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SCIENTIFIC articles

Modified cavity preparations for composite resins in primary molars

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Abstract

Recent clinical studies have suggested that composite resin may be an effective restorative material for the restoration of Class I and Class II preparations in primary molars for up to three years. The objective of this study was to advance understanding of the clinical performance of composite resin in primary molars.

Two composite resin systems (Profile and Visio Fil) and two cavity preparations (conventional and modified) were compared. Two hundred and forty restorations were placed in 30 patients ranging in age from four to eight years.

Baseline and 12-month clinical evaluations were performed independently by two trained examiners using the clinical evaluation criteria of the United States Public Health Service. Indirect evaluations were performed similarly for baseline and 12-month data using enlarged color transparencies. When placed in conventional Class I or II or modified Class I preparations, composite resin restorations performed excellently in this study for 12 months. The modified Class II preparation as described in this study performed poorly and cannot be recommended due to its failure rate.

In recent years there has been increasing concern about exposure of dental health personnel to the mercury in amalgam alloy restorations.[1] Concerns also have been expressed about the future cost and availability of the metals in dental amalgam.[2] These concerns have led to intense efforts to improve the characteristics of composite resin materials to make them more acceptable for use in posterior teeth. Today more posterior composite materials are emerging on the market and more are likely to be used by practitioners in the future. The use of composites in posterior teeth could change pediatric restorative dentistry dramatically since amalgam is widely used as the restorative material of choice in posterior primary teeth. Because there has been limited research on the subject, the purpose of this study is to advance the understanding of composite resin performance in primary molars.

Literature Review

Several clinical trials have been conducted to investigate the performance of composite resins in posterior permanent teeth and these have shown that the initial performance is similar to or better than that of dental amalgam.[3-6] However, after two or three years these restorations demonstrated unfavorable wear characteristics under occlusal stress.[3-6]

During the past decade improvements in the physical properties of composite resins have accelerated, and only recently Wilder and coworkers[7] have reported three-year results in which four light-polymerized composites showed little wear as compared to autopolymerized composite resins. These results suggest that the wear problem associated with posterior composites may be diminished appreciably in the near future.

Primary Tooth Studies

Little has been reported on the performance of composite resins in primary molars. Nelson[8] compared two composites (Adaptic[a] and Radio-Opaque Adaptic[a]) with an amalgam (Dispersalloy[a]) in 50 pairs of Class II preparations in primary teeth. Identical preparations were used for both amalgams and composites. Composite preparations were etched for 60 seconds with 38% phosphoric acid and a low viscosity bonding resin was applied after etching. Results were reported after three years; no significant differences were noted in color matching, cavosurface staining, or marginal adaptation. Anatomic form was the same for the three materials for two years, but the three-year evaluation showed amalgam to be slightly superior for anatomic form. Nelson concluded that composite resins were a suitable restorative material for primary molars when the tooth can be ex-

[a] Johnson & Johnson; East Windsor, N.J.
[b] Lee Pharmaceuticals Corp.; South Elmonte, Calif.

pected to be functional for three years or less.

In 1981, Tonn and coworkers[9] compared a composite resin (Epoxydent[b]) with an amalgam (Optaloy[c]) in primary molars. Conventional alloy preparations cleansed with citric acid were employed. The study included data from 70 amalgam and 67 composite Class II restorations. Results revealed that composite color match was excellent and cavosurface staining was minimal. After two years of clinical performance, there was no difference in marginal integrity but anatomic form was superior for the amalgam restorations.

Cavity Design For Composite Resins

Since acid etching significantly improves the retentive characteristics of composite resins, a number of cavity preparation designs involving no mechanical retention have been suggested.[10] Such preparations may conserve tooth structure since mechanical retention can involve removal of substantial amounts of enamel and dentin. Another cavity design modification suggested is the enamel bevel.[11-13] Beveling prior to acid etching has been credited with decreasing the incidence of enamel fractures at the enamel resin margin and decreasing marginal leakage.[11-13] A final and critical advantage gained with beveling is increased retention.[14,15]

There have been no studies reported which employed cavity design modifications in conjunction with posterior composite restorations. Vlietstra and coworkers[16] reported the use of acid etching in conjunction with preparations without mechanical retention, but their study involved the use of glass ionomer cements rather than composite resins.

