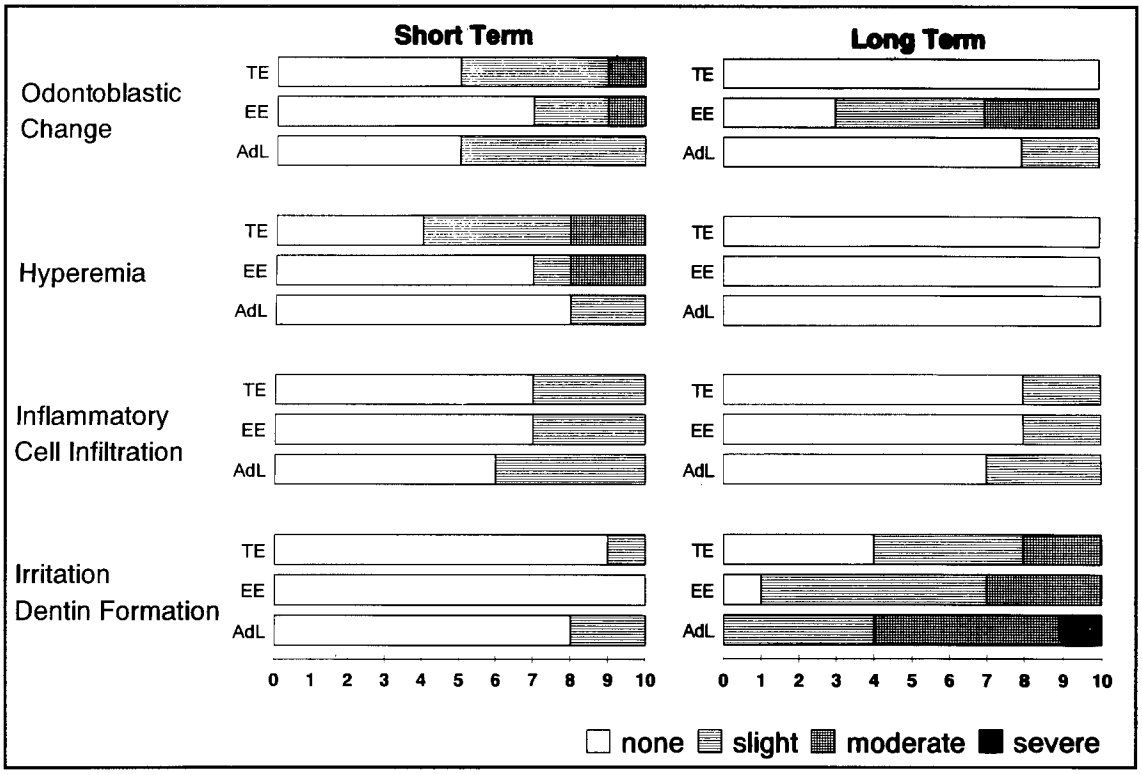

Figure 2. *Pulpal responses of three experimental groups*

section of the tooth. The intensities of the histological response, disarrangement and reduction of odontoblasts, hyperemia, inflammatory cell infiltration, and irritation dentin formation, were classified into four grades: none, slight, moderate, and severe (Mjör & Tronstad, 1972). The presence of bacteria along the cavity walls and floor was also evaluated.

The results of pulpal responses were statistically analyzed by the Kruskal-Wallis one-way analysis of variance (Siegel & Castellan, 1988) for difference among the three experimental groups for each time interval and by the Mann-Whitney U test (Siegel & Castellan, 1988) for differences between the two time intervals. Parametric one-way analysis of variance and Fisher's protected least significant difference test were used to determine significant differences among remaining dentin thickness of the six experimental groups.

RESULTS

Findings on the histological sections and mean values and ranges of the remaining dentin thickness (RDT) are summarized in Figure 2 and Table 2. Although the dental pulp was exposed in one case of the AdL group, all sixty specimens showed no severe

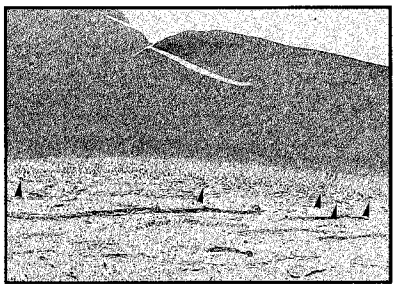

Figure 3. *The short-term Group TE. Capillaries packed with red blood cells (arrows) are apparent in odontoblastic layer and subodontoblastic area (moderate hyperemia). The cavity floor was partly torn at filling removal. RDT = 0.80 mm. (magnification X19.6)*

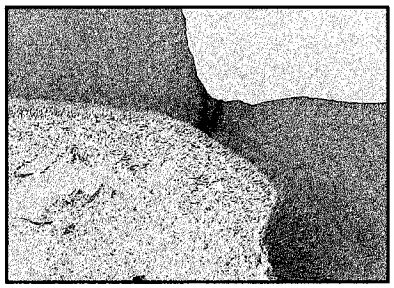

Figure 4. *The short-term Group AdL. No inflammatory reaction except for slight disarrangement of the odontoblastic layer directly beneath the cavity. RDT = 0.11 mm. (magnification X19.6)*

Figure 5. *The long-term Group EE. Moderate irritation dentin formation with severely flattened odontoblastic layer. RDT = 1.30 mm. (magnification X19.6)*

Table 2. Summary of Results

Time Intervals / Experimental Groups		Short-Term			Long-Term		
		TE	EE	AdL	TE	EE	AdL
# of Specimens		10	10	10	10	10	10
Odontoblastic Changes	none	5	7	5	10	3	8
	slight	4	2	5	0	4	2
	moderate	1	1	0	0	3	0
	severe	0	0	0	0	0	0
Hyperemia	none	4	7	8	10	10	10
	slight	4	1	2	0	0	0
	moderate	2	2	0	0	0	0
	severe	0	0	0	0	0	0
Inflammatory Cell Infiltration	none	7	7	6	8	8	7
	slight	3	3	4	2	2	3
	moderate	0	0	0	0	0	0
	severe	0	0	0	0	0	0
Irritation Dentin Formation	none	9	10	8	4	1	0
	slight	1	0	2	4	6	4
	moderate	0	0	0	2	3	5
	severe	0	0	0	0	0	1
Remaining Dentin Thickness (mm)	mean	0.81	0.92	0.53	0.97	1.27	0.89
	min	0.45	0.60	0.11	0.60	1.00	0.00
	max	1.25	1.20	1.10	1.20	1.50	1.50

