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The use of composite resins in primary molars

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Composite resins were introduced to the dental profession nearly 15 years ago. Developed by Dr. Bowen at the National Bureau of Standards, and first marketed by the 3M Company of St. Paul, Minnesota, this new material was enthusiastically accepted by the dental profession. While this was clearly an improvement over the traditional silicate cement which had been on the market for almost 85 years, the first generation of composites exhibited a number of problems. Most significant among these were inadequate shading, variable setting-time, and solubility in alcohol.

After resolving these deficiencies and further improving their mechanical properties, several manufacturers believed that composite resins could serve as a viable substitute for dental amalgam. Because of manufacturers' strong recommendations, many clinicians began using composite resin in Class I and II cavity preparations in the mid-60s. The substitition of this material for amalgam was further encouraged by the 1971 results of a one-year clinical study conducted at the University of Indiana.[1] In that study it was shown there was no significant difference in the wear rate of composite resin, Adaptic,[a] and the amalgam control, Velvalloy.[b] Furthermore, ditching, an unfavorable characteristic of amalgam restorations, was virtually absent in the composite resin restorations. Unfortunately, evaluation of these materials after two years revealed much less favorable results.[2] In fact, at the end of 24 months the composite resins had undergone substantially greater loss in anatomical form than had the amalgam controls. A number of subsequent investigations confirmed these findings.[3-6] As a result of these studies, most practitioners discontinued the use of composite resins in Class I and II cavity preparations.

Until recently, no long-term well-controlled research has been reported on the use of composite resins in primary molars. However, Tonn, Ryge, and Chambers[7] at the University of Pacific recently reported a two-year study in which they compared a composite resin[c] with an amalgam, Optaloy,[d] in primary molars. All composite resin restorations were placed in conventional cavity preparations without acid etching and composite/primer techniques. In that study, the composite resin exhibited appreciably more wear than did the alloy.

In a subsequent study, Nelson and coworkers[8] compared a composite resin, Adaptic,[a] with an amalgam, Dispersalloy,[a] in posterior primary teeth over a three-year period. This study, however, involved the use of acid etching and composite/primer techniques. From the results of that study, the authors concluded that a dentist would be justified in using composite resin and bonding agent in the late primary dentition, when the life span of the tooth is approximately three years.

While research on composite resins in primary molar teeth has been limited to date, there are reasons to believe that composite resins eventually could be the material of choice for posterior primary teeth. As a result of recent laboratory-clinical studies, a great deal has been learned about the factors responsible for the deterioration of these materials when subjected to occlusal stressing. Such factors or conditions are continuously being optimized by various manufacturers in an effort to improve clinical performance. Furthermore, efforts are being made by a number of investigators to design cavity preparations for posterior teeth that would be more appropriate for composite resin. A successful combination of these two factors could significantly change contemporary concepts of pediatric restorative dentistry.

Improved Composite Resin Materials for Posterior Teeth

While most clinicians are not presently using composite resins in areas of high stress concentration,

[a]Johnson & Johnson, East Windsor, NJ.
[b]S. S. White Dental Health Products, King of Prussia, PA.
[c]Lee Pharmaceuticals Corporation, South Elmonte, CA.
[d]L.D. Caulk Company, Milford, DW.

it is safe to predict that this practice may change in the near future. This prediction is based on the fact that a number of factors have recently been identified which are believed to have appreciable effects on clinical performance. Most notably these include; method of polymerization, particle size distribution, particle hardness, and the amount of water absorbed by the resin matrix. While there may be more factors involved, these have been shown to have a major influence on wear resistance, particularly in areas of high stress concentrations.

In a recent study published by Wilder, May, and Leinfelder,[9] it was shown that the wear resistance of photo-cured composites is significantly greater than those polymerized by chemicals. In that study, four different ultraviolet-cured composite resins were inserted into a series of Class I and II cavity preparations. These included Nuva Fil,[e] Nuva Fil P. A.,[e] Uviofil,[f] and Estilux.[g] At the end of two years the percent of restorations exhibiting no wear ranged from 67% for Nuva Fil to 100% for Estilux. Values for Nuva Fil P. A. and Uviofil were 91% each. These values compared to less than 45% for Adaptic and Concise after similar periods of service.

