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EDITORIAL

Teaching Smarter

Faculty members at most, if not all, North American dental schools continue to complain about the lack of curriculum time for teaching the mechanical skills essential in becoming a competent dentist. Those who have been around the longest yearn for "the good old days," when the vast majority of the curriculum time was dedicated to clinical operative dentistry and later to fixed partial dentures. Another large block of curriculum time was consumed in making removable dentures. But it is unrealistic to keep living in the past and to expect some form of revolution in dental education that will free up the amount of time that was available 30 or so years ago. Other clinical specialties have now become a standard part of the curriculum, and the exploding amount of knowledge and technology that must be taught and mastered demands that a well-balanced dentist spend more time studying than in years gone by.

Information and technological changes are coming almost too fast for us to learn, adapt to, and use in our educational endeavors. And there seems to be no end in sight. So we must adapt to our environment and learn how to make our educational programs more efficient; we must learn to "teach smarter."

There are two concepts that all schools should adopt as a "way of teaching." First, we must learn to teach our students to evaluate their own performances. To do so we must establish criteria for grading, criteria that determine what is satisfactory and what is not. Some schools have already done so. An amalgam cavity preparation might have as many as 6 - 12 established, measurable criteria that must be complied with to have an acceptable preparation. Any criterion that does not meet the minimum would result in an automatic failure, and any criteria that do meet at least the minimum would be evaluated for quality, for how well the procedure was accomplished. An example of a single criterion would be depth of the axial and pulpal walls. If the criterion is set to be 0.5 mm into dentin as the ideal, then a deviation of up to ± 0.1 mm might be the limit of a satisfactory grade. Any depth above or below that would result in an automatic failure.

Teaching students to understand how we set the criteria (rather than "just because I said so!") gets to the heart of our second problem. We need to teach our students how to think. Such teaching needs to start in the preclinical years. In these early formative years, we must give students a basis for making clinical decisions. We must teach them critical thinking skills. Instead of memorizing the rules for cavity design, we need students to think about those rules in such a way that they can make good decisions.

Teaching students to evaluate their own performances and to develop critical thinking skills applies not only to clinical procedures but also to the way in which we teach basic sciences. For every concept put forth, science teachers must learn to teach practical applications and thinking skills that will benefit students as dentists.

We will never get more curriculum time, so we must change the way we teach. It is time for us to change, before change devours us.

DAVID J BALES, DDS, MSD
Editor

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ORIGINAL ARTICLES

The Effect of Multiple Layers of Die-spacer on Crown Retention

C PASSON • R H LAMBERT
R L LAMBERT • S NEWMAN

Summary

The application of die-spacer to crown preparation dies prior to the fabrication of the cast crown is an acceptable procedure to improve the fit of the restoration. Previous studies have shown that the retention of the restoration will be improved, unchanged, or reduced when an appropriate thickness of die-spacer is used. No studies have determined the effect on retention if excessive die-spacer is used. This study evaluated the effect of increasing die-spacer thickness on the retention of cast full crowns. Cast copings were fabricated on dies coated with either 0, 4, 8, 12, or 16 coats of die-spacer, cemented on the respective teeth, and removed using an Instron Universal Testing Machine. There were no statistically significant differences ($P \leq 0.05$) between the mean force required to remove the cemented copings. It appears that increasing the application of die-spacer up to 16 coats (151 micrometers) does not adversely affect the retention of cemented cast copings.

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Introduction

For many years there has been a concern for the quality of fit of cast crowns. Methods to improve fit have been proposed, tested, and implemented. One widely held method is the fabrication of internal casting relief so as to provide space for cement. It is believed that unless there is some degree of internal relief provided in castings, they will fail to seat completely (Hollenback, 1943; Eames & others, 1978; Van Nortwick & Gettleman, 1981). Relief was advocated on the basis that, without it, cement would be unable to escape during seating, creating hydrostatic pressure and preventing the complete seating of the crown.

Methods have been suggested to provide this relief (Hollenback, 1928; Bassett, 1966; Fusayama, Ide & Hosoda, 1964). They include:

1. removing the wax from the internal surface of the wax pattern before casting,
2. removing metal from the inside of the casting before cementation by milling with burs, electromilling or chemical etching, and
3. applying die-spacer material to the die before fabrication of the wax pattern.

The application of die-spacer to dies prior to the fabrication of the wax pattern is popular because it is simple to use, convenient, and cost effective. There are many die-spacing materials available. Manufacturing, application, and environmental factors can affect the final die-spacer thickness (Donovan, Wright & Campagni, 1984; Campagni, Preston & Reisbick, 1982; Oliva, Lowe & Ozaki, 1988; Grajower, Zuberi & Lewinstein, 1989). However, all are formulated so that when properly applied, they will provide the recommended 25 to 40 micrometers of relief (Eames & others, 1978; Cherberg & Nicholls, 1979; Campagni & others, 1982).

One concern expressed about the use of die-spacers is the effect that these materials might have on the retentiveness of cemented cast crowns. Studies performed to look at this concern have produced mixed results.

Eames and others (1978) applied die-spacer with a uniform thickness of 25 micrometers to one set of dies while another set was not die-spaced. They found that cemented full crowns relieved with die-spacer were 25% more retentive than unrelieved cemented full crowns. This difference was statistically significant.

Hembree and Cooper (1979) performed a similar study. They applied die-spacer to a thickness of 25 micrometers directly to the prepared tooth, not to a stone die. They also found that the force required to remove cemented full crowns fabricated with relief was greater than for those fabricated without relief, although none of the differences were statistically significant.

Vermilyea, Kuffler and Huget (1983) fabricated full crowns on dies either coated or not coated with die-spacer. Die-spacer was applied to a thickness of between 40 and 50 micrometers. Their study found that cemented full crowns fabricated with relief required 32% less force to be removed than cemented full crowns fabricated without relief.

Gegauff and Rosenstiel (1989) also looked at the effect die-spacer applied to stone dies had on the retention of cemented full crowns. They found a significant reduction in the force required to remove the cemented full crowns when just one coat of die-spacer relief was used, compared to castings fabricated without relief. However, there was no significant difference in the force required to remove cemented full crowns fabricated with one coat of die-spacer and those fabricated with up to six additional coats of die-spacer.

The ADA Specification No 8 for zinc phosphate cement allows for 25-micrometer cement film thickness, which is in the range of die-spacer relief recommended and used by most investigations. This thickness has been reported as suitable for providing maximum resistance to cement dissolution and proper cement strength (Fusayama, 1959a & b; Jörgensen & Esbensen, 1968).

The method of crown loading during cementation has also been suggested as having an effect on the fit and retention of crowns fabricated with and without die relief (Oliveira & others, 1979; Van Nortwick & Gettleman, 1981; Gegauff & Rosenstiel, 1989).

Confusion still exists as to whether the use of die-spacer increases or decreases retention of cemented full crowns. In none of these studies did the investigators use more than six coats (presumably representing 50 micrometers) of die-spacer relief. If die-spacer relief of 25-40 micrometers does, indeed, improve the retention of cemented full crowns, as has been suggested, it would be interesting to know what the application of additional thickness of die-spacer relief beyond that recommended has on cemented full crown retention. Therefore, the purpose of this investigation is to reexamine the effect that the recommended amount of die-spacer relief (25-40 micrometers) has on cemented full crown retention and to determine the effect that the application of additional layers of die-spacer relief has on cemented full crown retention.

Methods and Materials

Twenty-five plastic dentoform molar teeth (# X-EP-TPR-1360-28/FC, Columbia Dentoform Corp, Long Island City, NY 11101) with standard full crown preparations and chamfer finish lines were used in this study (Fig 1). Prepared dentoform teeth were used to minimize the effects of preparation variation such as wall length, wall taper, and surface roughness likely to be found in prepared natural teeth. The dentoform teeth were labelled and divided into five groups of five teeth each. The entire experiment was performed twice using these same dentoform teeth. This method produced 50 observations (or N = 10) in each of the five test groups. All of the teeth were replicated using a reversible hydrocolloid duplicating material (All Purpose Nobiloid, Nobilium Co, Albany, NY 12201). Dies were immediately cast from the hydrocolloid impressions using an improved die stone (Die Keen, Columbus Dental, St Louis, MO 63188).

Fresh die-spacing material (Tru-Fit, George Taub Products and Fusion Co, Inc, Jersey City, NJ 07307) was used to coat the dies. The preparation surface (except for the seating groove) of each die was coated to within 1 mm of the preparation margin (Fig 2). At least one minute was allowed for drying between coats.

The dies were grouped and coated with die-spacer as shown in Table 1. The cast full crowns were made without regard for external anatomy. Therefore, they are referred to as copings in this paper. Wax patterns for the cast copings were fabricated on the lubricated dies using a Type II inlay wax (Kerr Regular Inlay Wax, Sybron/Kerr, Romulus, MI 48174). The patterns were formed by repeatedly dipping the die in molten wax until a pattern approximately 1.5 mm thick was formed. After cooling, the margins of the pattern were adapted to the die, and final shaping was accomplished. A wax loop was affixed to the occlusal of the pattern to serve as a handle for coping removal. An identifying number was marked in the wax so that each cast coping could be returned to the proper dentoform tooth. The wax patterns were sprued, invested (Beauty Cast, Whip Mix Corp, Louisville, KY 40217), and cast with a Type III gold (Midigold 50, Williams Gold, Buffalo, NY 14214) using

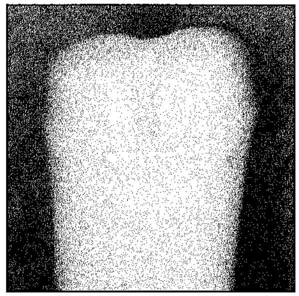

FIG 1. *Typical dentoform molar tooth used in this study*

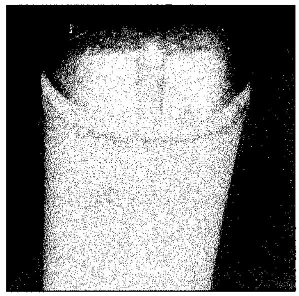

FIG 2. *Stone die coated with die-spacer*

Table 1. Mean Thickness of Total Coats of Die-spacer at Various Locations on the Dies

	DIE-SPACER THICKNESS (μ)			
	Number of Coats			
Surface	**4**	**8**	**12**	**16**
Facial	33(4)*	54(4)	93(19)	115(15)
Occlusal-facial	39(7)	75(19)	101(15)	179(42)
Occlusal-lingual	37(6)	85(30)	95(16)	177(42)
Lingual	28(12)	68(17)	111(41)	134(7)
Overall Surfaces	34(8)	71(22)	100(24)	151(40)

*mean (sd)

standard procedures.

After casting the copings were thoroughly cleaned of investment residue by evenly and lightly sandblasting the inner casting surface with a 50-micrometer aluminum oxide (Airbrasive Powder No 1, SS White Industrial Products, Holmdel, NJ 07733), and then they were inspected for internal regularities, such as minor casting bubbles of fins, at X7 magnification using a binocular microscope (Bausch & Lomb, Inc, Rochester, NY 14601). If irregularities were noted, they were removed. No other adjustment was made to the copings to attempt to improve their fit. As a result of manufacturing, the preparation surface of the dentoform teeth exhibited a dense, almost glazed, surface. This surface on all of the dentoform teeth was also evenly and lightly sandblasted with a 50-micrometer aluminum oxide to break this glaze and produce a surface more conducive for cement adherence. No measurement of the amount of material removed from either the coping or dentoform tooth was attempted. It is believed that any amount was minute, and since all copings and dentoform teeth were treated in this way, there should be little effect on the results of this study.

The copings were matched to and cemented on the proper dentoform teeth using a zinc phosphate cement (Fleck's Cement, Mizzy, Inc, Clifton Forge, VA 24422) mixed following the manufacturer's specifications. Immediately after the coping was placed on the dentoform tooth, a static 5-Kg load was applied to the coping and dentoform tooth along the long axis of the tooth during the first 10 minutes of cement setting. Excess cement was carefully wiped from the casting margins before final set. The cemented copings were stored in a moist environment at 37 °C until tested (approximately 48-72 hours). A typical cemented coping is shown in Figure 3.

Coping removal and force measurement were performed on an Instron Universal Testing Machine (Instron Corp, Canton, MA 02021) with a 1000-Kg tensile load cell at a crosshead speed of 0.02 in/min. Universal joints were used in the arms of the machine to aid with force alignment (Fig 4).

The stone dies were imbedded in model stone, sectioned faciolingually, and polished with 600-grit silicone carbide sandpaper. Measurements of die-spacer thickness were made at the facial, facial-occlusal, lingual-occlusal, and lingual surfaces of the die (Fig 5) using a Gaertner measuring microscope. A mean die-spacer thickness for each surface in each test group and an overall mean die-spacer thickness for each test group was determined.

