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EDITORIAL

Tenure: For a Lifetime?

Tenure of faculty is a way of life in most academic institutions. It supposedly protects the faculty members' right to think and teach freely, without having concerns about reprisals from the administration. Once tenure is granted, it provides the faculty person a lifetime position, because it is seldom revoked. Obviously, if the institution fails and closes its doors, a tenured position can be terminated under most circumstances, and tenured faculty can be terminated for criminal acts or other acts of gross misconduct, but usually tenure does mean a lifetime position.

Do we really need permanent tenure? The problems associated with obtaining it are many. It used to be granted for teaching skills, but today most institutions have moved toward a research and publication requirement, where education counts minimally or not at all for achieving tenure. It is mostly an up-or-out situation. That is, either faculty members obtain tenure within a specified time frame, or they are involuntarily terminated.

Because new faculty members must direct their focus on tenure, teaching suffers. Many faculty refuse to see students or show interest in their education because they are overwhelmed by the tenure-track system. Is this what education is all about? Students attend colleges and universities for their education, not to be shortchanged by a system that is focused away from educational endeavors.

It is becoming more difficult each year for faculty of dental schools to become tenured. The tenure workload takes up the faculty members' efforts and time, and other faculty must take over much of their teaching duties. This further dilutes the quality of the education.

When tenure is achieved, then what? Does being tenured make great faculty members? Indeed it does not. Once they achieve lifetime tenure, will faculty members become great educators? Will they go on to become great researchers, or will they slowly become complacent in their lofty tenured positions and coast for the next couple of decades? There can be no denying that some do just that.

Tenure may have merit in that it does provide for faculty members' peace of mind with the assurance that they are secure in their positions, but it is my supposition that permanent tenure costs more than it is worth. With a virtual guarantee of a lifetime position, some people tend to become recalcitrant and difficult for the institution and other faculty to deal with. Such are just not team players. Fortunately, all tenured faculty are not of this ilk; however, enough are that they have a negative effect on the morale of others and therefore drag the institution down.

Permanent tenure is something we can ill afford. It is time that we take a more pragmatic view. Tenure should be based on multiple factors and must include efforts in teaching. A balance between education, service, and research would be preferred. And when tenure is achieved, it should be for a specified time frame. If tenure is required to be awarded by the end of the fifth year, for example, then it should be for a period of five years. Under this system, faculty completing their fifth year of tenure must demonstrate that they can continue to perform to the same level at which they attained tenure.

Renewable tenure based on performance is what we should have in all dental schools. And a strong educational component should be a must to achieve it! Wouldn't it be grand if the American Association of Dental Schools would address this suggestion as a goal for all?

DAVID J BALES
Editor

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ORIGINAL ARTICLES

Strength Characteristics of Glass-Ionomer Cements

R E KERBY • L KNOBLOCH

Summary

The purpose of this investigation was to compare the compressive and diametral tensile strengths of two silver-reinforced and three conventional glass-ionomer cements of different powder-to-liquid ratios at 1 and 24 hours. ANOVA ($P < 0.001$) and Tukey's Studentized Multiple Range Test indicated significant differences between the compressive strengths of several of the cements tested ($P < 0.05$). No significant differences were noted between any of the cements for the diametral tensile strength test ($\alpha = 0.05$).

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Introduction

Glass-ionomer cements were introduced to the dental profession in 1972 by Wilson and Kent (1972). Since that time, they have gained considerable popularity and have been used in a variety of clinical applications (McLean, 1978; McComb, 1987). Glass-ionomer cements possess certain properties that make them useful as a restorative filling material. Because of their highly ionic nature they have the ability to physicochemically bond to both enamel and dentin (Lacefield, Reindl & Relief, 1985; Hotz & others, 1977). They also possess a low coefficient of thermal expansion similar to that of tooth structure (Shillingburg & Kessler, 1982; McLean & Gasser, 1985). Glass-ionomer cements release fluoride ions, which may contribute to a reduced incidence of recurrent decay (Swartz, Phillips & Clark, 1984).

Unfortunately these cements are also prone to fracture and show a low resistance to abrasion (McCabe, Jones & Wilson, 1979; McKinney, Antonucci & Rupp, 1987). To overcome some of these deficiencies, much attention has been directed at improving their physical properties with the addition of

metal powders (Simmons, 1983; McLean & Gasser, 1985; Sarkar & others, 1989). The compressive strength of glass-ionomer cement is significantly increased by the incorporation of silver-alloy powder (Simmons, 1983; Sarkar, El Mallakh & Kamar, 1990). McLean and Gasser (1985) also recommended the use of a sintered cermet glass/metal composition to improve abrasion resistance. However, questions still remain as to whether these silver-reinforced cements have sufficient strength to be used as core buildup materals in high stress-bearing areas (Prosser & others, 1984; McComb, 1987; Wilson & McLean, 1988).

The purpose of this study was to compare the compressive and diametral tensile strengths at 1 and 24 hours for two silver-reinforced glass-ionomer cements and three conventional glass-ionomer cements prepared with various powder-to-liquid ratios.

Materials and Methods

Five glass-ionomer cements were tested: two silver-reinforced glass-ionomer cements [Ketac-Silver (ESPE-Premier Dental Products, Norristown, PA 19404) and Fuji Miracle Mixture (G-C International Corp, Scottsdale, AZ 85260)] and three conventional glass-ionomer cements [Fuji Type II, Improved Fuji Type II, and Shofu Glass Ionomer (Shofu Dental Corp, Menlo Park, CA 94025)] (Table 1).

Fuji Miracle Mixture is a conventional glass-ionomer cement consisting of a mixture of an ion-leachable aluminosilicate glass powder, aqueous solution of poly(acrylic acid), and spherical amalgam alloy powder. Ketac-Silver is a water-hardened cement composed of an ion-leachable aluminosilicate glass sintered onto fine silver particles and a poly(acrylic-maleic acid) copolymer combined with a dilute aqueous solution of tartaric acid. Manufacturers' specifications as to powder-to-liquid ratio and proper mixing time were carefully followed in preparing standard viscosity mixes for each cement. In addition, special high-viscosity mixes were prepared for Fuji Type II and Improved Fuji Type II cements. Cement spatulation was performed on a glass slab at 23 ± 2 °C until all powder and liquid were incorporated. Ketac-Silver, which is encapsulated, was mixed for 10 seconds at high speed in an amalgamator. Only those cements with the same batch number were utilized.

Five cylindrical specimens of each cement type were made for both the compressive and diametral tensile strength tests utilizing silicone-lubricated stainless steel split molds. Specimens were removed from the split molds after one hour, and the ends were sequentially sanded with silicon carbide paper and water to produce a cylinder 6 mm in diameter x 12 mm long. All specimens were maintained in distilled water at 37 ± 2 °C until testing.

Testing of specimens was performed at 1 and 24 hours from the start of the mix on a mechanical testing machine (MTS Servohydraulic, Model 812, MTS Systems Corporation, Minneapolis, MN 55424) with a displacement rate of 1.0 mm/min for the compressive strength test and 0.5 mm/min for the diametral tensile strength test. A one-way analysis of variance procedure with subsequent pairwise comparisons utilizing Tukey's

Table 1. Conventional and Metal-reinforced Glass-Ionomer Cements

Cement	Code	Type	P/l Ratio g/g
Miracle Mix	MM	Conventional (silver-reinforced)	5.7/1
Ketac-Silver	KS	Water-hardened (silver-reinforced)	3.8/1 (capsulated)
Shofu	SG	Conventional	3.1/1
Fuji Type II (Standard Viscosity)	F(2.4)	Conventional	2.4/1
Fuji Type II (High Viscosity)	F(2.9)	Conventional	2.9/1
Improved Fuji Type II (Standard Viscosity)	IF(2.7)	Conventional	1.7/1
Improved Fuji Type II (High Viscosity)	IF(3.2)	Conventional	3.2/1

Studentized Multiple Range Test was then performed on all data.

Results

The results of the compressive and diametral tensile strength tests are presented in Tables 2 and 3. The ANOVA of the compressive strengths at 1 and 24 hours showed that overall significant differences existed among the cements tested ($P < 0.001$). Tukey's Studentized Multiple Range Test was then utilized to determine specifically which differences in means were significant ($P < 0.05$). No significant differences were noted between any of the cements for the diametral tensile strength test at both 1 and 24 hours ($\alpha = 0.05$).

The Shofu glass ionomer and high-viscosity Improved Fuji Type II were more than 26% greater in compressive strength at one hour than for Ketac-Silver, Miracle Mix, and the Fuji Type II glass-ionomer cement. The mean compressive strengths at 24 hours of the Shofu, standard and high-viscosity Improved Fuji Type II, and Miracle Mix metal-reinforced glass-ionomer cement were significantly higher than those of any of the other cements tested. The strength of the Shofu glass ionomer (242.5 MPa) was 15% greater in compression than Miracle Mix (211.1 MPa) and nearly 60% greater than Ketac-Silver (154.0 MPa) at 24 hours set time.

Discussion

The compressive strength values of the cements tested in the investigation are higher than those previously reported (Kerby & Bleiholder, 1989; El Mallakh & Sarkar, 1987; Sarkar & others, 1990; Wilson & McLean, 1988). Variations in specimen preparation as well as possible proprietary changes in the composition of the cements may be some of the reasons for these differences. It is interesting to note that the tensile strength values reported in the literature for conventional Type II and silver-reinforced cements generally fall in a narrow range between 10.9 and 15.7 MPa (Kerby & Bleiholder, 1989; El Mallakh & Sarkar, 1987; Sarkar & others, 1990; Wilson & McLean, 1988). This may explain why no significant differences were found between the diametral tensile strengths of the cements.

The compressive strength of amalgam has been reported to be in the range of 300-450 MPa, while that for composite resin is between 210-340 MPa (Craig,

Table 2. Mean Compressive Strength Values at 1 and 24 Hours with Standard Deviations in MPa

Cement*	1 Hour	24 Hours
SG	178.6 (5.1)	242.5 (15.4)
IF(3.2)	173.8 (9.7)	235.2 (15.8)
IF(2.7)	137.7 (8.9)	229.6 (12.3)
MM	142.2 (14.8)	211.1 (18.7)
F(2.9)	135.6 (15.6)	183.5 (5.3)
F(2.4)	125.2 (6.9)	169.3 (8.2)
KS	123.1 (5.9)	154.0 (13.8)

Mean values connected by vertical lines denote no significant difference ($\alpha = 0.05$).

*Cements are listed in descending order of strength at 24 hours.

Table 3. Mean Tensile Strength Values at 1 and 24 Hours with Standard Deviations in MPa

Cement	1 Hour	24 Hours
SG	14.0 (1.8)	15.4 (1.3)
F(2.9)	14.1 (1.9)	14.0 (1.7)
IF(3.2)	13.5 (1.3)	13.4 (2.2)
MM	13.4 (1.0)	13.5 (2.3)
F(2.4)	11.8 (1.9)	11.9 (1.6)
KS	11.2 (0.7)	12.5 (2.5)
IF(2.7)	11.1 (1.6)	12.4 (1.7)

Mean values connected by vertical lines denote no significant difference ($\alpha = 0.05$).

1989). In addition the tensile strength of amalgam and composite resin has been reported to be between 43-58 MPa and 40-70 MPa respectively (Craig, 1989). Although the mean compressive strength at 24 hours of several of the glass-ionomer cements tested in this study approached that of composite resin and amalgam at nearly 250 MPa, the tensile strength of these cements at 24 hours (14.0-15.4 MPa) is still only a quarter of that of amalgam. At the present time, the low tensile strength and poor wear resistance of many of the presently marketed glass ionomers preclude their use in high stress-bearing cavity preparations (Wilson & McLean, 1988).

Because of their poor strength and wear resistance, attempts have been made to improve the physical properties of glass-ionomer cement by the addition of metal powders (Simmons, 1983; McLean & Gasser, 1985). Several studies have reported that the compressive strength of glass-ionomer cement is significantly increased by the addition of silver-alloy powder (Simmons, 1983; Murrey, Nanos & Fontenot, 1986; Sarkar & others, 1990). Other studies have been inconclusive (Øilo, 1988; El Mallakh & Sarkar, 1987; Sarkar & others, 1990). The primary indication of the metal-reinforced glass-ionomer cements has been stated to be for crown buildups prior to preparation for a cast restoration (McComb, 1987; Taleghani & Leinfelder, 1988). The results of this investigation show that two of the unreinforced conventional glass ionomers, Shofu and the Improved Fuji Type II, had 24-hour compressive strength values that were significantly greater than those of the silver-reinforced cements, Miracle Mix and Ketac-Silver. Furthermore, Ketac-Silver had the lowest mean value for compressive strength at 24 hours of all the cements tested. These findings tend to agree with previous studies which also show that the strength of the unreinforced glass-ionomer cements may be equal to or greater than that of the silver-reinforced cements (Øilo, 1988; El Mallakh & Sarkar, 1987; Tjan & Morgan, 1988). It is apparent that in their present stage of development the use of silver-reinforced cements as core buildup materials based on strength remains suspect even when compared to some unreinforced glass ionomers.