Study Objectives

This study was designed to answer questions about the clinical performance of composite resins in primary molars. These included:

1. How does the conventional alloy preparation compare with a modified preparation designed to maximize the favorable characteristics of the acid-etch technique?
2. How does the clinical performance of an autopolymerized composite resin compare with that of a visible light-polymerized composite resin?

Methods and Materials

Sample Selection

Subjects were selected from a sample of children from Chapel Hill, North Carolina, and its surrounding area. Criteria for selection were formulated so that patients were:

1. Between the ages of four and eight years
2. Not presently under the care of a dentist
3. Available for recall appointments once every six months for a minimum of three years
4. Found to have at least two Class II carious lesions present on primary molars
5. Mentally and physically healthy so that no unusual treatment procedures were necessary.

Thirty-two children were invited to participate in the study and parental consent was obtained to proceed with treatment. Cavity preparations and composite restorative materials were assigned to patients using a random table. Treatment was performed at the Pedodontic Clinical Research Facility in the Dental Research Center at the University of North Carolina, Chapel Hill. The primary investigator and two full-time pedodontic faculty placed 240 Class I and Class II restorations in 30 patients utilizing local anesthesia and a rubber dam. (Two children moved from the state shortly after completion of their restorative care and their data could not be included.)

Cavity Preparations

Two cavity preparation designs were used in this study: conventional (control) cavity preparation and modified (test) cavity preparation.

The control cavity preparation was essentially the same as that used for amalgam restorations in primary molars. Teeth were prepared 0.2 mm into dentin with extension beyond contact in proximal boxes; however, all accessible enamel margins were beveled approximately 1 mm at 45°.

The modified or test cavity preparation involved removal of carious enamel and infected dentin only. Any enamel remaining after caries removal was retained, with cavity walls extended only for visual and mechanical access. All accessible enamel margins of the modified preparation were beveled approximately 1 mm at 45°. Cavity preparations used in the study are shown in Figures 1-3.

A gingival wedge was placed prior to initiating Class II cavity preparations. Exposed dentin was protected with calcium hydroxide (Dycal[c]) in all cavity preparations. All enamel margins were etched subsequently for 2 minutes with 37% unbuffered phosphoric acid. The teeth were washed copiously with water and dried with an air-water syringe. The low viscosity bond resin supplied with the restorative material was applied to the cavity preparation with a small brush. The restorative resin then was

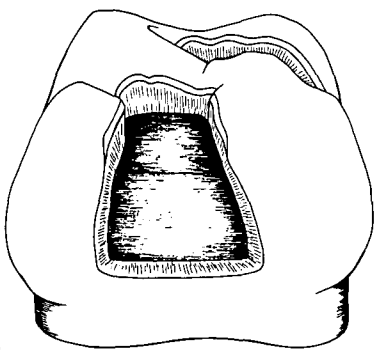

Figure 1. Conventional preparation.

[c] L.D. Caulk Co.; Milford, Del.

injected into the preparation using a Centrex C-R syringe.[d] After polymerization, final contouring of the restoration was completed with 12-bladed round and/or flame-shaped carbide finishing burs. After finishing, color transparencies were taken of each quadrant with the rubber dam in place.

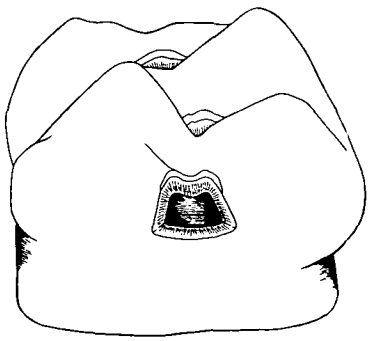

Figure 2. Modified preparation with minimal decay.

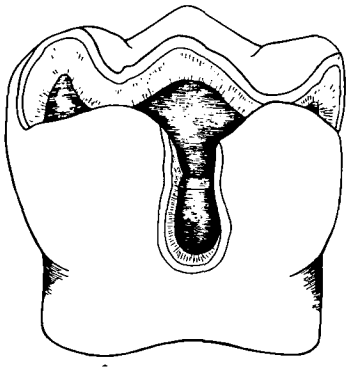

Figure 3. Modified preparation with extensive decay.