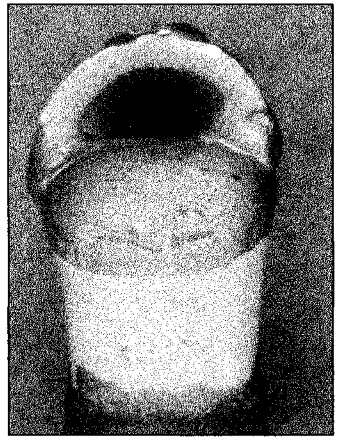

FIG 3. *Typical cemented coping*

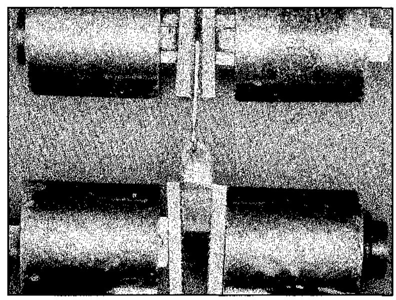

FIG 4. *Removal of cemented coping in an Instron Universal Testing Machine*

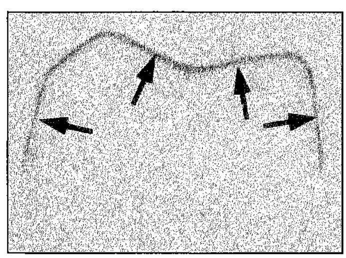

FIG 5. *Embedded and sectioned die for measuring die-spacer thickness at four locations (arrows)*

Statistical analysis of the mean force required to remove the cement copings for each test group was performed using ANOVA at the 95% confidence level.

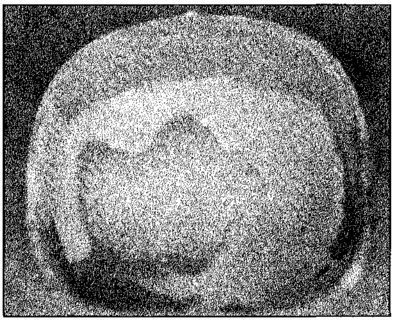

FIG 6a. *Internal surface of coping after removal*

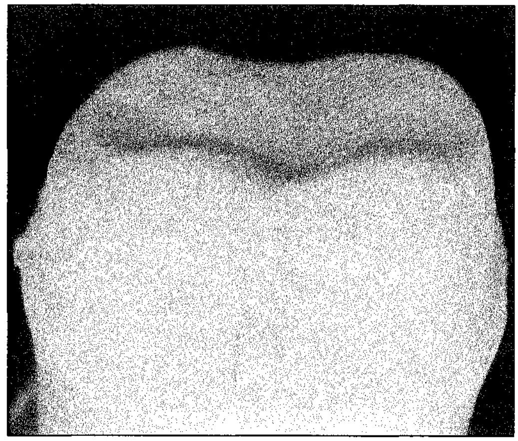

FIG 6b. *Preparation surface of dentoform tooth after coping removal*

Results

Observation of the dentoform teeth and copings after removal showed that the cement failed both adhesively and cohesively for all specimens. Failure occurred within the cement, between the cement and the casting, and between the cement and the dentoform tooth surface. The internal surface of a typical coping and the preparation surface of a dentoform tooth after coping removal are shown in Figures 6a and 6b.

Die-spacer thickness measured in micrometers on four surfaces of the die is presented in Table 2. Variation in die-spacer thickness between horizontal and vertical surfaces is noted. Generally, die-spacer applied on horizontal surfaces is thicker than on vertical surfaces. This result is most likely caused by pooling of the liquid material. The mean values for four coats of die-spacer are consistent with the thickness of 25-40 micrometers reported to be most favorable for improved crown seating. Further application of die-spacer produces a relationship that is somewhat linear. That is, eight coats of die-spacer is nearly twice as thick as four coats, and 12 coats is nearly three times as thick, etc. The mean die-spacer thickness per coat applied is approximately 8-9 micrometers.

Coping retention values are presented in Figure 7. The force in pounds required to remove the cemented copings is shown on the vertical axis. The mean force for each die-spacer group is indicated at the top of

Table 2. Die Groups and Coats of Die-spacer

Group	Coats of Die-spacer	N
1	0	10
2	4	10
3	8	10
4	12	10
5	16	10

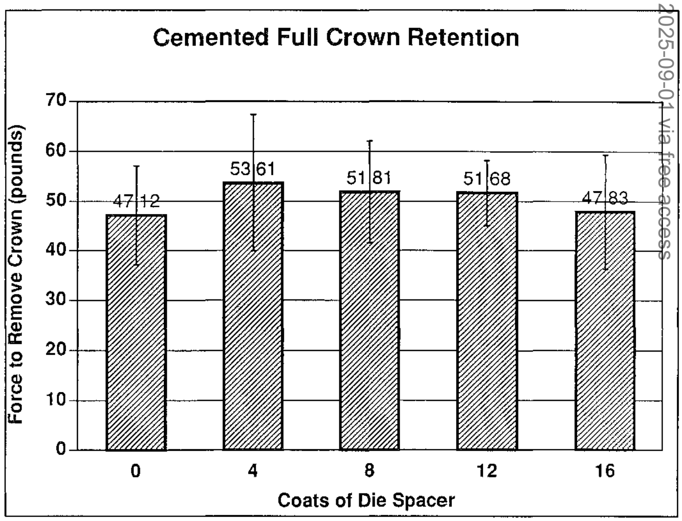

FIG 7. *Mean force required to remove cemented crowns fabricated on dies coated with the corresponding amount of die-spacer. Vertical bars represent the standard deviation.*

the column, and the standard deviation is indicated by the bar over each column. The number of coats of die-spacer applied to the dies is indicated on the horizontal axis. As shown, the force required to remove the cemented copings was greater by approximately 12% after four coats of die-spacer were applied to the dies when compared to those with no coats. The force required to remove the cemented copings decreased as subsequent coats of die-spacer were added. However, the force required to remove cemented copings fabricated with all amounts of die-spacer relief was greater than for those fabricated with no die-spacer relief. Statistical analysis revealed that none of the differences in the mean force required for coping removal among any of the test groups was statistically significant at $P \leq 0.05$.

Discussion

The coping retention results for four coats of die-spacer are consistent with those reported by Eames and others (1978) and Hembree and Cooper (1979). The force required to remove cemented crowns increased when die-spacer was used. These results differ, however, with those of Vermilyea and others (1983) and Gegauff and Rosenstiel (1989). Although crown retention values were expected to decrease dramatically after 16 coats of die-spacer, they did not; the results show that when multiple coats of die-spacer were applied, increasing the thickness beyond the recommended ideal, crown retention was not adversely affected. The force to remove the cemented copings did decrease as more coats were applied. However, after 16 coats, it was equivalent to those fabricated with no die-spacer.

The thickness of four coats of die-spacer as measured in this study is consistent with the thickness reported by other investigators in their crown retention studies (Eames & others, 1978; Vermilyea & others, 1983). The application of each additional coat of die-spacer deposited a predictable 8-9 micrometer thickness of material. This pattern of deposition agrees with the findings of Campagni and others (1982).

From a practical sense, counting the number of coats of die-spacer applied is preferred. However, it is not the number of coats that is important, but rather the resultant thickness. There are many types of die-spacer available. Each requires a different number of coats and a slightly different application technique to produce the ideal or desired die-spacer thickness (Donovan & others, 1984; Campagni & others, 1982). However, material age, method application, and environmental factors can affect the final thickness (Oliva & others, 1988; Grajower & others, 1989). This study demonstrates that if die-spacer is deliberately or accidentally applied so that the final thickness is greater than the 25-40 micrometers recommended, crown retention will not be significantly affected. Therefore, there should be little concern for the variability in die-spacer thickness that could result from differences in die-spacer material used, method of application, experience of the operator, and factors that, over time, could affect the nature and handling of the material.

Static loading was applied to the copings and teeth during the first 10 minutes of cement setting to standardize the seating force among the test groups. This type of loading was chosen as perhaps more typical of the method of crown seating used in clinical practice. It has been suggested that dynamic loading during cementation improves the seating of crowns (Oliveira & others, 1979); others have disagreed with these findings (Van Nortwick & Gettleman, 1981). An evaluation of cemented crown retention made on dies with or without die-spacer and seated dynamically indicated significantly diminished retention values for crowns fabricated with relief (Gegauff & Rosenstiel, 1989). However, negative marginal gap measurements (crown over-seating) and no significant differences in cemented crown retention between groups when from one to six coats of die-spacer relief was used clouds the results of that investigation.

It is believed that die-spacer provides space for the cement that reduces hydrostatic forces during crown seating. Furthermore, this relief may compensate for variations caused during the crown fabrication process, thereby allowing more complete seating. This study suggests that a uniform thickness of cement, if produced, may be more important than the final film thickness. The study by Jorgensen and Esbensen (1968) seems to support this contention; they found that variations in cement film thickness between 20 and 140 micrometers had only a moderate influence on retention; and that significant reduction in retention occurred only after a thickness of 140 micrometers occurred. Therefore, zinc phosphate cement may be more effective at a final film thickness beyond that embodied as ideal for acceptable margin closure. If this is the case and crown retention is a function of internal relief (and resulting cement thickness), then an optimum amount of internal relief needs to be determined that will produce maximum retention.

Die-spacer was not applied to within the final 1 mm of preparation surface. All castings had this relationship regardless of the amount of die-spacer applied. It may be that this area plays a more significant role in crown retention than is currently understood. Theoretically, as the amount of crown relief increases, discrepancies in restoration-tooth fit are significantly reduced or eliminated, and the marginal area of the casting (now more accurately related) assumes a greater role in retaining the casting.

Thickness of the cement was not evaluated. It is assumed, however, that with complete coping seating, the cement should be uniformly distributed to a thickness equal to the die-spacer thickness plus the thickness caused by the cement film thickness at the unrelieved margin. It has been reported that as the thickness of zinc phosphate cement increased, the mode of failure changed (Vermilyea & others, 1983) from higher shear strength to relatively low tensile strength. The results of this study did not indicate a relationship to cement thickness and mode of failure. It does suggest that the shear strength of the cement within the 1 mm-wide band of the crown margin may be more than enough to compensate for the shift to weaker tensile strength as cement thickness increases.

Other studies have used a variety of techniques to simulate prepared teeth and cemented crowns. This study is limited somewhat by the use of plastic dentoform teeth for the evaluation of crown retention. Identically molded, ideal full crown preparations were used to reduce the possibility of variation caused by preparation design, such as taper, wall length, total surface area, and surface characteristics. Factors such as instrument-caused roughness and biologic characteristics of teeth were not considered. As with all laboratory studies, it would be inappropriate to compare the results of this study and to directly apply these data to a clinical situation. Values for the force required to remove the cemented copings from dentoform teeth may not be comparable to values obtained in studies that used natural teeth or other systems. However, a comparison of values between test groups within this study is valuable.

The method of coping removal used in this study represents one mode of failure. This method was used exclusively by other investigators evaluating crown retention (Eames & others, 1978; Gegauff & Rosenstiel, 1989; Hembree & Cooper, 1979; Vermilyea & others, 1983). Clinical crown dislodgement, however, could be caused by other forces and actions during occlusal function. Caution is urged when attempting to apply the results of this study to all clinical conditions. Furthermore, one should not generalize about the effect increased die-spacer thickness may have on restoration retention when cast preparation designs different from that of the full crown design in this study are made.

Conclusion

Based upon the findings of this investigation, the following conclusion is offered:

Under the conditions of this study, the application of up to 16 coats (151 micrometers) of die-spacer did not statistically significantly affect ($P \leq 0.05$) the force required to remove cemented cast copings.

Acknowledgments

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Effect of Grooves on Resistance Form of Conservative Class 2 Amalgams

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F B DUTTON • J W OSBORNE

Summary

This study evaluated several means of providing retention for the approximal box in very conservative class 2 preparations (occlusal isthmus width 0.7 mm). Sixty class 2 mesio-occlusal cavities were prepared in sound human maxillary premolar teeth. Four types of retention grooves, 0.3 - 0.5 mm deep, were prepared at the axiofacial and axiolingual line angles and/or occlusal to those line angles. Specimens were loaded at an angle of 13.5° from vertical in an Instron Universal Testing Machine until the restoration failed. Results indicate that grooves located occlusal to the axiopulpal line angle provided more resistance than conventional grooves (gingival to the axiopulpal line angle) or no grooves. The use of a short retention groove or retention point located occlusal to the axiopulpal line angle, but not extending to the occlusal cavosurface margin, provided greater retention while removing minimal tooth structure.

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INTRODUCTION

The need for retention grooves in class 2 amalgam restorations is controversial. In his 1908 book, *A Work on Operative Dentistry*, G V Black advocated "convenience points," which are in essence short retention grooves, at the junctions of the approximal and axial walls of class 2 preparations for direct gold restorations. He stated that these "convenience points," which were used to start the compaction of gold foil, were not necessary in amalgam restorations. The class 2 preparations taught by Black were quite large because he felt that the wide isthmus was necessary to prevent fracture of the amalgam. With these large occlusal portions, retention grooves in the line angles of the approximal boxes may have added little to resistance form of amalgam restorations.

Perhaps one of the most conservative amalgam preparations was advocated by Markley (1951). Because of tradition as well as a scarcity of small burs and lack of high-speed preparation, these very conservative preparations did not become widely used until recently. Markley advocated the use of retention grooves, which he described as "locks," extending from the gingival seat to the occlusal surface, but without appreciably showing in the occlusal enamel. He stressed that the grooves must not undermine the approximal enamel.