TE: Total-etching group
EE: Enamel-etching group
AdL: Adhesive composite lining group

damage of the pulp, and all reactions were restricted to directly beneath the prepared cavities. Figures 3-7 show representative histopathological photographs of this study. The RDT of the short-term Group AdL and the long-term Group EE were significantly thinner and thicker than the rest of the groups (F=6.6; df=5.54; $P < 0.001$) respectively.

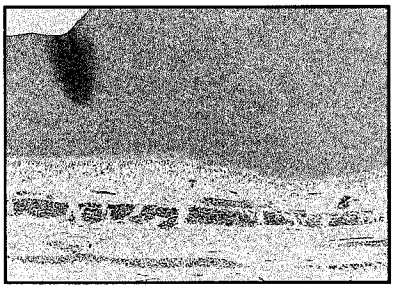

Figure 6. *The long-term Group TE. Slight irritation dentin formation with normal odontoblastic layer. RDT = 0.60 mm. (magnification X19.6)*

Short-Term Pulpal Responses

The disarrangement and reduction of odontoblasts were none to slight and comparable in all three groups. No aspiration of odontoblasts was observed. Slight-to-moderate hyperemia was noted in six out of 10 cases in Group TE (Figure 3), followed by Group EE, and the least in Group AdL, although the RDT was the thinnest in Group AdL (Figure 4). However, these changes were not statistically significant. Inflammatory cell infiltration was negligible in all groups. A trace amount of irritation dentin was observed in a few cases.

Long-Term Pulpal Responses

Although the disarrangement and reduction of odontoblasts were negligible in Groups TE and AdL, Group EE showed a statistically significantly higher incidence of morphological deformation of the odontoblastic layer under the irritation dentin, in spite of a relatively thick RDT (Figure 5) (KW=12.56; $P < 0.002$). No hyperemia was observed in any case. Inflammatory cell infiltration was none to slight in all groups and comparable to those of the short-term group. Comparing the results of the short- and long-term groups, only Group TE showed a significant decrease of odontoblastic change (U=25; $P < 0.012$) and hyperemia (U=20; $P < 0.005$).

The long-term group showed significantly higher incidence of irritation dentin formation than the short-term group (U_{TE}=25, $P < 0.05$; U_{EE}=5, $P < 0.001$; U_{AdL}=4, $P < 0.0005$). It was least in Group TE (Figure 6), followed by Group EE, and the greatest in Group AdL, and the differences were statistically significant (KW=6.33; $P < 0.05$). Although one case of Group AdL showed accidental pulp exposure and was directly coated with the adhesive resin, no inflammatory reaction was found, and the exposed area was partly narrowed by osteodentin formation (Figure 7).

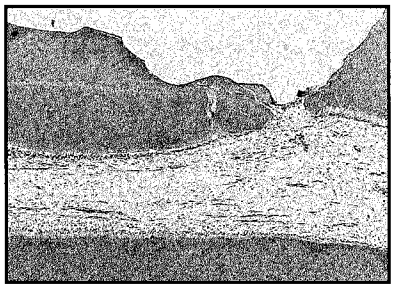

Figure 7. *The long-term Group AdL with pulp exposure. Accidentally exposed cavity was directly coated with the adhesive resin after total etching and restored with a composite inlay at 7 days after preparation. The dental pulp shows no inflammatory reaction, and exposed area is partly narrowed by osteodentin formation. (magnification X19.6)*

Bacterial Penetration

Bacterial penetration along the cavity walls/floors could not be detected in any cases of the short- and long-term groups.

DISCUSSION

In the present study, pulpal responses to resin composite inlays adhesively luted in etched-enamel and total-etched cavities were compared to those of inlays placed in cavities lined with an adhesive low-viscosity composite before impressions were taken. In comparison with pulp studies using direct restorative materials, indirect inlay restorations have additional sources of pulp irritation (Table 3). On reading the histopathological findings, it should be kept in mind that the short-term Groups TE and EE were not only groups of 3 days after final cementation, but also groups of 10 days after cavity preparation with 7 days temporary sealing. Temporary fillings covering freshly cut dentinal walls/floors might permit marginal leakage, and placement of an inlay requires re-exposure of the cut dentinal walls. On the other hand, the short-term Group AdL should be recognized as a group of 10 days after preparation and adhesive resin restoration with little effects of temporary sealing and final cementation.

Short-term pulpal responses of Group AdL were none to slight, although the cavities were totally etched with a 37% phosphoric acid gel for 40 seconds, and the mean RDT was the thinnest of all. This suggests that the adhesive resin coating of the prepared dentin surfaces protected the dental pulp from irritation caused by temporary sealing removal and the luting procedure. Phosphoric acid etching was reported to cause severe odontoblastic damage at 3 days after adhesive resin restoration placement (Fujitani, 1986; Fujitani & others, 1992), which seemed to be partly resolved 10 days later. It was interesting to note that a trace amount of irritation dentin was already formed at this early time.

A slightly higher incidence of vascular changes in Groups TE and EE was considered to be caused mainly by the mechanical and chemical irritation caused during temporary filling removal and the resin bonding/luting procedure. Although excellent sealing and biological properties of Cavit-G or Cavit were reported (Turner & others, 1990; Widerman & others, 1971;Provant & Adrian, 1978), marginal leakage during the first 7 days was an undeniable factor as a possible initial irritant to the pulp. Acidic conditioning of the whole cavity in Group TE led to a slight increase of hyperemia compared to Group EE, indicating additional irritation due to opening of the dentinal tubules of the cavity floor by the acid.