To assess the effectiveness of the materials and cavity preparations in situations involving advanced carious destruction, no stainless steel crowns were placed in this study. Rather, when a tooth was a candidate for a stainless steel crown (in the opinion of the operator), the tooth was restored using the preparation and material assigned by the random assignment table. These teeth were noted so this category could be analyzed separately.

Composite Resin Materials

The two composite resin systems used in this study were selected because their physical properties suggested they would be suitable for use in posterior teeth. One material was Profile,[e] an autopolymerized composite resin recommended by the manufacturer for both anterior and posterior restorations. The other was Visio Fil,[f] a visible light-polymerized composite resin. While Visio Fil is not advertised as a posterior restorative material, its physical properties are sufficiently similar to Profile to expect similar clinical performance. The physical properties of Profile and Visio Fil are listed in Table 1.

[d] Centrix Inc.; Fairfield, Conn.
[e] S.S. White Dental Health Products; King of Prussia, Pa.
[f] ESPE Corp.; Valley Stream, N.Y.

Evaluation Technique

Two methods were used to evaluate all restorations at baseline and 12 months. The first method used the United States Public Health Service (USPHS) evaluation criteria developed by Cvar and Ryge.[17] This method consists of evaluating restoration color match, marginal adaptation (marginal integrity), anatomic form (wear), cavosurface margin discoloration (interfacial staining), and any postplacement secondary caries. The criteria for rating restorations using this evaluation system are listed in Table 2.

The second method consisted of evaluating the color transparencies using the same rating system and criteria described for the USPHS technique.

All direct and indirect evaluations were performed by two trained evaluators. In cases where disagreement occurred between evaluators, the decisions were discussed immediately and a forced consensus was reached. A record of disagreements in all evaluation procedures was maintained to assess interexaminer reliability.

Method of Analysis

All data were recorded on evaluation forms at baseline and 12 months and were entered into a computer for storage and tabulation. Performance variables were analyzed using the Mantel-Haenszel Chi-square test[18] with an alpha of 0.01 as the level of significance for all statistical tests.

Results

Interexaminer reliability for the clinical and photographic baseline and 12-month evaluations ranged from 98.4 to 100%. Intraexaminer reliability for the photographic evaluations was examined by having examiners unknowingly re-evaluate 30 six-month slides during the 12-month photographic evaluation session. Intraexaminer reliability was found to range from 93.1 to 100%.

After 12 months 11 restorations were in teeth lost to natural exfoliation, thus the sample included 229 Class

Table 1. Physical Properties and Composition of Profile and Visio Fil

Product Description	*Profile*	*Visio Fil*
Manufacturer	SSW	ESPE
Particle Size (microns)	1-18	1-30
Filler % (weight)	75-80	80
Filler Composition	Strontium Glass	Quartz
Method of Polymerization	Auto	Visible Light
Coefficient of Thermal Expansion (ppm/degree C)	34	35
Water Sorption (mg/cm^2)	0.6	0.15

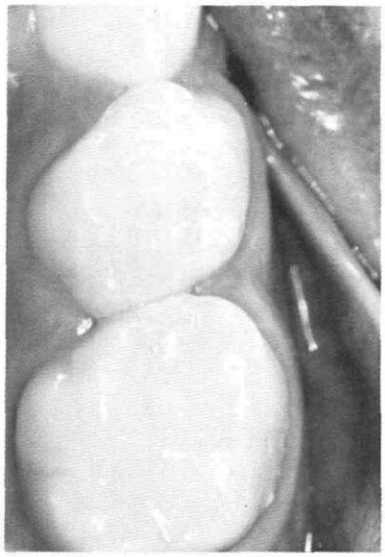

Figure 4. A modified preparation on the distal side of the first primary molar (Profile) and a conventional preparation on the second primary molar (Visio Fil). (Taken at 12 months.)

I and II composite restorations in primary molars. Because there was virtually no difference in direct clinical evaluations and color photographic evaluations at 12 months, only the direct clinical evaluation data will be presented. Clinical photographs at 12 months are illustrated in Figures 4 and 5.

A failure was defined as a circumstance in which the restoration material was either loose or completely missing. At 12 months a total of 15 restorations were considered to be failures, leaving 214 successful restorations.