Based on in vitro studies, several authors recommended the use of retention grooves in the axiofacial and axiolingual line angles of the approximal boxes of class 2 amalgam preparations (Crockett & others, 1975; Mondelli & others, 1974, 1981). Caplan, Denehy and Reinhardt (1990), in a recent in vitro study, concluded that compressive strength of class 2 amalgam restorations was increased almost 40% by the incorporation of approximal retention grooves.

Sturdevant and others (1987) studied conservative preparation designs for class 2 amalgam restorations using metal dies with retention grooves of two lengths. They reported no difference between grooves that extended from the gingival floor to the occlusal surface and grooves that extended from the gingival floor to the level of the axiopulpal line angle. In slot preparations (approximal box only, with no occlusal extension), retention groove length did not significantly affect the mean failure load; in the preparations that included an occlusal preparation, neither the presence nor length of the retention grooves had any effect on failure load. The authors reported that the box-only restorations tended to fail by displacement more often than restorations that had an occlusal dovetail; they stated that this seemed to contradict the fact that the box-only restorations required higher loads to produce failure. They gave as a possible explanation that the occlusal morphology of the marginal ridges of the box-only restorations may have been slightly different from the restorations with the occlusal extension.

In two clinical studies, Terkla and Mahler (1967) and Terkla, Mahler and Van Eysden (1973) reported that retention grooves were not necessary to avoid bulk fracture of amalgam at the isthmus. The retention grooves used by Terkla and Mahler were conventional grooves in the axiopulpal line angles, tapering out at the occlusal extent of each groove. With this groove configuration, the deepest portion of each groove was at the gingival floor. In the 1967 study, only conservative (narrow) amalgam restorations, with and without retention grooves, were compared. The 1973 study involved 422 restorations, some narrow and some wide, some with retention grooves and some without. Both studies found no difference in the clinical success of restorations with and without retention grooves. Terkla and Mahler (1967) regarded their preparations as "conservative"; however, this may be a relative term. Preparations pictured in their 1967 article have little resemblance to conservative preparations advocated by Markley (1951) and by Almquist, Cowan and Lambert (1973). The restorations pictured in the Terkla and Mahler (1967) article showed wide occlusal preparations and removal of cuspal tooth structure in blending the outline of the approximal box into the outline of the occlusal preparation.

In 1985, Childers reviewed the literature concerning retention grooves and concluded that the need for placing grooves was controversial. He began his article by stating that "one of the more difficult tasks for dental students to accomplish is the accurate and adequate instrumentation of approximal retentive grooves." He continued by saying that many otherwise well-instrumented cavity preparations were mutilated by poor instrumentation of the retentive grooves by dental students, and that it is probable that many teeth treated in private practice also suffer "rotary abuse."

Moore (1991) surveyed dental schools in the United States to determine the extent to which retention grooves are taught for class 2 amalgam preparations. Fifty-nine of the 64 schools surveyed responded, and 36, or 61% of those responding, reported that retention grooves are taught.

The benefits of a narrow occlusal preparation design for class 2 amalgam restorations have been well documented. Several investigators (Vale, 1956; Larson, Douglas & Geistfeld, 1981; Blaser & others, 1983) reported that teeth with narrow occlusal preparations are stronger than teeth with wider preparations. Clinical studies (Berry & others, 1981; Osborne & Gale, 1990) have demonstrated that there is less marginal breakdown associated with occlusal portions of amalgam restorations that are narrow faciolingually compared to wider restorations. Implied from these clinical studies is that narrow preparations survive longer than do wider preparations.

This study was designed to examine the effect of groove location and length on resistance form provided to very conservative class 2 amalgam restorations.

MATERIALS AND METHODS

Specimen Selection

Sixty extracted human premolars, free of caries or restorations, were sorted by faciolingual dimensions. Teeth were divided into five groups of 12 teeth, with sizes distributed to give approximately equal mean dimensions in each group. Roots were notched and embedded in Cerro-Bend Alloy (Cerro Metal Products, Bellefonte, PA 16823), which was confined by cylinders of polyvinyl chloride tubing 3/4 inch high with an outside diameter of 1 1/16 inch. Specimens were stored in tap water when not being prepared or tested.

Cavity Preparations

Mesio-occlusal preparations were cut to standardized ranges of dimensions using a #329 pear-shaped bur and #1/4 round bur (Midwest Dental Products Corp, Des Plaines, IL 60018-1884) in a high-speed handpiece (Star Futura 2, Star Dental, Valley Forge, PA 19482), and appropriate sharp hand instruments as follows:

Faciolingual width of the occlusal preparation	0.7 mm ± 0.1 mm
Depth of occlusal preparation	1.8 mm ± 0.2 mm
Faciolingual dimensions of approximal box,	
at occlusal	2.25 mm ± 0.25 mm
at gingival	2.75 mm ± 0.25 mm
Occlusogingival height of axial wall	1.75 mm ± 0.25 mm
Depth of box gingivally from marginal ridge	3.5 mm ± 0.5 mm
Width of gingival floor axially	1.25 mm ± 0.15 mm
Width of 45° bevel of axiopulpal line angle	0.5 mm - 1.0 mm

Cavities were prepared by two operators to the specified dimensions. The junction between the outline form of the occlusal portion of the preparation and the approximal portion was slightly rounded, with a distinct S-shaped curve joining the facial wall of the approximal box with the facial wall of the occlusal portion. Figures 1a and 1b show a typical preparation

1A

1B

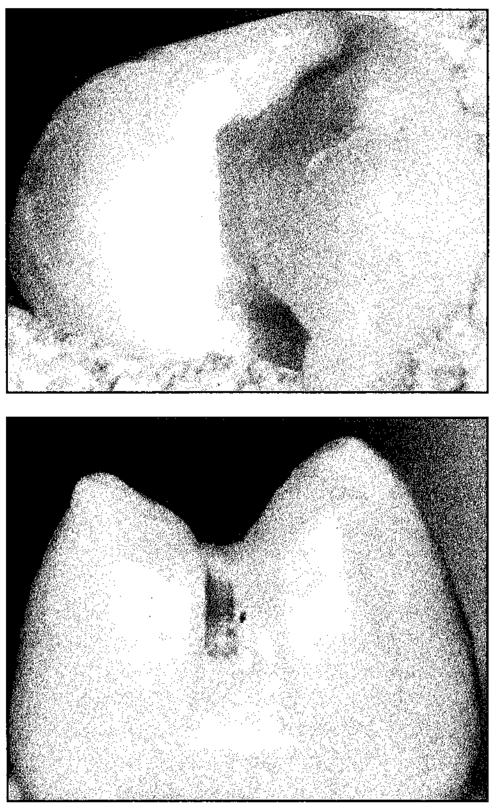

FIG 1. *Typical outline of a preparation shown from the occlusal (A) and the approximal (B)*

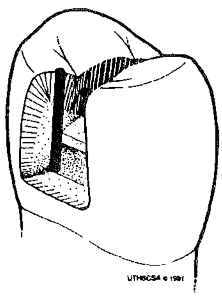

FIG 2a. *Retention groove from gingival floor to occlusal surface*

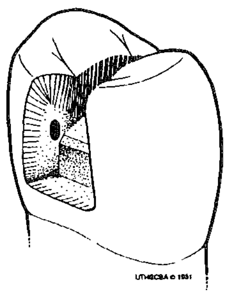

FIG 2b. *Short retention groove or retention point (< 1 mm occluso-gingivally) located just occlusal to axiopulpal line angle*

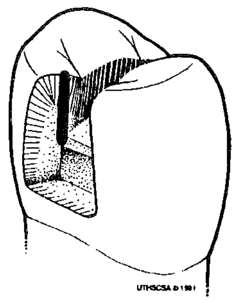

FIG 2c. *Retention groove from axiopulpal line angle to occlusal surface*

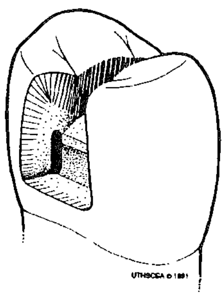

FIG 2d. *Conventional grooves from gingival floor to axiopulpal line angle*

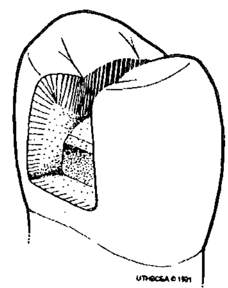

FIG 2e. *No grooves placed*

from the occlusal and from the mesial. The distinct S-shaped curve was employed to preserve the integrity of the facial cusp. After all cavities were prepared, retention grooves were placed by one operator to a depth of 0.3 to 0.5 mm and a width of 0.5 mm using a #1/4 round bur in a high-speed handpiece at very low speed. They were cut to bisect the axiofacial and axiolingual line angles when grooves were placed or extended gingival to the axiopulpal line angle. When grooves were placed occlusal to axiofacial and axiolingual line angles, they were cut parallel to the dentinoenamel junction. Retention grooves in each of the five groups are illustrated in Figures 2a through 2e.

Restorative Procedure

Two Tofflemire #1 (double thickness) matrix bands (Union Broach Corp, Long Island City, NY 11101) in a Tofflemire retainer were adapted to each premolar. Amalgam (Valiant PhD, L D Caulk Division, Dentsply International, Inc, Milford, DE 19963) was triturated in a Caulk Varimix III amalgamator for nine seconds at the "M" setting and inserted using vertical and lateral condensation with condensers that fit all areas of the preparations. The amalgam was condensed to overfill the preparation by at least 1/2 millimeter, then carved to contour with sharp carvers.

Testing

After aging one month in tap water at room temperature, specimens were positioned in a fixture at a 13.5° angle, and a #57 bur (Midwest Dental Products Corp) in a straight handpiece (Bell International, Burlingame, CA 94010) mounted in a paralleling device

(Fig 3) was used to flatten a 1 mm x 1.5 mm area on the amalgam at the marginal ridge. The specimens were positioned in the same fixture for loading. A rectangular rod with dimensions of 1.0 mm x 1.3 mm was used to load the amalgam in compression using an Instron Universal Testing Machine (Instron Corp, Canton, MA 02021) at a head speed of 1 mm/minute (Fig 4).

RESULTS

Failure load in newtons and mode of failure were recorded for each specimen. Results for each group are summarized in Table 1 and Table 2. The data were analyzed using a one-factor analysis of variance (ANOVA) to determine the presence of intergroup differences. A Student Newman-Keuls posthoc analysis was used to determine where those differences lay. The data indicated that group A (retention grooves extending from the gingival floor to the occlusal cavosurface margin) was strongest but not significantly stronger than group B (short groove or point just occlusal to the axiopulpal line angle). Group C (grooves extending from the axiopulpal angle to the occlusal cavosurface margin) was weaker than group A but was not significantly weaker than group B. Group D (conventional grooves) and group E (no retention grooves or points) were lowest in resistance and were not different from one another. Specimens without retention grooves or with conventional retention grooves (extending from the gingival floor to the level of the axiopulpal line angle) were statistically significantly weaker than specimens that had all or a portion of the retention grooves extending occlusally from the axiopulpal line angle ($P < 0.05$).

Failure occurred in several different ways. In all specimens, the amalgam in the occlusal portion of the preparation remained intact. Table 2 indicates the location in which failure occurred among the various groups.

DISCUSSION

This study evaluated the effect that approximal retention grooves have on the resistance form of very conservative amalgam restorations. The advantages of conservation of tooth structure are numerous and have been reported by several authors (Vale, 1956; Berry & others, 1981; Larson, Douglas & Geistfeld, 1981; Blaser & others, 1983; Osborne & Gale, 1990). Although an extremely conservative occlusal portion of a mesio-occlusal preparation was employed in this study, it, combined with the form of the approximal box itself, provided significant resistance to amalgam fracture and mesial displacement of the approximal portion of the mesio-occlusal restoration. This is demonstrated by the group

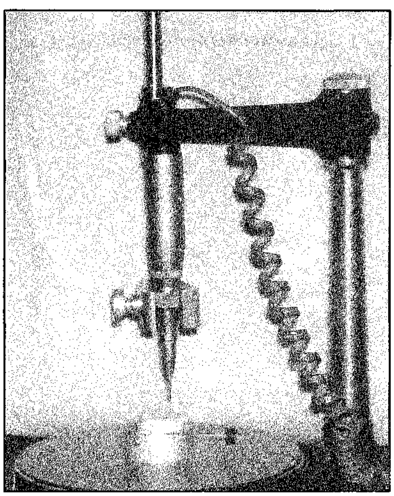

FIG 3. *Specimen positioned in fixture at 13.5° with marginal ridge area being flattened with #57 bur in straight handpiece*

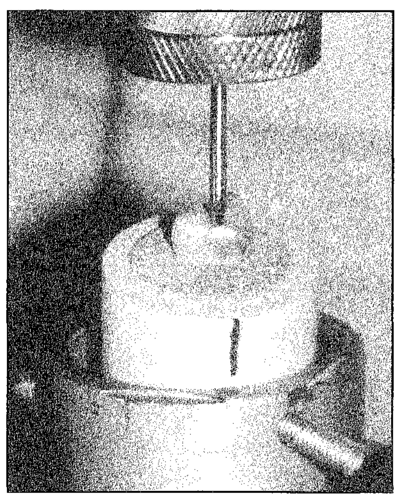

FIG 4. *Specimen being compression-loaded in Instron Testing Machine, using rectangular loading rod with dimensions 1.0 mm x 1.3 mm*

Table 1. Mean Failure Load [Newtons (N)] of Class 2 Mesio-Occlusal Amalgam Restorations in Maxillary Premolars either with No Retention Grooves or with Varying Locations of Retention Grooves. (Groups connected with a line are not significantly different.)