Formation of irritation dentin is a sign of initial damage to the odontoblasts (Diamond, Stanley & Swerdlow, 1966). In the long term for Group AdL, a high incidence of irritation dentin formation coincided with the results of previous pulp studies of the total etching technique using phosphoric acid (Inokoshi & others, 1982, 1986; Fujitani, 1986; Fujitani & others, 1992) and was considered to originate from the initial chemical and mechanical irritation by the phosphoric acid etching procedure, including water rinsing and air drying. Since Group TE showed much less irritation dentin formation than that of Group AdL, the 10-3 conditioner (10% citric acid containing 3% $FeCl_3$) was believed to be less irritating to the pulp than the 37% phosphoric acid gel.

Irritation dentin formation at the long-term period was greater in Group EE than in Group TE, despite the fact that total etching opened tubule orifices of the floor dentin, and initial irritation was greater in Group TE than in Group EE. It was reported that a greater initial response

Table 3. Possible Sources of Pulp Irritation in the Three Experimental Groups Comparing to Direct Restoration

	Experimental Group			
Source of Irritation	**TE**	**EE**	**AdL**	**Direct Restoration Using Total Etching**
Cavity preparation	Yes	Yes	Yes	Yes
Phosphoric acid etching / water rinsing / air drying			Yes	Yes
Primer / Bonding resin			Yes	Yes
Impression taking	Yes	Yes		
Marginal leakage during temporary restoration	?	?		
Mechanical irritation during temporary filling removal	Yes	Yes		
Acidic conditioning / water rinsing / air drying	Yes			
Primer	Yes	Yes		
Luting material / procedure	Yes	Yes		
Marginal leakage after (inlay) restoration	?	?	?	?

? stands for undeniable possibility.

due to irritation caused by a restorative procedure led to a greater subsequent prevalence of irritation dentin (Diamond, Stanley & Swerdlow, 1966). A greater incidence of irritation dentin formation in Group EE seems to indicate that Group EE caused greater irritation to the dental pulp than Group TE during 90 days after inlay placement. This might be due to inadequate adhesion of the luted inlays to the cavity floors. Although bacterial leakage could not be detected in any case, it might be lost during specimen preparation. Fujitani (1986) proposed that gap formation at the cavity floor without bacterial penetration was a possible irritant to the dental pulp. The luting composite, Bistite Resin Cement, contains an adhesion-promoting methacrylate, MAC 10, and has an additional priming system for improved dentin bonding. Although the manufacturer recommends avoiding dentin etching with the conditioning agent, Nikaido and others (1992) reported Bistite's bond strength to etched bovine dentin was 13 MPa after 24 hours, whereas the bonding system was less effective to unetched dentin (Maseki & Katsuyama, 1993). During histological specimen preparation, it was difficult to remove the composite fillings from the totally etched cavities after decalcification. This sometimes led to cohesive failure of the dentinal walls and floors. This never occurred in Group EE. Since temporary sealing significantly affects the marginal leakage at nonenamel margins of resin-bonded inlay restorations (Woody & Davis, 1992) and some components of temporary materials remain on the cavity surfaces after removal with a dental probe (Terata, 1993), total etching seems to be much more effective than only enamel etching to obtain a clean surface for better adhesion of the luting composite.

CONCLUSION

The present study showed that conventional indirect restorations requiring temporization and re-exposure of the cut dentinal walls/floors caused slight initial pulpal responses, which appear to be due to mechanical irritation during temporary sealing removal and/or mechanical and chemical irritation during the resin bonding/luting procedures. However, the initial pulpal responses subsided when a tight marginal seal was obtained by cementation of the inlay.

Application of adhesive resins to freshly cut dentinal walls may be a useful alternative technique in indirect resin restorations requiring temporary sealing to minimize pulp irritation from mechanical, thermal, and bacterial insults during impression taking, temporary restoration, and final cementation. It might also be possible to seal a small accidental pulp exposure with an adhesive resin to eliminate any further chance of pulpal infection during complex restorative procedures with the indirect method (Figure 7) (Kashiwada & Takagi, 1991; Masaka & others, 1991; Cox, 1992; Onoe, 1994). The more recent dentin bonding systems with excellent adhesive qualities are good candidates for this method.

Acknowledgment

The authors would like to thank to Dr Michael F Burrow, a part-time lecturer at Tokyo Medical and Dental University, for correction of the English.

(Received 13 May 1994)

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In Vivo Diagnostic Assessment of Dentinal Caries Utilizing Acid Red and Povidone-Iodine Dyes

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Clinical Relevance
The diagnostic dyes, acid red and povidone-iodine, appeared to be equally useful in assisting clinical decisions regarding removal of caries.

SUMMARY

In order to compare the clinical utilization of diagnostic dyes to identify carious dentin, the present in vivo study compared two caries-detector dyes, acid red (1% acid red in propylene glycol wt/wt) and povidone-iodine (8% povidone-iodine in water wt/vol). A total of 221 cavities prepared by 19 senior dental students under the supervision of two teachers at the Universidad Nacional Autónoma de México Dental School were used. Dyes were applied double-blind under standardized conditions to at least two teeth of the same patient. Data were analyzed using the Mantel-Haenszel chi-square test and a test of proportions. Results showed that molars or premolars did not appear to be positively stained more frequently by one dye or another. Also, 36.7% of teeth tested positive to either one of the two dyes. Prudent utilization of either acid red or povidone-iodine appeared to be equally useful in assisting clinical decisions concerning cavity size while restoring dentinal lesions. However, povidone-iodine may be preferred in clinical settings where acid red is expensive and/or difficult to obtain. Further research is necessary to establish accurately the mechanism of staining by povidone-iodine.

