The use of resin-based composite in children

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Abstract

Resin-based composites are an integral component of contemporary pediatric restorative dentistry. They can be utilized effectively for preventive resin restorations, moderate Class II restorations, Class III restorations, Class IV restorations, Class V restorations and strip crowns. Tooth isolation to prevent contamination is a critical factor, and high-risk children may not be ideal candidates for resin-based composite restorations. Important factors to consider during composite placement are isolation, polymerization shrinkage and extent of restoration. When utilized correctly, resin-based composites can provide excellent restorations in the primary and permanent dentition.(*Pediatr Dent*. 2002;24:480-488)

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The use of resin-based composite is a critical component of pediatric restorative dentistry. The acid-etch technique, originally recommended by Buonocore,[1] aids in providing retention for esthetic restorations in both the primary and permanent dentition. Problems associated with the initial resin-based composites have been addressed to create contemporary resin materials that wear better, have better color stability and maintain intact restorations for a desired length of time.

Resin-based composite materials

The initial resin, bis-GMA, was developed by Bowen[2] and remains the critical backbone of most contemporary resin systems. Quartz filler particles were introduced into the resin to provide desirable color properties, as well as desirable wear characteristics. These resins demonstrated initial success, but color dissipated over time and wear in the posterior dental arches exhibited disappointing restoration outcomes. By treating the filler particles with silane, the particles were actually bound within the resin matrix, causing less discoloration and degradation of resin restorative materials. Filler particles were ground smaller, compared to those utilized with the original resin-based composites, which allowed for more filler to be incorporated into the resin matrix and, subsequently, resulted in better wear of the material. All of these factors have contributed to the contemporary resin-based composite restorative materials available today.[3]

The American Dental Association (ADA) specification No. 27 for "direct filling resins"[4] classified restorative resins as Type I—unfilled and filled resins, and Type II—composite resins. According to Lutz et al,[5] almost all filled restorative resins consist of three-dimensional combinations of a minimum of 2 chemically different materials with a surface interfacial phase. The 3 phases are: (1) matrix phase; (2) surface interfacial phase; and (3) the dispersed phase.

In addition, each resin must include an accelerator-initiator system to begin and complete polymerization. For the chemically cured composite, the accelerator-initiator is usually an amine-peroxide system, whereas light-cured composites use a diketone-amine system, which is activated by the intense blue light. In addition, pigment and opaquers are added to control translucency (value) and shade (chrome). The resin matrix of all composites is a dimethacrylate oligomer such as bis-GMA or urethanediacrylate, and its viscosity is reduced by a low molecular weight diacrylate. The clinical characteristics are controlled by appropriate additions of thermochemical and photochemical initiators, accelerators and ultraviolet inhibitors. The surface interfacial phase consists of either a bipolar coupling agent (eg, an organosilane) to bind the organic resin matrix to the inorganic fillers, or a copolymeric or homopolymeric bond between the organic matrix and partial organic filler. The degree of interface adhesion and chemical stability is critical for successful clinical use of any resin.

Contemporary use of resin-based composite

Preventive resin restorations

Although caries has decreased, it is still the most prevalent infectious disease. Water fluoridation, patient education, fluoridated dentifrices, oral rinses and professionally applied topical fluorides have significantly reduced decay, however the occlusal surfaces of teeth remain the most caries-susceptible surface. Data indicates that greater than 80% of dentistry provided in a contemporary dental practice is attributed to pit and fissure caries.[6,7]

Preventive resin restorations were introduced by Simonsen and play an important role in the practice of contemporary pediatric dentistry.[8] The use of contemporary resin-based composites, due to bonding properties and acceptable wear resistance, allows for the cavity preparation to be minimized to include only caries-affected tooth structure. The traditional extension for prevention recommended for amalgam preparations is not necessary with resin restorations, due to the ability to place a sealant material over caries-susceptible pits and fissures which were not part of the preparation during caries removal. The overwhelming success of the preventive resin restoration makes it the treatment of choice for occlusal pit and fissure caries if the tooth can be adequately isolated.[8-10]

Caries can be removed effectively with the use of air abrasion or with standard dental burs in dental handpieces. Both of these techniques allow for caries to be removed conservatively, with tooth preparation extending only as far as caries progression. Likewise, both techniques for tooth preparation must be followed with the acid-etch technique for an adequate bond to the enamel surface.[11] Should preparations extend very minimally into enamel, sealant can be flowed onto the prepared and acid-etched surface. Simonsen termed this as a Group A preventive resin restoration.

