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

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EDITORIAL

Operative Instruction–Adequate or Not?

During the past decade or so, in many dental schools, the time allocated to teaching operative dentistry has been reduced—in some instances, drastically. Curriculum committees and school administrators have made the reduction, on the one hand to introduce new subjects, such as community dentistry, into the curriculum and, on the other hand, in the belief that the discipline of operative dentistry is now less important to dentists because soon most of it will be provided by dental auxiliaries. Departments of operative dentistry have tried to compensate for less teaching time by teaching more efficiently, by eliminating some exercises from the preclinical program, by accepting less clinical experience, and by resorting to witchcraft. The product of these changes is now on display.

Few accolades, if any, have greeted the results. On the contrary, most appraisals of the competence of recent graduates indicate they are not as well trained as formerly. These observations have come from practicing dentists, from members of departments of operative dentistry, and from examiners for dental licenses—all of whom are admirably situated to observe trends in clinical competence. "Not so," say curriculum planners and administrators, "you give us opinions only, not hard evidence. When you have quantitative data we shall be willing to listen to you." It should be noted, however, that no such data were required by the curriculum planners when they decided to reduce the time for operative dentistry.

Assessing clinical competence in operative dentistry is a complex task. Standardized quantitative methods of evaluation typically have not been used, so little quantitative data are available for purposes of comparison. The absence of quantitative data, however, does not mean that useful qualitative distinctions cannot be made. It all depends upon the level of precision required. For example, it is perfectly valid to stand at the North Pole and, without referring to a thermometer, state, "It is colder here than it is in Seattle." Our senses are adequate for making this distinction. On the other hand, the temperature of a water bath used for the hygroscopic expansion of inlay investment must be held constant within a degree or two or the casting will be inaccurate. For the water bath, then, a thermometer is needed. Thus, depending on the precision required, qualitative judgments may be entirely satisfactory. They may be, in fact, the only means of evaluation available.

To complicate matters, many of our decisions have to be made on the basis of incomplete information. This is because the information may not be readily available, may be impossible to obtain, or may involve excessive costs of time, effort, and other resources. We must assess the relevance of each bit of information at hand and, relying on experience, try to reach the best decision. The absence of quantitative information does not absolve us from using what qualitative information is available.

For the sake of those of the public that require dental treatment, and for the sake of the students, who are not getting their money's worth in dental education, curriculum planners and administrators would be wise to heed the opinions of dentists that know most about the quality of clinical operative dentistry and to give back to operative dentistry the curriculum time it has lost, even if, as a consequence, it means that graduates will be less skilled in examining ears and taking blood pressures. No time should be lost in deciding on the restoration, given the glacial speeds with which universities usually operate—except, of course, for bad policies; they can be instituted immediately.

A. IAN HAMILTON

OPERATIVE DENTISTRY, 1976, 1, 130-136.

ORIGINAL ARTICLES

Fracture of Enamel Walls by Composite Resin Restorations Following Acid Etching

J. C. MITCHEM • E. D. GRANUM

Composite resins adapted to enamel margins that have been etched tend to fracture the enamel when the resin shrinks. Fracturing can be reduced or eliminated, at least in the laboratory, by delaying the finishing for two days.

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A number of authors have concluded that etching enamel walls of intracoronal cavities prior to placing resins enhances adaptation and greatly reduces marginal leakage (Aubuchon, 1973; Buonocore, Sheykholeslam & Glena, 1973; Forsten, 1975; Hembree & Andrews, 1976a, 1976b; Ortiz *et al.,* 1976) or eliminates it (Brose *et al.,* 1975; Dogon & Henry, 1975; Retief, 1973). These results have led many investigators to recommend (directly or indirectly) routine etching of all enamel walls prior to placing resin restorations (Adipranoto, Beech & Hardwick, 1975; Barnes, 1975; Council on Dental Materials and Devices, 1976; Dogon & Henry, 1975; Eames, O'Neal & Rogers, 1976; Forsten, 1975; Jorgensen & Shimokobe, 1975; Kopel, Grenoble & Kaplan, 1975; Lee, Phillips & Swartz, 1971; Meurman, Aiskainen & Nevaste, 1975; Phillips, 1973, 1976; Retief, 1973). However, Jorgensen, Asmussen & Shimokobe (1975) have shown that etching so effectively bonds the resin to the enamel walls of Class V cavities that subsequent strains, resulting from polymerization contraction, thermal contraction, and elastic hysteresis, fracture the enamel surrounding the cavity. The results led the authors of that study to conclude that "it seems questionable whether further studies on bonding resin restorations to the *axial* surface of the enamel rods are motivated." The purpose of this study is to evaluate further this phenomenon, using different systems of composite resins and conditions of manipulation.

Methods and Materials

Flat surfaces were prepared on the enamel of human teeth that had been recently extracted and hydrated. The teeth were then mounted in plastic rings with cold cured acrylic so that the flattened surface was parallel and flush with one side of the ring. Round Class V cavities (2.5 mm diameter × 1.2 mm deep) were prepared within the flattened surface with a 170 straight fissure bur in a high-speed handpiece with ample water coolant. The base of the cavity was undercut with a 35 inverted cone bur. The cavosurface margin was kept as close as possible to 90°. After cleaning, the cavities were examined under 13x magnification to determine the condition and integrity of the margins and record the depth of the enamel walls at four locations around the cavity; mean depth ($\bar{X}$) was 0.64 mm. All teeth, before and after mounting, were stored in water at 23°C prior to use.

Four systems of composite resin were used. These systems were selected for the composition of their resin component. The basis for this criterion was suggested by Asmussen (1975b) where he demonstrated a correlation between the amount of diluent resin used in a specific product and the degree of separation, caused by polymerization contraction, between the restoration and the dentin wall of the cavity. Table 1 lists the composite resins, their manufacturer, and the composition of their resin components, according to Asmussen (1975a).

Four methods of placement were used: (1) no etch with immediate finish (15 minutes following placement); (2) etch, with immediate finish; (3) etch, plus use of an intermediary of low viscosity resin (Adaptic bonding agent with Adaptic, and Concise enamel bond system with the remaining composites), with immediate finish; and (4) etch, plus use of an intermediary of low viscosity resin (same as in 3) with a delayed finish (two days following storage in water at 37°C). The latter method was included in light of the work of Asmussen & Jorgensen (1971, 1972), demonstrating that delaying the finishing of composite restorations in which the enamel had not been etched produced better marginal adaptation. They explain that water sorption produces an expansion which partly or completely closes the gap caused by polymerization contraction, thus providing support for the enamel margins during finishing. Etching was performed with 37% phosphoric acid for one minute. Approximately 1 to 2 mm of the surrounding enamel surface were also etched. All restorations were placed within 30 seconds after mixing (the intermediary of low viscosity resin was placed within 10 seconds after mixing). The cavities were overfilled, covered with a mylar strip, and allowed to set for 15 minutes under a load of 65 gm at 23°C. Each material and condition was replicated eight times for a total of 128 restorations.

All restorations were finished (polished) in the same manner, the final surface being produced with 3μm diamond polishing compound. The margins were then observed under a light microscope (Olympus Vanox M) at a magnification of 200x, and the presence and magnitude of marginal separation and enamel cracking recorded for each sample. Observations were made immediately after finishing and at two days, one week, and two weeks. The latter samples were stored in water at 37°C. The delayed observations were essentially the same as the immediate in terms of the presence or absence of marginal separation and enamel cracking. The results of this study are compiled from the observations made immediately after polishing.

A random selection of restorations from each method (minimum of eight) was evaluated for leakage after water storage at 37°C for a minimum of two weeks. The samples were cycled in a solution of 0.25% methyl violet between temperatures of 2° and 50°C for 30 minutes with a dwell of one minute at each temperature. Leakage was assessed by evaluating the penetration of dye in sectioned samples and assigning a number depending on the degree of penetration (0 = no leakage; 1 = slight, no more than halfway to the dentinoenamel junction; 2 = to dentinoenamel junction; 3 = to base of cavity; and 4 = into dentinal tubules).

Results and Discussion

The results are tabulated in Table 2. Each value indicates the number of restorations (out of a total of eight) in that category, demonstrating enamel cracking or marginal separation. The presence or absence of cracking and separation were recorded—not the extent cir-

Table 1. *Materials and Composition*

Material	Manufacturer	Batch No.	Composition of Resin Component: % BIS-GMA	Composition of Resin Component: % Diluent Resin
Adaptic	Johnson & Johnson Dental Products Co., East Windsor, NJ 08520 U.S.A.	4B010	65	35
Concise	3M Company, Dental Products, St. Paul, MN 55101, U.S.A.	5210A9	64	36
Concise Cap-C-Ringe	3M Company, Dental Products, St. Paul, MN 55101, U.S.A.	53141	53	47
Prestige	Lee Pharmaceuticals, South El Monte, CA 91733, U.S.A.	HPRO103 HPRO104	43	57

Table 2. *Cracking and Marginal Separation*

Methods	Observation	Material: Adaptic	Concise	Cap-C-Ringe	Prestige
I. No etch	Cracking	3	4	1	0
	Marginal separation	6	8	8	8
II. Etch	Cracking	3	2	6	6
	Marginal separation	4	3	5	7
III. Etch + low-viscosity resin	Cracking	8	5	6	8
	Marginal separation	4	1	3	5
IV. Etch + low-viscosity resin & delayed finish	Cracking	0	1	0	1
	Marginal separation	1	1	2	5

Table 3. *Magnitude of Cracking and Separation*

Material	Cracking µm			Marginal Separation µm		
	Mean X		Standard Deviation Sx̄	Mean X		Standard Deviation Sx̄
Concise	5.5	±	0.6	6.5	±	1.4
Prestige	15.2	±	1.0	15.5	±	1.8

cumferentially. Figure 1 contains representative photographs of the marginal conditions recorded. Figure 2 illustrates the variation in extent of the enamel cracks when viewed in cross section. Figures 3 and 4 graphically illustrate the effects of materials and methods of placing on enamel cracking and marginal separation. The data were tested by analysis of variance and Tukey's least significant range test. Equal values are connected with horizontal lines. Table 3 contains the data for the magnitude of cracking and marginal separation in two of the systems included in this study. Adaptic and Concise Cap-C-Ringe had values approximating that of Concise.

In evaluating leakage, the restorations were sectioned and an attempt made to remove the restoration in order to assess the entire marginal area. In doing this the restorations placed into nonetched cavities separated very easily from the enamel wall. The restorations placed into etched cavities always separated with difficulty and many of those in which an intermediary of low viscosity resin had been used carried away portions of the enamel wall during removal. The results found in this study confirm numerous previous reports that acid etching reduces the incidence and magnitude of marginal leakage. All nonetched cavities demonstrated leakage to the dentinoenamel junction or beyond. The acid-etched cavities in which the resin was finished immediately showed occasional leakage in the enamel region only, explained by the presence of marginal separation or cracks in the enamel. No leakage was seen in those restorations which were acid etched and for which the finishing process was delayed, as described previously, and no marginal discrepancy occurred.

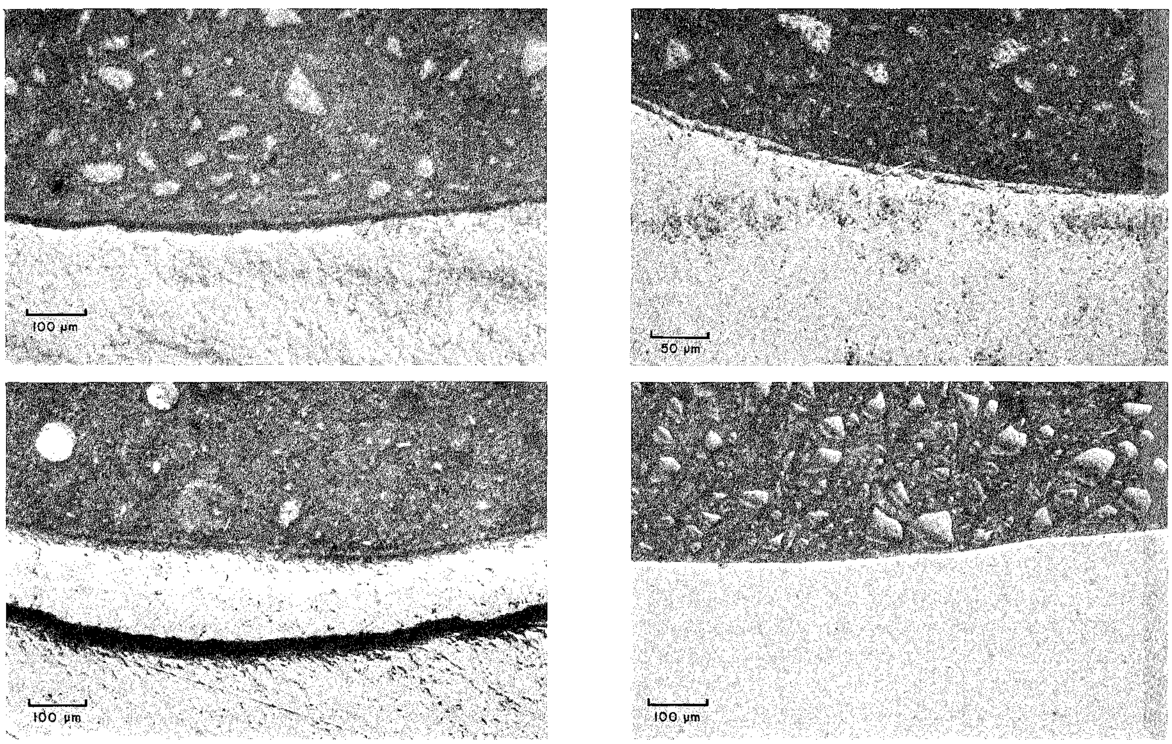
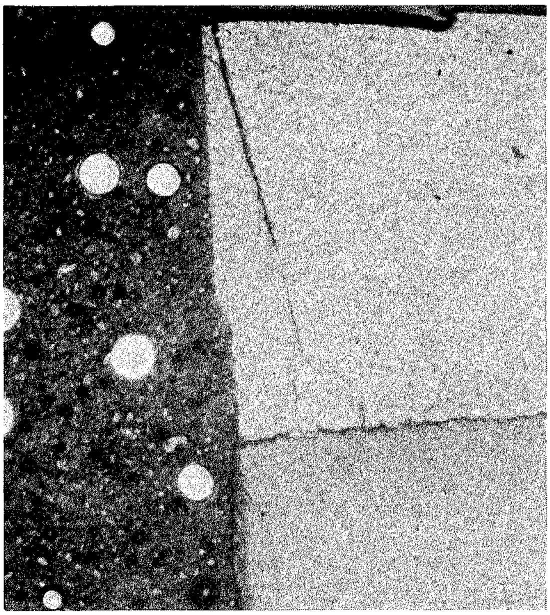


FIG. 1. Marginal conditions (composite resin above, enamel below); above left, marginal separation; above right, low magnitude enamel cracking; below left, high magnitude enamel cracking; below right, close adaptation.



