

Adaptation of composite resin restorative materials to retentive grooves of Class I cavity preparations

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Abstract

An in vitro study was conducted to determine the adaptation of composite resin restorative material to rounded and acute-angled retention grooves of Class I cavity preparations on 24 extracted premolars. Two chemically cured (P-10® and Miradapt®) and 2 light-cured (Prisma-Fil® and Ful-Fil®) composite resin materials, after being coded to create a blind study, were injected into cavity preparations containing rounded and acute-angled retention grooves. The restored premolars were cut in half and examined via SEM at 50× magnification. A standardized method was used to determine the adaptation of each composite resin to the grooves. Interjudge evaluation showed all composite resin materials adapted well to both rounded and acute-angled retention grooves. Mean and standard deviation values revealed no significant difference in the average dentin-resin gap between treatment groups and between the 2 types of retention grooves. There was only 0.6M difference between the lowest and highest mean values.

Retention form is an essential component of cavity preparations in primary teeth.^{1,2} Retention form to resist displacement of an amalgam restoration can take several forms: dove-tail shapes on the occlusal surface to resist horizontal displacement; truncation of the occlusal portion of the cavity preparation as well as the lateral walls of the proximal box to resist vertical displacement; and grooves placed within the dentin at the junction of the occlusal walls and pulpal floor to ensure intimate adaptation of the restoration material to the cavity preparation.³⁻⁷ Heim, while investigating the ability of an amalgam restorative material to be condensed into retention grooves,

demonstrated that acute-angled retention grooves were less likely to be filled completely by this material than were rounded retention grooves.⁸ His research suggested that rounded retention grooves allow better adaptation of amalgam restorative materials than do acute-angled retention grooves.

Retention of composite resins to cavity preparations can occur through acid etching of the enamel margins followed by bonding of the resins to these walls.⁹⁻¹⁷ Retention of posterior composite restorations could be enhanced by utilizing both enamel conditioning and retention grooves. Retention groove use in cavity preparations should be based on evidence of whether or not posterior resin restoration materials can adapt to such retention grooves.

The purpose of this investigation was to determine whether chemically cured and light-cured composite resin restorative materials adapt to rounded and acute-angled retention grooves of Class I cavity preparations.

Methods and Materials

Caries-free premolars extracted for orthodontic purposes from patients 12-25 years of age were stored in saline solution. After storage, each tooth was examined under a dissection microscope to eliminate those possibly having cracks in the enamel. A total of 24 teeth were identified for the study. To facilitate cavity preparation the cusp tips of each tooth were reduced, producing a flattened occlusal surface. Standardized cavity preparations were created in each tooth by mounting each specimen in plaster within a metal mold and using a variable-speed electric drill mounted

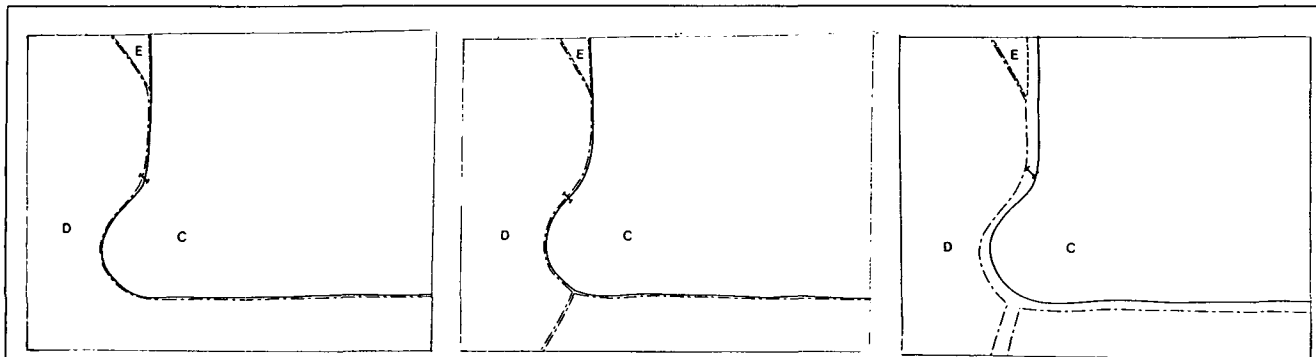


FIG 1. Representation of a composite resin restoration without evidence of cracks along the dentin surface—category X (C — Composite; D — Dentin; E — Enamel; I — Interface, 50×).