Preparations that extend substantially into enamel or even into dentin, but are limited to pits and fissures, can have a resin-based composite placed to replace lost tooth structure and then a sealant placed over the entire occlusal surface for prevention of future caries. Although this conservative approach is frequently termed "microdentistry," the concept was originally presented by Simonsen as a Group B preventive resin restoration. Flowable resin composites have been recommended for these types of restorations. Dentists must be aware of the filler content of the flowable resin, which can range from 45% to 75%. Areas of teeth, such as pits and fissures, can have almost any resin used because these resins do not need great wear resistance. As preparations extend to areas where functional occlusion causes wear, a more heavily filled resin composite is appropriate. Once caries has extended to the point that a bur larger than a size 2 round bur is necessary for caries removal, a conservative resin composite restoration can be placed. Simonsen refers to these resin composite restorations as Group C preventive resin restorations.

Class II restorations

Resin composite has been shown to be effective as a Class II restorative material in both the primary and permanent dentition. The studies cited were clinical studies with a minimum longevity of 3 years for the primary dentition [12-14] and 4 years for the permanent dentition,[15-30] standards set by the American Dental Association (ADA) for full acceptance as a restorative material. The ADA Statement on Posterior Resin-Based Composites clearly states recommendations for Class II restorations are associated with preparations that do not include restoration margins exhibiting heavy occlusal wear.[31] This can be interpreted as two or three surface restorations that do not extend beyond the line angles of the proximal surfaces of the teeth, which include cusp replacement. Clinical trials, from which the ADA recommendations were derived, were well-controlled trials that had good tooth isolation via rubber dam, sound enamel/dentin cavity preparation walls and preparations that remained conservative (approximately one-third to one-half the buccolingual intercuspal width).[32]

Therefore, in the primary dentition, Class II resin composite restorations would be recommended for preparations that do not extend beyond the proximal line angles. Obviously, exceptions can be made, particularly if the tooth is expected to exfoliate within 1 to 2 years.

Indirect resin composite restorations

Direct resin composite restorations have received significantly more attention than indirect resin composite restorations. This is due to the extended time necessary to place an indirect restoration, potential laboratory expense and the need to prepare the tooth according to guidelines associated with inlays and onlays. These factors have limited the popularity of indirect resin restorations. However, studies have demonstrated the clinical success of these type of restorations in both the primary and permanent dentitions.[33-35] Indirect resin restorations offer the advantages of more complete polymerization of the resin, alleviate stresses associated with resin polymerization shrinkage that occurs when direct resin restorations are placed and provide a highly esthetic final restoration. Although these restorations are not widely utilized, they can be an effective technique and dentists may use their clinical judgement in deciding instances where indirect restorations would be preferred.

Clinical factors

Risk assessment

Risk assessment is an important factor when any restorative material is chosen.[36-38] Questions that need to be asked are: (1) What is the caries history of the patient? (2) How many caries lesions are present? (3) What type of oral hygiene is present? (4) Is enamel demineralization noted at the free gingival margin of the anatomical crown? (5) What is the likelihood of the patient returning for routine preventive dental care? (6) Can the tooth be isolated? (7) How large is the restoration going to be? (8) Is the tooth primary or permanent? and (9) What are the desires of the parents and patient?

These questions merely offer a simplistic overview of risk assessment. Children that are at high risk, denoted by the previous questions 1 to 5, are not good candidates for resin restorations unless these factors can be modified. Likewise, teeth that cannot be isolated or restorations that are extensive should have restorative materials other than resins considered.

Restoration placement time

Research has indicated that the placement time of resin-based composite restorations is significantly longer than the placement of amalgam restorations.[39] The lack of cooperation of a child may determine that a resin-based composite is not the material of choice.

Tooth isolation

Isolation of a tooth to prevent contamination is critical during the placement of a resin-based composite restoration. Discussion of hydrophilic properties of some resins might confuse the clinician as to proper indications and contraindications of resin use. The presence of water may be possible with the use of some adhesive systems.[40] However, contamination of the adhesive surface to which the filled resin-based composite is to be adapted can lead to the inability of the filled resin-based composite to bond to the adhesive, potentiating restoration microleakage and subsequent failure.