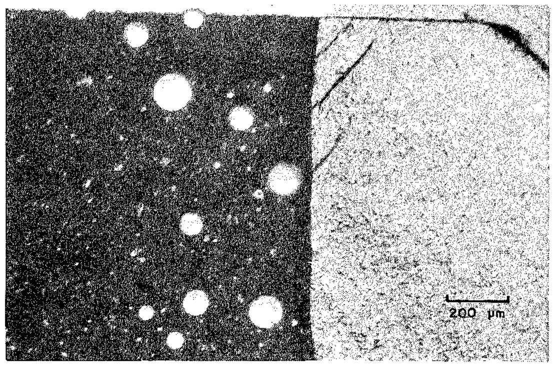


FIG. 2. Cross sections of enamel cracking (composite resin on left, enamel on right). At 100 μm (photo at left), and above at 200 μm.

As a result of this information and of that of previously published reports, we have concluded that: (1) the most amount of damage to enamel walls is produced by etching and finishing the restorations immediately after setting; (2) the least amount of damage to enamel walls that have been etched results from delaying the final finishing procedure, which has allowed the residual stresses resulting from polymerization contraction to be reduced by water sorption; (3) maximum separation between the restoration and cavity wall occurs when no etch has been used; (4) minimum separation occurs with the use of etching (and probably with an intermediary of low-viscosity resin); (5) Prestige produces the most marginal separation under all conditions evaluated in this study.

It is interesting to note that the presence of marginal separation and enamel cracking did not change significantly over the observation period of two weeks used in this study. A random check of remaining restorations which had been stored in water at 37°C for as long as six months still showed cracking and marginal separation. Evidently the subsequent expansion of the restoration by water sorption is not enough to close completely the gaps created by polymerization shrinkage in the resin systems used in this study. On the other hand, in three of the four resins evaluated, the expansion caused by water absorption appears to be sufficient to prevent the restoration from pulling away from the etched enamel or cracking the enamel wall.

It appears from this study and that of Asmussen (1975b) that the amount of diluent resin present in a composite, especially when in excess of 50% of the resin component, may have a significantly adverse clinical effect.

The clinical significance of these findings will, of course, have to await clinical evaluation; now we can only surmise that delaying the finishing of an acid-etched, intracoronal restoration will give a superior clinical result.

Summary

Fracture of the marginal enamel occurs when the walls of an intracoronal cavity preparation are etched and the restoration is finished immediately after setting. This fracturing can be greatly reduced or eliminated by delaying the finishing (until the next appointment), which evidently allows the expansion caused by water absorption to reduce the stresses created by polymerization contraction. One composite evaluated, Prestige, which contains a high percentage of diluent resin (57%), produced significantly more enamel fracture and marginal separation.

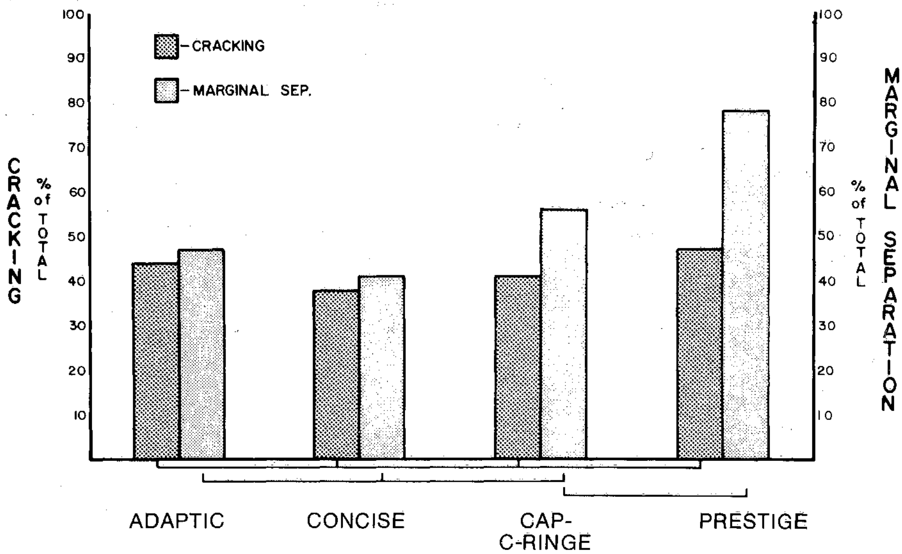


FIG. 3. Effect of material on enamel cracking and marginal separation.

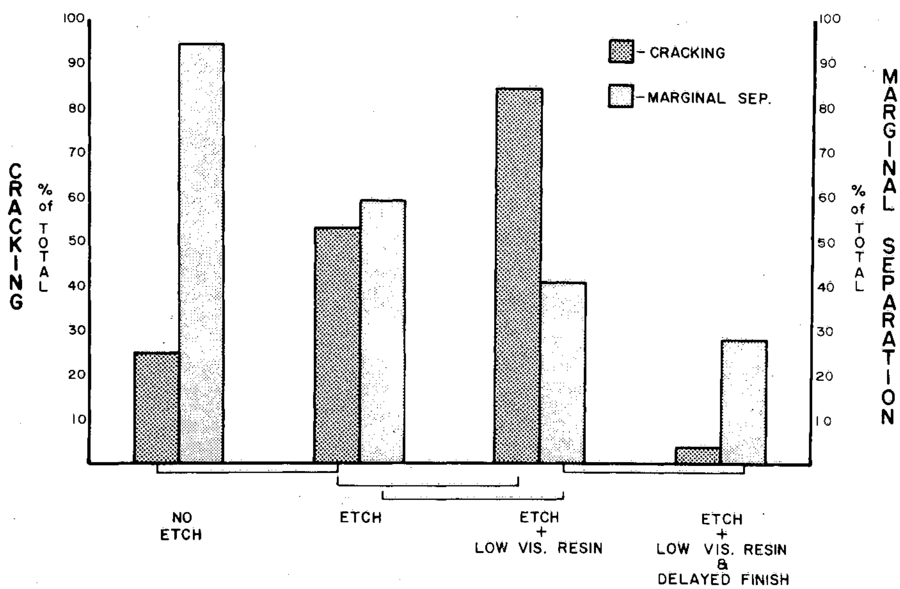


FIG. 4. Effect of method of placement on enamel cracking and marginal separation.

REFERENCES

Adipranoto, S., Beech, D. R. & Hardwick, J. L. (1975) Effect of pretreatment of enamel on bonding to composite restorative materials. *Journal of Dental Research,* **54,** *Special Issue A, Program and Abstracts of Papers,* Abstract No. L354, p. L89.

Asmussen, E. (1975a) NMR-analysis of monomers in restorative resins. *Acta Odontologica Scandinavica* **33,** 129-134.

Asmussen, E. (1975b) Composite restorative resins: Composition versus wall-to-wall polymerization contraction. *Acta Odontologica Scandinavica,* **33,** 337-344.

Asmussen, E. & Jorgensen, K. D. (1971) Adaptation of some plastic filling materials. *Tandlaegebladet,* **75,** 365-382.

Asmussen, E. & Jorgensen, K. D. (1972) A microscopic investigation of the adaptation of some plastic filling materials to dental cavity walls. *Acta Odontologica Scandinavica,* **30,**3-21.

Aubuchon, R. W. (1973) A laboratory comparison of the adhesion of unfilled and composite resins to acid etched enamel. A thesis. Indiana University School of Dentistry.

Barnes, I. E. (1975) The marginal adaptation of composite resins: An investigation using the scanning electron microscope. *Proceedings of the International Symposium on Amalgam and Tooth-coloured Restorative Materials.* Ed. Van Amerongen, A.J., Dippel, H.W., Spanauf, A.J. & Vrijhoef, M.M.A. Abstract No. 309, p. B136. Nijmegen: University of Nijmegen Dental School.

Brose, J., Cooley, R., Moser, J. B., Marshall, G. W. & Greener, E. H. (1975) In vitro bond strength of repaired fractured incisors. *Journal of Dental Research,* **54,** *Special Issue A, Program and Abstracts of Papers,* Abstract No. L355, p. L89.

Buonocore, M. G., Sheykholeslam, Z. & Glena, R. (1973) Evaluation of an enamel adhesive to prevent marginal leakage: An in vitro study. *Journal of Dentistry for Children,* **40,** 35-43.

Council on Dental Materials and Devices (1976) Composite restorative materials: Some clinical suggestions for their use. *Journal of the American Dental Association,* **92,** 606-607.

Dogon, I. L. & Henry, P. (1975) Calcium 45 penetration and scanning electron microscopy study of the acid etch system. *Journal of Dental Research,* **54,** *Special Issue A, Program and Abstracts of Papers,* Abstract No. 19, p. 49.

Eames, W. B., O'Neal, S. J. & Rogers, L. B. (1976) Composite plain talk. *Journal of the American Dental Association,* **92,** 550-554.

Forsten, L. (1975) Effect of acid etching on the marginal seal of composites. *Proceedings of the International Symposium on Amalgam and Tooth-coloured Restorative Materials.* Ed. Van Amerongen, A.J., Dippel, H.W., Spanauf, A.J. & Vrijhoef, M.M.A. Abstract No. 11, p. 157. Nijmegen: University of Nijmegen Dental School.

Hembree, J. H., Jr. & Andrews, J. T. (1976a) In vitro microleakage of several acid-etch composite systems. *Journal of Dental Research,* **55,** *Special Issue B, Program and Abstracts of Papers,* Abstract No. 309, p. B136.

Hembree, J. H., Jr. & Andrews, J. T. (1976b) In situ evaluation of marginal leakage using an ultraviolet-light-activated resin system. *Journal of the American Dental Association,* **92,** 414-418.

Jorgensen, K. D. & Shimokobe, H. (1975) Adaptation of resinous restorative materials to acid etched enamel surfaces. *Scandinavian Journal of Dental Research,* **83,** 31-36.

Jorgensen, K. D., Asmussen, E. & Shimokobe, H. (1975) Enamel damage caused by contracting restorative resins. *Scandinavian Journal of Dental Research,* **83,** 120-122.

Kopel, H. M., Grenoble, D. E. & Kaplan, C. (1975) The effect of cavosurface treatment on marginal leakage of composites. *Journal of the California Dental Association,* **3,** 56-63.

Lee, B. D., Phillips, R. W. & Swartz, M. L. (1971) The influence of phosphoric acid etching on retention of acrylic resin to bovine enamel. *Journal of the American Dental Association,* **82,** 1381-1386.

Meurman, J. H., Aiskainen, M. & Nevaste, M. (1975) Adaptation of some dental restoratives to cavity walls as observed with the scanning electron microscope. *Proceedings of the Finnish Dental Society,* **71,** 36-44.

Ortiz, R. F., Phillips, R. W., Swartz, M. L. & Osborne, J. W. (1976) Effect of composite bond agent on microleakage and bond strength. *Journal of Dental Research,* **55,** *Special Issue B, Program and Abstracts of Papers,* Abstract No. 307, p. B138.

Phillips, R. W. (1973) *Skinner's Science of Dental Materials.* 7th edition, p. 229. Philadelphia: W. B. Saunders.

Phillips, R. W. (1976) The new era in restorative dental materials. *Operative Dentistry,* **1,** 29-35.

Retief, D. H. (1973) Effect of conditioning the enamel surface with phosphoric acid. *Journal of Dental Research,* **52,** 333-341.

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Enamel-composite Interface Relative to Cavosurface Configuration, Abrasion, and Bonding Agents

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A laboratory study shows that microleakage around Class V composite restorations is least with a combination of butt joint margins, acid etching, and bonding agent.

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The introduction of the technique of etching cavity walls with acid as part of the procedure of restoring teeth with composite resin has resulted in a controversy about the design of the cavity preparation. Hitherto, a cavosurface margin of 90° has been used, producing a butt joint. It has been suggested that the conventional design of cavity with a butt joint and retentive cuts in dentin could be improved by beveling the cavosurface margin (Sockwell, 1976; Bjorvatn, 1975; Charbeneau *et al.,* 1975; Ibsen & Neville, 1974; Welk & Laswell, 1976).

It has been reported that beveling the cavosurface margin promotes adhesion of composite resins to enamel by increasing the surface of enamel in contact with the composite resin (Sockwell, 1976; Ibsen & Neville, 1974), improves esthetics (Bjorvatn, 1975), and reduces marginal leakage (Welk & Laswell, 1976; Hawkins *et al.,* 1976). On the other hand, microleakage has been found to be higher with a beveled margin than with a butt joint (Kopel, Grenoble & Kaplan, 1975).