FIG 2. Representation of a composite resin restoration in association with cracks along the dentin surface, but no apparent disturbances in the outline of the retention groove or displacement of the dentin wall — category Y (C — Composite; D — Dentin; E — Enamel; I — Interface, 50×).

FIG 3. Representation of a composite resin restoration in association with cracks in the dentin surface causing an obvious displacement either of a part or the entire perimeter of the retention groove — Category Z (C — Composite; D — Dentin; E — Enamel; I — Interface, 50×).

on a drill press apparatus^a to facilitate uniform preparation of cavities and retention grooves as well as accurate cavity depth measurement. The Class I cavity preparations followed an outline drawn on the occlusal surface of the tooth and were made with a #103 diamond bur. Production of heat during the cavity preparation was minimized by means of a cold water spray delivered to the tooth and bur. Burs were changed after every 2 cavity preparations.

The same apparatus^a was used to prepare retention grooves within the cavity preparations. Rounded grooves were placed along the buccopulpal and mesiopulpal line angles using #2 burs (round). Acute-angled grooves were placed along the linguo-pulpal and distopulpal line angle using #37 burs (inverted cone). While creating retention grooves, the tip of the bur passed along the pulpal floor and the shank of the bur passed along the cavity wall. A bur was passed twice in the area where a groove was being created.

Four groups of specimens, each corresponding to a composite resin material, were formed randomly from the 24 cavity preparations. To create a blind study, each composite type was coded and prepared for restoration by a coworker. In addition, a treatment group number was assigned to each tooth.

Two chemically cured (Miradapt^b and P10^c) and 2 light-cured (Ful-Fil^d and Prisma-Fil^e) composite res-

ins were used. Ful-Fil and Prisma-Fil resins were available in premixed syringe packages. These materials were selected because of their reported superior performance.^{18,19} Each group of teeth was restored with each of the 4 composite resin materials, using an injection technique to reduce voids in the resin.^{20,21} With injection of the composite material beginning at the pulpal floor, the cavity preparations were filled and then overfilled to allow equal distribution of pressure. Each filled tooth had pressure of approximately 100 psi applied to the composite material before polymerization began. The chemically cured groups were allowed to polymerize for 5 min and the light-cured resin received a 20-sec exposure to the visible light.

The crowns of the restored specimens were separated from the roots by a disk in an air turbine handpiece. The crowns then were sliced in half buccolingually on a water-cooled, hard tissue cutting machine.²² Each half was designated as being right or left by an indelible pencil. Each specimen also was marked with its treatment group number, tooth number in the group, and identified as the buccal or lingual portion of the tooth. The specimens were dried, mounted on metal stubs, sputter coated^f with gold and examined via SEM^g at a magnification of 50x.¹²⁻¹⁴ Photomicrographs were taken using Type 55 P/N Polaroid film^h.²³ Photomicrographs of the acute-angled and rounded retention grooves were evalu-

^a Dremel, Model 232-5—Division of Emerson Electric Co, Racine, WI.

^b Miradapt — Johnson and Johnson Dental Products, East Windsor, NJ.

^c P-10 — 3M Dental Products, St. Paul, MN.

^d Ful-Fil — LD Caulk Co, Milford, DE.

^e Prisma-Fil — LD Caulk Co, Milford, DE.

^f Varian Association, Palo Alto, CA.

^g ISI Super-Mim SEM, International Scientific Instruments, Mt. View, CA.

^h Type 55/Positive-Negative Film, Polaroid Corp, Cambridge, MA.

ated independently by 2 observers visually and by measurement to determine the adaptation of the composite resin material to the retention grooves.

A trial study indicated that restored specimens could be classified into 3 categories: (1) those without evidence of cracks along the dentin surface — category X (Fig 1); (2) those exhibiting cracks along the dentin surface, but with no apparent disturbances in the outline of the retention groove or displacement of the dentin wall — category Y (Fig 2); and (3) those exhibiting cracks in the dentin surface causing an obvious displacement either of a part or the entire perimeter of the retention grooves — category Z (Fig 3).