While the exact reason for this difference in clinical performance is not clearly understood, there are a number of factors that may be responsible. One of these is the extent of internal porosity, which has been found to be considerably less in the photo-cured composites than in the auto-cured systems.[9] The greater amount of porosity generally observed in auto-cured composites can be attributed to the process necessary for incorporating the two different pastes. To further illustrate this point, the difference in wear resistance between conventional Nuva Fil and Nuva Fil P. A. is quite substantial. The internal porosity in conventional Nuva Fil is grearer than in Nuva Fil P.A., and this increase in porosity can be attributed to the fact that the older Nuva Fil formulation required preactivation prior to exposure by ultraviolet light. The chemical was introduced into the Nuva Fil paste by mechanical mixing which introduced air or porosity. Furthermore, the carrier for the preactivator consisted of a plasticizer (dibutyl pthalate), a substance which tends to leach out of the restoration after one or two years in the oral cavity; this condition may result in even more porosity.

Another factor which may account for differences in wear resistance between photo-cured and auto-cured composites is physical manipulation. The auto-cured composites begin to polymerize as soon as the base and catalyst pastes are incorporated by mixture. Thus, the process of polymerization is disturbed continuously during both the mixing process and the insertion phase. Conversely, the photo-cured systems do not undergo polymerization until all the material has been inserted and exposed to the light source. It is possible that manipulation of the auto-cured material during polymerization reduces its potential strength as well as wear resistance.

It is interesting to note that all reported studies concerning the use of composites in posterior teeth involved the use of auto-cured resin systems. The newer incandescent or visible light polymerizing systems offer a number of advantages over the traditional ultraviolet light source. The depth of polymerization is generally greater with the visible light systems. A number of recently marketed materials can be polymerized to a depth of 3.0 - 5.0 mm within 20 seconds. In general, most of the ultraviolet sensitive composite resins could be polymerized to a depth of only 1.5 — 2.0 mm. Also, visible light can be transmitted through enamel. As a result, it is possible to polymerize composite resin which may be shielded from the path of the light by some enamel.

Particle Size

Conventional composite resins such as Adaptic and Concise originally contained hard ceramic filler particles 25 to 40 microns in diameter. When subjected to occlusal loading, these materials undergo a loss of material ranging from 0.1 to 1.0 microns per day, depending upon their location within the mastication area.[10] Paradoxically, these hard ceramic particles, which were added for the purpose of fortifying the composite resin, are partially responsible for the destruction of the restoration itself. During mastication, stresses are transmitted through the bolus of food to the ceramic filler particles extending above or slightly below the surface of the restoration. Since the filler particles are substantially harder than the resin matrix into which they are imbedded, the stresses are transferred to the matrix itself. As areas of high stress concentration develop within the resin matrix around the particle, small cracks begin to generate within the resin which eventually extend toward the composite surface. This process eventually leads to a loss of support for the particle.

The location of thousands of these sites across the occlusal surface causes the composite resin to wear in a rather generalized manner. The pattern of wear, or loss of occlusal surface, is analogous to the lowering of the water level in a container which has been perforated with small holes at its base. It is theorized that if the particles were substantially decreased in size or hardness, the wear rate could be reduced substantially. A number of clinical studies are now being conducted to determine if this hypothesis is correct.

[e]L.D. Caulk Company, Milford, DW.
[f]ESPE, Seefeld, Oberbay, West Germany.
[g]Kulzer Inc. 25251 Paseo de Alicia, La Guna Hills, CA.

Recently a limited number of European studies have claimed that the microfilled composites offer superior wear resistance to conventional composite resins in posterior teeth.[11,12] The filler content (colloidal silica) of these materials is extremely small. The average particle size, for example, is 0.04 microns or less. Unfortunately, as the particle size is decreased, the surface area-to-volume ratio is increased. As a result the amount of filler that can be incorporated into the resin matrix is reduced appreciably. Consequently, these materials exhibit a number of physical and mechanical characteristics which are inferior to conventional composites with a larger particle size. Such properties include increased water absorption, increased coefficient of thermal expansion, and increased polymerization shrinkage. Unfortunately, the data reported to date on the clinical performance of these materials are based on relatively short periods of time. Also, only a few proprietary materials have been included in the reported studies.

A number of manufacturers are now evaluating the performances of posterior composite resins in which the particle size is somewhat intermediate, averaging between 3-5 microns. The use of these intermediate-sized fillers not only permits the surface to be polished, but also makes it possible to incorporate more particles into the resin matrix. As a result properties such as coefficient of thermal expansion, water sorption, polymerization shrinkage, and abrasion resistance can be optimized.