Factors that should be considered with regard to the enamel-composite interface are: mechanical retention, which may be increased by beveling the cavosurface margin; thermal changes; and abrasion (Ibsen & Neville, 1974; Kopel, Grenoble & Kaplan, 1975; Lee, 1965). Improvement in the integrity of the margin between tooth and composite resin has been achieved by etching the enamel with acid and by using bonding agents.

Etching with acid significantly increases the mechanical interlocking of the composite resin in the etched enamel (Silverstone, 1975). Bonding agents (or primers) create a chemical bond between enamel and composite resin (Ibsen & Neville, 1974). As a result of these improvements in technique, current procedures permit the execution of tooth-colored restorations of improved quality. However, several problems remain and further evaluation is needed.

OBJECTIVES

We here report preliminary results of a study designed to investigate, by scanning electron microscopy, the effects of three variables on the enamel-composite interface. These variables are: thermal changes, mechanical abrasion, and the action of bonding agents.

MATERIALS AND METHODS

Ninety-six caries-free incisor and canine teeth were selected and divided into two groups of 48 teeth each. Class V cavities were prepared on all the facial surfaces by the same operator, using the following techniques:

Group 1: The cavosurface margin was prepared at an angle of 90° to produce a butt joint.

Group 2: The cavosurface margin was beveled at an angle of approximately 45°, producing a cavosurface angle of 135°. A white tapered stone was used in producing the bevel.

All the prepared cavities were etched with acid. A bonding agent was applied to 24 cavities within each group of 48 teeth. The other 24 teeth were not coated with the bonding agent. Within each of the four groups of 24 cavities, 12 were restored with Adaptic (Johnson & Johnson Dental Products Co., East Windsor, NJ 08520, U.S.A.) and 12 with Simulate (Kerr Mfg. Co., Romulus, MI 48174, U.S.A.).

The etching solution and the bonding agent were those supplied by the manufacturer and were used according to the manufacturer's instructions.

Glaze material, as provided by the Adaptic kit, was not used because of the high rate of abrasion and the short clinical life of the glaze materials (Garman *et al.,* 1976; Charbeneau, Bozell & Brandau, 1976).

Schematic representation of the procedures:

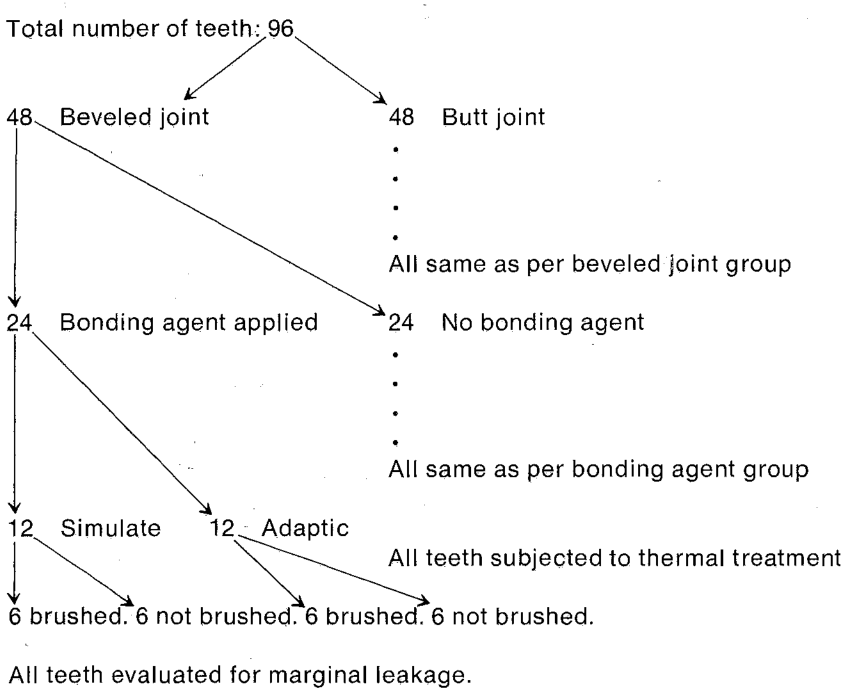


Table 1. *Beveled Joint Group. Leakage Rates. Mean Values, Percent of Maximum Possible*

Composite	Bevel without Bonding Agent		Bevel with Bonding Agent	
	Nonbrushed	Brushed	Nonbrushed	Brushed
Adaptic	0.424	0.812	0.125	0.375
Simulate	0.395	0.677	0.145	0.302

Table 2. *Butt Joint Group. Leakage Rates. Mean Values, Percent of Maximum Possible*

Composite	Butt without Bonding Agent		Butt with Bonding Agent	
	Nonbrushed	Brushed	Nonbrushed	Brushed
Adaptic	0.145	0.229	0.083	0.125
Simulate	0.145	0.177	0.062	0.093

Table 3. *Comparison of Brushed Beveled and Butt Joint Group*

Composite	Bevel Brushed		Butt Brushed	
	Without Bonding Agent	With Bonding Agent	Without Bonding Agent	With Bonding Agent
Adaptic	0.812	0.375	0.229	0.125
Simulate	0.677	0.302	0.177	0.093

Highest cumulative score per restoration: 16
Highest possible cumulative score per group: 96

The results are presented in percentage of score as part of the maximum.

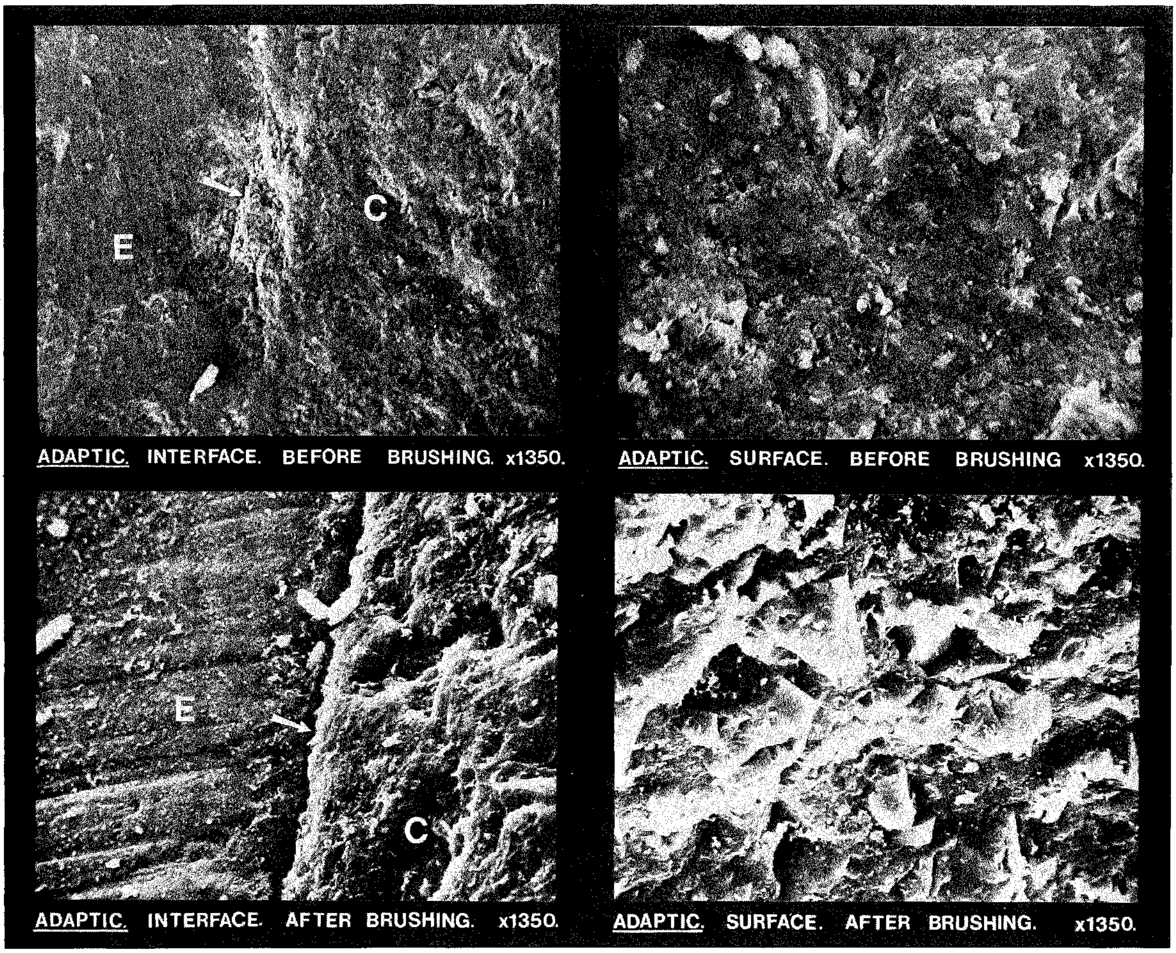


FIG. 1

After restoration, the teeth were left in water for 96 hours to achieve maximal absorption of water. The restorations were then polished with Composite stones (Shofu Dental Corp., Menlo Park, CA 94025).

All the teeth were subjected to the following thermal changes. They were suspended in a heat-controlled bath for one hour at 60°C. The temperature was then allowed to drop to room temperature when the teeth were transferred to water at 0°C for one hour. This process was repeated for a total of 12 cycles in 24 hours. The temperatures were selected to simulate the extremes that may be encountered within the mouth.

Mechanical Abrasion

After the thermal cycling, half the teeth within each subgroup of 12 teeth were subjected to a toothbrushing procedure. The teeth were mounted on a toothbrushing machine and soft nylon toothbrushes driven over them for 1100 strokes at a pressure of 10 grams. This procedure is roughly equivalent to eight weeks of toothbrushing in the mouth.

Marginal Leakage

The roots of the teeth were coated with a commercial nail polish to prevent the dye penetrating through the apical foramen or other surfaces. A 20% solution of Brilliant Red No. 19 dye was prepared and heated to 60°C. The teeth were suspended in this solution for two minutes and then transferred to the dye solution at 0°C for two minutes. This procedure was repeated four times in 16 minutes. The teeth were then sectioned and the degree of leakage was evaluated and scored according

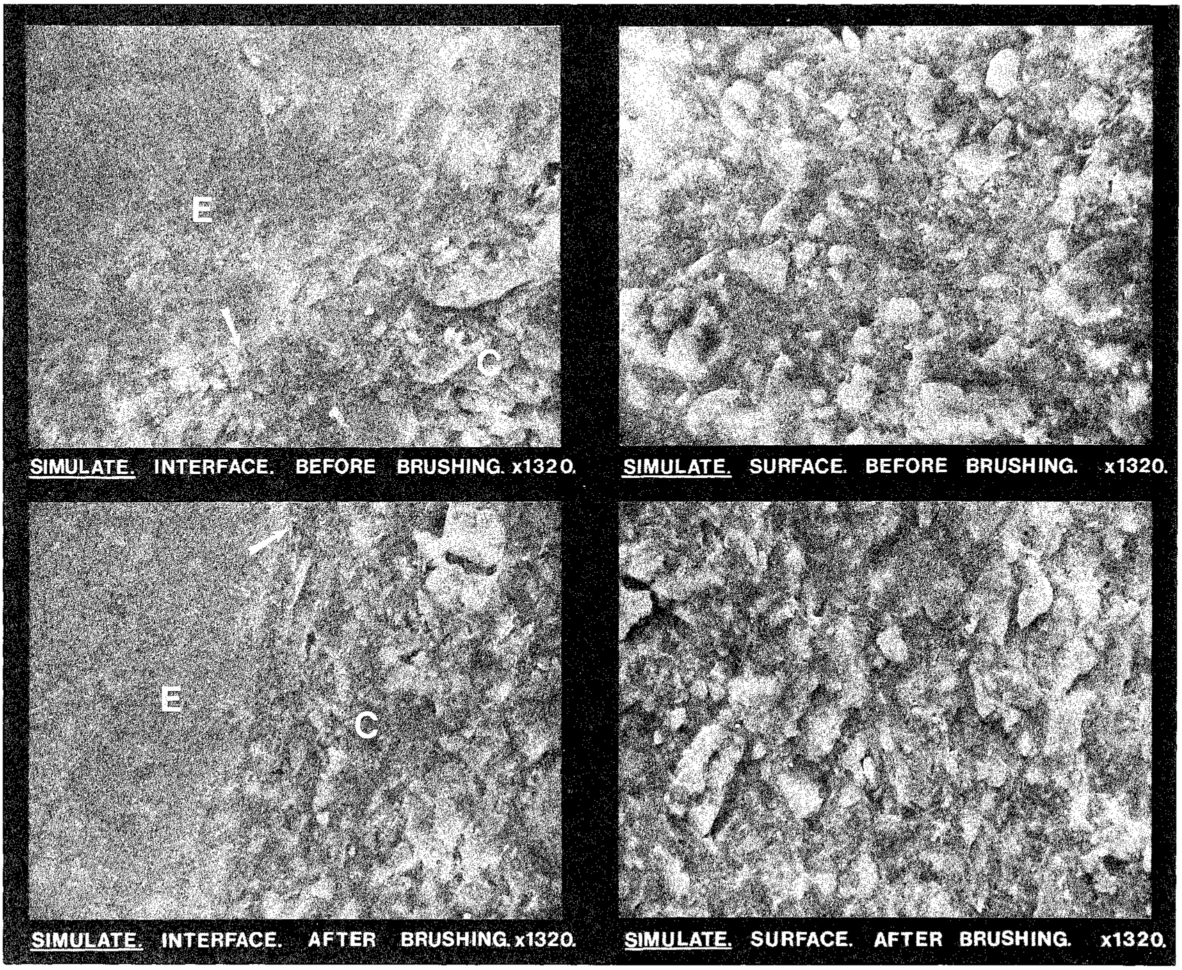


FIG. 2

to the method described by Ousley, Wagner & Taylor (1970).