For the two silver-reinforced cements, the compressive strength at 24 hours for Miracle Mix was nearly 40% greater than that of Ketac-Silver. The larger particle size and volume fraction of the filler and higher powder-to-liquid ratio (Table 4) of Miracle Mix when compared to Ketac-Silver may be contributing factors leading to greater strength (Craig, 1989; Mallik & Broutman, 1975; Lange, 1970). The Improved Fuji Type II was significantly higher in compressive strength at 1 and 24 hours than either the older Fuji Type II glass ionomer or Ketac-Silver. This may be due to improvements in the chemical composition, which, according to the manufacturer, were meant to sharpen the set of the cement and decrease moisture sensitivity.

Further studies to evaluate the comparative fracture toughness of the metal-reinforced and unreinforced cements, along with complimentary scanning electron microscopic observations of microstructures, are underway to explain the fundamental mechanisms for the foregoing differences in strength properties.

Conclusions

1. Shofu, Miracle Mix, and the Improved Fuji Type II glass-ionomer cements were significantly greater in compressive strength than any of the other cements tested. No significant differences were noted between any of the cements for the diametral tensile strength test.

Table 4. Formulation of Metal-reinforced Glass-Ionomer Cements

Cement	Filler/Glass/Ratio (g/g)	P/L Ratio (g/g)	Volume Fraction (V_f) % Filler	Filler Particle Size Average (μm)	Filler Type
Miracle Mix	1.1/1	5.7/1	24	24	amalgam alloy (spherical)
Ketac-Silver	0.7/1	3.8/1	15	3.5	pure silver

2. The use of silver-reinforced glass ionomers as core buildup materials based on strength remains suspect, especially when compared to other restorative filling materials such as amalgam and composite resin.

3. Results also suggest that the glass-ionomer cements tested in this study are inadequate for use in high stress-bearing cavity preparations.

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The Effect of Eugenol-containing and Eugenol-free Temporary Cements on Microleakage in Resin Bonded Restorations

T L WOODY • R D DAVIS

Summary

Eugenol is known to have a detrimental effect on both composite resin and dentin bonding agents. The purpose of this in vitro investigation was to compare the microleakage among groups of resin-luted inlays when the cavity preparations were pretreated with a eugenol-containing temporary cement, a eugenol-free temporary cement, or no temporary cement. Class 5 inlay preparations (20 per group) were completed in extracted human molars. Following the fabrication of composite resin inlays, the preparations were filled with either a eugenol-based temporary cement, a eugenol-free temporary cement, or no cement. After removal of the cement from the cavity preparations and application of a dentin bonding agent, the composite inlays were luted with a resin cement, thermocycled, stained, sectioned, and evaluated for microleakage under a stereomicroscope. None of the groups exhibited significant leakage at the enamel margins. Both of the groups treated with temporary cement leaked at the nonenamel margins significantly more than the control (no cement) group. No significant difference in leakage was demonstrated between the groups treated with the eugenol-containing and the eugenol-free temporary cements.

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Introduction

Resin cement has become the luting agent of choice for indirectly fabricated ceramic and composite resin restorations. Because these restorations require multiple appointments, the use of a temporarily cemented provisional restoration is necessary. Although resin-luted, indirect restorations are commonly placed, the

effects of temporary cement on the tooth/resin cement interface have not been thoroughly investigated.

Many temporary cements contain eugenol, which is a concern when a resin luting agent is used, because eugenol has been shown to adversely affect many of the physical properties of resin. For example, eugenol softens composite resin (Paige, Hirsch & Gelb, 1986), decreases transverse bend strength (Reisbick & Brodsky, 1971), and decreases surface hardness (Civjan, Huget & De Simon, 1973; Lingard, Davies & von Fraunhofer, 1981). It also increases surface discoloration (Lingard & others, 1981) and roughness (Grajower, Hirschfeld & Zalkind, 1974), and decreases shear bond strength of resin to resin (Dilts & others, 1986). Eugenol has also been shown to increase the gap width between the dentin bonding agent and the tooth (Hansen & Asmussen, 1987).

While the effects of eugenol on resin have been well documented, studies comparing the effects of eugenol-containing and eugenol-free temporary cements on resin bonding found that neither cement affected the shear bond strength of resin to either enamel (Schwartz, Davis & Mayhew, 1990) or to dentin (Lacy, Fowell & Watanabe, 1991). Because bond strength was not affected to a discernible degree in these studies does not imply that other clinically important characteristics, such as microleakage, are not affected by the eugenol-containing cement. The purpose of this investigation was to compare the microleakage in class 5 resin inlays cemented with a resin cement following treatment with a eugenol-based temporary cement, a noneugenol-based temporary cement, or no temporary cement.

Materials and Methods

Thirty extracted human permanent molars were selected. Class 5 inlay preparations were completed on the buccal and lingual surfaces of each tooth using a #330 carbide bur in a high-speed handpiece with water spray. A new bur was used for every five preparations. The preparations were cut to a standardized size: the mesiodistal length was 4 mm, the occlusogingival height was 2 mm, and the depth was 2 mm. The preparations were placed at the cementoenamel junction with the occlusal margins in enamel and the gingival margins in cementum. The enamel cavosurface margins were beveled with a #7901 carbide bur, while the cemental cavosurface margins were left at 90 degrees. The cavities were rinsed then dried with oil-free compressed air.

To fabricate the resin inlays, the cavities were lubricated with a water-soluble separating agent (Coltene Separator, Coltene, Altstätten, Switzerland) and dried with compressed air. A hybrid composite resin (Herculite X-R, Kerr/Sybron, Romulus, MI 48174) was placed in the cavities, light-cured for 60 seconds (Optilux 400, Demetron Research Company, Danbury, CT 06810), removed, and secondarily heat- and light-polymerized in a DI500 oven (Coltene) for eight minutes at 100 °C.

The teeth were divided into three groups of 10 teeth (20 preparations each). The preparations in Group 1 received no temporary cement, Group 2 received a eugenol-free temporary cement (Temp Bond NE, Kerr/Sybron), and Group 3 received a eugenol-containing cement (Temp Bond, Kerr/Sybron). Following storage in water for four weeks, the temporary cement was removed with a curette. The cavities were cleaned with a pumice-water slurry and a prophylaxis brush, rinsed, brushed with a toothbrush, and rinsed again. The enamel margins were etched with a 37% phosphoric acid gel for 30 seconds, rinsed for 30 seconds, and dried with oil-free compressed air. A dentin bonding agent (Prisma Universal Bond 3, L D Caulk Co, Division of Dentsply International, Milford, DE 19963) was used according to the manufacturer's recommendations. The primer was placed on all nonenamel surfaces for 30 seconds and allowed to air-dry. The adhesive was placed in the preparations, slightly thinned, and light-cured for 10 seconds. The restorations were luted in place with a dual-cure cement (Coltene Duo-Cement), which was light-cured for 60 seconds. All restorations were stored in water for two days, then finished with aluminum oxide disks (Sof-Lex, 3M Dental Products, St Paul, MN 55144). All three groups were thermocycled for 400 cycles (6 - 60 °C, 30-second dwell time).

The apices of the teeth were sealed with impression compound (Sybron/Kerr). Two coats of fingernail polish were placed on the roots and crowns of the teeth so that only the

restorations with a one-millimeter peripheral margin of tooth remained exposed. The teeth were stained in a solution of 2% methylene blue dye for two hours followed by a brief rinse with water. They were then embedded in autopolymerizing acrylic resin and sectioned buccolingually through the inlays with a thin diamond saw (Isomet, Buehler Ltd, Lake Bluff, IL 60044). The sectioned inlays were examined for microleakage using a stereomicroscope at X20 magnification. The presence of microleakage was recorded using an ordinal scale (Fig 1). Scanning electron micrographs were taken of representative surfaces from each group.

Results

The results are displayed in Tables 1 and 2. Statistical analysis was completed using the Kruskal-Wallis test for nonparametric data. Minimal leakage was found at the enamel margins of all groups. As for the cervical margins, Group 1, which received no temporary cement, exhibited significantly less microleakage than Groups 2 or 3 ($P < 0.05$). The cervical margins of the experimental groups leaked similarly both in terms of numbers of teeth exhibiting leakage and extent of dye penetration ($P < 0.05$). Two specimens were deleted from Group 2 due to a loss of the apical seal that resulted in saturation of the dentinal tubules with dye.

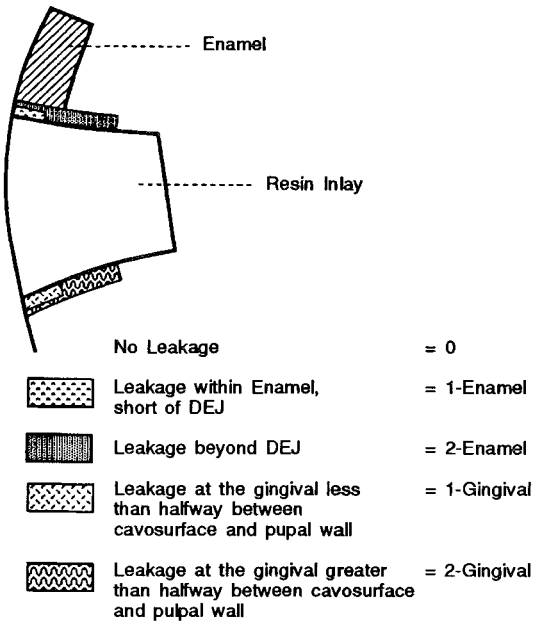

FIG 1. *Ordinal microleakage scale for enamel and nonenamel margins*

Discussion

A number of investigators have evaluated the effects of eugenol on composite resin by comparing eugenol-contaminated specimens with specimens receiving no treatment (Reisbick & Brodsky, 1971; Grajower & others, 1974; Dilts & others, 1986). In these studies the effects

Table 1. Results of Microscopic Evaluation: Enamel Margins

	Leakage Score		
Group	**0**	**1**	**2**
1 (control)	19	1	0
2 (eugenol-free)	17	1	0
3 (eugenol-based)	19	1	0

Score
0 = no microleakage; score
1 = leakage in enamel, not including the dentinoenamel junction; score
2 = leakage from the dentinoenamel junction to the axial.

No statistical difference was found between any groups (Kruskal-Wallis, $P > 0.05$).

Table 2. Results of Microleakage Evaluation: Nonenamel (Cervical) Margins

	Leakage Score		
Group	**0**	**1**	**2**
1 (control)*	20	0	0
2 (eugenol-free)	4	4	10
3 (eugenol-based)	6	2	12

Score
0 = no microleakage; score
1 = leakage less than half the distance from the cavosurface to the axial wall; score
2 = leakage greater than half the distance from the cavosurface to the axial wall.

*denotes significant difference in leakage (Kruskal-Wallis, $P < 0.05$.)

noted in the eugenol-contaminated groups were attributed to the presence of eugenol, which has been shown to have detrimental effects on resin. Few investigators (Hansen & Asmussen, 1987; Schwartz & others, 1990; Lacy & others, 1991) have compared specimens treated with both eugenol-containing and eugenol-free compounds to specimens receiving no treatment to determine if the effects noted were attributable to eugenol or to the other agents. None of these investigations evaluated the effects of temporary cement on microleakage.

The results of the present investigation indicate that temporization with a cement, whether it contains eugenol or not, increases microleakage at nonenamel margins. As demonstrated in Tables 1 and 2, both groups that were treated with temporary cements leaked to a similar degree and leaked more at the nonenamel margins than the group that received no cement. The group cemented with a eugenol-containing cement did not exhibit significantly more microleakage than the group cemented with a eugenol-free cement, despite the purported adverse effects of eugenol on resin. These findings imply that the cement itself rather than the eugenol was responsible for the leakage. Apparently neither the cement nor the eugenol was present in sufficient quantity following cleaning with pumice and etching with 37% phosphoric acid to allow microleakage at the enamel margins. Figures 2-9 demonstrate scanning electron micrographs of selected surfaces from each group.