Group	Retention Grooves Extending	Load to Fracture	SD
A	From gingival floor to occlusal surface	280	± 52
B	Point (< 1 mm occlusogingivally) just occlusal to axiopulpal line angle	241	± 47
C	From axiopulpal line angle to occlusal surface	222	± 48
D	From gingival floor to axiopulpal line angle (conventional groove)	177	± 52
E	None	166	± 29

Table 2. Mode of Failure for Each Group

Group	Retention Grooves Extending	Amalgam Left in Occlusal Only	Amalgam Left in Grooves	Amalgam Covering Axial Wall
A	Gingival floor to occlusal surface	0	12	11
B	Point just occlusal to axiopulpal line angle	0	12	8
C	Axiopulpal line angle to occlusal surface	0	12	5
D	Gingival floor to axiopulpal line angle (conventional)	0	10	9
E	No grooves	6	NA	3

means for restoration in which no retention grooves were employed.

There was no significant difference in the fracture resistance of the group with conventional grooves compared to the group with no retention grooves. This supports the clinical findings of Terkla and Mahler (1967), who reported no difference in fracture resistance clinically, using the same two retention forms but with wider occlusal preparations.

Sturdevant and others (1987) tested class 2 amalgam restorations in preparations with groove configurations similar to the ones tested in this study (groups A, D, E). There were differences in results of the two studies. The Sturdevant group reported, as did this study, that no additional resistance to failure was imparted by conventional grooves compared to no grooves. However, the Sturdevant study found that grooves extending from the gingival floor to the occlusal cavosurface margin imparted no additional resistance, whereas this study found the long grooves to impart significantly more resistance. There are several possible reasons for the differences. The 1 mm isthmus width in the Sturdevant study was 0.3 mm greater than the width of the occlusal amalgam in this study (0.7 mm ± 0.1 mm). The 1.5 mm pulpal depth of the occlusal portion of the preparation in the Sturdevant study was 0.3 mm less than in this study (1.8 mm ± 0.2 mm). To conserve cuspal tooth structure, our study used a somewhat more severe "S" curve to connect the approximal portion to the occlusal portion of the preparation. The Sturdevant study loaded the marginal ridge with a cylinder positioned perpendicular to the marginal ridge; to minimize stress concentration, our study employed a flattened rectangular rod to load a similarly flattened marginal ridge. Our study positioned the teeth at 13.5° from parallel to the long axis; the Sturdevant study used 10°. Any of these factors could have played a role in explaining the differences in the results of the two studies. Perhaps more significantly, however, the Sturdevant study used metal dies to provide consistency among preparations; this study employed extracted maxillary premolars.

Of great interest was the result that the resistance to loading in the marginal ridge area could be significantly increased by placing the retention grooves occlusal to the axiopulpal line angle. This increase was further amplified by the data indicating that the most conservative retention grooves (group B), a short retention groove or retention point located in dentin just occlusal to the axiopulpal line angle, was as effective as other more extensive retention grooves. This finding may be due to the mechanical advantage of placing the retention near the marginal ridge where stress concentration for fracturing the approximal portion of the restoration would be greatest.

CONCLUSIONS

1. The approximal portions of conservative class 2 amalgam restorations with conventional retention grooves (extending from the gingival floor to the level of the axiopulpal line angle) provided no more resistance to fracture than did the approximal portions of conservative class 2 amalgam restorations with no retention grooves. Results suggest that conventional retention grooves may not provide additional resistance over that provided by the approximal box alone.

2. Retention grooves that were located entirely or in part occlusal to the axiopulpal line angle provided significantly more resistance to fracture of the approximal amalgam than conventional retention grooves or no retention grooves.

3. Short retention grooves or retention points located in dentin just occlusal to the axiopulpal line angle provided as much resistance to fracture of the approximal amalgam as grooves that extended to the occlusal cavosurface margin. Results suggest that short retention grooves or retention points located in dentin just occlusal to the axiopulpal line angle might be indicated when the occlusal portion of the restoration is very narrow. It appears that these retention points are more retentive than conventional grooves. This new form of retention appears to be highly advantageous for both conserving tooth structure and increasing retention.

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Effect of Coating Materials on Restorative Glass-Ionomer Cement Surface

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Summary

Historically glass-ionomer samples have been coated with a varnish to protect the material from the effect of water on the surface. However, varnishes have been shown to peel from this surface. The set cement matrix may become chalky and can erode rapidly. Light-cured glazing agents may demonstrate the ability to limit water movement across the setting-cement surface. In this in vitro study samples were investigated colorimetrically to evaluate the effect of water contamination. Perceivable differences were not found, particularly when a coating of light-cured bonding or glazing agents was applied. We conclude that the color stability of glass-ionomer cements is enhanced with the use of a protective coating of light-cured bonding or glazing agents.

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INTRODUCTION

Glass-ionomer cement is used as a restorative material typically for wedge-shaped defects and root surface caries. Glass-ionomers are sensitive to hydration and dehydration during their initial set, so they are usually protected by coating materials: either cocoa butter or waterproof varnish (Asmussen, 1983; Earl, Hume & Mount, 1985); however, they have been shown to peel easily. If water is absorbed the matrix will become chalky and erode rapidly. Earl, Mount and Hume (1989) have shown that immediate covering of the immature glass-ionomer cement surface with light-activated bonding resin is the most effective method of limiting water movement across the surface. Color stability in the oral environment may be the most important factor in patient acceptance of the restorative glass-ionomer cement treatment. This paper describes the use of a protective coating (light-cured glazing agent) that may demonstrate a potential ability to limit water movement across the setting cement. This study was designed to evaluate the examination of coating materials treatment of the glass-ionomer cement surface in a wet environment by measuring the color change. A dental color meter was used to analyze the color of glass-ionomer cement surface in accordance with the L*a*b* color notation system. The surface microstructure of coating materials was observed with scanning electron microscopy by replication technique to evaluate the influence of the duration of water exposure.

METHODS AND MATERIALS

Preparation and Storage of Specimens

The present study used three restorative glass-ionomer cements made by three manufacturers and four coating materials made by three manufacturers (table). One coating material was a varnish and the other three were resins. The glass-ionomer cements were mixed according to the manufacturers' instructions. The mixture was placed into a stainless steel mold (4 x 4 x 2 mm) at room temperature (23 °C). The mold was slightly overfilled and compressed with a glass plate. After five minutes the hardened sample was removed and handled in one of two ways. The samples to be coated with Occlusin bonding agent or Bellfeel brightener were etched with 37% phosphoric acid for five seconds, rinsed, and then air-dried. The samples in Ketac varnish and Ketac glaze were not etched or air-dried. For both groups the coating agents were flowed onto the surface and the excess gently blown off. The light-cured bonding agent and glazing agent were then irradiated by a lamp unit (Pulaflex HL150, Litema, Baden-Baden, Germany) for 20 seconds. At least 15 minutes after mixing, the specimens were stored in distilled water at 37 °C for 24 hours, 48 hours, and 7 days before testing. Three specimens of each material were prepared for each category of testing, one of which was a control (no surface treatment).

Materials Tested

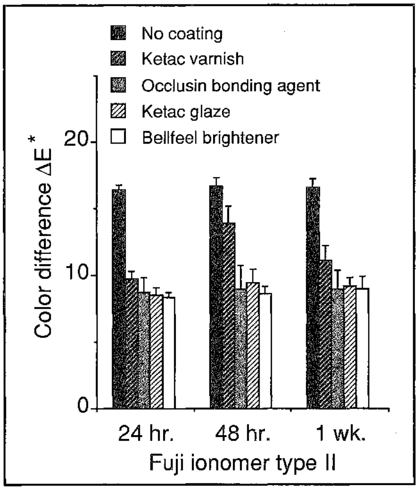
Material	Brand Name	Manufacturer
glass-ionomer cement	Fuji Ionomer Type II	G-C International Corp Tokyo, Japan
	Chemfil II	De Trey
	Chelonfil	ESPE Fabrik
coating agent	Ketac varnish	ESPE Fabrik
	Occlusin bonding agent	ICI Dental
	Ketac glaze	ESPE Fabrik
	Bellfeel brightener	Kanebo, Ltd

Measurement of Color Change

The specimens were removed from distilled water and wiped dry with lens paper in air of 23 ± 1 °C and 50 ± 10% relative humidity. Immediately thereafter the color and color difference were measured with specimens placed on a black background (Y:1.1, X:1.1, Z:1.4), and a Shade Matching Light (EFOS, Inc, Ontario, Canada) was used. The specimens were measured by a dental color meter (OFC-1001DP, Nihondenshoku, Tokyo, Japan). The diameter of the measuring spot was 2.0 mm.

Thritimulas values of X, Y, and Z were directly obtained and automatically calculated into color readings as CIE 1976 L*a*b* color coordinates, where L* is brightness, a* the red/green coordinate, and b* the yellow/blue coordinate. The color measurement was first calibrated by using a white MgO standard with the known (Xo, Yo, Zo) values of 92.9, 93.9, and 110.2. The color difference vector or color difference (ΔE*) is defined in the equation: $E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + \Delta b^*)^2]1/2$.

In addition, specimens were prepared for scanning electron microscopy evaluation by fabricating replicas to be spattered with gold. Replicas were prepared using a silicon impression (Exaflex, G-C International Corp) and an epoxy resin (Epofix, Strues, Copenhagen, Denmark).



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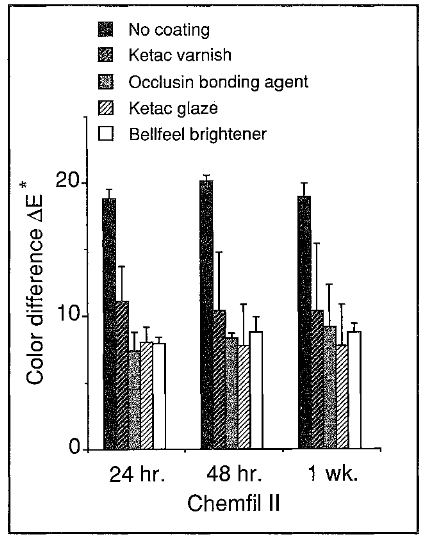

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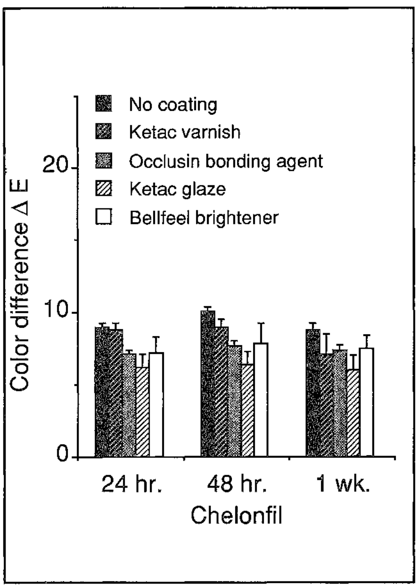


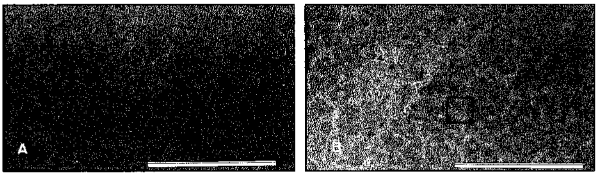
1C.

FIG 1. *Influence of time on colorimetric evaluation of the coated glass-ionomer specimens' surfaces following water contamination*

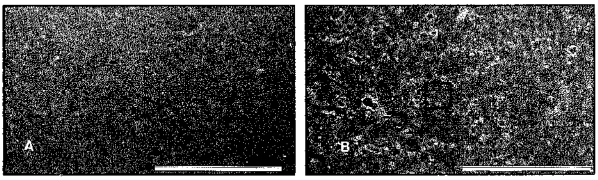
RESULTS AND DISCUSSION

The mean and standard deviation of color difference (ΔE*) are presented in Figure 1. Color differences for the glass-ionomer cement surface ranged from 8.8 to 20.1. The degree of color difference with Chelonfil was less than with Fuji Ionomer Type II and Chemfil II. Moisture affected the surface color of the glass-ionomer cement specimen within 15 minutes after mixing. It was established that early water contact with a glass-ionomer cement results in an increase in color difference. Color differences of Ketac varnish coating surface ranged from 7.1 to 13.9; however, color differences of the light-cured bonding and glazing agents ranged from 6.0 to 9.4. The data from Figure 1 show that the light-cured bonding and glazing agents were more effective in reducing water movement than the varnish material tested at 24-hour, 48-hour, and 7-day time intervals.