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INTRODUCTION

Clinical accuracy in the identification of carious lesions in vivo (Rytömaa, Järvinen & Järvinen, 1979) and in vitro (Merrett & Elderton, 1984) is not excellent. This could be of clinical importance, since minimum removal of sound tooth tissue improves long-term prognosis of teeth and restorations (Boyd, 1989; Elderton, 1977; Elderton & Davies, 1984; Gray, 1976). Diagnoses of carious lesions are based on visual or visual/tactile assessment of teeth, frequently in combination with radiographic aids. Since carious penetration into dentin is a commonly used criterion for restorative treatment (Downer, 1989), reliable detection of carious dentin is important if

only affected tissue is to be removed.

To distinguish between sound and carious dentin, some authors have attempted to utilize histologic changes in dentin as an indicator of caries (Fusayama & Terachima, 1972; Wirthlin, 1970). Such visual findings can be put to clinical use by means of selective dyes that highlight affected dentin in the prepared cavity (Sato & Fusayama, 1976; Kuboki, Ohgushi & Fusayama, 1977). Since several reports of clinical application of these dyes have become available in the last few years (Kidd & others, 1989; van de Rijke, 1991), the present study attempted to compare the visual and tactile method of detecting carious dentin using a mirror and explorer with a method involving one of two caries-detector dyes, acid red (1% acid red in propylene glycol wt/wt) and povidone-iodine (8% povidone-iodine in water wt/vol).

METHODS AND MATERIALS

Cavities prepared by final-year dental students under the supervision of two teachers at two dental clinics of Universidad Nacional Autónoma de México Dental School were used. Following a blind design, neither students nor teachers knew which dye was being used on a given tooth. All patients had at least two teeth tested, one with dye A (acid red) and another with dye B (povidone-iodine). The plan was to apply dye A to 100 teeth and dye B to 100 teeth. Selected teeth were either permanent first or second premolars and molars diagnosed as carious (but not grossly carious nor damaged) and allocated to restorative treatment (class 1 cavity preparation). Two teachers selected the students taking part in the investigation on a random basis. Students were told they were to use an antiseptic to clean cavities as a step in their preparation. It is worthwhile noting that caries-detector dyes are rarely used in clinical practice in Mexico, and are not part of the dental curriculum.

The students opened the cavity of a carious tooth, but once access was gained, they only removed carious tissue without proceeding to a formal cavity design. If the lesion reached dentin and no acute pulpal involvement was found, the tooth was allocated to the trial. This step was strongly emphasized to every student. Once the cavity was diagnosed as caries-free, the teachers noted the patient's and student's names and tooth type. Under relative isolation using cotton rolls and after air-drying the cavity for 10 seconds, the teachers applied one of the two blindly labelled dyes to the cavity on a pledget of cotton for 10 seconds: acid red (1% acid red in propylene glycol wt/wt) or povidone-iodine (8% povidone-iodine in water wt/vol). They alternatively tested teeth with one dye or another according to a pre-established schedule. The cavity was then thoroughly washed (10 seconds) and air-dried (10 seconds) and re-examined for dentin stained by the dye: The subjective assessment scale employed is shown in Table 1. The teachers noted the result, and the carious dentin was removed from the teeth. They were then restored following standard procedures.

Data were analyzed using a Mantel-Haenszel chi-square test and a test of proportions in which $Z = [(Par - P pi) / SE]$ and where Par = specificity of acid red dye; Ppi = specificity of povidone iodine dye; Qar = (1- specificity of acid red dye); Qpi = (1- specificity of povidone iodine dye); Nar = subjects tested with acid red dye; Npi = subjects tested with povidone iodine dye; and

$$SE = \sqrt{\frac{(Par\ Qar)}{Nar} + \frac{(Ppi\ Qpi)}{Npi}}$$

RESULTS

The trial was conducted on 221 cavities (124 premolars and 97 molars) prepared by 19 final-year dental students between July and October 1993. A total of 110 teeth were tested using the acid red dye and 111 using the povidone-iodine dye.

Considering teeth tested with either dye A or B, 140 teeth (63.3%) were subjectively allocated to Degree 1: i e, had no evidence of carious dentin left behind by students who believed they had removed it completely. These could be considered true negative teeth. Students left some degree of carious dentin in over one-third of teeth treated, since a further 36.7% of teeth (n=81) were false negative, exhibiting some degree of positive dye staining (Degree 2, 53 teeth; Degree 3, 25; Degree 4, 2; and Degree 5, 1).

Molars or premolars did not appear to be positively stained more frequently by one dye or another (chi square 0.787, $P = 0.374$, degrees of freedom [DF] 2).

Teeth belonging to Degrees 2, 3, 4, and 5 were clustered together for the purposes of the Mantel-

Table 1. Assessment of Dyes

Degree 1	No staining
Degree 2	Some areas (about 1-2 square mm) of staining can be seen.
Degree 3	Some areas (about 3-4 square mm) of staining can be seen.
Degree 4	Some areas (about 4-5 square mm) of staining can be seen.
Degree 5	A stained area larger than 5 square mm can be seen.

Haenszel analysis. Acid red and povidone-iodine did not stain teeth allocated to Degrees 1 or 2/3/4/5 in a manner suggesting that a clear diagnostic advantage could be found between one dye or another (chi square = 3.4, $P = 0.062$, DF = 1) (Table 2).

A strict comparison against a gold standard was not feasible for ethical reasons. It was therefore decided to use the clinical assessment done by the students as a gold standard to compare the performances achieved when using the diagnostic dyes. Since all students indicated that every tooth they diagnosed was caries-free prior to the dye application (following the research protocol), the sensitivity, negative predictive values, and positive predictive values of the diagnostic procedures could not be calculated from available data. Specificity values (acid red 0.57 and povidone-iodine 0.69) were not statistically significantly different ($P = 0.071$) when compared using a test of proportions.