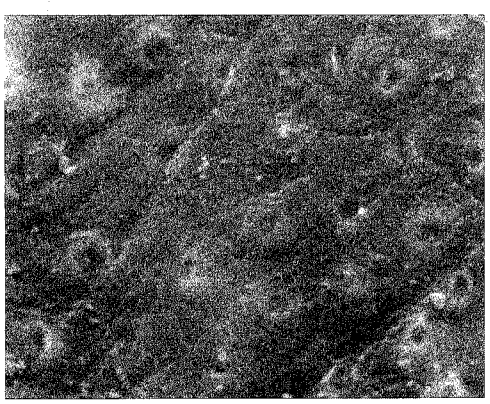

FIG 2. *Control group (no cement), dentin following cleaning with pumice-water slurry (X1455)*

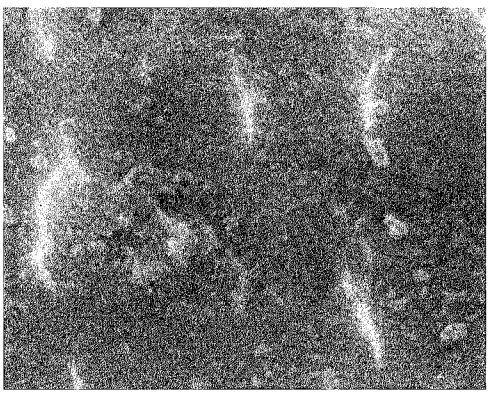

FIG 3. *Group 2 (noneugenol), dentin with cement removed with curette only (X3100)*

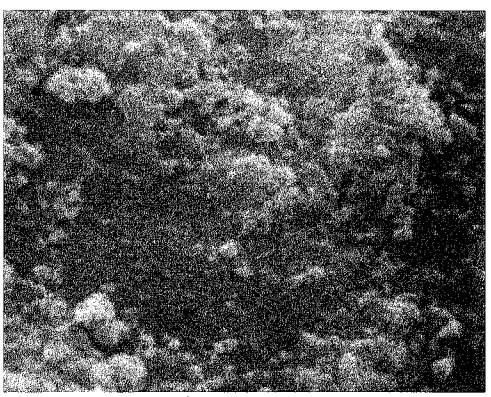

FIG 4. *Group 3 (eugenol), dentin with cement removed with curette only (X1550)*

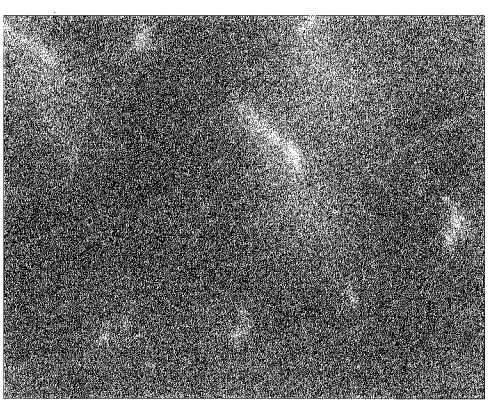

FIG 5. *Group 2 (noneugenol), dentin with cement removed with curette and pumice-water slurry (X1550)*

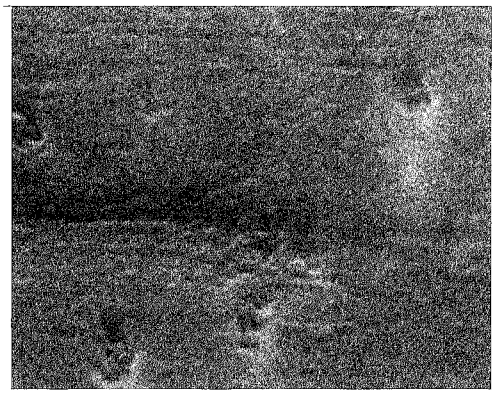

FIG 6. *Group 3 (eugenol), dentin with cement removed with curette and pumice-water slurry (X1550)*

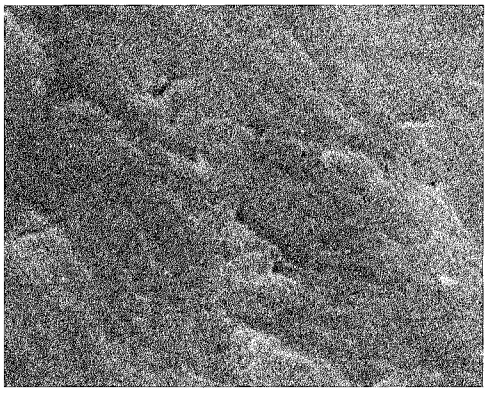

FIG 7. *Group 2 (noneugenol), dentin bonding agent conditioner on dentin following curette and pumice-water slurry cleaning (X1550)*

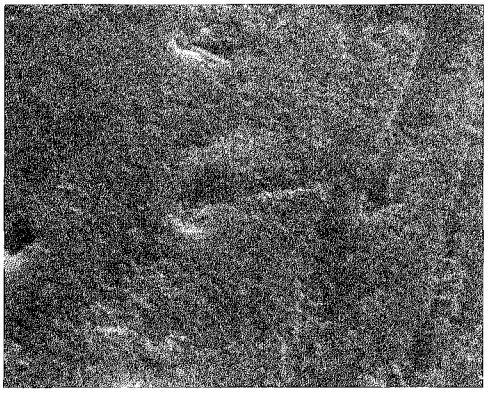

FIG 8. *Group 3 (eugenol), dentin bonding agent conditioner on dentin following curette and pumice-water slurry cleaning (X1550)*

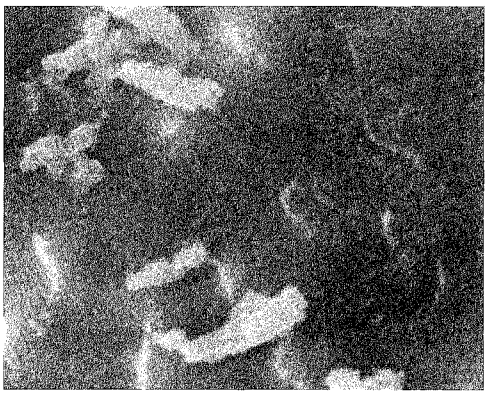

FIG 9. *Group 3 (eugenol), residual cement present on dentin after cleaning with curette and pumice-water slurry (X1550)*

Microscopically detectable cement remained on the dentin surfaces of both experimental groups when the cement was "removed" with a curette only (Figs 3 & 4). The presence of this cement, when the surfaces appeared clean to the unaided eye, illustrates the importance of cleaning preparations with pumice prior to resin bonding. Figures 5 and 6 display micrographs of dentin following removal of the residual cement with a pumice-water slurry. In spite of the pumice slurry cleaning, small amounts of cement remained in isolated areas, as demonstrated in Figure 9. Other investigators (Dilts & others, 1986; Worley, Hamm & von Fraunhofer, 1982; Gabryl & others, 1985) have also found residual cement on the dental substrate following cleaning. This residual cement may have contributed to leakage at the nonenamel margins.

Studies evaluating the bond strength of resin cement to enamel (Schwartz & others, 1990) and to dentin (Lacy & others, 1991) found that temporary cements, eugenol-based or eugenol-free, had no effect on bond strength. In view of the findings of the present study, these results raise the possibility that in vitro microleakage assays do not correlate with in vitro bond strength.

In this investigation, the smear layers of both cement groups appeared identical in scanning electron micrographs. If morphologic differences exist between the smear layers of the control group and the cement groups, they are subtle. Based on these observations, it appears that the microleakage observed is

primarily due to a qualitative rather than a quantitative difference in the smear layers. Residual cement may have been present as a component of the smear layer, resulting in microleakage at the nonenamel margins. Because the aim of this study was not to analyze the components of the smear layer, the amount of either eugenol or temporary cement present in the smear layers of the experimental groups was not determined.

The dentin bonding agent used in this study solubilizes components of the smear layer, but does not remove it. This is substantiated by the scanning electron microscopy views presented in Figures 7 and 8. The microleakage patterns obtained in the present study may have been altered by having used a dentin bonding agent designed to remove the smear layer. This possibility warrants further investigation.

Conclusion

Based on the results of this in vitro experiment, the pretreatment of cavity preparations with a temporary cement, either eugenol-containing or eugenol-free, permits microleakage of resin-luted restorations at the nonenamel margins, but not at the enamel margins.

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Carbamide Peroxide Bleaching: Effects on Enamel Surface Hardness and Bonding

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Summary

Three 10% carbamide peroxide home bleaching agents were evaluated to determine their effects on tensile bond strength of resin to enamel and enamel surface hardness. Eighty extracted bicuspid crowns were divided into four groups (three bleaching agents and control), and treated with the bleaching agents for five consecutive days. A bonding site on the buccal surface of each crown was etched with phosphoric acid and an orthodontic bracket bonded in place. The specimens were thermocycled and loaded to failure in an Instron Universal Testing Machine. Five hardness specimens per group were measured prebleaching and after five days' exposure. Analysis by one-way ANOVA indicated no significant differences in bond strength between the four groups ($P > 0.05$). There were also no differences in pre- or postbleaching Knoop hardness values for the four groups ($P > 0.05$). This study indicated that in short-term regimens 10% carbamide peroxide does not significantly affect enamel surface hardness or bonding ability.

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INTRODUCTION

The use of home bleaching agents to treat intrinsically discolored teeth has become widespread. Although research has been done to evaluate the effects of these products on tooth structure (Haywood & others, 1990; Covington, Friend, & Jones, 1991;

Hunsaker, Christensen & Christensen, 1990) and certain restorative materials (Burger & Cooley, 1991; Bailey & Swift, 1991; Friend & others, 1991; Kao, Peng, & Johnston, 1991), few studies have been carried out to examine their effects on bond strength of resin to enamel. This becomes clinically important when home bleaching is used to improve the appearance of teeth prior to orthodontic treatment or bonding with porcelain or composite veneers. The purpose of this study was to evaluate the effect of three commercially available home bleaching products (Table 1) on the tensile bond strength of orthodontic adhesive resin to human enamel. Additionally, the effect of these agents on the hardness of human enamel was examined.

MATERIALS AND METHODS

Eighty intact, noncarious human mandibular and maxillary bicuspid teeth were selected for the bond strength test. The crowns of the teeth were separated from their roots using a diamond saw with water spray. The crowns were mounted in autopolymerizing acrylic resin so that their buccal surfaces were exposed. Following cleaning with a toothbrush and soap, the teeth were randomly divided into four groups of 20 specimens and treated in one of the following ways: Group 1, Opalescence bleaching agent (Ultradent Products, Inc, Salt Lake City, UT 84124) was passively applied to the buccal surfaces of the specimens and allowed to remain for nine hours each day; Group 2, White and Brite bleaching agent (Omnii Products International, Gravette, AR 72736) was passively applied to the exposed buccal surfaces of the specimens and allowed to remain for 18 hours each day; Group 3, Dentlbright (Cura Pharmaceutical, Inc, Jacksonville, FL 32216) was passively applied to the exposed buccal surfaces of the specimens and allowed to remain for 18 hours each day; Group 4, no treatment (control).

During the test, the specimens were stored in a humidor at 37 °C and 100% relative humidity. The bleaching agent Opalescence was replenished once during each treatment period. Each day at the end of the active treatment period, the specimens were rinsed with deionized water to remove the carbamide peroxide and placed in a 37 °C artificial saliva solution (Table 2) for storage. All

Table 2. Composition of Artificial Saliva

Potassium chloride	2.498 gm
Sodium chloride	3.462 gm
Magnesium phosphate	0.649 gm
Dibasic potassium phosphate	3.213 gm
Monobasic potassium phosphate	1.304 gm
Deionized water	4000 ml

*Table 1. Bleaching Agents Evaluated**

	ACTIVE INGREDIENTS				
Product	**Bleaching Agent**	**Concentration**	**Other**	**pH**	**Viscosity**
Dentlbright	Carbamide peroxide	10%	Carbopol	6.0	medium
Opalescence	Carbamide peroxide	10%	Carbopol (high concentration)	6.5	high
White and Brite	Carbamide peroxide	10%	none	6.5	low

*After Albers, H F ed (1991)

bleaching solutions were applied for five days.

At the end of the treatment period, the specimens were rinsed with deionized water and stored in artificial saliva for 48 hours. They were then cleaned with flour of pumice applied using a slow-speed handpiece and rubber cup. The specimens were rinsed once again, dried, and prepared for bonding.