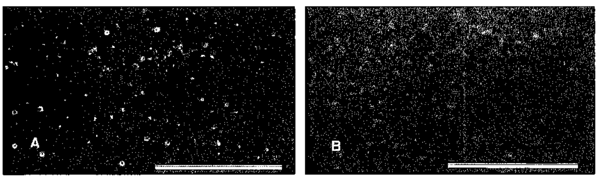
Scanning electron micrographs were taken to demonstrate the effect of the various protective coatings. As shown in Figures 2 and 3, the glass-ionomer cements developed cracks after moisture contamination and air-drying. The surface cracks of Fuji Ionomer Type II and Chemfil II tended to be the most severe. We consider the surfaces of Fuji Ionomer Type II and Chemfil II to be very unstable. As seen in Figure 4, the specimens bonded with light-cured bonding or glazing agents stored in a moisture environment were characterized by smooth surfaces. Judging from the scanning electron microscopy of the replicated surface, the light-cured bonding and glazing agents appeared to remain intact on the glass-ionomer cement surfaces; however, the coating of varnish was observed to have peeled away, resulting in water penetrating the



Fuji Ionomer Type II

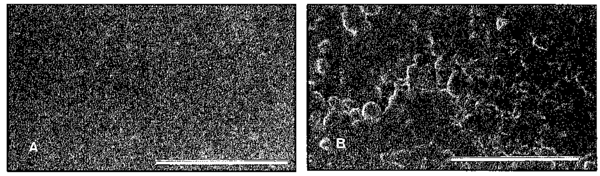


Chemfil II

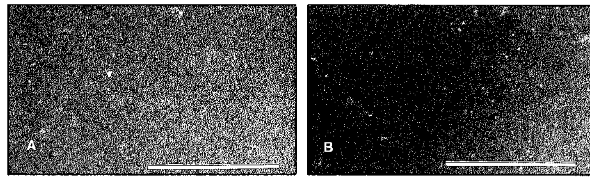


Chelonfil

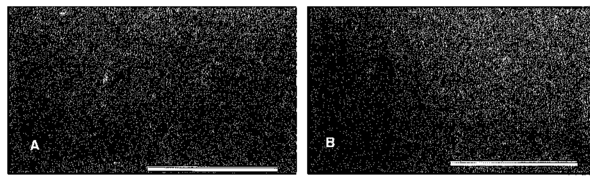
FIG 2. *Scanning electron micrograph pictures of the glass-ionomer cement surfaces before (A) and after (B) immersion in water for 48 hours (Original magnification X35; bar = 500 μm)*



Ketac-varnish



Occlusin bonding agent



Bellfeel brightener

FIG 4. *Scanning electron micrograph pictures of Chemfil II protected with various coating agents before (A) and after (B) immersion in water for 48 hours. Ketac varnish has been peeled way, showing the intact surface of the mature cement. (Original magnification X35; bar = 500 μm)*

Fuji Ionomer Type II *Chemfil II* *Chelonfil*

FIG 3. *Higher magnification of specimens shown in Fig 2 (B boxes). Cracks developed in the surface after moisture contamination and air drying; Fuji Ionomer Type II and Chemfil II cracked more severely. (Original magnification X500; bar = 50 μm)* surface. These circumstances gave rise to the increase in the color change of the varnish coating surface. On the other hand, the light-cured bonding and glazing agent-coated glass-ionomer cement surfaces proved to have a much smaller color change than the varnish. It has been shown that immediate covering of the immature glass-ionomer cement surface with a light-cured bonding or glazing agent is a more effective method of limiting water movement across the surface. We feel, however, that the coated glass-ionomer cement surfaces need tougher protective coating materials for clinical conditions over a long period.

CONCLUSIONS

The color change of each protective coating material was evaluated after 24 hours, 48 hours, and 7 days by a dental color meter with a black background. The light-cured bonding and glazing agent that had been exposed to water had a small color change. The color change of bonding and glazing agents was superior to that of varnish. Coating with a light-cured bonding or glazing agent is a useful and effective means of protecting restorative glass-ionomer cements in clinical practice.

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Microleakage of Class 2 Glass-Ionomer-Silver Restorations in Primary Molars

A B FUKS • G HOLAN
H SIMON • I LEWINSTEIN

Summary

The aims of this study were to assess microleakage at the cervical margins of class 2 "sandwich" restorations placed with two glass-ionomer-silver cements in primary molars, to compare the quality of the occlusal margins of these restorations to those prepared with Miracle Mix and Ketac Silver, and to assess by scanning electron microscopy (SEM) the marginal micromorphology of those restorations.

Fifty-two class 2 restorations were prepared in extracted primary molars and were restored as follows: 1) Ketac Silver + Estilux Posterior (sandwich), 2) Miracle Mix + Estilux Posterior (sandwich), 3) Ketac Silver only, and 4) Miracle Mix only. No or minimal leakage was evident in most of the occlusal margins, whereas severe leakage was observed in almost 70% of the cervical margins of the Ketac Silver groups.

Scanning electron microscopy evaluation demonstrated good adaptation at the buccal and lingual margins of all the restorations. Sixty-seven percent of the Miracle Mix restorations had no defects at the cervical margins, as opposed to only 17% of those with Ketac Silver.

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INTRODUCTION

Glass-ionomer-silver "cermet" restorations have been proposed as an alternative for amalgam restorations in primary molars (Croll

& Phillips, 1986), and high success rates were observed in two clinical studies utilizing Ketac Silver (Croll & Phillips, 1986; Stratmann, Berg & Donly, 1989). Conversely, Hung and Richardson (1990) compared silver amalgam with Ketac Silver in primary molars of schoolchildren and concluded that Ketac Silver was not suitable for restorations of interproximal cavities in primary teeth. These negative findings were reinforced by Guelman and others (1989), who reported that the mentioned "cermet" could not prevent leakage when utilized in class 2 restorations alone or with a composite coverage to improve esthetics.

In a recent study the superiority of Miracle Mix over Ketac Silver was demonstrated when applied as extended bases in composite "sandwich" restorations in permanent molars (Hirschfeld & others, 1991).

The objectives of the present study were:

1. to assess the microleakage at the cervical margins of class 2 composite "sandwich" restorations placed with the mentioned glass-ionomer-silver cements in primary molars,
2. to compare the quality of the occlusal margins of these "sandwich" restorations to those prepared with Miracle Mix and Ketac Silver only, and
3. to observe by SEM the micromorphology of the cervical buccal and lingual margins of the approximal surfaces.

MATERIALS AND METHODS

Fifty-two class 2 cavities were prepared in extracted or exfoliated primary molars. The collected teeth were stored in water and were intact, and had small carious lesions or amalgam restorations that were removed during cavity preparation. The cavities were prepared with a #330 bur using water cooling, and had all cervical margins placed in enamel. The teeth were randomly assigned to one of the four groups, as is presented in Table 1. The occlusal, buccal, and lingual cavosurface margins of the cavity preparations in groups 1 and 2 were beveled at an angle of approximately 45° with the tooth surface. All the materials were placed according to the manufacturers' instructions. Celluloid matrices (Howe-Neos Dental, CH-6925 Gentilino, Switzerland) were adapted to the teeth with a Tofflemire matrix holder.

Table 1. Experimental Design, Distribution of Restored Teeth

Group	Number of Teeth	Type of Restoration
1	13	Ketac Silver + Estilux Posterior*
2	13	Miracle Mix + Estilux Posterior*
3	13	Ketac Silver only
4	13	Miracle Mix only

*sandwich restoration

In group 1 a modified "sandwich" restoration was prepared. Ketac Silver (ESPE, GMBH & Co, KG, Oberbay, Germany) was applied in a thick layer at the approximal box up to the level of the occlusal pulpal wall, which was also covered (Fig 1). After five minutes the material was trimmed and etched, including the occlusal margins, for 20 seconds. A bonding agent was then applied, cured, and Estilux Posterior (Kulzer & Co Gmbh, Wehrheim, Germany) was placed in one increment, condensed with a large ball burnisher, and cured for 40 seconds. Upon removal of the matrix the glass ionomer in the approximal surface was covered by varnish (ESPE). The restorations in group 2, similarly to those in group 1, were also of the "sandwich" type. Miracle Mix (G-C Dental Industrial Corp, 76-1,

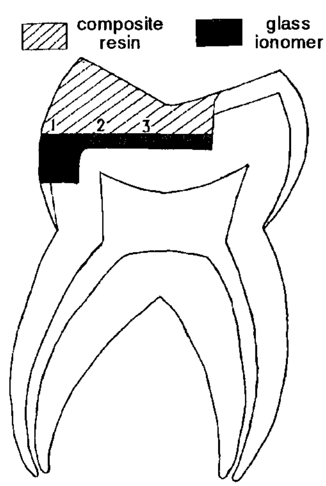


FIG 1. *Diagram of a "sandwich" restoration showing the intermediate layer of glass-ionomer-silver cement and the different degrees of dye penetration*

Hasunuma-cho, Itabashi-ko, Tokyo, Japan) was utilized to fill the approximal box and cover the occlusal pulpal wall (Fig 1). The material was then trimmed, etched for 20 seconds, and restored with Estilux Posterior as in group 1. In group 3 Ketac Silver was injected to fill the entire cavity. The restorations were condensed and shaped with a ball burnisher and covered by varnish after setting. The teeth in group 4 were restored with Miracle Mix similarly to the procedure used in group 3.

All restorations were ground off to the tooth surface. Composhape (Teledyne Densco, Denver, CO 80207) superfine finishing diamond burs were used for finishing, and Sof-Lex disks (3M Dental Products, St Paul, MN 55144) of decreasing roughness were employed for polishing the occlusal composites. The approximal surfaces that cured against a smooth matrix were left untouched.

The restored teeth were kept at room temperature and at 100% humidity for two weeks to prevent dehydration. They were then thermocycled for 250 cycles between 4 ± 2 °C and 60 ± 2 °C, with a dwell-time of one minute in each bath, and one-minute intervals between the baths in ambient atmosphere.

After thermocycling, silicone impressions (Provile P+L, Bayer, Leverkussen, Germany) were taken of six teeth of each group that were randomly selected and dried with a single air blast. Epoxy replicas (Epo-Kwick resin, Buehler, Ltd, Evanston, IL 60204) of the approximal surface were prepared in the impressions and gold-plated. The micromorphology of the margins was evaluated by SEM (Jeol JSM 35), and defects at the tooth-restoration interface were assessed at the cervical and approximal (buccal and lingual). These defects were classified according to the fraction of margin length showing gaps wider than 10 μm, as follows:

a: No gaps present at the tooth-restoration margins,

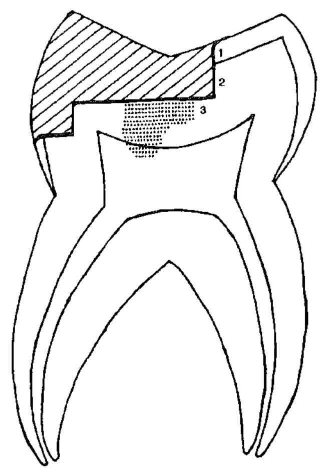
b: Gaps present at less than 1/3 of the margin,

c: Gaps present at up to 2/3 of the margin, and

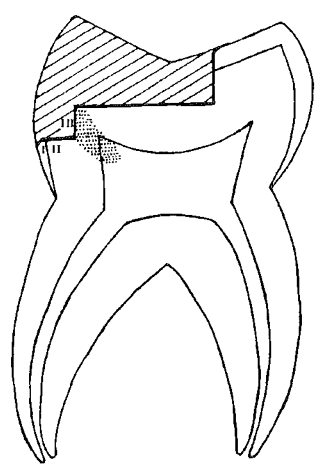
d: Gaps present along the entire margin.

The pulp chambers and/or remnants of roots were sealed with self-curing acrylic. All the teeth were coated with utility wax and nail polish, immersed in a 2% solution of basic fuchsin for 24 hours, washed in water, and embedded in acrylic resin as described previously (Fisbein & others, 1988; Holan & others, 1986). Mesiodistal sections were obtained by grinding off the embedded teeth (Guelman & others, 1989) and examined under a binocular microscope (Olympus, Tokyo, Japan). Occlusal and cervical margins were assessed for the degree of dye penetration on three sections that were obtained by sequential grinding. Four degrees of marginal leakage were distinguished for the occlusal and cervical margins, and represented by Arabic and Roman numbers respectively (Figs 2a & 2b): Degree 0: No penetration of dye; Degree 1 or I: Penetration of dye along the occlusal or gingival wall of the filling, adjacent to the

2A



2B



FIGS 2A & 2B: *Numerical evaluation of marginal leakage by depth of dye penetration at the occlusal (Arabic numbers—A) and cervical (Roman numbers—B) margins* enamel only; Degree 2 or II: Penetration of dye along the entire length of the occlusal or gingival wall of the filling, but not along the pulpal wall; and Degree 3 or III: Penetration of dye along the entire length of the occlusal or gingival wall of the filling, including the pulpal wall.