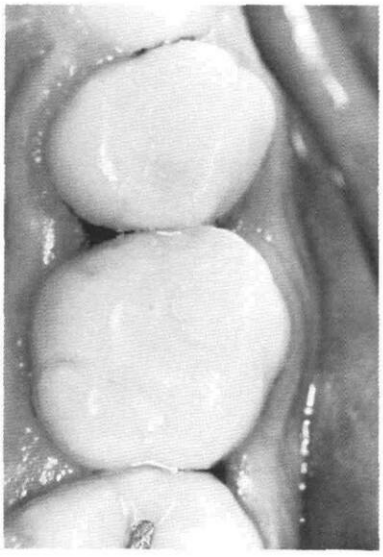

Figure 5. A modified preparation on the distal side of the first primary molar (Visio Fil) and a modified preparation on the mesial and occlusal surfaces of the second primary molar (Profile). (Taken at 12 months.)

Table 3 lists the clinical performance for the 214 successful restorations for two criteria: marginal integrity and wear. These two criteria were chosen since both have been problematic for posterior composites in other studies. As illustrated in Table 2 there was a slight deterioration for both materials for all criteria over 12 months, but this was not statistically significant. There were no significant differences between cavity designs at 12 months.

Table 4 illustrates the 15 (6.6%) failures at 12 months by category. Restorations placed in modified preparations failed more frequently than those placed in conventional

Table 2. Criteria for Rating Restorations Using USPHS System

Category	*Rating*	*Restoration*
Color Match	Alfa	Restoration matches adjacent tooth structure in color and/or translucency
	Bravo	Mismatch in color and/or translucency is not outside the normal range of tooth color and translucency
	Charlie	Mismatch in color and/or translucency is outside normal range of tooth color and/or translucency
Marginal Adaptation (Marginal Integrity)	Alfa	Restoration appears to adapt closely to tooth along periphery of restoration Explorer does not catch when drawn across margins; if it does catch, it will catch in only one direction. No crevice is visible
	Bravo	Explorer catches, and there is visible evidence of crevice into which explorer will penetrate, however, dentin and base are not visible
	Charlie	Explorer penetrates into crevice that is of such depth that dentin or base is exposed
	Delta	Restoration is fractured, mobile, missing
Anatomical Form (Wear)	Alfa	Restoration is continuous with existing anatomic form
	Bravo	Restoration is discontinuous with existing anatomic form, but missing material is not sufficient to expose dentin or base
	Charlie	Sufficient material lost to expose dentin or base
Cavosurface Margin Discoloration (Interfacial Staining)	Alfa	No discoloration anywhere on margin between restoration and tooth structure
	Bravo	Discoloration has not penetrated along margin in pulpal direction
	Charlie	Discoloration has penetrated along margin in pulpal direction

preparations, but that difference was not significant. There was no difference in failure rate between modified and conventional Class I preparations; however, the failure rate between modified and conventional Class II preparations was significant ($p < 0.01$). Nine of 15 failures occurred in modified Class II preparations. When all failures were analyzed separately, there was still no significant difference in the two materials.

Since the restorations were placed by three different operators, the effect of operator variable on the clinical

Table 3. Twelve-Month Clinical Performance Data by Material, Preparation, and Evaluation Ranking for Marginal Integrity and Wear

	Profile			*Visio fil*			*Total*		
Evaluation Rating for Marginal Integrity									
Preparation Design	A	B	C	A	B	C	A	B	C
Conventional									
Class I	18	0	0	14	1	0	32	1	0
Class II	21	3	1	22	2	1	43	5	2
SSC*	5	1	0	2	2	1	7	3	1
Total	44	4	1	38	5	2	82	9	3
Modified									
Class I	32	4	0	26	3	0	58	7	0
Class II	29	1	0	13	1	1	42	2	1
SSC	6	0	0	4	0	0	10	0	0
Total	67	5	0	43	4	1	110	9	1
Grand Total	111	9	1	81	9	3	192	18	4
Evaluation Rating for Wear									
Preparation Design	A	B	C	A	B	C	A	B	C
Conventional									
Class I	18	0	0	15	0	0	33	0	0
Class II	25	0	0	24	1	0	49	1	0
SSC	6	0	0	5	0	0	11	0	0
Total	49	0	0	44	1	0	93	1	0
Modified									
Class I	36	0	0	28	1	0	61	1	0
Class II	30	0	0	14	1	0	44	1	0
SSC	6	0	0	3	1	0	9	1	0
Total	72	0	0	45	3	0	117	3	0
Grand Total	121	0	0	89	4	0	210	4	0

* Stainless steel crown normally would be indicated because of extensive caries.