Etching solution (37% phosphoric acid) was applied to the enamel surfaces and allowed to remain for 15 seconds. The etchant was removed by rinsing with tap water for 15 seconds, and the surfaces were dried with oil-free, compressed air. A chemically activated orthodontic adhesive (Dyna-Bond Plus, Unitek/3M, Monrovia, CA 91016) was used to lute metal bicuspid orthodontic brackets (Mini Dyna-Bond, Unitek/3M) to the treated enamel surfaces. Dyna-Bond Plus primer solution was mixed and applied in a thin coat to the etched enamel surfaces. This was immediately followed by application of Dyna-Bond Plus adhesive to the back of the brackets. The brackets were carefully seated on the enamel surfaces and stabilized while the excess resin was removed. They were then allowed to remain undisturbed for five minutes until the resin was completely polymerized. The bonded specimens were placed in artificial saliva and stored for 14 days at 37 °C. During this storage period the specimens were thermocycled for approximately 27 hours. The teeth were subjected to 2500 cycles between a 5 °C water bath and a 45 °C water bath using a dwell time of 30 seconds and a transfer time of 10 seconds.

The specimens were loaded to failure in tension using an Instron Universal Testing Machine (Instron Corp, Canton, MA 02021) with a crosshead speed of 0.5 mm/min. A stress-breaking apparatus was used to minimize all forces on the specimens other than tensile ones. Following testing, failure sites were examined using a stereomicroscope to determine the mode of failure. Failures were classified as adhesive, cohesive, or mixed. Adhesive failures were those occurring between the adhesive and enamel or adhesive and bracket, while cohesive failures were those occurring within the tooth structure. Mixed failures were defined as those both within tooth structure and between the adhesive and enamel or adhesive and bracket. The data were then analyzed using one-way analysis of variance at the 0.05 level.

For the hardness test, the crowns of 20 intact, noncarious human mandibular and maxillary bicuspid teeth were separated from their roots using a water-cooled diamond saw. After mounting in autopolymerizing acrylic resin to expose their buccal surfaces, the specimens were randomly assigned to one of four groups. Prebleaching Knoop hardness readings were obtained using a Knoop Hardness Tester (LECO M-400 Hardness Tester, LECO Corp, St Joseph, MI 49085). Three indentations were made on each specimen using a 500 gm load and a dwell time of 20 seconds. The three values were averaged to produce one hardness value for each specimen. The five specimen values were averaged to produce an overall group mean. The groups were then treated with a bleaching agent or remained as a control as previously described. At the end of the five-day treatment period, the crowns were rinsed, dried, and subjected to hardness testing. The data were then analyzed using two-way analysis of variance at the 0.05 level.

RESULTS

Enamel Bonding

The mean failure loads for the four treatments are given in Table 3. The data were analyzed with Bartlett's test for homogeneity

Table 3. Mean Stress at Failure (MPa)

Opalescence	3.75 ± 1.50
White and Brite	2.78 ± 1.28
Dentlbright	3.47 ± 1.39
Control	3.73 ± 1.25

of variance and the samples were found to be homogenous. A one-way analysis of variance revealed no significant differences between the mean stresses to failure for the three bleaching treatments and the control ($P > 0.05$) (Table 4). The mode of failure for all the specimens was adhesive failure between the adhesive and enamel or adhesive and bracket.

Surface Hardness

The mean pre- and postbleach Knoop hardness values are given in Table 5. A two-way analysis of variance for repeated measures was applied and variance due to individual teeth isolated as a blocking variable. No significant differences due to bleaching agent, pre- or posttreatment, or an interaction between these variables was noted ($P > 0.05$) (Table 6).

DISCUSSION

Home bleaching agents are believed to effect the lightening of discolored tooth structure through decomposition of peroxides into unstable free radicals. The free radicals break down large pigmented molecules in enamel into smaller, less pigmented molecules through either oxidation or reduction reactions (Albers, 1991). These molecules are further acted upon to produce even less pigmented constituents. The net result is a noticeable lightening of discolored tooth structure.

Several studies have evaluated the effects of these agents on tooth structure. Haywood and others (1990) found that 10% carbamide peroxide, applied to simulate five weeks of exposure, did not alter surface morphology, etch or decalcify enamel. Hunsaker and others (1990) examined the effect of seven bleaching products on enamel and dentin and found that although the solutions were capable of removing the smear layer from dentin, few changes were noticeable in the enamel. Covington and others (1991) examined enamel and dentin compositional changes resulting from prolonged exposure to carbamide peroxide solutions. Although enamel was found to be altered more than dentin, the changes were not significant.

Table 4. Analysis of Variance Table for Orthodontic Bonding

Source	DF	SS	MS	F	P
Treatment	3	10.68	3.56	1.90	0.137
Error	69	129.15	1.87		
Total	72	139.83			

Table 5. Mean Hardness Values (KHN)

	Pretreatment	Posttreatment
Opalescence	390.22 (55.1)	394.88 (54.5)
White and Brite	418.26 (34.1)	419.74 (26.4)
Dentlbright	422.34 (19.6)	422.36 (24.5)
Control	392.46 (41.9)	399.46 (31.1)

N = 5
Standard deviation is given in parentheses.
There were no significant differences at the 0.05 probability level.

Table 6. Analysis of Variance Table for Enamel Surface Hardness

Source	DF	SS	MS	F	P
Treatment	3	7094	2365	1.64	0.201
Time	1	108	108	0.07	0.786
Treatment*Time	3	74	25	0.02	0.997
Error	32	46276	1446		
Total	39	53553			

The findings of the present study support previous publications by Haywood and others (1990) and Hunsaker and others (1990). The surface hardness of enamel exposed to the various bleaching agents was not affected by any treatment. The laboratory design provided no dilution with saliva of the active bleaching agent, and bleaching surface contact was maximized. The Opalescence treatment group was strictly replenished at the midpoint of the treatment per the manufacturer's instructions. This evaluation provided bleaching solutions that were potentially more active than would occur in vivo.

The bond strength of the enamel was also unaffected by the bleaching regimens. The cumulative findings of these studies tend to indicate that enamel bonding of orthodontic brackets, laminate veneers, or direct composite restorations would not significantly be affected by prior bleaching with one of the tested agents. It should be noted, however, that each tooth surface was thoroughly cleansed with pumice prior to bonding to remove surface film and debris and that 48 hours elapsed between the last application of bleaching agent and bracket placement.

CONCLUSIONS

Widespread use of carbamide peroxide in dentist-monitored home bleaching programs to treat dark or intrinsically stained vital teeth has been noted. This study indicates that in short-term regimens carbamide peroxide does not significantly affect enamel surface hardness or bonding ability.

The opinions expressed herein are those of the authors and do not necessarily represent those of the Department of Defense or the United States Air Force.

Acknowledgment

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The Effect of Incremental versus Bulk Fill Techniques on the Microleakage of Composite Resin Using a Glass-Ionomer Liner

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Summary

Incremental placement of composite resin has been suggested to reduce microleakage, particularly at the gingival margin of class 5 cervical restorations. It has become clinically advantageous to place a glass-ionomer liner over dentin to further minimize microleakage resulting from a bond between the dentin and glass ionomer, and glass ionomer and resin. The objective of this study was to compare the microleakage behavior of three hybrid composite/bonding agent systems using bulk and incremental filling techniques utilizing a glass-ionomer liner. This was accomplished in vitro using freshly extracted bovine incisors and a Ca^{45} radioisotope and autoradiography. Sixty bovine incisors were divided into six experimental groups of 10 specimens per group. Class 5 preparations were cut at the cementoenamel junction and restored with the appropriate combination of Herculite XR/Bondlite, P50/Scotchbond 2, or Pertac Hybrid/Pertac Bond. All teeth were lined with the glass ionomer Ketac Bond before the final restoration was placed. The samples were finished and stored for 24 hours in distilled water before thermocycling. The samples were tested for microleakage using a Ca^{45} radioisotope technique and autoradiography. Incisal (enamel) and gingival (dentin) margins were scored separately for

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microleakage but grouped for statistical analysis. Results were analyzed using the Kruskal-Wallis H test. Pertac Hybrid exhibited more leakage than Herculite XR or P50. The difference between microleakage of bulk and incremental filling techniques was only significant for P50.

INTRODUCTION

Microleakage of light-cured composite resins has been a significant concern for the clinician, especially in class 5 cervical areas where the gingival margin extends apical to the cementoenamel junction (Welsh & Hembree, 1985; Hembree, 1980; Hembree & Andrews, 1978). To achieve clinical success of class 5 cervical restorations with a gingival margin on dentin/cementum, marginal leakage must be minimized or eliminated. With newer generation dentin bonding systems, attempts to seal the cervical margin have often experienced limited success in vitro (Fitchie & others, 1990; Swift & Hansen, 1989; Reeves & others, 1988). Others studies have shown an improvement in the marginal sealing ability of the newer bonding agents (Crim, 1988).

Attempts have been made to limit the amount of microleakage of composite resins by incremental layering. The theory is that increments of resin layered on each other will distribute the polymerization shrinkage throughout the layers. A strong bond between these resin layers has been reported (Gordon, von der Lehr & Herrin, 1986). As each incremental layer is sequentially placed and cured, the space created by the previous layer's shrinkage is filled in. The small final increment results in a diminished force of contraction. A smaller dimensional area and corresponding force are available to pull resin away from the gingival margin (Schwartz, Anderson & Pelleu, 1990). The previous study by Schwartz and others (1990) concluded that the glass ionomer/composite resin sandwich technique showed less leakage at the dentin/restoration interface when compared to the incremental technique in vitro. A study by Crim and Chapman (1986) showed limited success in using the incremental fill technique. In another study by Crim (1991) the results suggested that the occlusal, two-step incremental placement technique improved the performance of the four bonding systems used.

In addition to polymerization shrinkage of light-cured composite resin, the differences in thermal expansion coefficients between tooth structure and composite resin will lead to compression and tensile forces on the margins of the restoration during thermocycling. These forces will cause a flow of oral fluids in any gaps between the restoration and the tooth. This phenomenon (thermal percolation) can lead to marginal discoloration and damage to both the hard tissue and the pulp (Asmussen, 1974; Bullard, Leinfelder & Russell, 1988). In a recent study Hengchang, Wenyi and Torq (1987) measured the thermal expansion coefficients of extracted, wet human teeth across the crown and found them to be 11.4 ppm/°C. The thermal expansion coefficient of posterior composite restorative materials range from 26 to 40 ppm/°C (Yamaguchi, Powers & Dennison, 1989).

Glass-ionomer cements offer improved sealing ability by chemical adhesion to enamel and dentin (McLean & Wilson, 1977). The bond of etched glass-ionomer cement to composite resin is stronger than the cement itself (McLean & others, 1985). In a study by Schwartz and others (1990) leakage in the sandwich (glass ionomer) restoration generally occurred just beyond the gingival wall, and it was suggested that the bond of the composite resin to the glass ionomer may have been strong enough to separate the ionomer from the dentinal wall. The results from a shear bond strength study by Sneed and Looper (1985) indicated that the bond strength between an etched glass ionomer/composite was stronger than the cohesive strength of the glass ionomer itself.

The benefits of etching the glass ionomer appear to be controversial, from the results of the previous studies mentioned. The increase in bond strength from etching does not appear to improve the microleakage characteristics of the composite resins (García-Godoy & others, 1988). If etched too soon after placement, the glass-ionomer liner may be weakened or may be damaged by etching too long. In the present study the glass ionomer was intentionally not etched and was protected from dessication over the setting period.

The purpose of the present study was to

compare the microleakage behavior of three hybrid composite resin/bonding agent systems using bulk and incremental placement techniques over a glass-ionomer lining cement.

MATERIALS AND METHODS

The composite/bonding agent systems used are described in Table 1. Volumetric polymerization shrinkage was measured for each material using a modified version of ASTM Method D792 (Puckett & Smith, 1992). The thermal expansion coefficients were obtained from the respective manufacturers.

Cavity Placement

Because a large number of freshly extracted human teeth is difficult to obtain, it was decided to use bovine teeth in this study. It has been shown that adhesion to bovine enamel and dentin is comparable to that of human dentition (Nakamichi, Iwaku & Fusayama, 1983). Sixty freshly extracted bovine incisors were selected and stripped of calculus and debris using a scalpel. The teeth were then cleaned with a flour of pumice using a rubber cup on a slow-speed handpiece. These teeth were kept in distilled water prior to tooth preparation. Class 5 preparations were cut using a #330 bur on high speed on the facial surface of the freshly extracted bovine teeth. The preparation dimensions were approximately 2 mm axially, 3 mm mesiodistally, and 2 mm incisogingivally. The incisal margin was on enamel and the gingival margin was a butt joint in dentin. A 45° bevel was placed at the incisal/enamel margins. Preparations were then cleaned with a water slurry of nonfluoridated pumice in a rubber cup, rinsed with distilled water, and lightly dried with an air syringe.