The interface between the composite and the glass ionomer was similarly assessed in four degrees as follows (Fig 1): Degree 0: No penetration of dye, Degree 1: Penetrations of dye up to the middle of the mesiodistal depth of the box, Degree 2: Penetration of dye beyond the level of the axiopulpal line angle, but less than half of the mesiodistal length of the restoration, and Degree 3: Penetration of dye to half or more of the mesiodistal length of the restoration.

The most severe degree of dye penetration observed on any section of each tooth was recorded. Statistical differences were evaluated by means of the chi-square test.

RESULTS

Dye Penetration

Penetration of the dye at the different groups is presented in Table 2 and Figures 3-5. No or minimal leakage (degrees 0 and 1) was observed in most of the occlusal margins of the "sandwich" restorations and in 77% and 85% of those in groups 3 and 4 respectively. These differences were minimal, and with no statistical significance. Severe penetration of the dye (degree 3) was observed in almost 70% of the cervical margins of the teeth restored with Ketac Silver, with and without a composite coverage (groups 1 & 3), as opposed to 7.5% and 23% of those restored with Miracle Mix (groups 2 & 4). These differences were statistically significant ($P < 0.001$). All the restorations in group 1 leaked at the interface between the composite and the glass-ionomer cement, whereas 38.5% of those in group 2 presented no leakage. This difference was also statistically significant ($P < 0.025$). Representative restorations of the different groups are presented in Figures 6 - 8.

SEM Evaluation of the Margins

The micromorphology of the buccal, lingual, and cervical margins of the restorations was evaluated by SEM, and the results are summarized in Table 2. Adaptation at the buccal and lingual margins was good in all groups,

Table 2. Assessment of Marginal Leakage by Depth of Dye Penetration

Depth of Dye Penetration	Group 1 Ketac Silver Estilux Posterior		Group 2 Miracle Mix Estilux Posterior		Group 3 Ketac Silver		Group 4 Miracle Mix	
Occlusal margin	#	%	#	%	#	%	#	%
0	11	84.6	8	61.5	9	69.2	11	84.6
1	2	15.4	4	30.8	1	7.7	0	0
2	0	0	1	7.7	0	0	1	7.7
3	0	0	0	0	3	23.1	1	7.7
Cervical margin								
0	4	30.7	7	54.0	2	15.4	10	76.9
1	1	7.7	0	0	1	7.7	1	7.7
2	0	0	3	23.0	1	7.7	1	7.7
3	8	61.6	3	23.0	9	69.2	1	7.7
Interface								
0	0	0	5	38.5				
1	6	46.0	5	38.5				
2	6	46.0	3	23.0				
3	1	8	0	0				

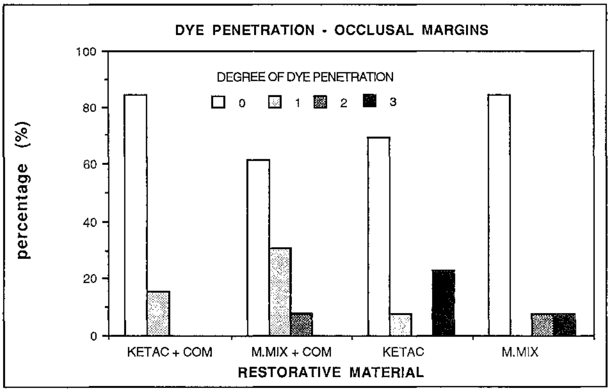


FIG 3. *Bar diagram representing the percentage of restorations with microleakage at the occlusal margins*

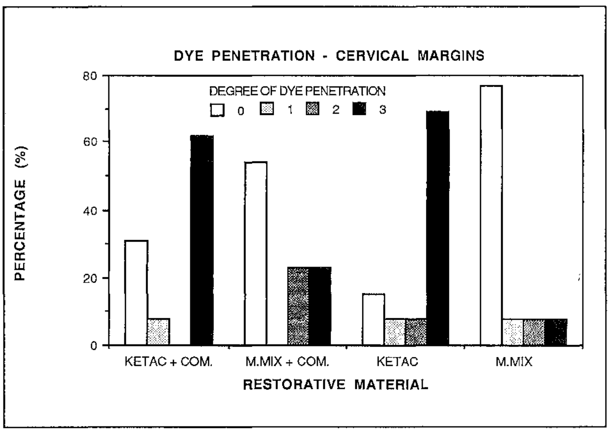


FIG 4. *Graphic representation of the percentage of restorations with microleakage at the cervical margins*

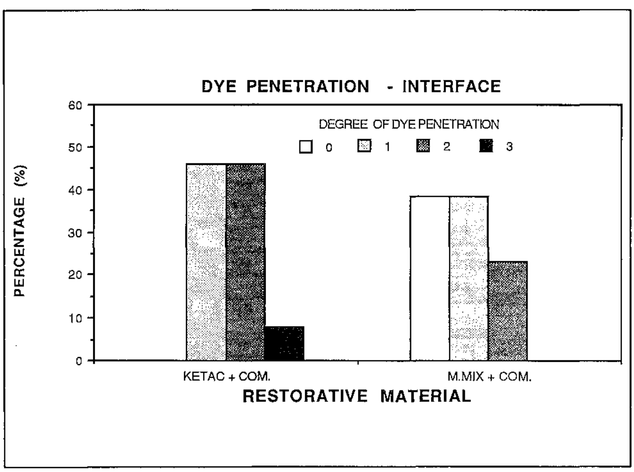


FIG 5. *Degrees of leakage at the interface of the two types of "sandwich" restorations*

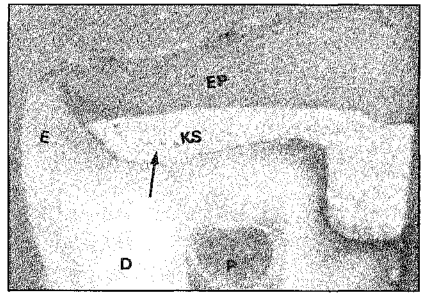


FIG 6. *Longitudinal section of a "sandwich" restoration prepared with Estilux Posterior over Ketac Silver. No leakage is seen at the occlusal margin, while penetration of the dye is evident along the entire length of the cervical wall (degree III). Notice penetration of dye at the interface (degree I) and the presence of porosities (arrow) in the glass ionomer. E = enamel; EP = Estilux Posterior; KS = Ketac Silver; D = dentin; P = pulp.*

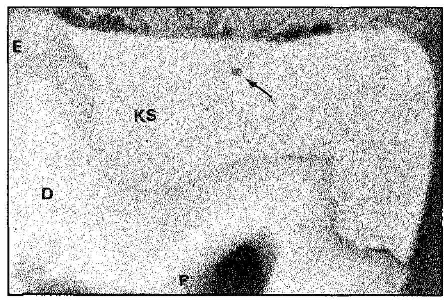


FIG 7. ***Longitudinal section of a Ketac Silver restoration. No leakage is present at the occlusal margin, as opposed to considerable leakage (degree III) that is disclosed at the cervical margin. Porosities (arrow) were a constant finding in this material. E = enamel; KS = Ketac Silver; D= dentin; P= pulp.***

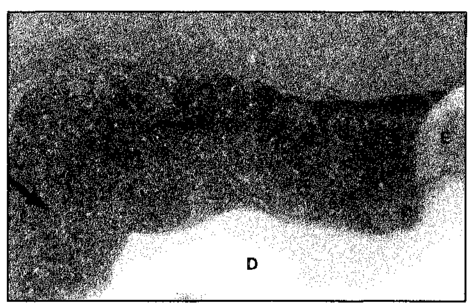


FIG 8. ***Section of a Miracle Mix restoration with no leakage. Notice the rough texture of the mateial, and the presence of cracks (arrow) in the bulk of the restoration. E = enamel; MM = Miracle Mix; D = dentin.***

and no defects were present in 83% of the Ketac Silver restorations (groups 2 & 4). No defects could be found at the cervical margins in 67% of the Miracle Mix restorations (groups 2 & 4), as opposed to 17% of those with Ketac Silver (groups 1 & 3). These differences were statistically significant ($P < 0.025$). No defects were observed at the composite/glass-ionomer interface in all restorations of group 2 ("sandwich" Miracle Mix), as opposed to 17% of those with Ketac Silver and composite. This difference was also of statistical significance ($P < 0.025$). Representative samples of the micromorphology of the margins as observed by SEM are shown in Figures 9 and 10.

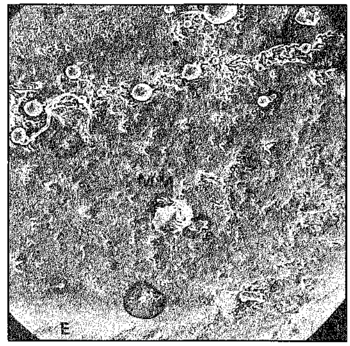


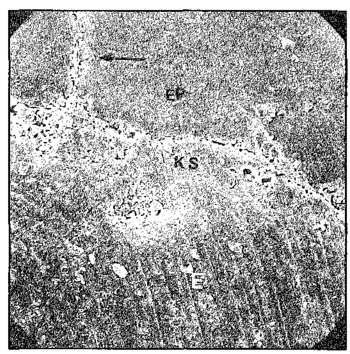
FIG 9. *SEM micrograph of a Miracle Mix "sandwich" restoration demonstrating good adaptation of the material. E = Enamel; MM = Miracle Mix; EP = Estilux Posterior.*

DISCUSSION

Glass-ionomer cements have the capacity to bond to tooth structure and release fluoride (Croll & Philips, 1986; McLean & Gasser, 1985; Swift, 1988). Hicks, Flaitz and Silverstone (1986) found glass-ionomer restorative materials to be resistant to a caries-like attack at the enamel-restoration interface, providing protection against secondary lesion formation. In addition, Retief and others (1984) demonstrated that the fluoride release from the glass-ionomer cement could be found in enamel and cementum 7.5 mm from the restoration margin. These properties could be an asset, and reinforced glass ionomer could eventually be recommended for class 2 restorations, alone or with a posterior composite coverage, to improve esthetics. In the present study, the quality of the margins of these two types of restorations placed with two brands of glass-ionomer-silver cements was assessed. Similarly to the findings discussed in a previous study utilizing the same materials in permanent molars (Hirschfeld & others, 1991), the sealing qualities of Ketac Silver scored better when the cervical margins were placed in enamel, and most of the teeth presented with no or only minimal leakage. In the present experiment, although the gingival step of the cavities was also located in enamel, penetration of dye could be observed in about 30% of the Miracle Mix restorations. These differences could be due either to differences

10A

10B



FIGS 10A & 10B. *SEM micrograph of the adaptation of Ketac Silver in a "sandwich" restoration showing a gap along the entire cervical margin (A), and small gaps and overlap of the material (arrow) at the composite/Ketac Silver interface (B). E = enamel; KS = Ketac Silver; EP = Estilux Posterior.*

in direction of the enamel prisms at the cervical margins between primary and permanent teeth, or to thinner enamel, particularly at these margins, on primary teeth (Guelmann & others, 1989). Gwinnet (1973) described aprismatic etch patterns in surfaces where the prisms do not extend to the surface, as in the cervical margins. He found more and deeper etched pits on surfaces perpendicular to the prism direction than on surfaces parallel to the prism. Another explanation for the superior results observed in permanent teeth could be related to the different bond strength of the materials to dentin. Walls, McCabe and Murray (1988) demonstrated that the bond strength of glass ionomer to deciduous dentin was significantly less than that of permanent dentin. Conversely, the results of Ketac Silver in the present study were better than those described by Guelman and others (1989). Since cavity preparation and restoration techniques employed were identical, these differences could probably be due either to a more severe thermocycling regime, or to a longer etching time in that study. The mentioned authors submitted the restorations to 1000 cycles, as opposed to 250 in the present study. It should be stressed that the marginal micromorphology of these restorations prior to thermocycling compare to the ones in the present study. The glass ionomer was etched for 60 seconds, as clinically recommended at the time that experiment was undertaken. Etching time was 20 seconds in the present study, following the manufacturer's instructions. Joynt and others (1989) demonstrated that the etching time had an effect on surface morphology, and in the adhesion of a posterior composite resin to glass-ionomer cements. They found that a short etching time (30 seconds) produced the strongest bond to resin. This could be another reason for the difference in microleakage observed in the two studies.

Unlike Miracle Mix, which has not been previously employed as a restorative, Ketac Silver was utilized in several clinical studies (Croll, Riesenberger & Miller, 1988; Croll, 1988; Stratmann & others, 1989; Hickel & Voss, 1990; Hung & Richardson, 1990; Forsten & Karjalainen, 1990). The results of these studies were contradictory, leading to different conclusions: while some, like Stratmann and others (1989), Croll and others (1988), Croll (1988), and Hickel, Petschelt and Voss (1989), consider this material to be a possible alternative to amalgam in appropriate conditions, Hung and Richardson (1990) concluded that Ketac Silver was not a suitable material for the restoration of interproximal cavities in primary molars. Hickel and Voss (1990) compared the efficacy of glass-ionomer cermet with amalgam as filling materials in primary molars of children ranging in age from 4 to 10 years. They concluded that since the failure rate of amalgam was lower, it should be preferable for older and cooperative children. In young and/or difficult children, where amalgam cannot be placed under optimal conditions, and the filling has to be finished in a short time, glass ionomer should be preferred. This reasoning is not accepted by our group: alternative behavior-management techniques should be employed not to compromise the quality of the restorations, even for young children.