DISCUSSION

If it is imperative to remove all carious dentin during cavity preparations, some method to identify it is necessary. Kidd and others (1989) emphasized its importance especially when a dietary substrate remains to allow residual caries to progress. This could also be important when the difficulty of the diagnostic task increases if there is dark staining of residual lesions adjacent to restorations. In view of the current trend to keep cavities as small as possible, prudent utilization of dyes to identify carious dentin might be an appropriate basis for objective decision-making on cavity size. Nevertheless, utilization of dyes for routine removal of carious dentin on the pulpal floor does appear to be contraindicated due to the risk of pulpal exposures (Kidd & others, 1989).

In the present investigation, the clinical skills of final-year dental students were used to assess the removal of carious dentin during cavity preparations. There was no significant difference in the ability of the dyes to stain carious dentin. However, about one-third of cavities that were supposed to have had all carious tissue removed were subsequently shown to contain carious dentin. These results resemble previous reports in which dye stain was present in 57% and 59% of cases assessed as caries-free under clinical conditions (Kidd & others, 1989; Anderson & Charbeneau, 1985). The greater diagnostic accuracy exhibited by students in the present research, as compared to other reports, does not have a satisfactory explanation from available data. However, it seems clear that detection and removal of all cariously affected dentin during operative procedures is not certain.

Table 2. Positive Tests to Acid Red and Povidone-Iodine

	Degrees of Staining		
Dye	**No Staining Degree 1**	**Positive Staining Degrees 2,3,4,5**	**Total**
Acid Red	63 teeth 28.5%	47 teeth 21.3%	110 teeth 49.8%
Povidone-Iodine	77 teeth 34.8%	34 teeth 15.4%	111 teeth 50.2%
Total	140 teeth	81 teeth	221 teeth

(Mantel-Haenszel chi-square = 3.4; $P = 0.062$; DF = 1.)

Anderson and Charbeneau (1985) considered the dye technique an objective guide that could help in eliminating or reducing deficiency in clinical judgement. In the light of the present research, it would appear that carious dentin can be detected by either of the two techniques tested. However, the mechanism of staining by povidone-iodine is not fully understood (Pérez-Herrerías & Koloffon, 1991; 1992). It has been proposed that affected tissue in the decayed layers of dentin is responsible for the stainability (Castillo-Moya & Rubio-Argüello, 1981), but no objective assessment of this has been undertaken. Fuchsin-stained portions of dentin contain bacteria, thus suggesting that the staining front corresponded roughly to the bacterial invasion front (Fusayama & Terachima, 1972). However, it appears that staining by the dye is not the result of loss of mineral nor of bacterial presence but the denaturation of collagen fibers (Kuboki & others, 1983). Whether the same structures are stained by povidone-iodine should be addressed by studies to strengthen beyond anecdotal evidence the rationale supporting the utilization of povidone-iodine.

Because no substantial difference between acid red and povidone-iodine staining of carious dentin could be found, we suggest that povidone-iodine be used to assess complete removal of carious dentin during cavity preparation. This recommendation could be of importance in the Mexican clinical setting, where acid red is expensive and difficult to obtain. Comparatively speaking, povidone-iodine is a commonly found, locally-marketed antiseptic. Also, the antiseptic features of povidone-iodine could be a convenient side aspect of its utilization, even though its real disinfectant potential for cavity preparations needs to be independently assessed. Other clinical settings may also take advantage of the wider availability of povidone-iodine solutions. It should be emphasized that even though unstained dentin is probably not infected and thus may be left intact, it has also been proposed that the imprudent utilization of dyes may lead to an excessive removal of dentin. Removal of the soft dentin by tactile means may be enough, because as much hard dentin as possible should be

left in the final cavity preparation (van de Rijke, 1991). If the objective is to remove all stained dentin, which may require a second or even a third application of dye to corroborate, it is clear that a risk of excessive dentin removal does exist.

CONCLUSIONS

1. No substantial difference was found between acid red and povidone-iodine staining of carious dentin.
2. Povidone-iodine is recommended for use in those clinical settings where its cost and its availability compare advantageously to acid red.

(Received 26 May 1994)

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DEPARTMENTS

BOOK REVIEWS

OROFACIAL PAIN: UNDERSTANDING TEMPOROMANDIBULAR (TMJ) DISORDERS

Joseph A Gibilisco, Charles McNeill, and Harold T Perry, Editors

Published by Quintessence Publishing Co, Inc, Chicago, 1994. 60 pages, 23 illustrations. $28.00, softbound.

The purpose of this book as stated by the authors is to provide guidance and basic information to those suffering from temporomandibular disorders. The authors are superbly qualified to prepare an instructional book such as this. Dr Gibilisco is Emeritus Professor of Dentistry at Mayo Clinic and is a past president of the American Academy of Craniomandibular Disorders. Dr McNeill is the director of the Center for Temporomandibular Disorders and Orofacial Pain at the University of California, San Francisco. He has been director of TMD, orofacial pain, and occlusion study groups since 1968. Dr Perry is co-director of the Facial Pain Clinic at Northwestern University Dental School and current editorial chairman of the *Journal of Orofacial Pain*.

The goals the authors set for themselves offer quite a challenge. Trying to construct meaningful information for the general public about a subject often the topic of heated discussions between treatment specialists is not easy. However, a sincere effort was made to discuss orofacial pain at the patient's level. Beautiful color pictures are presented to help explain concepts, and the print is comfortably large, signifying easy reading. Seven common questions often asked by patients are addressed in an attempt to educate the patient. Starting with a discussion of "How does my jaw work?", the authors progress through the seven questions, ending with a discussion of "Will I always have pain and difficulty chewing?"

As simple as the authors have tried to make this instructional book, there are several different terms used with the same meaning that would be confusing to the lay person. For example, the book refers to the "jaw joint," then reverts to "temporomandibular joint." Additionally, TMD is used when referring to "jaw pain." It is also felt that some of the descriptions of associated problems are stretching the patient's ability to comprehend—the discussions of internal derangement, disk slippage, orthotics, intraoral splints, arthrocentesis, lavage, arthroscopy, myofascial pain dysfunction syndrome, etc, may be too advanced for the average TMD patient. The radiographs on pages 19 and 28 might be more than the average person can comprehend. The physical therapy section of treatment options is excellent, and the color illustrations of posture factors and jaw exercises are interesting and easily understood.