The adaptation of the composite resin materials was measured in the X and Y category specimens by selecting a reference point on the outline of the greatest curvature of the retention groove. A circle having a radius of 20 mm was drawn there, thus marking the region where the material was most likely not to adapt (Figs 4a,4b). The extent of the groove involved was determined by marking the points where the circle intersected with the retention groove. A strip of flexible material was placed along the outline of the retention groove to mark off (on the flexible material) the points where the circle and the outline of the groove intersected. The flexible material then could be extended and the length between the 2 marks measured. The length of the interval between the 2 points of measurement then was subdivided by dividing the length of the segment by 20. The sites of measurement thus obtained were marked along the outline of the retention groove. Using a Boley gauge, the amount of space between the border of the composite resin and the wall of the retention groove was measured at each predetermined site (Fig 2).

This measuring procedure was omitted for category Z specimens since displacement of the dentin wall resulted in the creation of a false space between

the resin material and the retention groove.

The composite resin of X and Y category specimens was considered to be adapted when: (1) the amount of space between the border of the resin and the wall of the retention groove did not exceed 1 mm, and (2) the outline of the border of the resin conformed to the outline of the wall of the retention groove (Fig 2).

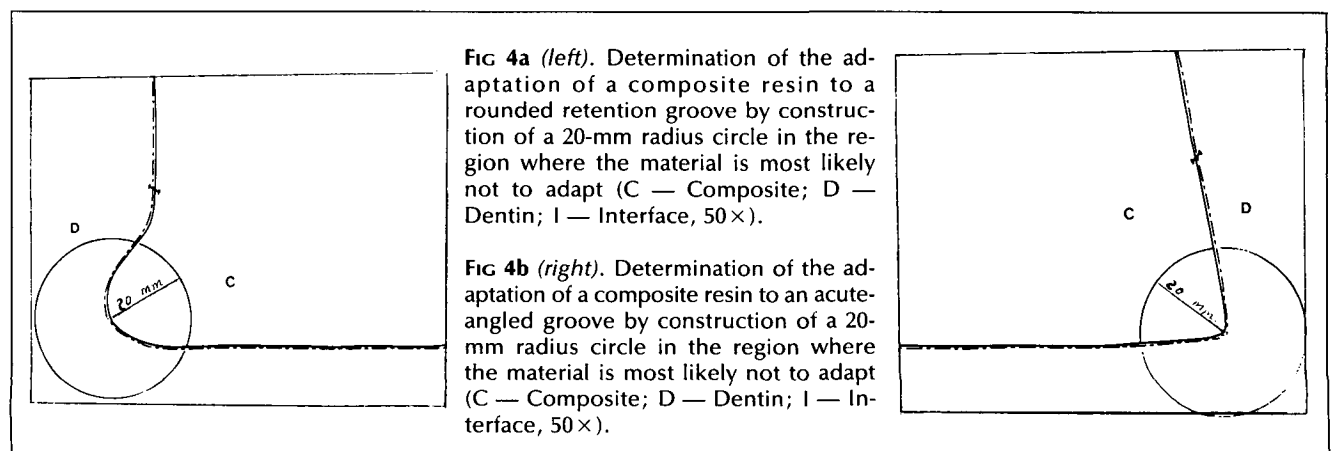
The composite resin of X and Y category specimens was considered *not* to be adapted when: (1) a space greater than 1 mm occurred at 2 or more sites along the retention groove, and (2) the outline of the border of the resin where space greater than 1 mm occurred did not conform with the outline of the wall of the retention groove.

The composite resin of Z category specimens was considered to be adapted when visual examination of the outline of the border of the composite material conformed to the outline of the retention groove, regardless of the amount of space between the resin material and the retention groove.

When the dentin walls were displaced downward or laterally in category Z specimens, a composite resin was considered to be adapted where the border of the resin conformed to the outline of the groove, regardless of the amount of space between the resin and the groove. The resin material was considered *not* to be adapted in category Z specimens when there was an obvious nonconformity in the outline of the resin material with that of the retention groove. Interjudge evaluations were made of the photomicrographs by 2 investigators.

Results

The experimental resin materials, coded with letters to create a blind study, were distributed as follows: I) Prisma-Fil; II) Ful-Fil; III) Miradapt; and IV) P-10. The composite resin restorative material filled completely both rounded and acute-angled retention



grooves of the 24 Class I cavity preparations (Figs 5,6).