The effect of glass ionomer on the dental pulp is also controversial. Langeland and Pascon (1986) described inflammatory changes in dental pulps of monkeys after application of glass-ionomer cements to prepared vital dentin. Other investigators (Tobias & others, 1978; Kawahara, Imanishi & Oshima, 1979; Croll & others, 1988) reported that glass ionomers are biocompatible with the dental pulps. Bacterial contamination has been shown to be the main source of pulp inflammation under restorations with leaky margins (Browne & Tobias, 1986). Moreover, Cox and others (1987) demonstrated that pulp exposures healed, and no inflammation was evident under amalgam and silicate fillings placed directly over the pulp and surface-sealed with zinc oxide-eugenol to prevent microleakage. Based on this evidence, several questions arise:

1) Even if glass ionomer is biocompatible and harmless to the pulp, what would be the effect of leakage under these restorations?

2) Could the fluoride released decrease demineralization and prevent further deterioration of the leaky restorations?

3) Could this fluoride penetrate demineralized enamel and promote its remineralization?

4) Would the bactericidal properties of fluoride be sufficient to prevent bacterial penetration through the cavity margins?

CONCLUSIONS

Until questions such as those above can be positively answered, we feel that glass-ionomer cements should not replace amalgam in restorations for primary teeth. Miracle Mix, which presented better results, is difficult to handle, is esthetically poorer than amalgam, and when utilized in "sandwich" restorations could not completely prevent cervical microleakage.

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Placement and Replacement of Amalgam Restorations in Italy

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Summary

The reasons for placement and replacement and the longevity of amalgam restorations were recorded by 62 Italian private practitioners. The survey compiled 1935 amalgam restorations inserted due to primary caries (59%) and failed restorations (41%). The clinical diagnosis of secondary caries constituted 59% of failures of amalgam restorations. The age of 46% of the restorations needing replacement was noted. The median longevity was 4.7 years.

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Introduction

Surveys to elicit the reasons for placement and replacement of restorations have been conducted in many countries. Many of the investigations also include information on the longevity of the restorations that need to be replaced. The proceedings from a recent International Symposium on Criteria for Placement and Replacement of Dental Restorations review the relevant literature on these topics up until 1987 (Anusavice, 1989).

Information on the reasons for placement and replacement of restorations is essential as a basis for the recording of treatment patterns and for the prevention of future failures. Data on longevity of restorations are needed to assess the long-term outcome and cost of restorative dentistry (Kroeze, 1989). Among the many factors affecting the results from such surveys are national differences (Qvist, Thylstrup & Mjör, 1986a,b) and the time when these surveys were conducted (Qvist, Qvist & Mjör, 1990a,b). Therefore, surveys from different countries at different time periods are needed. The present survey was initiated to record the reasons for placement and replacement and the longevity of restorations in Italy, where no such data have previously been published. This report will be limited to amalgam restorations. The data on composite restorations will be published elsewhere (Mjör & Toffenetti, 1992).

Materials and Methods

The same survey forms used in previous investigations (Mjör, 1981) were translated into Italian and distributed to 133 members of the Italian Academy of Operative Dentistry. In addition to the criteria for replacements used before, pain/sensitivity was added to evaluate any differences in clinical behavior between amalgam and composite restorations. Such modifications in survey forms have also been made in other investigations (Klausner & Charbeneau, 1985; Qvist & others, 1986a).

The clinicians were asked to record the reasons for placement or replacement of all restorations in permanent teeth during a two-week period in their practice. If the new restoration replaced a failed restoration, they were also asked to record the reason for the failure. The age of the restoration was recorded only if this information was available in the patient's chart. The following alternative diagnoses for failure of amalgam restorations were listed on the survey forms: secondary (recurrent) caries, poor margins without caries, isthmus (bulk) fracture, fracture of tooth, pain/sensitivity, other reasons.

If more than one reason for failure existed, which is unusual (Mjör, 1979), the clinicians were asked to record only the predominating diagnosis.

Results

Survey forms were returned from 62 clinicians, a response rate of 47%. The distribution of the restorations that were placed is shown in Table 1. Approximately 59% of all amalgam restorations inserted were indicated for the treatment of primary caries. Table 2 summarizes the reasons for failure as diagnosed by the clinicians. Secondary caries, i e, caries directly associated with the original restoration, was by far the most common reason recorded for failure of amalgam restorations. Fracture of tooth, pain/sensitivity, and other reasons were rarely indicated as causes for replacing restorations.

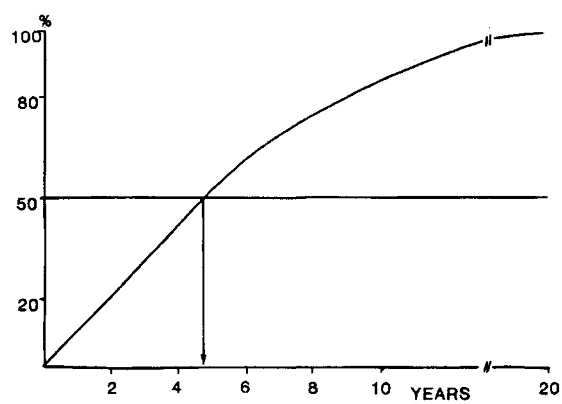
Table 1. Distribution of the Restorations Inserted

Material	Total Number	Primary Caries	Failed Restorations
Amalgam	1935 (65%)	1148 (59%)	787 (41%)
Composite*	1025 (35%)	530 (52%)	495 (48%)
Total	2960 (100%)		

*These restorations will be reported in a separate paper (Mjör & Toffenetti, 1992).

Table 2. Reasons for Failure of Amalgam Restorations in Italy Expressed as Percentages (n = 787)

Category of Failure	%
Secondary caries	59
Poor margins	11
Isthmus fracture	13
Fracture of tooth	7
Pain/sensitivity	3
Other reasons	7



Accumulated percentage distribution of the age of failed amalgam restorations. The point where the horizontal 50% line crosses the curve represents the time on the abscissa when 50% of the failed restorations had been replaced, i e, the median longevity or "half-life."

Information about the age of the failed restorations was retrieved for 360 (46%) of the 787 replaced restorations. The median age of these 360 restorations was 4.7 years (see figure), and about 16% exceeded 10 years of age. The oldest documented amalgam restoration replaced in the present study was 20 years.

Discussion

The response rate in this survey was lower than that reported in some similar studies (Mjör, 1979; Qvist & others, 1986a). The most likely reason for the lower return is that it was not directly associated with the participation in continuing education courses, as was the case in the previous surveys. Similar surveys without such a stimulating impetus have resulted in response rates as low as 31% (Klausner & Charbeneau, 1985) and 21% (Klausner, Green & Charbeneau, 1987), indicating that the selected group of Italian clinicians who participated in an Academy of Operative Dentistry meeting were more engaged in the survey than the average dentists.

The reasons for replacement of amalgam restorations reported in the present study are in remarkable agreement with data published by others, and only 7% were listed as "other reasons," indicating that all main diagnoses had been identified. The majority of surveys on the reasons for failure of amalgam restorations indicates a frequency of secondary caries diagnosis in the 50-60% range (Mjör & Leinfelder, 1985), but lower frequencies have also been reported (Qvist & others, 1986a; Letzel & others, 1989). It is an important diagnosis because it invariably leads to replacement of restorations. Unfortunately, the clinical diagnosis of secondary caries is not a well-defined or a reproducible entity (Rytömaa, Järvinen & Järvinen, 1979; Nuttall & Elderton, 1983; Söderholm, Antonson & Fischlschweiger, 1989). In fact, it has been suggested that this clinical diagnosis is often made whenever the explorer catches within any gap between enamel and a restoration without any verification of the presence of an active carious lesion (Mjör, 1985). However, the general reduction in caries (Hugoson & others, 1983; Qvist & others, 1990a,b) noted in some countries also has a positive effect on the reported levels of secondary caries, which seems to indicate that a significant frequency of recurrent caries is diagnosed accurately.

Poor margins, or "ditching," as a reason for replacement of amalgam restorations is also somewhat subjective, and it has been claimed to be a common reason for overtreatment (Boyd & Richardson, 1985). However, the other reasons for replacment, such as bulk fracture of restoration and fracture of tooth are not subjective per se. Pain/sensitivity was rarely an indication for replacement of amalgam restorations, and it was at about the same frequency as for composite restorations (Mjör & Toffenetti, 1992).

The results from cross-sectional surveys in general practice differ markedly from those obtained in well-controlled longitudinal studies, especially with respect to the frequency of secondary caries (Letzel & others, 1989). Data obtained from studies in dental school environments,where the patient populations often are dental students or dental hygiene students and where specially qualified clinicians without any time restraints work on these selected patients, usually demonstrate little or no recurrent caries. Such data have academic interest in that they show the optimal effects of the treatment provided or materials tested, but they are of limited value for an evaluation of the efficacy of the materials in general practice.

The treatment pattern is different from that reported previously in Scandinavia (Mjör, 1981) and the Netherlands (Kroeze, 1989), where only about 30% of all amalgam restorations inserted in adults are due to primary caries; the rest were replacements of failed restorations. In the present study, 60% of the restorations inserted were due to primary caries, i e, similar to the results reported in the United Kingdom (Nuttall & Elderton, 1983). Such marked differences in treatment patterns probably reflect differences in previous treatment experiences.

The median longevity of 4.7 years for amalgam restorations recorded in the present survey is low in comparison to similar studies. However, these data are comparable to those reported from a study in the United Kingdom (Elderton, 1983). In cross-sectional studies such as the present one, a median restoration age of 7-8 years is commonly recorded (Mjör, Jokstad & Qvist, 1990). There are many factors that can affect the longevity of restorations, e g, the reason for the failure, the dentition, the age of the patient, the patient's oral hygiene, the size of the restoration, the material, and the operator. Furthermore, the clinical diagnoses of failure, and especially of the presence/absence of secondary caries, are subjective.

Conclusions

It is difficult to single out specific reasons for the low median age of the amalgam restoration in this survey, and the possibility for collection bias exists, because the ages of the oldest restorations are most difficult to obtain. Irrespective of the cause(s) for the low median longevity in the present study, further studies should be carried out, with the aim to increase our knowledge to improve the longevity of restorations.

Acknowledgment

The authors would like to thank the Italian Academy of Operative Dentistry for consenting to the distribution of the questionnaires during its 1990 annual meeting.

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Hollenback Prize for 1992

George Hollenback

The Hollenback Memorial Prize for 1992 has been awarded to Marjorie L Swartz, currently Professor Emeritus of Dental Materials at Indiana University School of Dentistry. This award is given annually by the Academy of Operative Dentistry to recognize excellence in research and dedication to the advancement of operative dentistry. Dr George Hollenback was an outstanding clinician and dental researcher. His research involved the application of dental materials to improve the quality of restorative dentistry. Professor Marjorie Swartz has spent a distinguished career in similar pursuits. She is a most deserving recipient of the Hollenback Prize since she embodies dedication and devotion to research and to her many students.

Professor Swartz is an internationally recognized researcher, leader, and teacher in dental materials. She was born 1 February 1924 in Indianapolis. After high school she matriculated at Butler University, graduating in 1946 with a BS in chemistry. Indiana University School of Dentistry then offered her an appointment as an assistant in the Dental Materials Department, a position she held until 1953, when she was appointed an instructor in dental materials. In 1959 she was promoted to assistant professor in dental materials, and progressed to associate professor in 1964. She became professor in dental materials in 1969, and served as chairperson for the Department of Dental Materials at Indiana from 1988 through 1990.

During her years at Indiana, she has influenced many lives. The faculty, staff, and students love and admire Professor Swartz. She has the unique ability to make dental materials research interesting, entertaining, and even fun. Her enthusiastic interaction with students has fostered new generations of dental researchers who might otherwise have thought of research as drudgery.

The dental community knows of Professor Swartz's academic and research abilities. However, at Indiana University, she is equally honored for her understanding, empathy, and compassion. She served for many years as chairperson for the Second-Year Student Promotions Committee and has been involved in more graduate student committees than she would probably care to admit. During this time she has never been too busy to listen to problems, offer help, give sound advice, and occasionally deliver a well-deserved and well-intentioned "kick in the rear." Her colleagues have frequently joked that she needs a sign like Lucy's saying "The Psychiatrist is IN" to hang on her office door.

Her academic accomplishments are exemplified by her numerous appointments and professional consultantships. She has held appointments with NIDR-NIH; the American National Standards Committee; the National Board of Test Constructors of the ADA; the Naval Postgraduate School at Bethesda, MD; the Veterans Administration; and other organizations.

Professor Swartz is a member of the IADR, the ADA, and the American Chemical Society. She has served as chair of the Indiana Section of the AADR, is a past president of the Theta Theta Chapter of Omicron Kappa Upsilon, and belongs to numerous other organizations.