The several areas of this book dealing with information and treatments of a more difficult nature beyond the patient's interest or comprehension dilute the excellent baseline information provided by the authors, thereby making it less attractive for the average patient to purchase as a reference guide. On the other hand, this book will be of interest to patients with chronic TMD who have, by desire or necessity, educated themselves to a level above the less-interested patient. This book would be good waiting room reading in practices involved with treatment of myofascial disfunction patients.

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PROCEEDINGS OF THE 1st EUROPEAN WORKSHOP ON PERIODONTOLOGY

Niklaus P Lang and Thorkild Karring, Editors

Published by Quintessence Publishing Co, Inc, Chicago, 1994. 478 pages, 64 illustrations. $58.50.

In 1993, a periodontal workshop was held in Switzerland. Representing nine national periodontal societies in Europe, 81 highly recognized researchers and educators met to review current knowledge in periodontology. The proceedings cover the reported findings by each of five session groups. The results of this work are presented in a highly consistent format that is easy to read. After the introduction of the task for each session, a thorough review of the literature sets the stage for a careful analysis of current knowledge in the field. Each chapter ends with concluding remarks followed by excellent consensus reports. The individuals participating in each session

are listed, including the names of the two editors of each session. A thorough literature list is included at the end of each session report. Several of the reports include summaries of literature findings in easy-to-read tabular form.

The content of Session I comprises epidemiology, etiology, a review of risk factors, and a discussion about diagnostic gold standard for detection of periodontal diseases. Session II reports background and findings about the usefulness of nonsurgical and surgical periodontal therapies, regenerative, and mucogingival procedures. Session III discusses oral hygiene and maintenance care. Sessions IV and V are dedicated to tissue integration in implant procedures and periodontal aspects in medically compromised patients respectively. In conclusion, the proceedings cover major aspects of periodontology. If any session should have been further extended, it would be the microbiology and immunology sections of Sessions I and III.

Session II is exemplary in demonstrating how a very large body of literature on the benefits of nonsurgical and surgical procedures can be summarized to provide evidence of differences in expected outcomes. This report will undoubtedly put to rest a longtime ongoing dispute about the benefits of various procedures. Session IV provides interesting and thoughtful considerations about the maintenance, monitoring, and therapy of failing implants. Most readers will find Session V very informative about periodontal management of medically compromised patients. In fact, it would be difficult to find more or better information about periodontal considerations in such patients.

The participants of the meeting and the editors should be highly commended for their thorough reviews and considerations. In fact, the proceedings are probably the most comprehensive nonbiased reports available today in periodontology. The objective of the work was not to publish a text to be used by all levels of students and clinicians interested in periodontology; however, and in spite of the absence of descriptions of clinical procedures, the reader will gain substantial in-depth knowledge of why clinical procedures should or maybe should not be performed.

The proceedings cannot be used alone as a textbook for beginning students in periodontology. However, properly complemented, the text will serve as a very much needed resource supporting the conscientious clinician in making proper clinical decisions.

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CONTEMPORARY ESTHETIC DENTISTRY: PRACTICE FUNDAMENTALS

Bruce J Crispin, Editor

Published by Quintessence Publishing Co, Inc, Chicago, 1994. 303 pages, 933 illustrations. $120.00.

Esthetic dental procedures, once somewhat of a fringe element of clinical dentistry, are now well established as an integral part of a general or specialty practice. This text reflects the essential position of esthetic procedures in present clinical practice and the general acceptance and promotion of esthetic dentistry as a clinical discipline. The editor, Dr Crispin, is the director of the UCLA Center for Esthetic Dentistry, and his co-authors have full- or part-time associations with that institution. It is clear that this combination of academic principles and practice-related practicality have produced an excellent text on this topic.

The book is divided into six chapters with multiple sections for each chapter. Appropriately, the first chapter deals with communication techniques including photography, computer imaging, and video techniques. Treatment planning and patient education are well delineated, as are the various imaging procedures. The second chapter deals with nonrestorative esthetic procedures including methods to modify color and tooth contours. The section on bleaching, both vital and nonvital, is particularly well written and described. The next chapter deals with esthetic restorative materials and characterizes early materials such as silicate and acrylic resin and goes on to describe the characteristics of contemporary composite resins, glass ionomers, and bonding agents. A discussion of the physical properties of materials can often act as a soporific to many dentists, but the writing style and generous use of illustrations make this treatise easy to read and understand. Chapter 4 covers the procedures involved with direct placement of composite and glass-ionomer materials, and the next chapter describes the indirect composite techniques, primarily the composite inlay procedure. The last chapter (6) comprises nearly half of the text and covers materials and procedures in ceramic restorative techniques. This includes an important review of the historical perspectives of ceramic dental restorative materials and a careful look at ceramic crowns, inlays, and veneers. There is also a brief introductory discussion of ceramic bridges and similar esthetic fixed partial dentures.

Overall, this is a well-written text with an excellent organizational format. It deals with a topic about which much is written, but does so in an unusually adept scientific manner while maintaining much of the practical approach important to the practicing dentist.

Much of the published literature and individual presentations on esthetic dentistry are a virtual show-and-tell of successful cases with very little of substance on the procedures and material characteristics so critical to success in this arena. That is not the case in this situation, and the major strength of the written material in this text is the ability to combine the scientific background with the pragmatic application of techniques.

It would be negligent to fail to mention the superb illustrations and photographs that accompany the text in this book. While we have come to expect high-quality illustrations in Quintessence publications, this text is particularly striking in its quality portrayal of clinical and laboratory procedures. Not only are the clinical photographs produced with exceptional clarity and color rendition, but the diagrams and charts are remarkable for their clarity and arrangement.

This is an excellent text, certainly one of the best on the topic and one that deserves careful consideration by all dentists with interests in esthetic procedures. It is particularly appropriate for general dentists but would also be applicable for specialists in prosthodontics and other related fields.