Liner Placement

The pumiced preparations were kept moist with a damp cotton pellet until glass ionomer placement to prevent dessication of the glass ionomer. The glass ionomer Ketac Bond (Aplicap System, ESPE) was mixed in a Caulk Varimix II (L D Caulk, Division of Dentsply International, Milford, DE 19963) according to the manufacturer's directions. The axial dentin of the preparations was covered with a thickness of 0.5 mm of glass ionomer using a small ball burnisher and allowed to reach initial set for four to five minutes, then covered with a damp cotton pellet until the bonding agent could be applied. The dentin was not treated with polyacrylic acid before placement of the liner. The liner was not etched with phosphoric acid in this study.

Bonding and Filling

Enamel margins were etched with the phosphoric acid gel supplied by the respective manufacturers for 30 seconds. The acid was rinsed with a water spray for 30 seconds. Care was taken not to apply etchant to the liner. For the Scotchbond 2 groups, Scotchprep (3M Dental Products) was applied to the liner and dentin according to the manufacturer's directions. Bonding agents

Table 1. Materials Used

Composite	Bonding Agent	Manufacturer	Batch Number	Packaging	Polymerization[1] Shrinkage (%)	Filler Loading (wt %)	Resin	Thermal[2] Expansion Coefficient (ppm/°C)
Pertac-Hybrid	Pertac Bond	ESPE-Premier Norristown, PA 19404	0001	syringe	2.74 (0.07)	80	Modified BIS-GMA	35
P50	Scotchbond 2	3M Dental Products St Paul, MN 55144	OCR5D	syringe	2.84 (0.05)	87.5	BIS-GMA	19-21
Herculite XR	Bondlite	Sybron/Kerr Romulus, MI 48274	9-2508	syringe	3.13 (0.04)	78	BIS-GMA	26

[1]Puckett & Smith (1992)
[2]As reported by manufacturer

were applied with a brush to obtain an even layer and light-cured the recommended time. The appropriate hybrid composite was then either placed with a bulk technique or incrementally. For the bulk technique the preparation was slightly overfilled and contoured using a plastic instrument and light-cured for 60 seconds. The incremental three-layer technique used the following placement system: the first placement was diagonal, covering 2/3 of the gingival and axial; the second increment covered 2/3 of the first increment and extended diagonally just short of the incisal cavosurface margin; and the third increment covered all previous increments slightly beyond the cavosurface margins. Each increment was light-cured for 30 seconds. A diagram illustrating the incremental technique and microleakage scoring method is shown in Figure 1. All restorations were finished with the Sof-Lex disc system (3M Dental Products) to the respective margins. Teeth were stored in distilled water at 37 °C for 24 hours before thermocycling.

Microleakage Evaluation

After 24 hours the samples were thermocycled 100 cycles in water between 4 and 58 °C. The cycles lasted one minute in each bath with a 10-second transfer time. The teeth were coated with one application of fingernail polish up to 1 mm of the restoration margins. The samples were immersed in a Ca^{45} solution for two hours, scrubbed with a detergent, and sectioned on a wet aluminum oxide wheel. Specimens were placed on ultraspeed periapical dental x-ray films to produce autoradiographs. The microleakage of the samples was scored using the following criteria:

0 = no evidence of isotope penetration at the interface of the tooth and restoration;

1 = any evidence of isotope penetration at the interface of the tooth and restoration up to 1 mm;

2 = evidence of isotope penetration beyond 1 mm up the tooth and restoration interface but short of the axial wall; and

3 = evidence of isotope penetration to the axial wall.

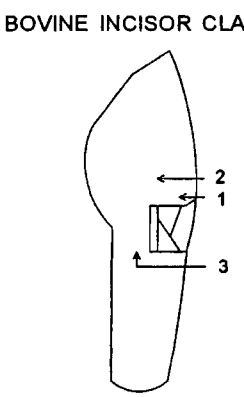

FIG 1. *Illustration showing the incremental placement technique and microleakage grading scale*

RESULTS

Three evaluators analyzed the microleakage in a blind analysis. The frequency of the individual microleakage values for the bulk fill technique is separated into incisal and gingival scores for each of the three composite/bonding agent groups. The scoring for the bulk fill techniques are summarized in Table 2. The frequency of the microleakage scores for the incremental technique is also separated into incisal and gingival scores and is given in Table 3. Microleakage scores for

Table 2. Frequency of Microleakage Scores--Bulk Fill

Material	Incisal Score				Gingival Score			
	0	2	1	3	0	1	2	3
Pertac/Pertac Bond	4	0	2	4	1	3	1	5
Herculite XR/Bondlite	8	0	2	0	2	4	4	0
P50/Scotchbond 2	5	1	0	2	1	4	2	2

Table 3. Frequency of Microleakage Scores--Incremental Fill

Material	Incisal Score				Gingival Score			
	0	1	2	3	0	1	2	3
Pertac/Pertac Bond	8	0	0	2	0	1	3	6
Herculite XR/Bondlite	9	1	0	0	1	5	3	1
P50/Scotchbond 2	8	0	0	2	7	1	0	2

the incisal and gingival margins were graded separately but grouped for statistical analysis. The grouped data are shown in Figures 2-4. Microleakage scores for each composite/bonding agent grouping were compared for placement technique and against each other using the Kruskal-Wallis H test.

The gingival margins leaked more than the enamel margins for all materials tested. Herculite did not have a score above 2 for the enamel margins using both placement techniques, but when both margins were grouped for analysis, there was no significant difference between P50 and Herculite ($P < 0.01$) for both placement techniques. When the placement techniques were compared for each material separately, P50 showed significantly less leakage when it was placed incrementally. In contrast, placement technique did not have a significant effect on the leakage behavior of Pertac and Herculite XR.

Polymerization shrinkage has been suggested as a major cause of microleakage. To overcome this problem, incremental placement and curing of the composite have been suggested. In this study Herculite exhibited the highest polymerization shrinkage, followed by P50 and Pertac. The polymerization shrinkage did not correlate well with the manufacturers' reported weight filler content. This result could be a function of differences in filler densities and resin composition. Comparison of the shrinkage values using ANOVA ($P < 0.01$) showed no statistical differences for the three composites. However, P50 did show less microleakage when placed incrementally. This result cannot be explained at the present time, and will require further investigation.

Another factor that has been suggested to contribute to microleakage is the thermal expansion coefficient of restorative materials. The values of the thermal expansion coefficient reported by the manufacturers suggest that there are significant differences between the composites tested. Pertac was reported to have the largest value, followed by Herculite and P50. Pertac also exhibited significantly more leakage than either of the other composites, suggesting that the thermal expansion of this resin may be a major factor contributing to its microleakage.

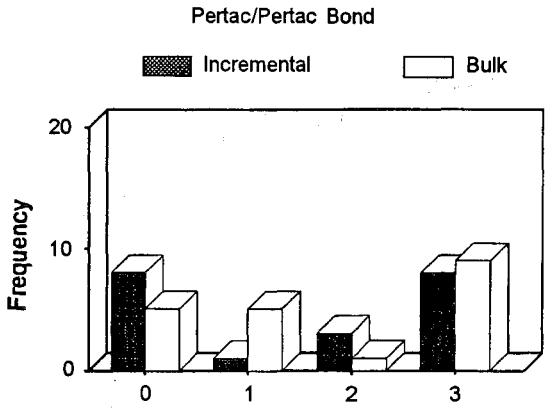

FIG 2. *Frequency of grouped microleakage scores for Pertac hybrid separated by placement technique*

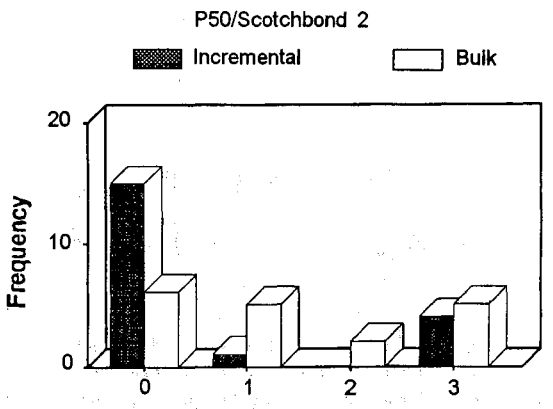

FIG 3. *Frequency of grouped microleakage scores for P50 separated by placement technique*

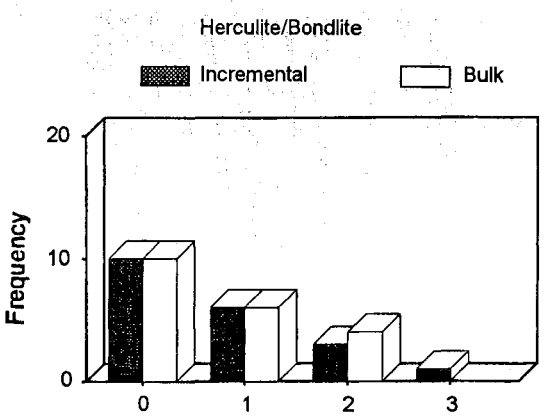

FIG 4. *Frequency of grouped microleakage scores for Herculite XR separated by placement technique*

CONCLUSIONS

1. There were no significant differences in the polymerization shrinkage measured for Pertac, P50, and Herculite XR.
2. The effect of placement technique was only significant for P50, with incremental placement significantly improving its microleakage behavior.
3. Manufacturers' reported values of the thermal expansion coefficient for the three composites suggest significant differences, with Pertac exhibiting the largest expansion.
4. Pertac exhibited significantly more leakage than the other composites, regardless of placement technique. This result may be directly related to its thermal expansion coefficient.

Acknowledgments

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The Influence of Matrix Use on Microleakage in Class 5 Glass-Ionomer Restorations

J D SPARKS • T J HILTON
R D DAVIS • S E REAGAN

Summary

This in vitro study examined the relationship of matrix use to microleakage in class 5 Ketal-Fil glass-ionomer restorations. Class 5 glass-ionomer restorations were placed on the facial and lingual surfaces of 40 extracted human molars. The occlusal margin was located on enamel, and the cervical margin was located on cementum or dentin. Each tooth had one restoration placed with and without the aid of a soft metal matrix. Specimens were thermocycled (1234 cycles, 6 °C - 60 °C, 30-second dwell time) and immersed in 5% methylene blue dye for four hours. The teeth were sectioned occlusogingivally through the center of each restoration, viewed with an optical microscope (X10), and each restoration was scored for dye penetration around the cavity walls. The enamel and cementum margins were scored separately for the extent of marginal leakage. No difference in leakage was found between restorations placed with or without a matrix ($P > 0.05$). Enamel restorations leaked significantly less than nonenamel margins, regardless of matrix use ($P > 0.05$).

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Introduction

The properties of adhesion, fluoride release, and color match make glass ionomer a viable choice for the restoration of class 5 lesions. In 1978 Maldonado, Swartz and

Phillips investigated some of the properties of glass-ionomer cements in an in vitro setting and reported that these materials were resistant to microleakage. While this finding was supported by the work of others (Welsh & Hembree, 1985; Hembree & Andrews, 1978), it was not a universal finding. Studies by Alperstein, Graver and Herold (1983), Hembree and Andrews (1984), and Cooley and Robbins (1988) indicated that glass-ionomer restorations were prone to leakage. Research by Gordon and others (1985) and Crim and Shay (1987) reported leakage at the cavosurface margin of glass-ionomer restorations even when the glass ionomer was veneered with unfilled resin. Though the fluoride-related antibacterial properties of glass-ionomer cement may mask some of the clinical effects of microleakage by inhibiting the ingress of bacteria, leakage may have other adverse effects, including marginal staining.

Clinical techniques for the placement of class 5 glass-ionomer restorations vary. Some clinicians utilize a matrix after insertion of the glass ionomer, while others do not. Beneficial effects of matrix usage for glass ionomer placement have been reported related to surface smoothness (Mount & Makinson, 1978) and axial contour development (Mount, 1981). Mount and Makinson (1982) reported the advantages of protecting glass-ionomer restorations with a matrix during the initial setting reaction. No studies have been completed, however, investigating the relationship of matrix use to microleakage in glass-ionomer restorations. Adaptation of glass ionomer to the cavity preparation may be improved by the use of a matrix during restoration placement. By permitting the initial setting reaction to take place under the pressure of a matrix, the leakage behavior of the glass-ionomer restoration may be improved. The purpose of this in vitro study was to evaluate the effect of matrix use on the occurrence of leakage in class 5 glass-ionomer restorations.