Particle Hardness

As already discussed, the hard filler particles, such as quartz, are inappropriate for occlusal restorations. This is particularly true if the diameter of the particles are 30 to 40 microns in diameter. The greater the hardness, the greater the possibility that the particles will act as multiple stress-risers. On the other hand, softer and lower abrasion-resistant particles have a tendency to fracture or abrade when subjected to occlusal stressing. In other words, they absorb some of the energy rather than transmiting all of it into the surrounding matrix.

Water Sorption

The final property to be considered is water sorption. Most developers, researchers and manufacturers of composite resins believe that there is a strong inverse relationship between wear resistance and water uptake. In general, the more hydrophobic the resin, the greater its resistance to wear under clinical loading. While the reason for this relationship is not fully understood, it is possible that the uptake of water may result in a degradation of the ester groups in the resin molecule by hydrolysis. Subsequently, this may contribute to the formation of free carboxyl groups, which will then absorb additional water. Such a process commonly results in decreased wear-resistance.

Special problems Associated With Posterior Composites

Interproximal Contacts

Most clinicians who have placed composites in posterior Class II cavity preparations have experienced a number of difficulties. One of these is a tendency to produce open or loose interproximal contacts. This problem is directly related to the fact that the viscosity of composite resins during the preset state is considerably different from amalgam. While condensing pressure can be exerted on the amalgam causing a distortion of matrix band, this pressure cannot be applied when a composite resin is injected into the cavity preparation. Consquently, it is necessary to prewedge the tooth before the cavity preparation is initiated. It is also important to employ a noncollapsible wedge and to apply intermittent wedge-pressure during the operative procedure. Failure to follow this technique may result in improper interproximal contact.

The problem of inadequate interproximal contact could be avoided if the composite resin exhibited condensing characteristics similar to amalgam during the insertion phase. At least one company (Degussa) has developed such a product. However, this innovative but experimental material is not currently available to the dental profession. Preliminary clinical studies conducted in our facilities have shown this composite resin to be rather effective in overcoming that particular problem.

Macroscopic Voiding

Another problem related to the use of composite resins in posterior teeth is the occurrence of porosity or voids in the finished restoration. Such a defect becomes serious when it approximates the wall of the cavity preparation near the surface of the restoration. Under this condition, secondary caries becomes a possibility.

Macroscopic porosity will occasionally occur regardless of the operator's skill. However, this problem can be minimized by injecting the composite resin slowly, and in a fashion similar to that used for injecting a viscous rubber base impression material.

The condensable composite resin also provides a means for minimizing or eliminating voids. Using a condensable resin, the placement technique consists of inserting several increments of composite resin, with each increment followed by condensation with a large amalgam plugger. Careful evaluation of each increment of the restorative material for voiding, and careful condensation of each portion, can be effective in eliminating the macroscopic porosity problem.

Postoperative Sensitivity

Current data suggests that postoperative sensitivity associated with composite resins in posterior permanent teeth is appreciably greater than other types of restorative materials. Typically, when the sensitivity does occur, it generally develops shortly after insertion and then persists for periods ranging from one to two weeks to several months or longer. This sensitivity is most commonly initiated or aggravated by cold temperature or high stress concentrations developed during normal mastication. While the etiology of this sensitivity has not been determined, it is possible that micro-leakage may be a factor, particularly if the adaptation of the composite resin to the prepared enamel walls is less than ideal. The sensitivity may also be related to excess monomer present at the base of the restoration. Postoperative sensitivity, however, has not been reported as a problem in studies of composite resins in primary molars. In fact, an evaluation of over 200 composite restorations in primary molars for periods of up to six months has revealed no problem in this regard.[13]

Modifications in Cavity Preparations for Primary Molar Teeth

All studies reported in the literature involving composite resins in primary molar teeth have employed a conventional cavity preparation. In each case the preparations were essentially the same as those used for amalgam restorations. Since the conventional Class I and Class II cavity preparations have been designed to accommodate the physical and mechanical characteristics of dental amalgam, it would seem that a preparation modified for composite resin may have promise. In this regard, several modifications are being evaluated in the Pedodontic Clinical Research Program at the University of North Carolina.