Scanning Electron Microscopy

A gold layer, 150 to 200 nm thick, was evaporated onto the specimens in an Edwards vacuum evaporator equipped with a tilting stage. This is necessary in order to make the specimen conductive to the beam (Revel, 1975). The specimens were examined in the scanning electron microscope (Cambridge Stereoscan S4) and photomicrographs taken.

RESULTS

Results are shown in Tables 1, 2, and 3.

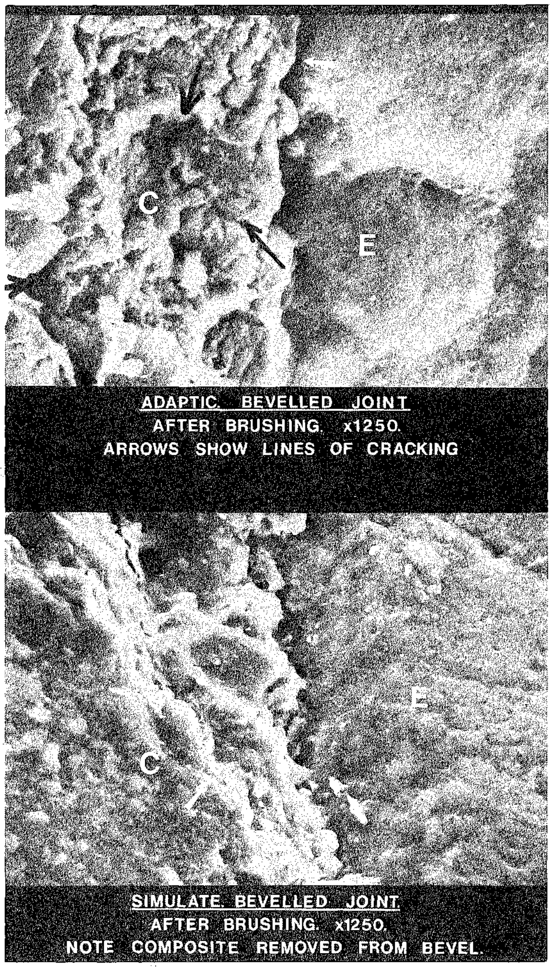
From the tables, it is evident that the least marginal leakage was detected in the group with butt joints with bonding agent, both brushed and nonbrushed.

The most leakage was observed for the group with beveled joint, no bonding agent, and brushing.

Comparing the microleakage between brushed and nonbrushed restorations, it is evident that the brushed restorations show a higher degree of leakage than do the nonbrushed.

The results are consistent for both materials used. Simulate shows slight superiority but the results are parallel and very close.

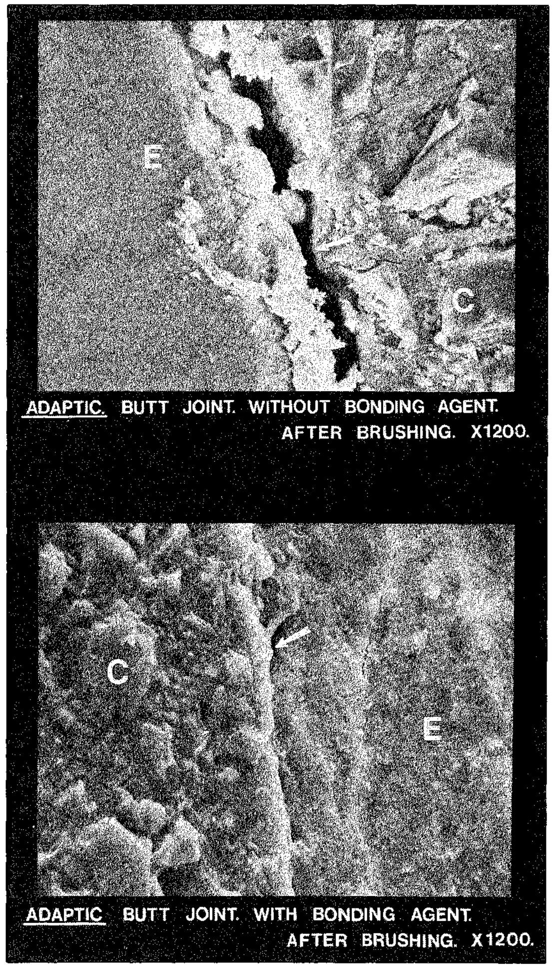
The restorations where bonding agents were applied prior to the placement of the composite resin show less leakage than do the restorations with no bonding agent. Photomicrographs (Figs. 1 & 2) show the surface integrity, before and after brushing.



ADAPTIC. BEVELLED JOINT
AFTER BRUSHING. x1250.
ARROWS SHOW LINES OF CRACKING

SIMULATE. BEVELLED JOINT.
AFTER BRUSHING. x1250.
NOTE COMPOSITE REMOVED FROM BEVEL.

FIG. 3



ADAPTIC. BUTT JOINT. WITHOUT BONDING AGENT.
AFTER BRUSHING. X1200.

ADAPTIC. BUTT JOINT. WITH BONDING AGENT.
AFTER BRUSHING. X1200.

FIG. 4

A comparison of marginal bonding between a butt joint and a beveled joint and in relation to the primers is shown in Figures 3, 4, and 5.

DISCUSSION

The procedures used in this study reproduce some of the important physical conditions to which the composite resin restoration is subjected in the mouth, including thermal shifts and mechanical abrasion caused by toothbrushing.

The results in Table 1 show that for both composite systems used with a beveled joint there was more microleakage in the brushed than in the nonbrushed groups. The bonding agent decreased microleakage.

Similar results can be observed in Table 2 for the group with butt joints. In this group all the results are markedly lower than those in the group with beveled joints (Table 3).

It is evident that the best seal at the enamel-composite interface was achieved by the butt joint with bonding agent.

It should be remembered that all the cavity preparations were etched with acid prior to any manipulation. The use of acid etching with composite resins has been widely documented, the concept of etching the enamel has been accepted and is considered an integral part of the composite restorative technique.

It has been reported recently that the bond between composite resin and etched enamel becomes stronger with age and stress (Joos, Nachtsheim & Langager, 1976). The interrelations between the variables examined in

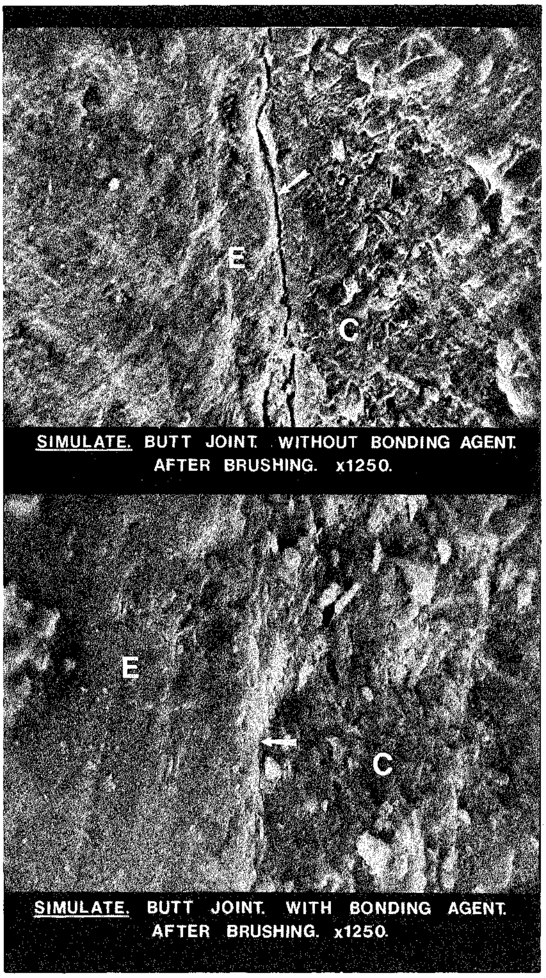


FIG. 5

this study appear to be important when assessed in terms of marginal leakage and surface.

The coefficient of thermal expansion of composite resins is within the range of 27-39in/in/°C$\times 10^{-6}$. The thermal conductivity of the composite resins is also low, compared with amalgams: 25 vs. 550 [cal/sec/cm^2/°C/cm)x10^{-4}] and, therefore, transient exposure to fluids would be expected to have a correspondingly smaller effect on the seal at the margins (Ibsen & Neville, 1974; American Dental Association, 1975). Temperature shifts have been reported to cause increase and decrease of the width of the gap at the enamel-composite interface (Ibsen & Neville, 1974; Going, 1972). Etching with acid may reduce the gap under elevated temperatures but cannot eliminate it. The use of bonding agents may be important in this regard, as the bonding agents create chemical bonds between the composite resin and calcium ions in the hydroxyapatite. Nevertheless, concern has been expressed in regard to solubility of those materials (Ibsen & Neville, 1974; Lee, 1965; Cornell, 1961).

The combination of acid etching and bonding agent seems to provide the best results as observed in the results in Tables 1, 2, and 3. This combination has been reported to virtually eliminate marginal leakage (Galan, Mondelli & Coradazzi, 1976; Dogon, 1975).

As to the configuration of the cavosurface margin, from the results in this study it is evident that the butt joint provides better results than the beveled joint. Our results confirm the results of Kopel, Grenoble & Kaplan (1975). The effect of abrasion has a cardinal role in regard to marginal configuration, as it is known that composite resins do not have sufficient resistance to wear. The surface of composite resins deteriorates with toothbrushing, with other abrasives introduced into the oral cavity, and with foods or habits, such as pica (Lee, 1974; Flynn, 1976; Abbey & Lombard, 1973; Phillips, 1975).

In beveled joints a thin layer of composite resin is exposed to abrasion, and this thin layer is prone to disintegrate and expose a large surface to the oral environment (Farrington & Young, 1976). The scanning electron micrographs in Figures 1 and 2 show this.

Insufficient resistance to wear, combined with the effect of shifts of temperature, will affect beveled joints more severely. It has been reported recently that deterioration of the restoration seemed to accelerate as marginal movement approached the cavity line (Flynn, 1976). Deterioration of the composite resin is evident as well in the group with butt joints, but much less so because no thin layer is exposed to abrasion as in the beveled joint (Table 2).

When a bonding agent was applied, with a beveled joint, the leakage was less than without the bonding agent even after brushing, due to the increased sealing afforded by the bonding agent. The scanning electron micrographs (Figs. 3, 4 & 5) demonstrate these observations.

The difference in results between the two composite resins used is related to resistance to wear of the composites. Difference in the size of filler particles may be responsible for those differences. Adaptic seems to have larger particles than Simulate, therefore, under equal conditions of abrasion the larger particles may be displaced faster than the smaller particles. It has been reported that the patterns of leakage observed in teeth are influenced by the material used (Roydhouse, 1968). Our results confirm that the type of composite resin influences the result.

CONCLUSIONS

- The combination of a butt joint in a Class V cavity to be restored with composite resins with acid etching and bonding agents will provide a better seal at the enamel-composite interface compared with beveled joints.
- Beveled cavosurface margins in Class V cavities etched with acid and coated with a bonding agent had less marginal integrity than butt joints.
- The composite resin ledge over the beveled joint disintegrated under toothbrushing, exposing the enamel-composite interface. This did not happen to the same extent with the butt joint.
- The use of bonding agent improved significantly the seal at the enamel-composite interfaces.
- The type of composite resin used is important, as the wear resistance differs for different materials. The higher the resistance to wear, the longer will the enamel-composite margin maintain its integrity.
- The butt joint cavosurface configuration appears to be the preparation of choice for Class V preparations to be restored with composite resins.
- Acid etching, followed by application of bonding agent prior to placement of the composite restoration is recommended, as it will reduce marginal microleakage.

SUMMARY

The relative merits of butt joint and beveled joint surface configurations in Class V cavity preparations and their effects on the enamel-composite interface were examined.

Ninety-six cavity preparations were etched with acid. Half were then coated with bonding agents, the other half were not.

After restoration of the cavity preparations with composite resins, the teeth were subjected to thermal cycling in temperatures ranging between 0°C and 60°C. Half the teeth within each group were subjected to a toothbrushing procedure. All the teeth were tested for microleakage and the surfaces examined by scanning electronic microscopy.

The best results were obtained with the butt joint cavosurface when bonding agent was applied.

Beveled cavosurface margins showed more leakage than the butt joint, and marginal disintegration of the composite resin at the enamel-composite interface was observed.

The best results are obtained by the combination of the butt joint margin, acid etching, and bonding agent in Class V cavity preparations to be restored with composite resins.

The authors wish to thank Mrs. Maria Maglio, M.S., for her technical assistance.

REFERENCES

Abbey, L. M. & Lombard, J. A. (1973) The etiological factors and clinical implications of pica: Report of a case. *Journal of the American Dental Association,* **87**, 885-887.

American Dental Association (1975) *Guide to Dental Materials and Devices.* 7th edition, p. 118. Chicago: American Dental Association.

Bjorvatn, K. (1975) The use of acid etch technique in pedodontics in Scandinavia: Clinical and technical studies. In *The Acid Etch Technique,* Proceedings of an International Symposium, ed. Silverstone, L. M. & Dogon, I. L., pp. 230-237. St. Paul, MN: North Central Publishing Co.

Charbeneau, G. T., Bozell, R. & Brandau, H. (1976) A comparative clinical study of glaze materials with conventional finishing for composite resin. *Journal of Dental Research,* **55**, Special Issue B, Program and Abstracts of Papers, Abstract No. 513, p. B190.

Charbeneau, G. T., Cartwright, C. B., Comstock, F. W., Kahler, F. W., Snyder, D. T., Dennison, J. B. & Margeson, R. D. (1975) *Principles and Practice of Operative Dentistry.* Philadelphia: Lea & Febiger. Pp. 316-317.