Materials and Methods

Forty extracted human molars free of cracks, caries, and restorations were selected for this study and stored in 10% buffered formalin at room temperature. The teeth were hand-scaled, polished with nonfluoridated flour of pumice, rinsed with water, and stored in room-temperature tap water. Class 5 preparations 3 mm x 4 mm and 1.5 mm deep (Fig 1) were made on the lingual and facial surfaces of each tooth using a #330 tungsten-carbide bur in a high-speed handpiece with water-spray coolant. All cavities were placed at the cementoenamel junction so that the occlusal margin was located on enamel and the cervical margin was located on cementum or dentin. A depth-limiting device was used to ensure constant depth of preparation, and a standard template was used to reproduce the external cavity design. The bur was replaced after every eight preparations. Completed preparations were treated with 10% polyacrylic acid for 20 seconds, rinsed with water for 30 seconds, and dried for 10 seconds with oil-free compressed air. Twenty teeth were selected at random to have glass-ionomer cement (Ketac-Fil, ESPE-Premier Sales Corp, Norristown, PA 19401) placed on the facial using a metal cervical matrix form (Premier) and on the lingual without matrix use. The second group of 20 teeth had glass ionomer placed on the lingual with a matrix and on the facial without the matrix. The soft metal matrix was placed over the preparation, burnished to conform to the contour of the tooth, and removed. The capsulated glass ionomer was mixed according to the manufacturer's recommendation for 10 seconds, using a Caulk Vari-Mix II Amalgamator (L D Caulk, Division of Dentsply International, Milford, DE 19963) set at

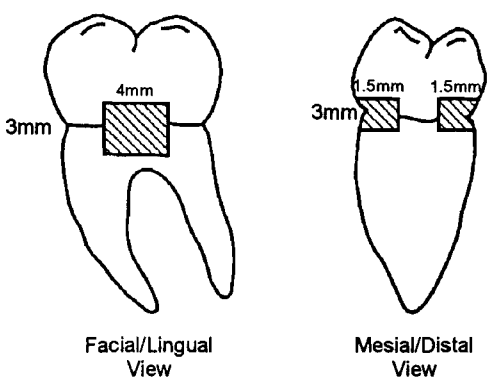
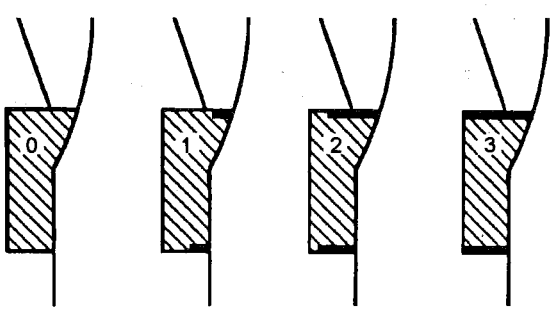


FIG 1. *Preparation design*

medium-3, and syringed directly into the preparation. The matrix was placed over the preparation and held for 30 seconds on the teeth selected for matrix use. After 30 seconds pressure was removed from the matrix, but the matrix was left in place on the tooth. The remaining cavities were restored by syringing the glass ionomer into the preparation and contouring the unset glass-ionomer cement with a flat-bladed metal hand instrument. All of the restorations were protected by covering the exposed glass ionomer with the manufacturer's recommended unfilled resin (Ketac-Glaze, ESPE-Premier), which was cured for 10 seconds with an Optilux 400 visible-light curing unit (Demetron Research Corp, Danbury, CT 06810). The matrix was left in place for 15 minutes, after which all restorations were finished with aluminum oxide discs (Sof-Lex, 3M Dental Products, St Paul, MN 55144) using a constant water irrigant. Unfilled resin was again placed over the restorations, light-cured for 10 seconds, and the teeth then stored in distilled water at room temperature for one week. Following storage, specimens were again finished with aluminum oxide discs and thermocycled for 24 hours. Thermocycling consisted of 1234 cycles using 6 °C and 60 °C distilled water baths with a 30-second dwell time. Each tooth was dried, the apex sealed with low-fusing compound, and the occusal surface etched with 37% phosphoric acid and sealed with pit and fissure sealant (Concise White Sealant System, 3M Dental Products). After coating the teeth with two applications of fingernail polish to within 1.5 mm of the class 5 restoration, they were immersed in 5% methylene blue dye for four hours, rinsed, and then stored in tap water. Before sectioning, each specimen was gently brushed to remove excess superficial dye and then completely embedded in clear orthodontic resin. The teeth were sectioned occlusogingivally through the center of each restoration with an Isomet Plus Precision Saw (Buehler Ltd, Lake Bluff, IL 60044) using a glycerin/water irrigant. An optical microscope (Meiji-Labax Co, Ltd, Tokyo, Japan) at X10 magnification was used to examine each restoration for dye penetration around the cavity walls. The enamel and cementum margins were scored separately for the extent of marginal leakage using a modified version of the ordinal scale used by Khera and Chan (1978) (Fig 2). The data were analyzed using a Kruskal-Wallis analysis of variance for nonparametric data.



0 - No leakage	0 - No leakage
1 - Leakage between cavosurface and DEJ	1 - Leakage less than or equal to ½ the distance from the cavosurface to the axial wall
2 - Leakage between DEJ and the axial wall	2 - Leakage more than ½ the distance from the cavosurface to the axial wall but not including the axial wall
3 - Leakage to, or beyond, the axial wall	3 - Leakage to, or beyond, the axial wall

FIG 2. *Schematic and numerical scoring scale for microleakage of both enamel and nonenamel margins*

Results

The results are presented in the table.

Microleakage around Class 5 Glass-Ionomer Cement Restorations

	OCCLUSAL MARGIN		GINGIVAL MARGIN	
Score	Group 1 with matrix	Group 2 without matrix	Group 1 with matrix	Group 2 without matrix
0	5	7	0	0
1	7	8	0	0
2	16	10	1	1
3	12	15	39	39
Total	40	40	40	40

The enamel margins leaked significantly less than the nonenamel margins ($P < 0.05$). No statistically significant differences in leakage were found between Group 1 and Group 2 ($P > 0.05$).

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Effect of Admixed Indium on the Clinical Success of Amalgam Restorations

G H JOHNSON • D J BALES • L V POWELL

Summary

The purpose of this study was to clinically evaluate two formulations of a dispersed-phase, high-copper dental amalgam alloy (Indisperse), which contained admixed indium. One alloy tested contained 5% indium, and the second alloy contained 10% indium. A similar alloy without indium, Dispersalloy, was also placed for comparison. Over the course of the five-year study, there were no differences clinically or statistically regarding texture and luster. The margins of the restorations containing indium incurred slightly less fracture than the non-indium-containing restorations; however, these differences were not clinically significant. It can be concluded that the admixture of 5 - 10% indium as well as the increased ratio of eutectic spheres to lathe-cut particles found in the indium alloys enhance the clinical performance of amalgam restorations.

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INTRODUCTION

Laboratory studies have shown that admixed indium improves the properties of dental amalgam. Youdelis (1979a, 1979b) showed that less mercury was required for mixing and that compressive strength increased markedly for increases in indium content up to 10%. In a study utilizing a full range of laboratory tests, Johnson (1985) evaluated amalgam alloys containing 5% and 10% admixed indium along with a similar alloy that did not contain indium.

Both groups demonstrated extensive leakage at both enamel and nonenamel margins, but the enamel margins leaked signficantly less in both the matrix and nonmatrix groups ($P < 0.05$). No statistically significant difference in leakage was detected between Group 1 (matrix) and Group 2 (no matrix) ($P < 0.05$) at either the enamel or nonenamel margins.

Discussion

The results of this study agree with those investigations that demonstrated microleakage in glass-ionomer cements. This study also agrees with the observation by Cooley and Robbins (1988) that there is greater leakage at the cervical margins of class 5 glass-ionomer restorations than at the enamel margins. In a microleakage study Barnes (1977) concluded that adaptation of the composite resin to etched enamel surface was not influenced by matrix use, and this study indicates that leakage around glass-ionomer restorations, likewise, is not influenced by the use of a matrix during placement of the restorative material. This is not to say that a matrix should not be used in the placement of glass-ionomer class 5 restorations. Other reasons exist for using a matrix: as an aid in the development of a smoother surface (Mount & Makinson, 1978), protection of the glass ionomer during the initial setting reaction (Mount & Makinson, 1982), and to aid in establishing contour of the restoration (Mount, 1981). The influence of matrix use on the bond strength of glass-ionomer restorative materials to tooth structure requires investigation.

Conclusions

The following conclusions may be made from this in vitro study:

1. Glass-ionomer cements exhibit microleakage at both enamel and nonenamel margins;
2. Enamel margins are more resistant to leakage than nonenamel margins; and
3. The use of a matrix has no effect on the occurrence of microleakage around class 5 glass-ionomer cement restorations.

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Results demonstrated improved resistance to creep and corrosion, reduced dimensional change on setting, and improvements in compressive strength with higher content of indium and compared to an alloy without indium. Mueller and Narea (1985) demonstrated lower mercury-to-alloy ratios, reduced creep, and increases in compressive strength as the indium content was increased up to 15%. Powell, Johnson and Bales (1989) showed that mercury vapor from the setting amalgam was reduced significantly with the admixture of indium in concentrations of 8% by mass or greater.

Biological tests have been conducted as well for an amalgam alloy containing 10% admixed indium (Townsend, Hamilton & Sbordone, 1983a, 1983b; Faucher, Townsend & Hamilton, 1983). Results showed the alloy was no more cytotoxic or hemolytic, nor did it induce any greater tissue reaction than standard ADA Certified alloys. Given encouraging results from laboratory tests and acceptable biological behavior, it was of interest to evaluate the alloys containing admixed indium clinically and to compare the results to a similar alloy that does not contain indium. The purpose of this research was to conduct a longitudinal clinical trial to evaluate the clinical success of dispersion-type, high-copper dental amalgams containing two different concentrations of admixed indium.

METHODS

The amalgam alloys used in the clinical trials were the same as those described in a previous laboratory study (Johnson, 1985). Dispersed-phase, high-copper amalgam alloys containing 5% admixed indium (Indisperse-5%, Youdelis Associates, Windsor, Ontario) and 10% admixed indium (Indisperse-10%) were used along with a similar alloy that does not contain indium (Dispersalloy, Johnson and Johnson Dental Products, East Windsor, NJ 08520). The compositions, percent mercury in the mix, and trituration times are shown in Table 1.

From a previous study (Youdelis, 1979b), the percentage of silver-copper eutectic spheres relative to the lathe-cut phase was found to be optimum in terms of strength at 42% by mass. Thus the indium-containing alloys contain 42% of the spherical phase compared to 33% for Dispersalloy. One other difference is that the spheres in Indisperse-5% contained a small amount (1.5%) of germanium. This addition was shown to reduce oxidation and improve castability during processing (Youdelis & Youdelis, 1981).

Subjects were selected who required at least three amalgam restorations so that all three restorative materials could be placed in each subject. A total of 25 subjects were treated in which 60 Dispersalloy, 54 Indisperse-5%, and 61 Indisperse-10% restorations were placed by two operators. The three amalgam alloys were uniformly distributed by type of tooth, class of restoration, number of surfaces, and size of restoration. For example, the distribution of restoration between molars and premolars was 78% in molars for Dispersalloy, 76% for Indisperse-5%, and 80% for Indisperse-10%. All restorations were polished, and baseline information was gathered.

Table 1. Composition, Percent of Mercury in Mix, and Trituration Times for Amalgam Alloys

	Dispersalloy	Indisperse-5%	Indisperse-10%
Lathe-cut			
% Ag	70.0	69.0	69.0
% Sn	25.0	26.0	26.0
% Cu	4.0	4.0	4.0
% Zn	1.0	1.0	1.0
Spherical			
% Ag	72.0	71.0	72.0
% Cu	28.0	27.5	28.0
% Ge	0.0	1.5	0.0
Percent Spherical/ Lathe-cut	33.0	42.0	42.0
Percent Indium	0.0	5.0	10.0
Percent Hg	50.5	45.5	44.0
Trituration Time	13.0	10.0	10.0

Although subjects were recalled annually for general dental care, records were taken and analyzed for 2.5 and 5 years of clinical service. Table 2 shows the number of restorations, by product, evaluated at each recall.