In spite of using crack-free cavity preparations before inserting the restoration material, some specimens, when examined under SEM, exhibited cracks of the dentin surface, as well as gross displacement of the restoration. These findings were statistically analyzed to determine if there was any relationship between the type of resin material employed and the occurrence of errors. Chi-square analysis of these data revealed statistically significant differences among the resins tested ($X^2 = 16.15$, $p = .013$). Treatment with the P-10 composite resin material (group IV) resulted in only 2 of 24 specimens without any evidence of cracks along the dentin surface. Eleven of the 24 Ful-Fil (group II) specimens were found to be free of any cracks (Table 1).

As previously noted, adaptation of the composite materials to the grooves was *not* measured in those specimens that exhibited obvious displacement of either all or part of the perimeter of the retention grooves. Therefore, the number of specimens available for assessment of adaptation was 19, 13, 14, and 13 for Prisma-Fil, Ful-Fil, Miradapt, and P-10, respectively. The means and standard deviations for the amount of space between the border of the composite resin and the wall of the retention groove of those specimens that did *not* exhibit any gross displacement of the restoration revealed little or no differences between treatment groups or between the 2 types of retention grooves, (Table 2, Figs 1,2). The smallest mean gap value was 3.6μ and was observed with the rounded retention groove and Prisma-Fil material, while the largest mean gap values were noted with the rounded groove and Miradapt restorative material and the acute-angled groove of P-10 restorative material (4.2μ). There was a 0.6μ difference between the smallest and largest mean values. The mean gap value for all rounded groove specimens was 3.91μ and 4.05μ for the acute-angled groove specimens, irrespective of the resin material employed.

Discussion

The adaptation of the composite resin restorative material to rounded and acute-angled retention grooves tested in this study was found to be excellent. These findings are in contrast to those of Heim⁸ in which it was found that acute-angled retention grooves were not filled completely with amalgam following restoration of cavity preparations. The sizes of the burs used in preparing the retention grooves in this study were #1/2 for rounded grooves and #37 for acute-angled grooves. While similar information was not provided in Heim's investigation, if his acute-angled retention grooves were more angled than those of the present investigation it would be more difficult for amalgam, a relatively less fluid material, to be condensed into constricted areas. A relatively viscous composite resin material may flow better than amalgam into acute-angled grooves when a considerable amount of pressure is applied.¹⁸

Chi-square analysis indicated the P-10 treatment group had a significantly greater number of cracks in the retention of its specimens than did those of the other 3 groups. As it is unknown at what stage of the specimen preparation (condensation of the composite material, sectioning of the teeth, vacuum drying, sputter coating) the cracks occurred or began to occur, it is difficult to explain their cause. As this observation involves *in vitro* research, additional investigation of its cause would seem to be warranted.

The mean and standard deviation values for the amount of space between the border of the composite resin and the wall of the retention groove in examined specimens indicated no differences in the adaptation of the composite resin material tested in either rounded or acute-angled retention grooves. The difference between the 27 rounded and 31 acute-angled groove specimens was only 0.14μ . The largest difference in the mean gap values among the resins, irrespective of the type of retention groove employed, was 0.31μ between P-10 and Prisma-Fil.

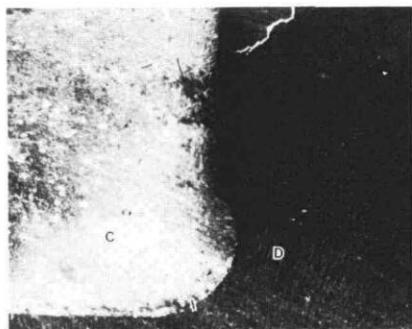


FIG 5 (left). Photomicrograph of a specimen without dentin cracks (category X) in which the resin is adapted well to the rounded retention groove ($50\times$).

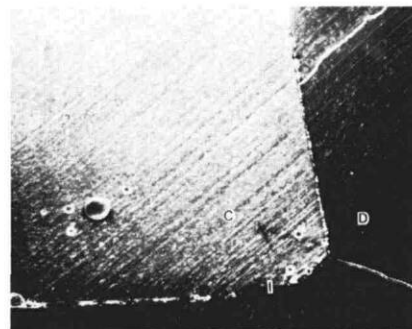


FIG 6 (right). Photomicrograph of a specimen with cracks in the dentin (category Y) in which the resin is adapted well to the acute-angled retention groove ($50\times$).