Cornell, J. (1961) Adhesion to natural teeth. In *Adhesive Restorative Dental Materials,* ed. Phillips, R. W., p. 159. Spencer, IN: Owen Litho Service.

Dogon, I. L. (1975) Studies demonstrating the need for an intermediary resin of low viscosity for the acid etch technique. In *The Acid Etch Technique,* Proceedings of an International Symposium, ed. Silverstone, L. M. & Dogon, I. L., pp. 100-118. St. Paul, MN: North Central Publishing Co.

Draughn, R. A., Farrington, F. H. & Young, F. A. (1974) SEM investigation of the *in vivo* performance of restored fractured incisors. *Journal of Dental Research,* **53**, Special Issue, Program and Abstracts of Papers, Abstract No. 400, p. 154.

Flynn, M. (1976) SEM investigation of *in vivo* performance of twelve tooth-colored restorative materials. *Journal of Dental Research,* **55**, Special Issue B, Program and Abstracts of Papers, Abstract No. 520, p. B191.

Galan, J., Jr., Mondelli, J. & Coradazzi, J. L. (1976) Marginal leakage of two composite restorative systems. *Journal of Dental Research,* **55**, 74-76.

Garman, T., Fairhurst, C., Beglau, D. & Heuer, G. (1976) A comparison of glazing materials for composite restorations. *Journal of Dental Research,* **55**, Special Issue B, Program and Abstracts of Papers, Abstract No. 512, p. B189.

Going, R. E. (1972) Microleakage around dental restorations: A summarizing review. *Journal of the American Dental Association,* **84**, 1349-1357.

Hawkins, I. K., Fairhurst, C. W., Kinzer, R. L. & Okabe, T. (1976) Effects of cavity design on microleakage in class V restorations. *Journal of Dental Research,* **55**, Special Issue B, Program and Abstracts of Papers, Abstract No. 316, p. B140.

Ibsen, R. L. & Neville, K. (1974) *Adhesive Restorative Dentistry.* Philadelphia: W. B. Saunders Co. Pp. 11, 51-63.

Joos, R. W., Nachtscheim, H. G. & Langager, B. A. (1976) Resin bond stability to acid etched enamel. *Journal of Dental Research,* **55**, Special Issue B, Program and Abstracts of Papers, Abstract No. 322, p. B142.

Kopel, H. M., Grenoble, D. E. & Kaplan, C. (1975) The effect of cavo-surface treatment on marginal leakage of composites. *Journal of the California Dental Association,* **3,** *56-62.*

Lee, H. L. (1966) Advances in the synthesis of epoxy resins for adhesion to dry and wet tooth structures. In *Adhesive Restorative Dental Materials,* ed. Austin, R. H., Wilsdorf, H. G. L. & Phillips, R. W. Vol. 2, U.S. Public Health Service Publication No. 1494, pp. 232-257. Washington, D.C.: U.S. Government Printing Office.

Lee, H. L., Orlowski, J. A., Kidd, P. D. & Glace, R. W. (1974) An evaluation of wear resistance of dental restorative materials. In *Advances in Polymer Friction and Wear,* ed. Lee, L.-H. Vol. 56, pp. 705-722. New York: Plenum Publishing Corporation.

Ousley, J. S., Wagner, M. J. & Taylor, P. P. (1970) Effect of surface conditioners on amalgam marginal leakage. *Journal of Dentistry for Children,* **37**, 62-68.

Phillips, R. W. (1975) Should I be using amalgam or composite restorative materials? *International Dental Journal,* **25**, 236-241.

Revel, J.-P. (1975) Elements of scanning electron microscopy for biologists. *Scanning Electron Microscopy 1975,* Proceedings of the 8th Annual Scanning Electron Microscope Symposium, ed. Johari, O. & Corvin, I. Pp. 687-696. Chicago: Illinois Institute of Technology Research Institute.

Roydhouse, R. H. (1968) Penetration around the margins of restorations. 2: Nature and significance. *Journal of the Canadian Dental Association,* **34**, 21-28.

Silverstone, L. M. (1975) The acid etch technique: *In vitro* studies with special reference to the enamel surface and the enamel-resin interface. In *The Acid Etch Technique,* Proceedings of an International Symposium, ed. Silverstone, L. M. & Dogon, I. L., pp. 13-39. St. Paul, MN: North Central Publishing Co.

Sockwell, C. L. (1976) Clinical evaluation of anterior restorative materials. *Dental Clinics of North America,* **20**, 403-422.

Welk, D. A. & Laswell, H. R. (1976) Rationale for designing cavity preparations in light of current knowledge and technology. *Dental Clinics of North America,* **20**, 231-239.

OPERATIVE DENTISTRY, 1976, 1, 146-150.

DENTAL PRACTICE

Amalgam Polishing

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Polishing is an important but often neglected step in the finishing of an amalgam restoration. Failure to polish an amalgam leaves the patient with an inferior service.

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The need for polished surfaces on silver amalgam restorations has been recognized for years. However, though restorations of silver amalgam constitute two-thirds to three-fourths of all dental restorations placed during the past century, few have been polished (DeMaar, 1972). The usual excuses given for not polishing amalgam restorations are that sufficient heat may be generated to damage the amalgam and injure the pulp, and that polishing takes too much time. Careful operating minimizes the production of heat and a well-organized technique minimizes the time needed for the operation. The purpose of this article is to discuss the rationale of polishing amalgam restorations and to describe a rapid and successful technique for polishing.

Reasons for Polishing Amalgams

The main reason for polishing amalgams is to remove surface irregularities which retain plaque and thus irritate the gingiva. A smooth surface not only resists the attachment of plaque but also resists tarnishing and thus provides a more esthetic restoration. In addition, polishing should remove any excess amalgam over the cavosurface margin because if the excess is not removed the amalgam is likely to fracture during mastication and leave a trough between tooth and amalgam. Studies by scanning electron microscopy have shown that it is possible to attain a surface on amalgam that is smoother than the surface of the adjacent enamel (Tidmarsh & Gavin, 1973) and the benefits of a polished surface on amalgam have been demonstrated (Mahler, Adey & Van Eysden, 1973; Svare & Chan, 1972; Charbeneau, 1964; Wing, 1965).

Preliminary Considerations

Polishing is facilitated if the amalgam, when inserted, is carved to proper form with attention to anatomical details and if the surface is made as smooth as possible. Polishing should not be attempted until at least 24 hours after the insertion of the amalgam. A dry operating field should be obtained with either the rubber dam or cotton rolls.

Avoid Generating Heat

If care is not exercised during polishing, excessive heat may be produced (Grajower, Kaufman & Rajstein, 1974; Aplin, Cantwell & Sorensen, 1967; Christensen & Dilts, 1968; Eames, Minnock & Wasden, 1966). Heat may bring mercury to the surface of the amalgam resulting subsequently in reduced surface hardness. Heat may also cause pain and pulpal damage. Rubber cups and polishing instruments must be used carefully because they generate heat faster than do discs, polishing burs, or stones (Eames, Minnock & Wasden, 1966; Tsuchitani & Ryge, 1965). Cooling with air and using rotary instruments at slow speed reduce the possibility of irritating the pulp and damaging the surface of the amalgam (Christensen & Dilts, 1968).

Polishing Materials

The materials needed for the polishing procedure presented here include small round finishing burs, Nos. ¼, ½, 2, and 4; soft black-bristle brushes, both blunt and pointed, and wheel-type soft brushes (William Dixon Incorporated, Carlstadt, NJ 07072, U.S.A.); soft webless rubber cups, snap-on old style, Revelation, University of Washington (Young Dental Mfg. Co., Maryland Heights, MO 63043, U.S.A.); and suitable polishing abrasives, such as M303 Centriforce Abrasive and M309W white rouge (American Optical Corporation, Southbridge, MA 01550, U.S.A.). Other commercially available abrasives, such as tin oxide, are acceptable substitutes for white rouge. In addition a small mandrel, Sproule type (Hepworth Instrument Company, 375 Broadway, Vancouver, B.C., Canada) and fine, medium, and coarse cuttle discs (J. Bird Moyer Co., Philadelphia, PA 19132, U.S.A.) must be available. Carving instruments, such as the cleoid and discoid, and suitable gingival carvers must be at hand. Fine-cuttle extra-narrow linen finishing strips (J. Bird Moyer Co., Philadelphia, PA 19132, U.S.A.) for interproximal areas are used where appropriate.

Polishing Procedure

The procedure begins with an evaluation of the amalgam restoration; the occlusion is examined and adjusted as required. A bitewing radiograph may be taken if a gingival overhang is suspected. Gingival excess or overhangs may, in some cases, be removed with carvers, curettes, files, or strips. Extensive gingival overhangs are not effectively removed in this manner and such restorations must be replaced.

Remove marginal excess on the occlusal and smooth ridges with a No. 2 or 4 round finishing bur in the slow-speed handpiece (Fig. 1). Use a No. ¼ or ½ round finishing bur to smooth the depths of pits and grooves. Redefine fossae and fissures with a small sharp cleoid.

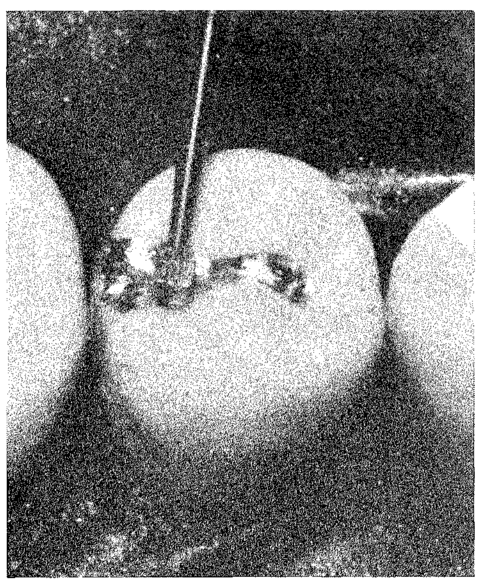


FIG. 1. A small round finishing bur initiates the polishing. Excess amalgam is removed from cavosurface margins. Pits and grooves are refined.

Smooth proximal surfaces, where accessible, with cuttle discs (Fig. 2). Scanning electron microscope studies have shown that medium cuttle discs, running in the direction from amalgam to tooth, actually pull the metal across the marginal crevice toward the adjacent enamel and produce the narrowest gap (Swedlow *et al.,* 1972). Discs also smooth and blend surface contours on occlusal surfaces. Fine-cuttle extra-narrow linen finishing strips remove surface irregularities on the proximal surfaces of restorations gingival to the contact area.

After initial finishing with burs, discs, and hand instruments, begin polishing with flour of pumice, followed by M303 Centriforce Abrasive and then white rouge. Use blunt or wheel brushes to polish the occlusal surface, but be careful not to remove desired anatomical contours (Figs. 3 & 4). Pointed brushes are preferred for the proximal surfaces, if access permits. Alcohol may be used to moisten the abrasive; its use will decrease the amount of air needed to dry the abrasive as the brush is moved over the surface of the restoration. Some air must be applied to prevent overheating. Rinse the operating area between each succeeding abrasive. The precise contact area is not polished unless the adjacent tooth is missing or an adjacent open cavity provides access.

Perform final finish with a webless rubber cup. The cup is preferred by many for its ability to reach into embrasures and the depths of the grooves. Of prime concern here is the generation of heat; light pressure and an air coolant are essential. M303 Centriforce Abrasive is applied first. A satin finish should result from this step. Then M309W white rouge is applied to the tooth and the final luster obtained as the abrasive is blown away from the tooth under the rotating cup.

Pass dental floss gently through the contact to remove excess polishing abrasive which may have worked itself into the interproximal embrasures. Loop the floss back to the facial and pull facially through the contact area to remove all polishing abrasives (Figs. 5 & 6). Apply fluoride before removing the dam.

After the rubber dam has been removed, the gingival sulcus is examined to see that all polishing abrasive has been removed. The patient is advised of the reason for polishing the amalgam and oral hygiene is reviewed (Fig. 7).

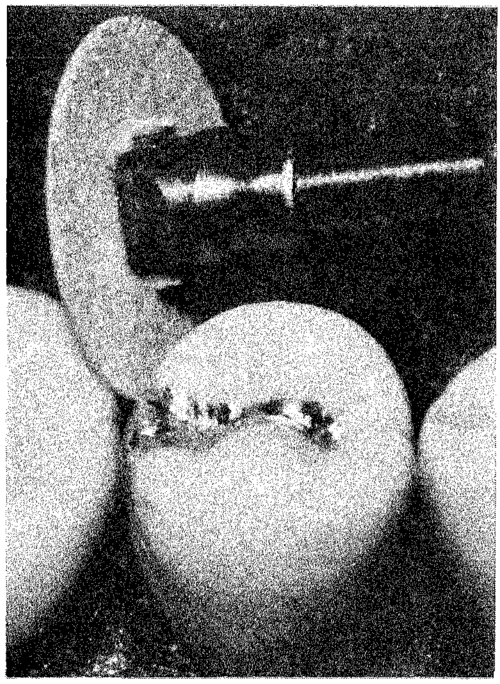


FIG. 2. A small cuttle disc finishes amalgam at cavosurface margins. The small Sproule mandrel provides access to embrasures.