At the records appointments, the restorations were photographed in color and black and white. An intraoral evaluation of texture and luster was conducted by two examiners, utilizing the criteria shown in Tables 3 and 4. A roughness standard obtained from the National Bureau of Standards was used to calibrate the examiners. Individual restorations were rated blindly and independently by the two examiners, and agreement was achieved by a forced consensus between the two examiners where ratings differed (Cvar & Ryge, 1971).

Breakdown of margins was evaluated using a photo-rating scale (Mahler & Marantz, 1979) in combination with gypsum models of the restorations as described by Bryant, Mahler and Engle (1985). The rating scale begins at 1 for a completely intact margin and increases to 11 in approximately equal steps. The entire range of the scale was used with low-copper amalgams, but with the success of high-copper amalgams, only the lower half of the scale is typically used (Mahler, Marantz & Engle, 1980). Two calibrated examiners evaluated gypsum replicas using loupes with a magnification of X2.

Since all the rating scales were ordinal rather than continuous, a nonparametric test, the Friedman analysis of variance by ranks, was employed to test the null hypothesis that the mean rank for each product did not differ (Siegel, 1956). In this analysis the subject, rather than individual restorations, was treated as the independent observation. Thus a within-subject average rating of marginal breakdown was used when multiple restorations of a given product existed in a subject. In this manner, subjects who have more restorations than others could not influence the results of the study to a greater extent. This treatment of the analysis of the data, coupled with the design of having all three products placed in each subject, minimizes the effect of differences between subjects. Mean ratings rather than mean ranks are shown for results to better relate the results to the rating systems used. All reported statistical tests were based on mean ranks, however.

Table 2. Number of Restorations Evaluated

	Baseline3	2.5 Years	5 Years
Dispersalloy	60	52	30
Indisperse-5%	54	48	28
Indisperse-10%	61	52	30
Total	175	152	88

Table 3. Texture Evaluation

Rating	Description
1	Smooth
2	Slightly smooth
3	Rough
4	Very rough

Table 4. Luster Evaluation

Rating	Description
1	Bright
2	Dull
3	Tarnished
4	Very tarnished

RESULTS

Marginal Fracture

The results of the evaluation of marginal fracture are shown in Figures 1 - 4. Figure 1 shows the trend of marginal fracture for each amalgam alloy over the five-year time period. At the two recall periods, Dispersalloy restorations incurred more marginal fracture than either of the Indisperse alloys (P = 0.03). At five years, the mean rating for Dispersalloy was 1.98, followed by Indisperse-5% and Indisperse-10%, at 1.77 and 1.68 respectively. The magnitude of the change over five years in comparison to baseline was nearly 0.5 of a division in the rating scale (Fig 3) for the Indisperse restorations compared to 0.65 for Dispersalloy. Although the differences between Dispersalloy and the two Indisperse restorations were statistically significant, clinically this does not represent a large difference on the Mahler photographic scale for marginal fracture.

A frequency distribution for all restorations evaluated at the five-year recall is given in Figure 2. These curves are relatively normal in shape, and show that the means and modes for the Indisperse restorations are clearly less and distinct from the mean and mode of the curve for Dispersalloy. Figure 4 provides marginal fracture results at five years, stratified by the size of restoration. In all cases, the mean rating is higher for

MARGINAL FRACTURE
OVER A FIVE-YEAR PERIOD

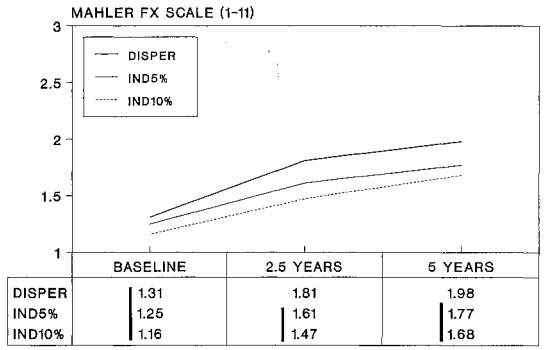

FIG 1. *Marginal fracture over a five-year period*

FREQUENCY DISTRIBUTION OF
MARGINAL FRACTURE AT FIVE YEARS

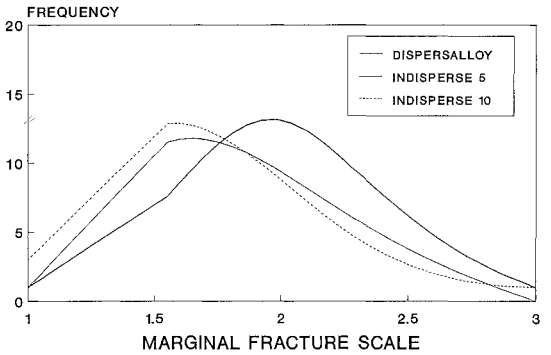

FIG 2. *Frequency distribution of marginal fracture at five years*

NET CHANGE IN MARGINAL FRACTURE
OVER A FIVE-YEAR PERIOD

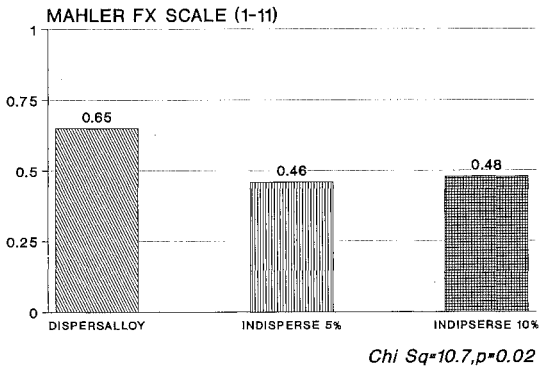

FIG 3. *Net change in marginal fracture over a five-year period*

CHANGE IN FX RATING AT FIVE YEARS
(stratified by size of restoration)

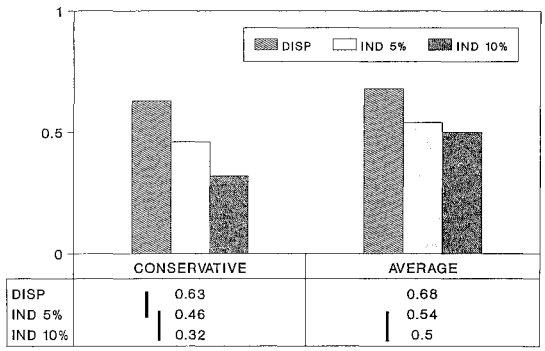

FIG 4. *Change in FX rating at five years*

averaged-sized restorations in comparison to conservative restorations. The same relative ranking of restorations was evident for both sizes as was noted in the composite mean (Fig 3).

Texture

Results for the evaluation of texture are shown in Figures 5 and 6. Since all amalgam restorations were polished, all were rated smooth at baseline. Mean ratings show that the restorations containing indium were slightly more rough compared to Dispersalloy (P = 0.006) at 2.5 years; however, at five years there were no large differences (P = 0.19). The roughness rating increased about 0.6 for both Dispersalloy and Indisperse-10% over the five-year period, and that for Indisperse-5% increased 0.9. Based on Figure 6, nearly all restorations were rated either smooth or slightly rough at five years. These are both clinically successful categories.

Luster

Results for evaluation of luster are shown in Figures 7 and 8. At baseline, all restorations were polished and were given a rating of bright. At 2.5 years, 38% of the Dispersalloy restorations remained in the bright category, compared to 11% and 14% for Indisperse-5% and Indisperse-10% respectively. Nearly all (98%) of the Dispersalloy restorations were rated either bright or dull, compared to 58% for Indisperse-5% and 65% for Indisperse-10%. Between 2.5 and 5 years, the luster rating for the Indisperse alloys did not change measurably, whereas Dispersalloy continued to become somewhat more tarnished, so that at five years there were no significant differences among the three materials (P = 0.28), as the mean rating was 2.0 for Dispersalloy and 2.2 for the Indisperse amalgam restorations. All were in clinically successful categories and most (70-80%) of the restorations were given "dull" ratings. Photographs of Indisperse-10% and Dispersalloy restorations

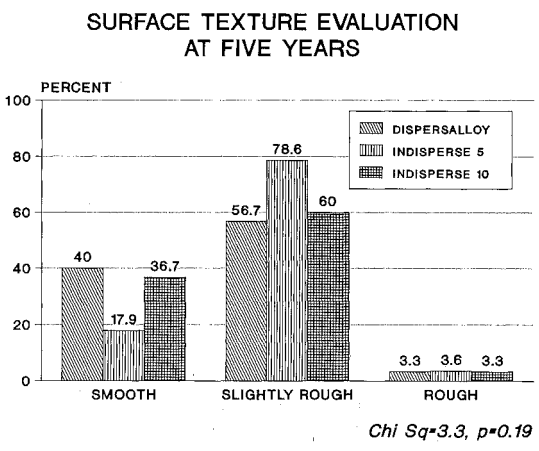

FIG 6. *Surface texture evaluation at five years*

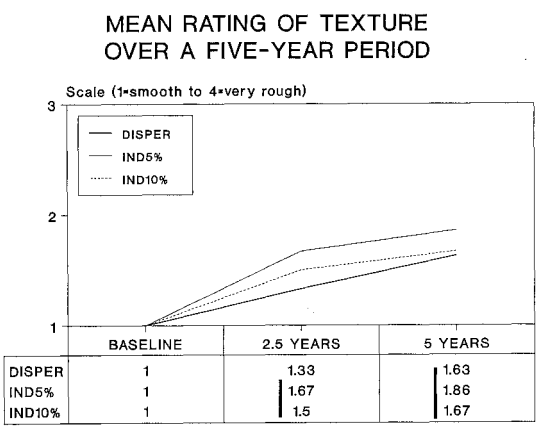

FIG 5. *Mean rating of texture over a five-year period*

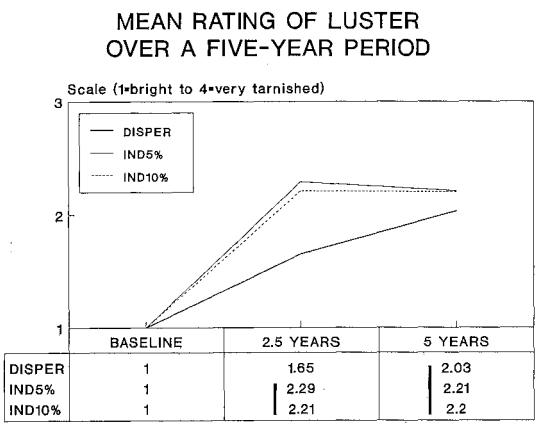

FIG 7. *Mean rating of luster over a five-year period*

at the five-year recall are shown in Figures 9 and 10.

Other Parameters

Caries, replacement of restorations, and sensitivity were also monitored at recalls. None of the amalgam restorations were replaced during the course of this study for either reasons of fracture or decay. No sensitivity to stimuli was reported at either 2.5 or 5 years, although subjects reported some sensitivity to cold stimuli at the time of placement of the restorations. There was excellent agreement in results between the two operators, based on a statistical analysis in which the data were stratified by operator. For example, the mean rating for marginal fracture after five years for all products combined was 1.83 for Operator #1 compared to 1.80 for Operator #2, with both having the same standard deviation of 0.41.

DISCUSSION

Previous laboratory studies (Youdelis, 1979a, 1979b; Johnson, 1985; Mueller & Narea, 1985) have demonstrated improvements in creep, compressive strength, corrosion resistance, and dimensional change with the admixture of indium to high-copper, dispersed-phase amalgam alloy. It was of interest to determine if differences shown in the laboratory setting would be significant clinically. It is for this reason that this clinical investigation was undertaken.

The incidence and extent of marginal fracture has long been used as an indicator of clinical success of amalgam restorations (Mahler & Marantz, 1980). Results from this clinical study showed that at five years, the restorations containing admixed indium exhibited less marginal breakdown than those of Dispersalloy; however, the ratings for all three products are principally 2 or lower. Thus all three materials can be considered very acceptable clinically.

Based on long-term clinical trials with dental amalgam, trends seen early are generally maintained, so that the relative ranking of alloys does not change significantly with time even for high-copper amalgam restorations (Mahler & others, 1980). After five years, Dispersalloy restorations exhibited greater marginal fracture in comparison to the indium-containing amalgams (Figs 1-4). Some of the improvement observed may be attributed to an increase in the amount of silver-copper eutectic spheres relative to Dispersalloy, as well as to the admixture of indium.