Beveled Margins

While there are presently no reports in the literature relative to beveling the enamel margins prior to acid-etching primary teeth, there is substantial evidence that this technique is advantageous in permanent teeth. Beveling the margin prior to etching has been cited as decreasing the incidence of enamel fractures adjacent to the enamel-resin interface,[14] and increasing the retention of the resin itself.[15] Welch[16] reported that beveled and etched enamel walls provide sufficient retention of the restoration, thereby eliminating the need for conventional mechanical retention. A clinical study evaluating the effect of beveled preparations in primary molars is currently being carried out at the University of North Carolina.[17]

Caries Removal

To date, little or no information is available regarding cavity modifications designed to maximize the benefits of the acid etch technique with primary molars. In this regard, the Pedodontic Clinical Research at the University of North Carolina is evaluating the relative clinical performance of composite resins in conventional and modified cavity preparations. The modified preparations simply involve the removal of carious enamel and dentin, with extension only for visual and mechanical access. The effect of beveling in conjunction with this type of preparation is also being evaluated. An example of the modified cavity preparation is illustrated in Figures 1-4.

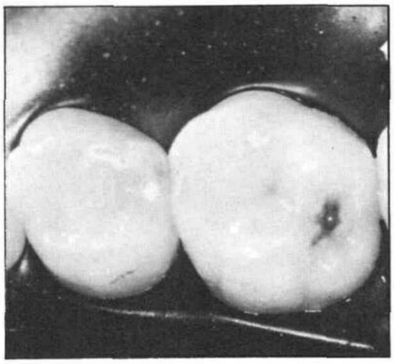

Figure 1. Preoperative clinical photograph (1.5x) of primary molars which have interproximal caries (#B-distal and #A-mesial and occlusal).

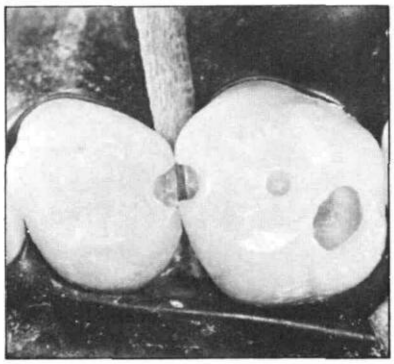

Figure 2. Primary molars prepared for composite resins with modified preparations.

The modified cavity preparation offers a number of advantages. First of all, it minimizes the amount of tooth structure reduction. Also, when used with the acid etch/composite technique, it may preclude the need for stainless steel crowns. If composites can be used in such clinical situations, there may be implications for improved periodontal health adjacent to such teeth, since this modified preparation can often be restricted to supragingival primary tooth structure.

Summary and Conclusions

Interest in composite resins as a posterior restorative material has been growing at an increasing rate. Materials with improved physical and mechanical properties are being developed continuously. While the present day compositions have yet to be proven for use in posterior permanent dentition they may be acceptable for primary teeth.

Regardless of the materials' performance in the oral cavity, however, there still remains a number of problems which will require considerable attention. Most notable among these are loose or open interproximal contacts, voiding or porosity along the gingival floor, and, in the case of permanent dentition, prolonged postoperative sensitivity.

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Photographs courtesy of Drs. Paquette, Vann, and Oldenburg, and the Pedodontic Clinical Research Program at the University of North Carolina.

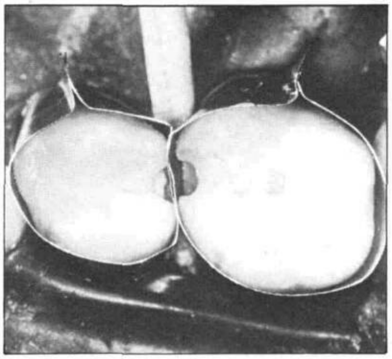

Figure 3. Modified preparations completed with matrices and wedge in place.

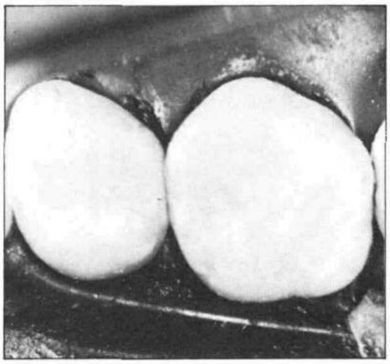

Figure 4. Composite resin restorations placed and margins finished.

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