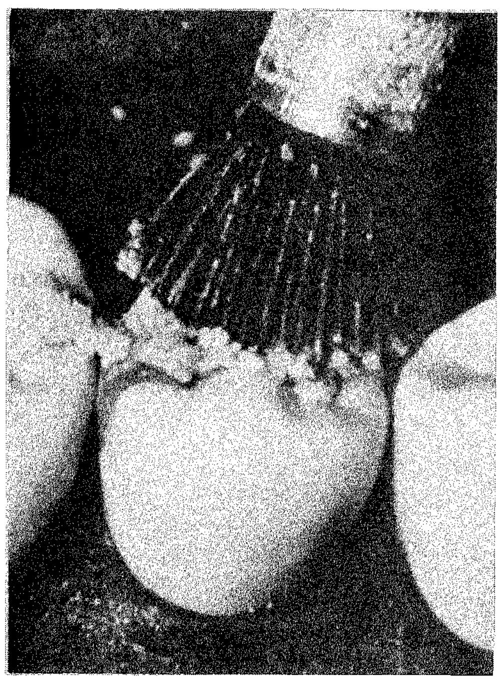


FIG. 3. A blunt brush is used to apply polishing abrasives to amalgam restorations. Bristles may be trimmed to create a pointed brush if preferred.

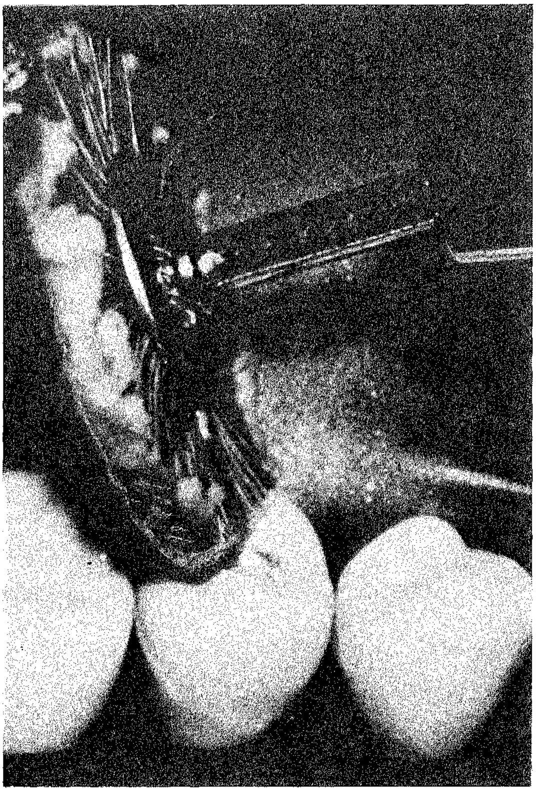


FIG. 4. A wheel brush is effective in applying polishing abrasives to amalgam. Care is required to avoid flattening contours.

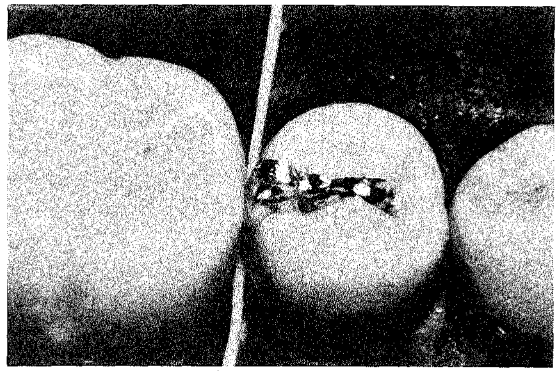


FIG. 5. A polished disto-occlusal amalgam in the lower second premolar. Anatomical form is correctly reproduced; margins and surface contours are smooth. Waxed dental floss passed gently through proximal contact to remove debris from contact area.

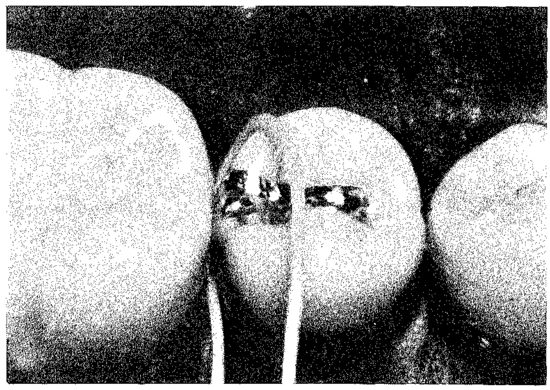
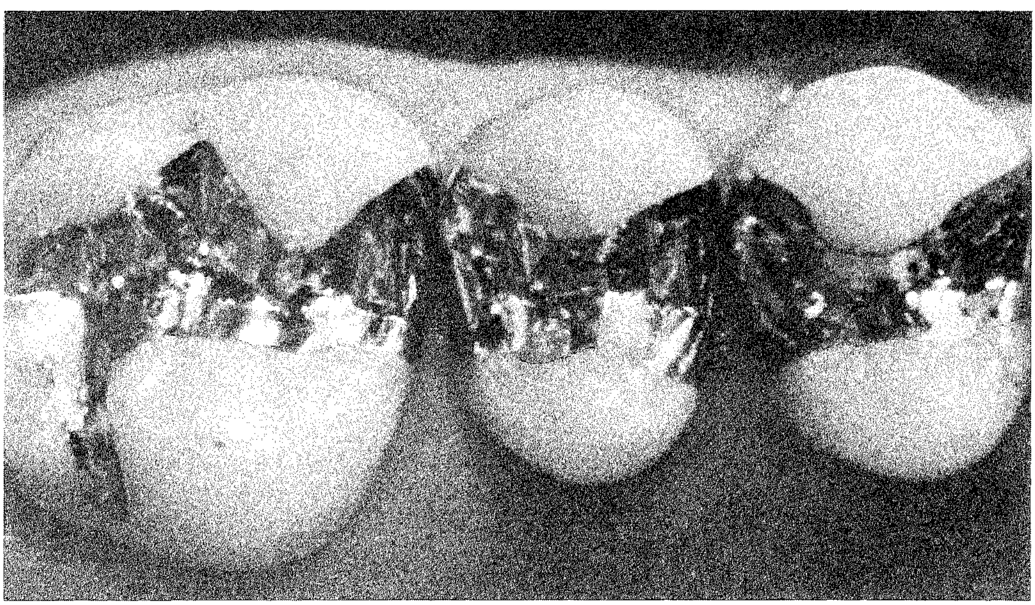


FIG. 6. Dental floss looped facially is now pulled facially through contact area to remove debris from embrasures.

FIG. 7. A quadrant of amalgam restorations successfully polished in a single appointment. After rubber dam is removed, patients are shown the finished restoration and home care instructions are reviewed.



Conclusion

Polishing a silver amalgam restoration can be accomplished easily and rapidly with a well-organized technique. Polishing is an important part of placing an amalgam restoration. Failure to polish is to provide the patient with an inferior service—one that may lead eventually to destruction of the supporting tissues of the tooth.

REFERENCES

Aplin, A. W., Cantwell, K. R. & Sorensen, F. M, (1967) Effect of overheating on amalgam hardness. *Journal of Dental Research,* **46,** 1420-1424.

Charbeneau, G. T. (1964) An appraisal of finishing and polishing procedures for dental amalgam. *Journal of the Michigan State Dental Association,* **46,** 135-138.

Christensen, G. J. & Dilts, W. E. (1968) Thermal change during dental polishing. *Journal of Dental Research,* **47,** 690-693.

DeMaar, F. E. R. (1972) Historically, when and by whom was silver amalgam introduced? *International College of Dentistry Scientific Education Bulletin,* **5,** 23-26.

Eames, W. B., Minnock, J. B. & Wasden, L. (1966) Thermal response of amalgam to polishing instruments. *Journal of the American Dental Association,* **73,** 1111-1113.

Grajower, R., Kaufman, E. & Rajstein, J. (1974) Temperature in the pulp chamber during polishing of amalgam restorations. *Journal of Dental Research,* **53,** 1189-1195.

Mahler, B. D., Adey, J. D. & Van Eysden, J. (1973) Microprobe analysis of amalgam. I: Effects of surface preparation. *Journal of Dental Research,* **52,** 74-78.

Svare, C. W. & Chan, K. C. (1972) Effect of surface treatment on the corrodibility of dental amalgam. *Journal of Dental Research,* **51,** 44-47.

Swedlow, D. B., Kopel, H. M., Grenoble, D. E. & Katz, J. L. (1972) Dental amalgam polishing with discs as observed by scanning electron microscopy. *Journal of Prosthetic Dentistry,* **27,** 536-543.

Tidmarsh, B. G. & Gavin, J. B. (1973) Finishing amalgam restorations: A scanning electron microscope study. *New Zealand Dental Journal,* **69,** 175-184.

Tsuchitani, Y. & Ryge, G. (1965) Tarnish of dental amalgam. *Journal of Dental Research,* **44,** 421-426.

Wing, G. (1965) The polished amalgam surface. *Journal of Dental Research,* **44,** 1411.

DENTAL EDUCATION

Are Students Trained Adequately in Operative Dentistry?

ANTHONY D. ROMANO

There has been growing concern in recent years that dental graduates are not as well qualified as formerly in the important discipline of operative dentistry. The decline in competence is attributed to untested curricular innovations which have been merely changes—sometimes for the worse.

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The adequacy of a student's training in operative dentistry depends on how well prepared he is to provide a service of high quality for his patients. His competence reflects the quality of his instruction, and the time and opportunity provided during his instruction to learn the required skills. There is a growing conviction that in recent years the clinical competence of dental graduates has declined. I should like here to reaffirm the importance of operative dentistry in dental practice and to plead for the restoration of adequate time in the curriculum for the teaching and learning of operative dentistry.

Importance of Operative Dentistry

About 95% of the population have dental caries (Young, 1961). As a result, a dentist in general practice spends about 60% of his time restoring teeth (Martens & Meskin, 1971). Furthermore, endodontic and periodontic treatment today are saving more and more teeth, which will have to be maintained by the operative dentist. When we see the relative importance of operative dentistry in dental practice, there can be little argument about the importance of operative dentistry in the curriculum of a dental school. The teaching of operative dentistry is central and mandatory.

Who Shall Decide the Curriculum?

Before we can allocate sufficient time for a subject in a curriculum we must delineate the scope and content of the program required. Curricular objectives should have mutual support among those groups most closely associated with the management, implementation, and evaluation of the curriculum—the administrators, the faculty, and the practicing profession.

The involvement of administrators is clear because they are responsible for management and must justify the curriculum to all inquirers. The faculty's responsibility can be readily understood because its members must implement the chosen curriculum. However, I expect some raised eyebrows when I suggest the profession's role in determining the curriculum. I recognize the autonomy of universities and I respect academic freedom, but I also realize that there is an ever-present danger of academics becoming isolated from the real world. Dental schools would be wise to seek advice from those who are actively providing dental services. This would temper the influence of those curricular planners who have not practiced dentistry, or have practiced very little, or who may not even be dentally qualified. Professional people, in developing standards for a high quality of health service for their patients, look with concern on the product of the dental schools—the new professionals who will inherit the patients of dentists now in practice. To repeat, I believe the product of any dental school is the concern of not only administrators and faculty, but the professional community as well.

If we are to heed the profession in determining the content of the dental course, we must concern ourselves with two other points. First, practitioners take exception to the reference that restorative procedures, especially amalgam restorations, are repetitious or boring. Perhaps they are boring to some in other parts of our profession, but to the general practitioner they constitute an interesting, challenging, and important part of dental service. If a student that plans to be a general practitioner truly becomes bored with routine restorative procedures, he should think seriously of getting out of dental school and pursuing lion taming or something equally exciting. Secondly, the dental profession, by way of a resolution passed in 1973 by the House of Delegates of the American Dental Association, has gone on record as opposing the training of auxiliary personnel to carry out routine intraoral procedures that are not included in the Dental Practice Act. Additionally, on November 18, 1975, Robert Shira, president of the American Dental Association, appearing before Senator Edward Kennedy's subcommittee on health, commented that "final legislation should include language specifying those functions that an auxiliary should not be trained to perform." (Shira, 1975)

Goals of Teaching in Operative Dentistry

Our primary goal is to establish a foundation of tried and true principles upon which an individual may continue to grow and develop a lifelong pursuit of dental education. It should prepare every graduating student to pass any licensing examination. A further goal is to identify students who grasp these principles early in their course and to channel these students into more challenging aspects of the program.

Curricular Priorities

How much time does it take to accomplish our goals? This leads us to the matter of cutting the curricular pie. An essential body of information, clinical knowledge, and skill must be mastered by a graduating student. Without this fundamental background he or she cannot become a dentist. We, in operative dentistry, are aware that our courses, though necessary, do not in themselves provide sufficient training for a dentist. We are but a segment of the whole. On the other hand, we are also aware that without the training offered in operative dentistry a dentist is not a dentist at all, especially in the eyes of the patient. Our responsibility is to provide a central and important part of dental training, namely, to teach the techniques and skills and the reasons for their use needed to restore individual teeth that have been affected by pathosis or trauma. In carrying out these procedures we must protect the pulp and avoid losing the vitality of teeth, we must protect and maintain the surrounding tissues, we must create restorations that function properly and conform to the gnathologic requirements of the patient, and finally, we must carry out our procedures as comfortably and as esthetically as possible for the patient.

We would all agree that the mere mechanical ability to restore a tooth satisfactorily falls woefully short of that required by a competent dentist, yet this ability is an absolutely essential part of our finished product. Therefore we are concerned about the priority of the items constituting the curriculum. Religion, metaphysics, and sound investment policy should be part of every dentist's life, but they simply are not as pertinent as oral anatomy, occlusion, and prevention.

Our approach to teaching operative procedures is based on precepts that were organized first by G. V. Black in the early part of the century. These principles have been modified, of course, but they remain useful and acceptable guides. A large part of operative dentistry is the matter of choosing materials suitable for restorations, and of modifying cavities to receive specific materials. For each clinical situation there is probably one material that is best suited therapeutically for the operation. Therefore, we are responsible for training our students to deliver all types of restorative service. Otherwise a treatment plan is based not on therapeutic considerations but on the limitations of the dentist.