TABLE 1. Chi-Square Analysis of Treatment Groups by Degree of Error (Group I = Prisma-Fil; Group II = Ful-Fil; Group III = Miradapt; Group IV = P-10)

		DEGREE OF ERROR		
		NO ERROR	FRACTURE OF DENTIN	GROSS DISPLACEMENT OF RESTORATION
TREATMENT GROUPS	I	10	9	5
	II	11	2	11
	III	9	5	10
	IV	2	11	11

$$\chi^2 = 16.15 \quad df = 6 \quad P = .013$$

TABLE 2. Mean and Standard Deviation of Rounded and Acute-Angled Retention Grooves According to Treatment Group (Group I = Prisma-Fil; Group II = Ful-Fil; Group III = Miradapt; Group IV = P-10)

		TREATMENT GROUPS							
		I		II		III		IV	
		Round Groove	Acute Groove	Round Groove	Acute Groove	Round Groove	Acute Groove	Round Groove	Acute Groove
TYPE OF ANALYSIS	\bar{x}	3.6	4.0	4.0	4.0	4.2	4.0	4.0	4.2
	S.D.	.011	.094	.082	.089	.013	.076	.012	.089
	N	9	10	7	6	6	8	5	7

The gaps observed between the composite resin and the dentin wall of the cavity preparation may be attributed to polymerization shrinkage of the restorative material, dentin shrinkage during dessication, oil residue from the compressed air,^{14,16} or the presence of dentinal fluid in the tubules.¹⁷ In this study, polymerization shrinkage may not be as significant as dentin shrinkage.

Although efforts were made to standardize the size and depth of the retention grooves by use of a drill press apparatus, observation revealed little uniformity in depth, especially in some rounded retention grooves. The greater depth of some rounded grooves could be attributed to an upward movement of the

tooth-holding metal mold used while creating the grooves. Similar findings were not evident in the acute-angled grooves, perhaps due to the wide cutting surface of the inverted cone bur compared to the round cutting bur.

It has been demonstrated in this study that composite resin material adapts well to both rounded and acute-angled retention grooves. Whether this adaptation with the grooves will increase the retention of resin restorative material to the cavity preparation has not been determined.

Conclusions

The following conclusions can be drawn from this study.

1. Composite resin restorative material filled completely both rounded and acute-angled retention grooves of Class I cavity preparations.
2. No difference among composite resin restorative materials used in this study could be detected.
3. Further study of retention grooves used in cavity preparations to hold composite resin restorative materials is indicated to determine if such grooves in dentin provide additional retention of the composite resin material.

Dr. Allanigue was a graduate student at the time of writing; Dr. Rapp is a professor and chairman, pediatric dentistry; Dr. Piesco is an assistant professor, Dr. Elliott is an assistant professor, Dr. Nirschl is an associate professor, Dr. Guevara is an associate professor, and Dr. Zullo is a professor — departments of pediatric dentistry, anatomy, prosthodontics, and learning resources, respectively, at the University of Pittsburgh School of Dental Medicine. Reprint requests should be sent to: Dr. Robert Rapp, Department of Pediatric Dentistry, School of Dental Medicine, University of Pittsburgh, Pittsburgh, PA 15261.

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Quotable quote: obesity in children

Current knowledge of human obesity has progressed beyond the simple generalizations in the past. It is almost certain that obesity has multiple causes and that there are different types of obesity.

To assess the health implications of obesity, new knowledge and new epidemiologic observations have introduced a variety of complications that must be addressed. The interpretations of different studies have been complicated by smoking behavior, the coexistence of other diseases and variations in methods of data collection. Because population studies have not been representative of the United States, there have been uncertainties as to how far the results can be projected.

There is evidence that an increasing number of children and adolescents are overweight. Even though not all overweight children necessarily will become overweight adults, the increasing prevalence of obesity in childhood is likely to be reflected in increasing obesity in adult years. The high prevalence of obesity in our adult population and the likelihood that the national population of the future will be even more obese indicates a reassessment of the health implications of this condition.

Health Implications of Obesity (NIH Consensus Development Conference Statement). Contemporary Nutrition. 10(9). September, 1985.