There were no clinical or statistical differences

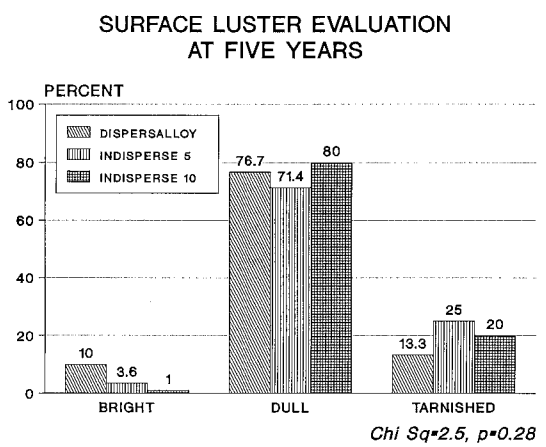

FIG 8. *Surface luster evaluation at five years*

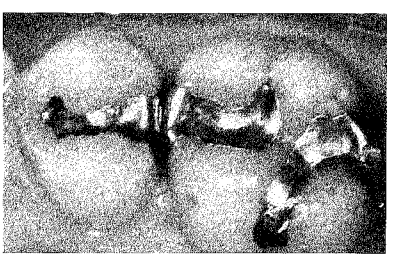

FIG 9. *Five-year recall of Indisperse-10 (maxillary right second premolar) and Disperalloy (maxillary right first molar)*

FIG 10. *Five-year recall of Indisperse-10 (mandibular left first molar)*

among the three amalgam restorations for the evaluation of texture or luster. All restorations were polished at baseline, and nearly all remained either smooth or slightly rough after five years of clinical service. Comparing these results with those of another, similar study, it appears that amalgam alloys benefit from postinsertion polishing in terms of surface texture. The ratings for Dispersalloy after five years were 40% smooth, 56.7% slightly rough, and 3.3% rough in this study. In another study (Johnson, Bales & Powell, 1991) with the same two operators, the restorations were not polished. After five years, the ratings were 23% smooth, 56% slightly rough, and 21% rough. The mean rating for polished restorations was 1.63 and for unpolished was 1.97. With polishing, only 3% were rated rough compared to 21% when not polished. Thus the surface finish is well maintained over time when polished in comparison to unpolished restorations.

CONCLUSIONS

High-copper amalgam alloys containing admixed indium were shown to have excellent properties and acceptable biological behavior in laboratory tests. Clinical trials were conducted to evaluate high-copper amalgam restorations containing 5% and 10% admixed indium, and to compare these restorations to those made with a similar alloy that does not contain indium (Dispersalloy).

After five years, there were no significant clinical or statistical differences between the indium-containing amalgams and Dispersalloy in the evaluation of luster and surface texture. When polished, amalgam restorations maintained a significantly smoother surface over time compared to unpolished amalgam restorations.

The margins of the indium-containing amalgam restorations incurred slightly less breakdown than those of Dispersalloy; however, these differences were not clinically significant after five years of clinical service, as all restorations were very acceptable. Given the consistency and trends over the five-year period, it does appear that the addition of pure indium as well as an increase in the ratio of eutectic spheres to lathe-cut portions of the alloy contribute to an improvement in the clinical performance of high-copper dental amalgam restorations. The differences shown here should result in improved survival rates as well.

Presented at the 69th General Session of the International Association for Dental Research, 17-21 April 1991, Acapulco, Mexico.

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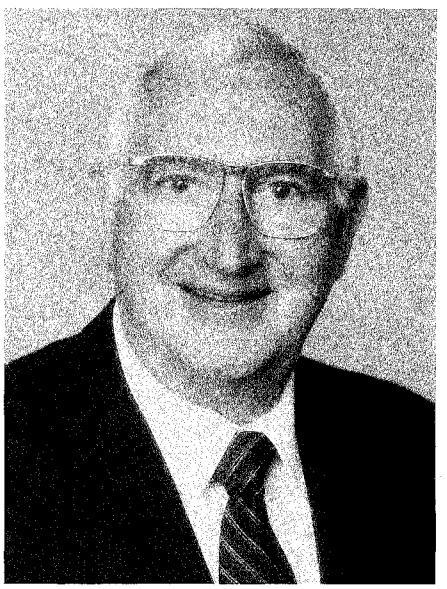
Award of Excellence

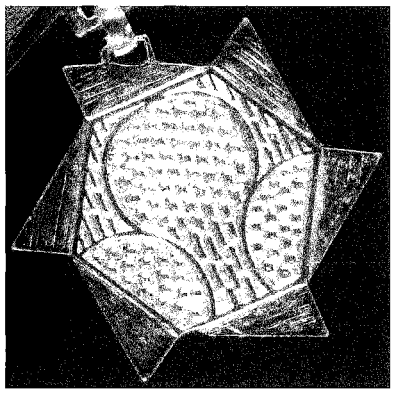
The recipient of the Academy's 1992 Award of Excellence is Richard V Tucker of Ferndale, Washington, better known as Dick to his many friends and students around the country. There is just no one in dentistry today who better exemplifies excellence than does Dick Tucker.

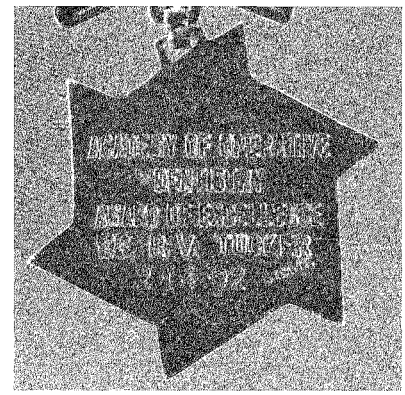
Dick was born in Orofino, Idaho, in 1922. His teenage years were influenced by growing up during the Great Depression. During the summer between his junior and senior years in high school and after graduating from high school, he worked in Alaska. After working there for fifteen months, he enrolled at the University of Washington, where he completed his predental requirements. In the fall of 1943, he entered the Washington University Dental School in St Louis, completing his education in three years by attending school during the summers. He was a member of the Naval Reserve. In 1944, he married Elaine, whom he had met in a sophomore psychology class. Upon graduating from dental school he spent two years in the Navy.

After leaving the Navy, the family moved to Seattle, where Dick set up practice. Not being too happy in the big city, they moved to Ferndale when an opportunity arose. While in Ferndale, Dick met Dr George Ellsperman, who was a very prominent dentist in the Northwest and practiced in nearby Bellingham. Dr Ellsperman recognized Dick's talent and desire to provide excellent care for his patients. He took Dick under his wing, helping and encouraging him in his pursuit of excellence, and he was instrumental in Dick's being invited to join the prestigious W I Ferrier Gold Foil Study Club in Vancouver, BC. Dick was on his way to an endless list of accomplishments and honors in both his personal and professional life over the next 30 years. Dr Ellsperman continued to be



Richard V Tucker





Front and back sides of medallion

Dick's mentor and close personal friend until his death in 1984.

Dick Tucker has served as president of his local dental society, president of the Washington State Dental Association, delegate to the ADA from the 11th District, president of the American Academy of Gold Foil Operators, and also of the Academy of Operative Dentistry. He is a Fellow of the Academy of General Dentistry and the American College of Dentists, and he is a member of the Academy of Restorative Dentistry and the CAIC.

In 1989, Dick was presented the Baggia Award, an international award in recognition for outstanding contributions to international dental education. He has published numerous articles and has given well over 100 clinics, essays, and presentations worldwide. Currently he is completing an educational video of the conservative cast gold restoration. Over the years he has developed numerous technical improvements in the production of the cast gold restoration that have become known as the Tucker Technique for conservative cast gold restorations. Dick is presently mentoring or co-mentoring 17 study clubs in Vancouver, BC; California; Arizona; and New Mexico.

Dick Tucker's pursuit of excellence, his personal integrity, and his gentlemanly nature all combine to make him a man easy to respect and admire. These qualities help make him a great teacher.

We are very grateful for all Dick has contributed to dentistry, but we are specially thankful for what he has done for us individually, and we will never forget. And, of course, we expect him to continue to contribute for many years to come.

BARRY EVANS

STUDENT AWARDS

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DEPARTMENTS

Book Reviews

QUINTESSENCE OF DENTAL TECHNOLOGY 1992

Robert P Renner, Editor

Published by Quintessence Publishing Co, Inc, Chicago, 1992. 172 pages, 571 illustrations. $54.00, softbound.

Quintessence of Dental Technology is an annual publication presented in the form of a soft-cover, journal-size yearbook of original articles on current scientific research and the latest developments in dental laboratory technology and clinical practice. Typically a featured article is presented at the beginning of each issue, and the remaining articles are grouped into sections on ceramics, implantology, complete dentures, fixed and partial dentures, orthodontics, dental materials, and lab technology. The publication is written by and targets both dental laboratory technicians and dentists, with the intention of bridging the gap between the two.

The overall presentation of *Quintessence of Dental Technology 1992* is good, with clearly written, interesting articles that are generally illustrated by excellent color photographs. This issue would appeal particularly to those interested in dental ceramics, as there are several excellent articles in the ceramics section by top international dentists and technicians in this field.

One of the two feature articles is Makoto Yamamoto's paper on the Value Conversion System, which he presented at the 10th International Symposium on Ceramics. The system was developed to manage the disparity he feels exists between the currently available shade guides and natural teeth. There are also two articles describing the use of In-Ceram in the fabrication of all ceramic crowns and fixed partial dentures. The first is from the University of California—Los Angeles by John Sorensen, Helmut Knode, and Tony Torres; the second is by Norbert Futterknecht and Vanik Kinoian from Switzerland. Other articles in this section include Claude Sieber's paper, "Illumination in Anterior Teeth," featuring some of the material about In-Ceram that he presented at the ceramic symposium, and an article by Naoki Alber describing Willi Geller's technique of building up porcelain crowns with internal characterization.

The second feature article in this issue of *QDT* is in the area of implantology and is by Gerard Chiche and Alain Pinault. They present their technique and recommendations for prosthetically restoring the integral implant with fixed partial dentures. Some of this material was also presented at the symposium. Other notable articles are G Bird's article on hollow pontics and H Kupper's article on the use of pure titanium as an alternative material in restorative dentistry.

This text is recommended for those interested in the latest technology on dental ceramics.

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COLOR ATLAS OF COMMON ORAL DISEASES

R P Langlais and C S Miller

Published by Lea & Febiger, Malvern, PA, 1992. 167 pages, 384 color illustrations. $29.50, softbound.

The *Color Atlas of Common Oral Diseases* by Langlais and Miller, like several other good atlases, succeeds in delivering a text with high-quality illustrations and concise descriptions of diseases. This very much facilitates the task of differential diagnosis and identification of disease. The authors designed this book for students at both pre- and postdoctoral levels. It is appropriate for dental students, dental hygienists and dental assistants. The authors target all students with a very basic coverage of the most common diseases of the oral cavity. This renders this atlas unique and significant. It is very important for students and clinicians to think of common diseases first in the formulation of a differential diagnosis so that final diagnosis is reached in a systematic manner.

The level of organization of this atlas is very impressive. It reflects well on the authors' knowledge and clinical experience. The authors approach the teaching of disease in a basic but effective manner by the use of schematic diagrams accompanied by definitions of certain disease processes. This is evident in Section One. The authors dedicate Section Two to oral diseases of infants and children. While not unique to this atlas, this is an excellent arrangement of an area that requires more attention in texts. In Section Three, the authors cover a wide variety of tooth diseases, ranging from developmental to acquired. Section Three also covers common oral diseases, classifying them according to anatomical location. The main emphasis is on epithelial and soft tissue lesions. This is apparent throughout this text. In Sections Four and Five diseases are further classified by color (white, red, red/white, pigmented) and by surface morphology (modules, papalonodules, vesiculobulous, and ulcerative lesions). Section Six deals with the oral manifestations of sexually transmitted diseases with emphasis on AIDS.

This atlas also has five appendices, which include a dictionary of common medical and dental terms and a chapter organized in the form of a table where the clinical features of common diseases and disease groups are discussed with brief comments on management and treatment. Also included are several commonly used prescriptions written in a standard manner. A self-assessment chapter with color illustrations concludes the atlas.

I strongly recommend this affordably priced atlas for students in the dental field. It should serve as an excellent adjunct for establishing a basic knowledge of clinical oral pathology.

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INSTRUCTIONS TO CONTRIBUTORS

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