Approach to Teaching

One dental educator (Christensen, 1975) writes that: "Dental education has long been very authoritarian in its approach to presenting concepts to students. Inquisitiveness has been discouraged or even punished. Acceptance of long-proved philosophies or techniques have been encouraged or demanded. (Fortunately dental education is changing away from such stifling teaching and learning environment.)" If truly we are teaching in a stifling fashion in a stifling environment, then let us change the methodology and create a more receptive environment. However, if freedom of inquisitiveness means a license for the dental neophyte to ridicule, undermine, or reject well-understood and proven concepts that make up the very foundation—the "essential body of information"—we are certainly headed for trouble.

Need for Clinical Training

We have already established the relevant importance of teaching operative dentistry. However, some curriculum planners have adopted a different viewpoint. One group (Bohannan *et al.,* 1972), describing its idea of a future curriculum, states: "CLINICAL SCIENCES. Revision of the clinical sciences to meet the needs of the future practice will involve: reorientation to the program to emphasize prevention rather than repair; less technical training through reduction of laboratory work and repetitious intraoral procedures likely to be performed by the future subprofessional auxiliary personnel; and reallocation of time to shift emphasis from therapeutic to diagnostic techniques." Further, this curricular planning group made the following remark, the disparity of which is difficult, if not impossible, to understand: "Technical training in the future will decline in amount but will meet the needs of the student for clinical experience." (Bohannan *et al.,* 1971). How can that be done? If our students are at one level of competence now, less training would produce less competence. The implication, then, is that students are overtrained clinically. I dispute that such is the case. No school to my knowledge can in fact say that its students are so well trained in the clinical sciences that this part of the student's experience can be reduced. Cutting back in clinical teaching can produce only a product that is less well trained. In an editorial a few months ago the following statement was made: "For several years across the country, many dental state board examiners, experienced dental practitioners, and 'old pro' teachers of clinical dentistry have contended that the current graduates of dental schools are not as competent clinically as they should be. With so much smoke there must be some fire of truth in these allegations." (Butts, 1975)

Need for Laboratory Teaching

The recommended reduction of laboratory teaching is of great concern to me. Preparing a student to perform well when he or she reaches the clinic is of great importance to school patients. Laboratory preparation is as important for clinic training as the clinical preparation is for the student's impending unsupervised general practice after graduation. It must be apparent to any planner that the concern for and care of school patients during the student's education is of paramount importance to the success of clinical training.

Competence in Operative Dentistry

In 1974 the Council on Dental Education of the American Dental Association pointed out in a letter sent to the deans of all dental schools: "The Council expects educational programs, culminating in the awarding of the basic dental degree (DDS or DMD), to provide all students with an adequate background and appropriate experience in all aspects of clinical dentistry. In this regard, the Council will expect all graduates to have attained competency in all clinical disciplines. Early specialization is not intended to circumvent completion of minimum educational objectives nor is it to be used as a substitute to achieving the basic skills of a dentist. Flexibility in curricular design is encouraged, but assurance must be included within any curriculum that the educational experience is adequate to insure that all graduates are clinically competent dentists."

What does 'competency' mean to the operative teacher? Does it mean the dictionary definition, "Sufficiency without excess," or does it mean more truly a synonym, 'proficiency,' "one well advanced in any business, art, science, or branch of learning; an expert"? I would say probably somewhere in between. To be directed to train a student just well enough to get along is imposing a ceiling of mediocrity and surely is not in the best interest of excellence or academic endeavor. When does a dentist reach the height of proficiency? Very likely after he has practiced a good many years, when his hands perform beautifully and just before his eyes begin to fail.

What, then, do we mean when we speak of a student being competent? Our definition should in any case be shared by all the groups involved in the evaluation of our graduates. It will be absolutely necessary, if state reciprocity by credentials, as supported by the House of Delegates of the American Dental Association, is to come into being. Does being competent in operative dentistry mean only being able to pass the licensing examination of the state or regional board? We hope it means more than that. However, there is little doubt that that should be the least for which both administrators and students should settle—always providing that the examination is reasonable. If competence means more than just passing the licensing examination, we have reason to be concerned because many curricula require many students to use all the time allotted to operative dentistry just to clear that one hurdle. They would be hard pressed to achieve that goal with even less curriculum time.

Amount and Sequence of Curriculum Time for Operative Dentistry

It would not be appropriate for me to propose a specific allotment and sequence of time for operative dentistry that would be necessary to develop a competent dentist at every school. Although I can recommend the number and distribution of curricular hours for operative dentistry at the University of Minnesota, they might not transfer well to other programs. Comparing dental school bulletins or wrestling with the problem of establishing advanced credit for a transferring student bear this out. Many factors enter into the overall process of teaching operative dentistry effectively. The quality and ability of the staff, the equipment and physical design of the school, availability of patients, teaching methodology, and the depth and scope of a program are all important factors. How much do other programs depend on operative dentistry for developing beginning skills? Differences in requirements, approaches to total care of the patient, traditions of the dental community, availability of funding, and the philosophies of deans and faculty affect the approach of each school to the requirements of teaching and time. It would perhaps be undesirable to expect all schools to fit the same mold, but the ultimate product, the graduate, must have similar clinical and academic qualifications. It is essential that the time assigned for operative dentistry not be looked on as a pool or curricular slush fund from which new programs will extract their credit hours. If all "fat," redundancy, and overlap are trimmed from all programs, a curriculum is not improved by removing one essential part and replacing it with something new but perhaps less essential. This is not progress—it is curricular cannibalism.

Curricular Innovations

Innovations in the curriculum should not be discouraged, but when enthusiasm for innovation is given greater importance than the realization of goals, innovation should be rejected. One can point out other areas in education where unfounded, adventuresome approaches have impeded seriously the student's learning. Reading is one notable area; mathematics another. A recent report in *Newsweek* has revealed that reading skills have declined since 1965, and the Scholastic Aptitude Test scores this year showed the biggest drop in two decades (Sheils, 1975). This is attributed to the abandonment of the more structured, classic teaching approach and allowing the student to write it the way he would say it—a sort of free verse in prose. Similarly, innovation—though reputed to be progressive—has in fact impeded the student's ability to carry out elementary mathematical calculations.

Curricular innovations should be tested and proved before they are implemented. It has been said that curricular planners, like prudent poker players, should learn to quit before they lose their pants, or get out of the game. When considering certain curricular plans I am reminded of the comic strip where the son of 'Hagar the Terrible' asked his Viking mother while she was peeling potatoes in the kitchen, "Mother, what makes the sun hang in the sky?" "I don't know," she said. "Go ask your father, he's outside." Hagar was busily sharpening his sword for the next invasion, and when asked about the sun, he paternally laid down his sword and, patting the lad on the head, said, "My boy, over the hill to the east of us lives a gigantic soccer player. Each morning he kicks the sun like a soccer ball and his strength is so great that the sun sails over us, hangs in the sky until it becomes spent, and then falls into the fjords far off to the west." The little lad, his eyes wide, looked up with great admiration and said, "Gee, thanks, dad." "Anytime, son," Hagar beamed. With that the boy returned to the kitchen. "What did he say?" his mother asked. "He doesn't know either," he answered.

REFERENCES

Bohannan, H. M., Rovin, S., Packer, M. W. & Costich, E. R. (1971) A concept of the flexible dental curriculum. Paper presented at the annual meeting of the Dental Examiners and Educators in Chicago, February 1971.

Bohannan, H. M., Rovin, S., Packer, M. W. & Costich, E. R. (1972) The flexible dental curriculum. *Journal of the American Dental Association,* **84,** 112-124.

Butts, H. C. (1975) Dental education: Is the pendulum swinging back? *Journal of the American Dental Association,* **90,** 897.

Christensen, G. J. (1975) The dental materials dilemma. *Dental Survey,* **51,** December, 50.

Martens, L. V. & Meskin, L. H. (1971) The current character of practice and the expectations of dental students. *Journal of Public Health Dentistry,* **31,** 268-271.

Sheils, M. (1975) Why Johnny can't write. *Newsweek,* **86,** December 8, 58-65.

Shira, R. B. (1975) Shira testifies on manpower bills in Senate. *American Dental Association News,* **6,** December 1, 1, 7.

Young, W. O. (1961) Dental health. In *The Survey of Dentistry,* dir. Hollinshead, B.S., p. 14. Washington, D.C.: American Council on Education.

OPERATIVE DENTISTRY, 1976, **1**, *156-157.*

POINT OF VIEW

I Am Proud To Be a Dentist

NORMAN C. FERGUSON

Many dentists ask: Has it been worthwhile to become a dentist? Did I do the right thing?

June 1976 marked the 32nd anniversary of my graduation. May I take it upon myself to answer?

Yes, I am glad to be a dentist because I am proud to be a dentist. Through the years, dentistry, besides being my vocation, has to a great extent become my avocation, my hobby. It has given me my best friends, men whom I can trust and admire, and with whom I am proud to identify. The material rewards have been adequate, the prestige sufficient to fulfill my youthful dreams.

Pessimists may say that the prestige of the profession is declining, but I do not think this is so. There have always been people to point out our faults, and this will always be so. Some of the people who worry about our public image are the public relations counselors, who then offer to improve our image—for a large fee, of course.

The new minister of health once pointed out to us that our services were not well distributed. To that, I must reply with a "mea culpa," but only to the degree of the guilt of all mankind. If dentists are alone responsible for those who cannot obtain adequate dental care, are not then the bankers to the same extent responsible for those who have no money? Or the insurance companies for those who cannot obtain a mortgage? Or the automobile

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Reprinted from the *B.C. Dental Bulletin,* **17**(3), February 1974.

dealers for those who have no transportation.

Agreed, there are men in dentistry of whom I do not approve, and men I do not like. But by and large my colleagues form a group that stands equal to any group in the community.

Many dental educators, I believe, are guilty of denigrating the profession because of the mechanical aspects of dentistry, and tell their students they must imitate "real doctors." To me this is unfortunate. Should I have to pretend to be a psychiatrist in order to do dentistry for a retarded child? I have a feeling the qualified dentist handles the child better in a dental environment than does any other professional.

It has been stated that all dentists should do blood pressure and cardiovascular examinations on all patients in order to detect latent conditions and thus enhance our prestige. The reason: not enough people see their physicians regularly. Then, logically, because not enough patients see their dentists regularly, the physicians should do a full dental examination including prophylaxis. Carried to its conclusion, the system would make dentistry and medicine interchangeable to the damage of both. The separation of medicine and dentistry in North America has allowed each to grow to a stature not seen anywhere else in the world.

Please, as dentists, do not waste your time worrying that you are merely artisans. The great cathedrals of Europe were built by artisans long before the mathematics that could calculate their stresses had reached the western world. We do the surgery of the mouth, with a skill requirement that would stagger the most capable of medicine's plastic surgeons.

It is often pointed out that we do not prevent, we mostly repair. This is changing to some extent, but our medical friends are faced with the same problem with their most prevalent diseases.

Finally, take pride in your work. The happy man is traditionally the one who works with his hands. We have the advantage of sufficient mental challenge to stimulate the brightest student coupled with a need for skill and dexterity matched by no other occupation.

I am proud to call myself a dentist.

DEPARTMENTS

Press Digest

The cracked-tooth syndrome and fractured posterior cusp. Snyder, D. E. (1976) *Oral Surgery, Oral Medicine and Oral Pathology* (41), 698-704.

The incidence of cracked-tooth syndrome and fractured posterior cusps was determined by reviewing the information collected from 3,537 visits of patients during the year 1974. Sixty-two cases were recorded, the largest number being found in the age range 30 to 59 years. Only 11 cases consisted of the cracked-tooth syndrome alone. Only two teeth had to be extracted. All teeth had previous restorations. Though teeth without restorations can crack, this study shows that large restorations weaken teeth. A plea is made for conservative cavity preparations including the preservation of the oblique ridge in upper molars and the transverse ridge in lower first premolars. Amalgam is not the best treatment for teeth that are seriously damaged. MOD onlays and three-quarter crowns should be more popular.

Fissures at risk. Crabb, H. S. M. (1976) *British Dental Journal* (140), 303-307.

During an investigation of the outer enamel of unerupted premolar teeth, which was shown to contain a porous zone 180 to 300 μm wide, the author discovered a widespread carious lesion surrounding a fissure of a tooth with only one erupted cusp—a tooth which only four months earlier had been entirely unerupted. This prompted an examination of ground sections of 100 unerupted premolars to determine the dimensions of the fissures and the thickness of enamel between fissures and dentine. From the results the author deduced that if caries were to begin from the sides of a fissure, it might be expected to reach the dentine from 3½ to 8½ months after the start of eruption, and from 4½ to 11½ months if the lesion began from the base of the fissure. These findings support the view that the clinician has available only a limited time after eruption to apply fissure sealants for maximum effect. More information is needed on the effectiveness in the long term of the application of sealants to fissures around which the dentine is already affected by caries.

Pulp protection. Shovelton, D. S. (1976) *Journal of the British Endodontic Society* (9), 57–66.

An excellent review of the causes of pulp damage, its avoidance, and pulp protection is presented in this article by an authority on the subject.

The origins of pulp damage are categorized as: bacterial (caries, tooth fracture, and periodontal disease); traumatic (acute and chronic); iatrogenic (cavity preparation, restoration, and orthodontic treatment); and chemical (medication, liners and bases, and restorative materials).