Table 4. Twelve-Month Failures by Material and Preparation Design

	Profile		*Visio Fil*		*Total*	
	Evaluation Rating					
Preparation Design						
Conventional						
Class I	0/18	(0.0%)	0/15	(0.0%)	0/33	(0.0%)
Class II	0/25	(0.0%)	1/26	(3.8%)	1/51	(2.0%)
SSC	1/7	(14.3%)	0/5	(0.0%)	1/12	(8.3%)
Total	1/50	(2.0%)	1/46	(2.2%)	2/96	(2.1%)
Modified						
Class I	0/36	(0.0%)	1/30	(3.3%)	1/66	(1.5%)
Class II	6/36	(16.7%)	3/18	(16.7%)	9/54	(16.7%)
SSC	2/8	(25.0%)	1/5	(20.0%)	3/13	(23.1%)
Total	8/80	(10.0%)	5/53	(9.4%)	13/133	(9.8%)
Grand Total	9/130	(6.9%)	9/99	(6.1%)	15/229	(6.6%)

performance of the restorations was examined. No operator effect was found for any variable.

Discussion

The evaluation data on the 214 successful restorations revealed that both materials exhibited excellent clinical performance after 12 months and no postoperative sensitivity was recorded.

Color matching characteristics were excellent at 12 months and there was no difference between the autopolymerized and light-polymerized material. Color match was not affected by the differences in homogeneity or degree of polymerization of the material which might have been expected as a function of the polymerization method. However, 12 months is probably inadequate time to draw firm conclusions about the interaction of polymerization method and change in color match.

The incidence of staining which occurred at the enamel-resin interface was minimal for both materials. This is an important consideration since marginal stain may be a precursor to recurrent decay. In those cases where staining was noted, it was superficial. While decay was noted around several restorations which were loose within the preparation, the results of this study support the findings of other studies which have found minimal recurrent decay around intact restorations after 12 months.[4,7]

After 12 months there was no wear or loss of anatomic form observed for any restorations in this study. This concurs with findings of Leinfelder[4] and Wilder[7] who demonstrated that wear of composites in posterior permanent teeth does not become apparent until after at least one year of service. One may hypothesize that occlusal wear may not be as critical a problem in primary molars since primary molars usually undergo more occlusal attrition than permanent molars and premolars. This gradual loss of material actually could be an acceptable characteristic if such wear occurred at the same rate as the natural attrition of the tooth structure. Two-year data from this child population are expected to help resolve this hypothesis and further elucidate wear characteristics of composites in primary molars.

The incidence of material deterioration at the margin was minimal and was not affected by preparation type or method of polymerization. This finding was not unexpected since the data were based on one year of service and other investigators[8] have shown acceptable marginal integrity after three years.

The performance of the two resins was very similar when considering only serviceable restorations (excluding failures). All modified and conventional Class I preparations showed excellent clinical performance after 12 months. There was no difference in any category between modified or conventional Class II restorations, nor between Class I and Class II preparations. In addition there was no significant difference between those teeth which traditionally would have been restored with amalgam and

those which would have been restored with a stainless steel crown; however, the number of restorations in the stainless steel crown category was too small for meaningful statistical analysis.

The differences between preparations became significant only when the failures were examined. The majority of failed restorations were in modified Class II preparations suggesting that the failures were probably associated with insufficient retention and resistance form. Some investigators feel that primary tooth enamel has peculiar etching characteristics,[19,20] a possible explanation of inadequate retention. Another cause of failure may relate to the fact that the enamel of primary teeth is usually only about 1 mm thick in the occlusal and interproximal areas; consequently, some modified preparations may not have provided sufficient surface area for a resin layer thick enough to withstand the displacing forces of occlusion. These potential explanations for failure should be explored in future studies.

Conclusions

There was no difference in the 12-month clinical performance of an autopolymerized and a visible light-polymerized composite resin in primary molars.

As described in this study, the modified Class II preparation does not have adequate retention and resistance form to serve as an acceptable substitute for the conventional Class II preparation.

The composite materials evaluated are acceptable for use in modified and conventional Class I preparations and conventional Class II preparations in primary molars for at least 12 months.

The views expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Air Force or the Department of Defense.

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