She has previously received many professional honors including the Wilmer Souder Award for research in dental materials, honorary memberships in the American Association of Women Dentists, and the International College of Dentists. She is an honorary fellow of the American College of Dentists, and received the Award of Excellence in Research from Indiana University School of Dentistry.

Marjorie L Swartz

She has published over 130 scientific articles in the field of dental materials and served as co-investigator with the late Dr Ralph Phillips on a number of NIH grants. She co-authored the textbook *Materials for the Practicing Dentist*, and she has honored us by teaching before the Academy of Operative Dentistry on several occasions.

Professor Marjorie L Swartz has served dentistry well over the past 46 years. We each make daily treatment decisions based on her research. It is an honor for the Academy of Operative Dentistry to present the Hollenback Prize for 1992 to such a distinguished researcher, teacher, and outstanding humanitarian.

MAXWELL H ANDERSON

DEPARTMENTS

Table Clinic Abstracts

From the 1992 Annual Meeting of the Academy of Operative Dentistry

Interproximal Finishing of Esthetic Restorations

With the ever-increasing clinical use of esthetic restorative materials for both the anterior and posterior region, one area that has remained problematic is the finishing and polishing of the gingival interproximal margin. Although accessible margins on the occlusal, facial gingival, and lingual gingival are easily finished and polished with diamonds, finishing burs, and rubber abrasive points, the interproximal gingival margin is more difficult to manage.

Several instruments have been introduced to manage the finishing and polishing of gingival margins. These instruments include a reciprocating action handpiece, the Profin (Weissman Technology International, Inc, New York, NY 10016), that provides a back-and-forth motion to a thin, flat tip that fits into the head of the handpiece; hand instruments that allow for fine control with effective removal of excess composite resin at the gingival margins of anterior and posterior restorations, including the Esthetic Carving Knives CR20 and CR21 (Hu-Friedy, Chicago, IL 60618); and carbide steel-tipped anterior composite resin carvers that come in a wide variety of shapes. There are times that the composite resin flows between adjacent teeth, literally bonding them together. How do you get these teeth apart without ruining the restorations you just placed? When this happens you can saw these teeth apart using an ultrathin stainless steel saw, either the CeriSaw (Den-Mat Corp, Santa Maria, CA 93456), a mini-hacksaw handle and blade, or the Horico saw (Pfingst & Co Inc, So Plainfield, NJ 07080).

Another aid to help get through the interproximal contact to have access for placement of a matrix strip or an interproximal finishing strip is the Contact Disc (Centrix Inc, Milford, CT 06460 or Den-Mat Corp). This thin, rigid stainless steel disc has a handle and can be inserted from the incisal or occlusal surface to force the teeth apart using rapid orthodontic separation. ESPE-Premier (Norristown, PA 19404) has developed a disc that provides the benefits of the Contact Disc with the presence of fine-grit diamond abrasive. The CompoDisc allows for access between teeth and the ability to finish the interproximal margin at the same time.

As more restorations with bonded, esthetic restorative materials are placed, the gingival margin will continue to be a challenge to contour and finish to maintain periodontal health and reduce recurrent caries.

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The Pros and Cons of Thermafil: An Endodontist's Perspective

Thermafil™ is a relatively new concept in endodontics that uses a flexible carrier (stainless steel, titanium, or plastic) to deliver and condense an "alpha-phase" gutta-percha into a canal. The carrier subsequently becomes a component of the obturation. Alpha-phase gutta-percha, in contrast to "beta-phase" or conventional gutta-percha, plasticizes more readily upon heating and becomes tackier, thus enabling the material to adhere to and fill the canal three-dimensionally. After proper heating in a specially designed oven and a slow-setting sealer has been introduced into the canal, a Thermafil™ obturator corresponding to the master apical file size is inserted with firm apical pressure (without rotation) to the desired length. The handle is removed with either heat (plastic only) or a bur so that 1-2 mm of carrier protrudes above the canal orifice. A small plugger is then used to vertically condense the gutta-percha around the shaft. If post space is desired, a plastic obturator is recommended over a metal one; removal of the carrier/gutta-percha to the desired level can be accomplished with either a peeso drill or heat.

Thermafil™ appears to be a quick, relatively simple way to fill root canals; however, *the success of the technique is predicated upon proper cleaning and shaping of the canal, strict adherence to the manufacturer's instructions, and practicing the technique prior to clinical use.* Although there have been a number of studies supporting its clinical efficacy, antibacterial properties, and sealability, more research including evaluation of solvency and biocompatibility of plastic carriers as well as long-term sealability will be necessary to support its use as a primary method for obturating root canal systems.

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Resin-bonded Porcelain Restorations: A Comparison of the Wear Resistance of Different Composite Resin Luting Agents

A comparison of the wear resistance of five different dual-cured composite resin luting agents was made using a three-body wear machine.

The composite samples were mixed according to manufacturer's instructions, light-cured, and then subjected to 250 000 wear cycles. The amount of wear was measured by a profilometer and the results were significantly different (One-factor ANOVA with multiple comparisons; $P = 0.000$) between all materials. The mean wear in microns for each material is as follows: Cosmedent Insure™, 17.75 $\pm$ 0.75; Vivadent Dual-Cement™, 24.15 $\pm$ 2.25; Kerr Porcelite Dual Cure™, 27.41 $\pm$ 1.42; Jeneric Pentron Optec™, 33.67 $\pm$ 0.77, and Myrons Mirage FLC™, 41.70 $\pm$ 1.23. This *in vitro* data, considered along with other physical properties, may be useful for assisting the clinician in the selection of different materials.

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Current Trends in Replacement of Amalgam and Composite Restorations

Fifty members of the Academy of Operative Dentistry, selected at random, agreed to in-office data collection of replacement of amalgam and composite restorations. Each practitioner received 50 forms for both amalgam and composite restorations, and 3177 usable data collection forms were returned: 1467 composite forms, and 1710 amalgam forms.

The descriptive findings of the study included: 53% of the study participants were male and 47% were female; 65% of the participants were ages 21-60; amalgam was used primarily in class 1 and class 2 situations, and composite was used primarily in class 3, 4, and 5 situations. The percentage of current amalgam restorations replaced with amalgam restorations was 91, and 91% of composite restorations were replaced with composite restorations; for both amalgam and composite replacement, the primary reason was recurrent caries. Of 330 cases reporting exact amalgam age, the mean was 11.95 years with a standard deviation of 8.11 years. Of 285 cases reporting exact composite age, the mean was 7.02 years with a standard deviation of 6.25 years.

Many amalgam forms were returned with the "unknown" age column marked as 20-30+ years. The authors believe this was based on patient memory and was not included in the descriptive data. However, this points out that the study of replacement restorations is not the best method to determine longevity, and further studies need to be undertaken.

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Photoelastic Analysis of the Stresses Produced by Various Designs of Self-threading Retention Pins

This table clinic presented a laboratory study in which six self-threading retention pins were evaluated using the two-dimensional photoelastic technique. The experimental samples consisted of 60 blocks of PSM-1 photoelastic material measuring 1"x1"x1/4". The samples were divided into six groups of 10 blocks each, with each group representing one of the pins used in the study. Pins were inserted and cores of amalgam and composite were fabricated over the pins. The samples were observed in the polariscope and photographed after pin insertion and after loading the cores with a constant, compressive force of 20 pounds. Using magnification, fringe orders were counted and rounded to the highest 0.5 fringe order. Each sample was evaluated for apical and shoulder stress. All statistical analyses were done using ANOVA at the $P = 0.05$ significance level. It was concluded from this study that the insertion of self-threading retention pins results in stress at the apical and shoulder areas of the pin. Pin design features, such as shoulder stops, significantly affect the magnitude and location of stress. There were no significant differences in either the apical or shoulder stresses induced when cores were made of either amalgam or composite resin.

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"The views expressed in this abstract are those of the author and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the US Government."

A Method for Placing Self-threading Pins and Implants in Difficult Areas

An instrument that was designed for self-threading pins and implants in hard-to-reach areas was demonstrated. The instrument consists of a hand driver, approximately five inches long, which is permanently fastened to a latch-type, slow-speed contra-angle. Pin replacement wrenches and implant seating tools have been designed to fit in the contra-angle, and when the driver is rotated by hand, the pin or implant screw is rotated at the same speed. The demonstration included the method for placing Whaledent TMS and Link-type pins. Also shown were Hex and screw-driver-type seating tools for use in placing various fixtures to implants. Use of this instrument eliminates the danger of dropping a hand wrench and still provides the operator with the same tactile sense as the hand wrench. This "EZ Place Driver" instrument is manufactured and marketed by the Whip Mix Corporation, Louisville, KY 40217.

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Posture and Its Relationship to Efficient Dentistry

This study was designed to investigate the role that posture plays in efficiency and skill in performance.

A pilot study was initiated using a chair design that emphasized proper posture during task performance. Three secretaries were asked to type for five minutes in a conventional chair. The electromyographic activity (EMG) of the upper trapezius muscles was recorded at one minute and five minutes. This exercise was repeated using an experimental chair that emphasized correct posture. Without exception subjects using the experimental chair elicited less activity of the right and left upper trapezius muscles.

Further study will be initiated to ascertain the feasibility of a chair design that can improve dental efficiency.

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Evaluation of Gingival Gaps Using Clearfil CR Inlay Material

Gingival marginal accuracy was measured after light- and heat-curing and storage in water for 24 hours on a steel die (D), on a stone impression (IN), and after gingival marginal readaptation, light- and heat-curing (IR). Using two-factor ANOVA, direct placement was most accurate after light-curing ($P = 0.0017$), producing inlays meeting Leinfelder's criteria that a gingival gap was desirable if less than 75 microns. After readapting, IR was not different from D ($P = 0.0001$) nor after 24-hour water storage ($P = 0.0002$). If contours and contact can be adequately controlled, the direct method is recommended. If an indirect method is used, it is recommended that the laboratory use an additional cured layer of composite material at the gingival margin after initial curing to minimize the gaps.

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Book Reviews

RISK MARKERS FOR ORAL DISEASES VOLUME I, DENTAL CARIES

Edited by N W Johnson

Published by Cambridge University Press, New York, 1991. 507 pages. $100.00.

This is the first volume of a three-volume set. The other two volumes cover the topics of oral cancer and periodontal diseases. The purpose of the book is to characterize caries at-risk patients and to define the markers by which they can be identified and treated. It does not meet these goals.

The book is divided into three parts. Part 1 provides the background evidence for the existence of caries high-risk groups and individuals, and the global epidemiology of caries. Part 2 examines the methods for detection of high- and low-risk caries groups and individuals. Part 3 looks at the practical applications of the caries knowledge.

The book is of primary interest to researchers and teachers. The volume is well referenced and authored. Individual contributors are generally well versed in their topic areas. About one-third of the book is devoted to the demographics of caries. Half of the text concerns predictions of high- and low-risk groups and individuals. The final one-fifth speaks to the application of the previous material.

With the exception of a clearer understanding of the caries infection and process, there is little to recommend this volume to the private practitioner, but it is recommended for dental schools and preventive dentistry and public health dentistry department libraries.

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ANATOMICAL ATLAS OF THE TEMPOROMANDIBULAR JOINT

Y Ide and K Nakazawa

Published by Quintessence Publishing Company, Chicago, 1991. 116 pages, 95 color illustrations. $142.00.

Until recently, a definitive text on the anatomy of the TMJ was badly needed. Quintessence may have rushed to fill the void. According to the authors, this book "attempts to visually represent and explain the structure and functions of the temporomandibular joint through minute illustrations, so the joint can be understood as a three-dimensional image." It also "explains the muscular and nervous systems associated with mastication." Barely.

Visually, the exquisite airbrush and pen renderings by Kamimura convey a remarkable sense of depth. The artist projects vignettes of the joint complex from unusual aspects that reveal important components in a graphically satisfying way. By the creative use of vellum overlay, he dramatically presents the arterial circulation of the head, though he is less effective with other overlays. In my opinion, his anatomic artistry transcends that of the venerable Frank Netter, MD.

Unfortunately, the supporting text is not commensurate with the illustrations, nor does it support the authors' objectives. The English translation is often stilted and is plagued with typographical errors. Most of the descriptions of form and function are simplistic, with inadequate reference to pertinent literature. For instance, the authors fail to separate the superior from the inferior lateral pterygoid muscle when discussing innervation and function. In addition, they stray from the TMJ all the way to the shoulder in pursuit of musculature, yet fail to depict the posterior attachment apparatus in the glenoid fossa. After mentioning the ear as part of embryonic joint derivation in an early chapter, they later ignore the functional importance of petrotympanic communication between the fossa and the middle ear. These misconceptions and oversights detract significantly from the book's impact.

In summary, this eye-catching text is not a definitive work on the TMJ. Though the graphics are excellent, they are not comprehensive. The text is inadequate to fulfill the authors' objectives and, in the case of innervation for the lateral pterygoid muscle, frankly misleading. Even for predoctoral students, this presentation is too simplistic to fill the void in TMJ anatomy texts.

Reviewer's note: The void may have been filled in 1990 by Norman, J E de B and Bramley, P, eds, *Textbook and Color Atlas of the Temporomandibular Joint*, Year Book Medical Publishers, Inc, Chicago, 1990. This is an exhaustive text.

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