- Carious lesions usually produce small and reversible disturbances until they are within a millimeter of the pulp. However, early treatment gives the best protection.
- Complete or incomplete fracture of the crown allows bacteria to penetrate to the pulp. Symptoms are discomfort during eating and sensitivity to cold, culminating in acute pulpitis. For prevention, amalgam should be limited to small restorations and gold restorations should cover cusps.
- Vascular damage of apical vessels may result from traumatic blows. The pulp usually dies unless the patient is young, the apex wide open, and the periodontium resilient. Damage is difficult to prevent.
- Bruxism, attrition, and abrasion can cause pulp death. Though effects of excessive occlusal forces on the pulp may be slight, occlusion should be adjusted carefully when fixed bridges are placed. This insures that only minimal effects are added to pre-existing pulp damage.
- During cavity preparation the pulp may be damaged by heat, vibration, and dehydration. Generation of excessive heat can be avoided by the use of a coolant, and dehydration can be prevented by keeping the tooth moist. Water spray is more effective than air, but studies have shown that in young teeth after long periods both methods of cooling give comparable results. Deeper cavities injure pulps more than do shallow cavities. The area covered by a preparation is not as important as the depth, though a larger area may lead to greater pulpal damage if chemicals are used.
- Pins seem not to injure the pulp unduly if they do not expose it. Pins that require cementing with zinc phosphate cement result in greater pulpal inflammation.
- Gold foil requires mallet blows, which may be injurious, and also the use of separators. Great care is needed with these procedures.
- Orthodontic treatment attained too rapidly may damage apical blood vessels and care is needed if such teeth must be restored.
- Evidence on the effect of stannous and sodium fluoride as medicaments is equivocal though in polycarboxylate they are bland.
- Alcohol and chloroform probably cause more damage by desiccation than by chemical action.
- The advantage of using antibiotics has not been demonstrated and the evidence on the use of steroids is equivocal.
- Calcium hydroxide and zinc oxide eugenol kill organisms over time; calcium hydroxide also induces remineralization of softened dentine.
- Varnish alone does not protect the pulp from chemical irritation but varnish prevents microleakage.
- Recent studies have shown that damage from zinc phosphate cement may not be as great as has been formerly thought.
- Amalgam is a good thermal conductor but dentine is a good thermal insulator. Cavities should not be deepened just to provide room for an insulating base.
- Composite resin damages the pulp and requires a base of calcium hydroxide. Well-adapted bases do not eliminate completely pulp responses. Calcium hydroxide covered with copal ether varnish gives excellent protection.

Book Reviews

HUMAN PULP RESPONSE TO OPERATIVE DENTAL PROCEDURES

By Harold R. Stanley

Available from Storter Printing Company, Inc., P.O. Box 1409, Gainesville, FL 32602. 80 pages, illustrated. $4.95

One of the biological elements in restorative dentistry, the human dental pulp, is the subject of this small text or monograph published by Harold Stanley. Dr. Stanley is recognized as an eminent researcher on the human dental pulp, and has provided in this text, in a condensed form, the essential information related to responses of the pulp to operative procedures. The material is not esoteric or packed with basic research information, yet all the research evidence is cited to permit the reader to explore the background for the text.

This material has been designed for a predoctoral teaching program and is easily read, but it is most pertinent for the practicing dentist and teacher in its presentation of the biological effects of daily restorative dentistry.

In a concise form, the text describes the normal tooth at the histological level; develops the effects of acute and chronic inflammatory reactions; describes healing of the dental pulp in relationship to time and rate of reparative dentin formation; discusses the precise effect of various cutting procedures on dentin and the effect of frictional heat and burn lesions; differentiates between dentinal and pulpal pain; and describes the effect of liners and varnishes and why sterilization of a cavity preparation is no longer necessary.

A great deal of information is presented on the value of reparative dentin and the significance of the amount of remaining dentin during cavity preparation.

The text is well illustrated and written in simple and concise language. For the teacher it offers a behavioral objective format to aid in student instruction.

The book, then, is a major contribution for use by the clinical dentist, as well as by the student and teacher. It contains information which can enable the dentist to predict with greater certainty than ever before whether he should, in fact, "pulpcap" or carry on with a complete endodontic procedure. It should convince the reader that minimal irritation of the pulp may, when controlled, be beneficial rather than detrimental.

This text should prove invaluable to restorative dentists. Dr. Stanley should be commended for providing us with an opportunity to become more familiar with one of the important biological aspects of operative dentistry.

PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM ON AMALGAM AND TOOTH-COLOURED RESTORATIVE MATERIALS

Edited by A. J. Van Amerongen, H. W. Dippel, A. J. Spanauf & M. M. A. Vrijhoef

Publisher: University of Nijmegen, 1975.

279 pages. $10.00, payment to be made to the Algemene Bank Nederland, N. V. Nijmegen: postal transfer account No. 82.10.25 in favor of Stichting Researchen Techniek Account No. 53.71.19.892; refer to OP DENT BOOK.

A limited number of texts of the *Proceedings* of this symposium are still available. Topics covered and their authors are:

- *Technological and Biological Aspects of Amalgam Restorations,* Jørgensen, Hals, Vrijhoef & Granath. Amalgam in relation to corrosion and creep; experimental and natural carious lesions in relationship to amalgam restorations; techniques to improve the life of an amalgam restoration; leakage around this material.
- *Clinical Research on Amalgam and Tooth-colored Restorations,* Letzel, Rupp, Going & Leinfelder. Clinical research on amalgam and composite restorative materials.
- *Tooth-colored Restorations, Their Technological and Biological Aspects,* Heyde, Christensen, Barnes & Forsten. The ultraviolet polymerizable mechanisms, the acid-etch techniques and marginal adaptation.
- *Influence of Filling Materials on the Pulp,* Langeland, Schroder & Rowe. Microbiological aspects of dentinal caries on the pulp, pedodontic and endodontic information, and calcium hydroxide, antibiotic steroid preparations and isobutyl cyanoacrylate as pulp-capping agents.
- *Cavity Preparation Instrumentation,* Renggli, Grainger, Elderton & Sturdevant. The gingival

reaction to cast restorations, cavity design in relation to the gingival embrasure, research on cavity design for amalgam restorations, cavity preparation design for composite restorations, and information on brace-inlays.

- *Cavity Preparation Instrumentation as Used in Teaching,* Steures & Wittrock. Reorganizing preclinical techniques and a problem-solving curriculum.

Although this is not a text but a monograph of the series of papers presented, the information is up-to-date and provides a resource for teachers, clinicians, and researchers that is significant in that it presents information from the United States as well as European countries. The editors are to be congratulated for this well-presented, well-printed, and appropriately illustrated addition to the literature.

David A. Grainger

Announcements

NOTICE OF MEETINGS

Academy of Operative Dentistry

Annual meeting: February 17–18, 1977
Hyatt Regency Hotel,
Chicago

American Academy of Gold Foil Operators

Annual meeting: October 6–7, 1977
University of Florida
College of Dentistry
Gainesville, Florida

Student Achievement Awards

Each year the American Academy of Gold Foil Operators requests the name of an outstanding graduating senior from the deans of the 70 dental schools in the United States and Canada to receive the Academy's award. One student is selected by the faculty from each participating dental school. A certificate acknowledging scholarly and clinical excellence is awarded. In addition to the certificate, the recipient of the award receives a one-year subscription to the journal *Operative Dentistry.* This year 36 students received these awards acknowledging outstanding achievement in operative dentistry, with proficiency in direct gold restorations. They are:

Alvin T. Benson, West Virginia University; Glen L. Bollenbach, Baylor College of Dentistry; Sallyanne Bonner, New Jersey College of Medicine and Dentistry; George F. Briginshaw, Marquette University; Stephen K. Buckingham, Indiana University; Dennis J. Conlon, Georgetown University; Yves Doyon, Université Laval; Samuel L. Earley, University of Pittsburgh; Duncan G. Foulds, University of Texas (Houston); Gordon N. Gates, Loma Linda University; Stanley R. Heiner, University of the Pacific; John Hinton, Washington University.

Kerwin J. Kahlich, University of Texas (San Antonio); Steven D. Kaminsky, Tufts University; Darrell B. Kelley, University of Illinois; Richard J. Kovach, University of Saskatchewan; Gregory W. Ling, University of Minnesota; David Mark Loshin, Washington University; Daniel T. Mayeda, University of Missouri—Kansas City; Brent C. Mackay, University of Southern California; Robert B. Muncy, Jr., University of Kentucky; Alexander M. Neidhardt, Temple University; Xavier F. Nemerkenyi, State University of New York at Buffalo.

Daniel J. Pepin, University of Michigan; Howard E. Pointer, Howard University; Jeffrey M. Pomerantz, Fairleigh Dickinson University; Samuel W. Quillen, Jr., University of Louisville; Mark R. Spector, Loyola University of Chicago; Jeanette Clarke Tejada, Columbia University; Marc Dennis Tollefson, Case Western Reserve University; Richard D. Tucker, University of Washington; Albert A. Tysor, University of Maryland; Robert K. Wadlin, University of Oklahoma; Maurice H. Weintraub, Medical University of South Carolina; Richard E. Wheatfill, Northwestern University; David K. Yashikawa, University of California (Los Angeles).

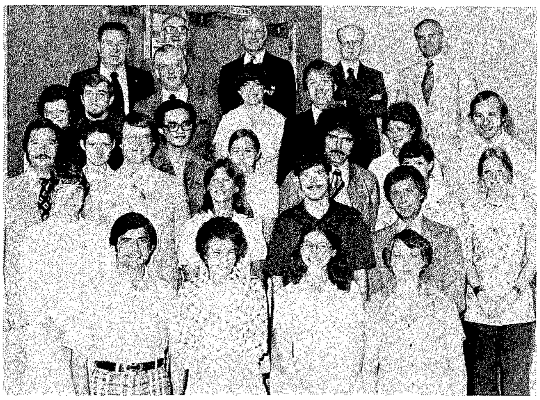
NEWS OF THE STUDY CLUBS

Gold Foil Course, Seattle

Twelve dentists and their assistants participated in a course on gold foil sponsored by the Associated Ferrier Study Clubs during the last two weeks in June.

Instruction was under the direction of Gerald Stibbs, assisted by co-instructors Ralph Stenberg, Richard V. Tucker, and Ian Hamilton. Participants came from Pennsylvania, Texas, Colorado, and British Columbia, as well as from the local area. Each participant placed a foil for a patient each morning and afternoon, except for the first morning, given entirely to lectures. Lectures also preceded each morning's operating session.

Anyone interested in attending a similar course in June 1977 should write for information to: Dr. Harold L. Sondheim, Secretary, Associated Ferrier Study Clubs, 1532 Medical & Dental Building, Seattle, WA 98101.



Attending the Seattle Gold Foil course in June were, front row, left to right: Robert J. Cavalieri, Moscow, Pa.; Evelyn Richardson, Seattle; Pam Lavers, Ferndale, Wash.; Julie Haddock, Seattle.
Second row: Betty Samuelson, Seattle; Darlene Dickson, Houston, Texas; Richard D. Tucker, Bellingham; Marvin H. Goldfogel, Denver, Colo.
Third row: Ronald J. Zokol, Yvette Johnson, both Vancouver, B.C.; Frank K. Eggleston, Houston; Michael Fung, Elizabeth Dewhirst, Terry H. McKay, all Vancouver, B.C.; Toni Bazzoni, Seattle; Debbie Helgeson, Burlington, Wash.
Fourth row: Dolly Homman, Seattle; Paul W. Johnson, Vancouver, B.C.; Norman C. Ferguson, Jane Christopherson, Art Lien, Karen Jacobsen, all New Westminster, B.C.; Paul Bergman, Burlington, Wash.
Back row: Johnny N. Johnson, Seattle; instructors Richard V. Tucker, Ferndale; A. Ian Hamilton, Gerald D. Stibbs, both Seattle; and Ralph G. Stenberg, Lynnwood, Wash.

Gerry Stibbs, assisted by Pam Lavers, demonstrates part of an operation to Dick Tucker. Bob Cavalieri (on right) observes over Dr. Stibbs' shoulder.

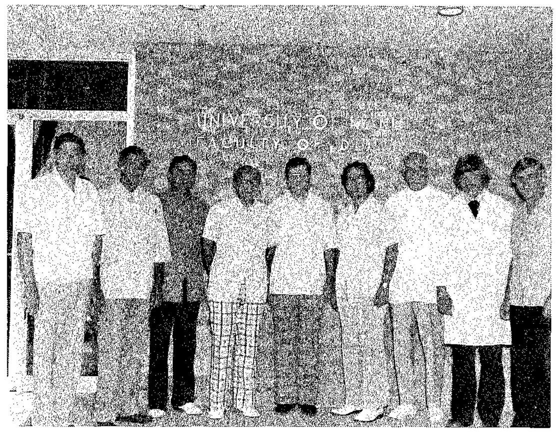
Richard V. Tucker (right), assisted by Pam Lavers, helping Richard D. Tucker with an operation.

Gerry Stibbs, assisted by Darlene Dickson, showing Frank Eggleston a refinement of cavity preparation.

Johnny Johnson condensing gold with the help of Dolly Homman. Terry McKay observes.

Winnipeg Course: New Gold Foil Study Club

A new gold foil study club, the Winnipeg Ferrier Society, has recently been established. The members of this new group are: Beryl Actinov, George A. Brass, Louis N. Green, Gary L. Hill (Minneapolis), Leonard H. Kahane, Andre S. LaChance, George Lister, and Allan Osborn. A course of instruction by Bruce B. Smith of Seattle, assisted by Allan Osborn as co-instructor, was given to the members during the two weeks June 28 to July 10. The society, directed by Allan Osborn, will meet monthly for operating sessions at the University of Manitoba, Faculty of Dentistry, Winnipeg, Manitoba, Canada R3T 2N2.



Attending the Winnipeg course of instruction were, left to right: Bruce B. Smith, Leonard H. Kahane, Beryl Actinov, Louis N. Green, George Lister, André S. LaChance, George A. Brass, Gary L. Hill, and Allan Osborn.

Bruce Smith analyzes Gary Hill's cavity preparation. Elaine Hill is assisting.

Bruce Smith examining a Class III cavity with Lenny Kahane and Mrs. Kahane observing.

André LaChance condensing foil.

At right:
Beryl Actinov condensing foil with the assistance of Mrs. Actinov.

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INSTRUCTIONS TO CONTRIBUTORS

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