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THE CLEFT PALATE STORY

Samuel Berkowitz

Published by Quintessence Publishing Co, Inc, Chicago, 1994. 240 pages, 92 illustrations. $24.00, softbound.

Dr Berkowitz is both a well-known and respected orthodontist who has treated children with clefting for over 30 years. Currently, he is a clinical professor of pediatrics and surgery and is the staff orthodontist on the Craniofacial Team in the Miami Children's Hospital.

In his preface, the author outlines that the main focus of this book is to provide information for parents of children born with clefting. Indeed, he states, "I believe that parents are motivated and capable of understanding more about their children's clefts." In this regard, I feel Dr Berkowitz has done an admirable job but perhaps sells himself short; this book would be of great value for many health care providers as well. Although not written with a level of technical detail to satisfy practitioners who work every day with cleft patients, it would be superb as an excellent overview for family medical practitioners, nurses, and operative dentists who may see cleft patients as part of their practices. Additionally, students of many disciplines would find this book an excellent introduction to this challenging field.

The book logically proceeds through the sequence of care for a cleft patient. The initial chapters deal with issues such as psychological acceptance of the cleft child, feeding, the causes of clefting, and how to relate to the professions on the Cleft Palate Team. Later chapters deal with treatment issues like surgical needs, speech, and dental procedures. Dr Berkowitz has superbly balanced his information to allow for acceptable variations of approach from team to team. Concluding chapters deal with resources in the care of these children, and he deals openly with issues of finances and insurance.

In short, this book should be of great value for any reader of *Operative Dentistry* who has any interest in treating these very complex and deserving patients.

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AN ATLAS OF GLASS-IONOMER CEMENTS: A CLINICIAN'S GUIDE
Second Edition

Graham J Mount

Published by Martin Dunitz Ltd, London, 1994. 140 pages, 250-plus illustrations. $45.00.

This guide extensively utilizes illustrations and pictures to demonstrate chemistry and sequences of instrumentation for nearly all glass-ionomer dental applications. The overall organization of this book remains unchanged from the first edition with a section devoted to a description of glass-ionomer cements and other sections covering luting cements, aesthetic and reinforced restorative materials, lining cements, and modified cavity designs. The final sections provide illustrated instructions for dental assistants and condensed instructions in outline form.

Practical information, arising from the author's vast clinical experience, is offered in detail. Observance of the recommended practices put forth by Dr Mount will most certainly enhance longevity of restorations. The second edition, published four years after the first, expands on traditional chemical-cured glass ionomer and

adds information on the newer dual-cured resin/glass-ionomer products.

Overall, the text is a useful clinical reference and well worth the purchase price. The only deficiency noted was the lack of photographic sequences with accompanying text to illustrate the variations in technique required for use and placement of the new dual-cured resin/glass-ionomer restorative products. I am sure these products will be well illustrated in the next revision of this clinician's guide.

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COLOR ATLAS OF PERIODONTAL SURGERY

Teruo Ito and Jeffrey D Johnson

Published by C V Mosby, St Louis, MO, 1994. 319 pages, illustrated. $112.00.

This American version of a classic Japanese atlas of periodontal surgery was authored by one of the preeminent figures in Japanese periodontics, seconded by a public health periodontist from the University of Louisville, with several additional contributors to this English edition. The authors intend this work as a reference volume for "anyone involved with the periodontal treatment of patients"; it depicts periodontal surgical procedures that the authors suggest should be within the capabilities of the well-trained general dentist.

There are a number of very significant limitations to this volume that severely restrict its usefulness and, in fact, promulgate misinformation. Perhaps the most damning of these is the illustration and instruction for use of the "Boiling Water Sterilizer" and reference to it as a method of instrument sterilization. In addition, there are included references to alcohol, benzalkonium chloride, and mixtures of chlorhexidine, sodium nitrite, and alcohol as methods of "instant sterilization." The publication of this inaccurate and potentially very damaging antediluvian folklore in a current dental text condemns the work at the outset.

The periodontal topics addressed are done in a superficial and incomplete fashion, with no index provided. There is no significant review of such current periodontal topics as guided tissue regeneration, subepithelial connective tissue grafts, and very little information on bone grafting and materials. The segment on implants is very basic with little emphasis on the very important treatment-planning aspects of this therapy. Many of the illustrations are mediocre at best, in particular a number of the surgical examples where blood or photographic angle in part obscures the point to be illustrated. Beyond the previously cited examples, there is an archaic tone to the volume which includes illustration of outmoded and little-utilized techniques, instruments, and materials.

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DENTAL MANAGEMENT OF PATIENTS WITH HIV

Michael Glick

Published by Quintessence Publishing Co, Inc, Chicago, 1994. 320 pages, 57 illustrations. $68.00.

The *Dental Management of Patients with HIV* is a comprehensive look at the AIDS epidemic and the role of the dental health care provider. The author states, "With information about HIV and AIDS, dental professionals can provide safe and appropriate dental care and take an active part in the overall medical treatment of infected patients. The information contained in this book will also help dental providers become much-needed resources in their community for information about this disease."

The book gives a detailed evolution of the disease and compares it to other epidemics in history. It reviews the influence HIV has had on politics, nations, and the structure of society. The examination of this disease progresses into the impact HIV has had on the law and ethics of health care. This is well illustrated in the discussions of patient confidentiality and the legal and ethical frameworks governing treatment of the HIV-infected patient. The book also reviews the epidemiology, transmission, and pathogenesis of the disease.

The medical review of HIV in this book will be very helpful to the restorative dentist. Dentists are among the first health care professionals to uncover initial signs of the disease. The role of the dentist in identifying the patient with HIV and the importance of early medical intervention to prolong and enhance the quality of life is explored. This book is helpful in reviewing the clinical manifestations of HIV. A thorough discussion of

intraoral manifestations of HIV is presented. Color clinical photographs give the reader a good appreciation for what is described in the text. Discussion of the various opportunistic infections and the medical management of these diseases is concise and easy to understand. A review of the drugs used to treat the individual with HIV is presented and will be useful to those who are unfamiliar with HIV medical management.

The author also gives a detailed discussion on the medical evaluation of the HIV-infected patient, including a review of different laboratory parameters important to the dentist. A chapter is devoted to the modifications necessary for dental care. Discussions include treatment planning, antibiotic prophylaxis, oral surgery, and periodontal therapy. Current information regarding infection control, management of exposure to blood-borne pathogens, and staff training are useful as guides for incorporation into practice.

This book is a timely publication for the practitioner who desires to review the approach to treating the HIV-infected patient. It is easy to read and full of information that would be useful to the dentist. The author is clearly an expert in the area of HIV oral health care and has assembled contributing authors to present a plethora of information in a concise format that will complement any dental practitioner's library.

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PERIODONTAL REGENERATION: Current Status and Directions

Alan M Polson, Editor

Published by Quintessence Publishing Co, Inc, Chicago, 1994. 200 pages, 252 illustrations. $72.00.

Until a few years ago, the clinical experience did not indicate that predictable regeneration of the periodontium could occur. At best, the clinician could anticipate that therapy would prevent further loss of periodontal attachment. However, the last 15 years have changed this concept, and it now seems possible to induce regeneration of the periodontium. The development in this area has been very fast. Only within the last five years some 300 peer-reviewed research publications are listed on the Medline.

This textbook provides an excellent and thorough update on recent developments in a very interesting area of periodontology. In addition, the restorative dentist and the clinicians interested in esthetic dentistry will find this text, *Periodontal Regeneration*, very informative. Dr Polson and his collaborators describe the principles and the methods involved in periodontal regeneration. There are 12 chapters, with approximately 200 excellent clinical and as many histological illustrations. Each chapter covers a specific topic and has a separate reference list. In four different chapters, the authors thoroughly review the mechanisms of wound healing and the potentials of regeneration.

The interest and knowledge about growth factors and biological mediators in regeneration of the periodontium have grown rapidly. The authors provide current information about these factors. This area is probably the most interesting aspect of periodontal regeneration, and it seems important to follow this development very closely. This book provides good background for a better understanding of mediators in regeneration. For many years bone grafting procedures have been used to augment periodontal surgery in eliminating bone defects by filling these defects with freeze-dried bone allografts. The two chapters on allografts by Mellonig and Yukna provide important information and support the text with excellent clinical and histological illustrations. They also include pertinent statistical information from a series of published studies.

Three chapters are dedicated to methods of guided tissue regeneration. The experiences on the use of nonresorbable and resorbable membranes have grown exponentially and will probably continue to do so. The authors provide current information about the techniques, and illustrations included are helpful to better understand how to approach the procedures. However, the authors primarily give case presentations, and the review of the literature is limited. Furthermore, statistical support indicating the success rate of the procedure is limited.

One chapter is dedicated to the principles and methods associated with root surface coverage. This area of periodontal therapy has become of more interest as the clinicians seem to dedicate more efforts toward esthetic dentistry. Several different clinical methods are discussed and supported by excellent clinical pictures. What is missing in this book is a chapter on the potential and negative influence of inflammation caused by microbial infection following regenerative procedures. The clinician will find little guidance in how to use anti-inflammatory agents and antibiotics to prevent site-specific infections. The information provided about the development of a pathogenic microflora around membranes used is also limited.

The textbook is aimed at the clinician who wants a combination of basic knowledge and clinical aspects of

potential regenerative procedures. This book serves well as a reference text to give an update on the principles and procedures currently used in the attempts to regenerate the periodontium.

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PLAQUE AND CALCULUS REMOVAL: Considerations for the Professional

David L Cochran, Kenneth Kaalkwarf, Michael Brunsvold, and Carol Brooks

Published by Quintessence Publishing Co, Inc, Chicago, 1994. 109 pages, 86 illustrations. $32.00, softbound.

The literature on the removal of dental plaque and calculus is extensive. This new book aims at general dentists and dental hygienists and provides condensed information and color illustrations of plaque and calculus removal. The authors discuss the rationale for plaque removal and review how mechanical removal of plaque can be accomplished by the patient. This portion of the book, with its many illustrations, may serve patients well in helping them to better understand how plaque control can be achieved.

In the chapter on mechanical plaque and calculus removal by professionals, the authors present common instrumentation including hand instruments, ultrasonic devices, and abrasive devices, but they do not provide illustrations about operator position or how to position individual instruments. The use of anesthetic agents and methods to keep the patient comfortable during treatment are described. It is interesting to note that the authors discuss the use of fiber optics and magnifying lenses. Although the literature on professional nonsurgical periodontal instrumentation is extensive, the authors provide only a limited reference list on this topic. Chemotherapeutic adjunct agents are discussed, emphasizing that Chlorhexidine and Listerine are the only ADA-approved mouth rinses. The introduction of titanium implants has created new needs, and the authors illustrate how new devices, primarily plastic instruments, may be used for plaque removal.

Today, several texts on plaque removal are available. This softbound book is well written. Several illustrative intra- and extra-oral pictures provide additional information. The general practitioner and dental hygienist will probably find the text useful to get an update on recent developments in plaque and calculus removal. The information is not thorough enough to provide in-depth knowledge of issues related to plaque and calculus removal. Dental students who are about to begin their professional training should select a text that is more specific.

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CORRECTION

An apology is in order for misspelling the name of the President of the American Academy of Gold Foil Operators who provided the guest editorial for issue 20(2). It should have been spelled Glenn H Birkitt, NOT Glenn H Birkett.

ANNOUNCEMENT

There are two dozen copies of Supplement 5 left. If anyone would like to purchase one or more of these excellent "bonding" reference issues, they can be purchased from the Editorial Office for $10.00 each.

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MAY-JUNE • VOLUME 20 • NUMBER 3 • 85-128

EDITORIAL

CLINICAL ARTICLE

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