Adhesive dentin bonding

Swift and García-Godoy have provided excellent papers in this issue of the journal on adhesive bonding and clinical utilization to which the reader is referred for clarification. The reader is referred to their papers for clarification of adhesive systems and appropriate uses in children. It is essential that the manufacturer's instructions be followed. Dentin bonding is technique sensitive.[41-42] The chemical-cured primer, whether it is present alone in a multibottle system or with other components in a single-bottle system, must be chemically cured before the light-polymerized bonding resin is set. This allows for true dentin bonding to occur and alleviates restoration marginal microleakage. Although the dentin can be wet during dentin bonding adhesive placement, the adhesive cannot be wet prior to the placement of the bis-GMA resin-based composite restorative material.

Bases/liners

Glass ionomer cement is an appropriate base or liner when resin composite is used as the restorative material.[43-48] Calcium hydroxide is much more soluble than glass ionomer cement, an unfavorable property adjacent to resin which has hygroscopic properties and makes water available within the restoration.[49-52] Glass ionomer cement or resin-modified glass ionomer cement physiochemically bonds to tooth structure. Adapting the glass ionomer cement to the dentin of the cavity preparation eliminates the need for a dentin bonding adhesive. Unfilled bis-GMA bonding agent will bond to the glass ionomer cement base/liner, and then resin-based composite can be placed, polymerized and the final restoration contoured and polished.

Cavosurface preparation margins

The enamel cavosurface margins should be beveled to increase the surface area and to remove the aprismatic layer of enamel.[53] The bevel should be placed on the entire length of the cavosurface margin. The aprismatic layer will not etch well and may leave "islands" of unetched enamel that can act as pathways for bacterial leakage and/or reduce resin bond strength to the enamel.[54]

Polymerization shrinkage

Resin polymerization shrinkage has been a problem associated with resin-based composite restorations since the development of bis-GMA resin.[55-56] Most of the resin-based composite systems available have volumetric polymerization shrinkage percentages that range between 1.4% and 5.67%.[55-58] The placement of smaller filler particles within the resin matrix has decreased the amount of unfilled resin present, thereby decreasing the volumetric polymerization shrinkage. Although this has benefited the control of polymerization shrinkage, the problem remains and will continue to be a negative factor until resin composite systems are developed that have negligible shrinkage during polymerization.

The introduction of newer resin polymerization systems, such as the plasma arc curing units, lasers and pulse-delay halogen light systems, makes it necessary to clarify the polymerization of resin.

For small pit and fissure resin-based composite restorations, the resin can be cured with most any system without concern due to the low volume of resin utilized. Some of the faster light polymerization systems have a narrow light spectrum range for polymerization. Therefore, it is important that the resin-based composite being utilized falls within the light spectrum of the polymerization light source.[59] As Class I and II restorations are placed, polymerization shrinkage becomes a much more important factor. As the resin is polymerized, there is an effective shrinkage of the resin.[60-64] Researchers have described this setting reaction, explaining that the setting rate be retarded to allow the polymer to adequately flow and dissipate the stress while maintaining a sufficient bond to tooth structure.[65,66] When resin polymerizes, there is enough "flow" within the restorative material that bonded margins remain intact.

This helps explain the desired outcome of the pulse-delay polymerization technique when halogen lights are used.[67,68] Caution must be instituted when using faster polymerization systems to be sure the resin is not polymerized so quickly that stresses develop at restoration margins which could lead to marginal fracture and/or postoperative sensitivity. Placing resin in 2-mm increments eliminates this concern to a great extent and ensures that the light source is penetrating the resin adequately to maximize polymerization.

Recently, a 1.4% volumetric shrinkage resin-based composite was introduced to the market.[69] As resins continue to minimize volumetric shrinkage, placement technique will become less critical, as long as the polymerization light source is able to effectively penetrate the resin composite depth and isolation to prevent contamination is possible. Currently, there are no shrink-free polymers for use in dentistry, but research is pursuing this goal. A resin-based composite has been introduced to the marketplace, where bis-EMA6 replaces bis-GMA as the resin matrix.[70] Due to the larger bis-EMA6 molecule, polymerization shrinkage percentage was reduced by approximately 25%.

Flowable resin-based composites

Flowable resins range from 45% filler (by weight) to 75% filler. For this reason, dentists should be aware of resin filler content so that clinically they may be utilized. The lower the filler content, the more the polymerization shrinkage and wear expectations.[71,72] Although some unfilled resin within the restorative system can be prepolymerized to decrease the polymerization shrinkage clinically, in general, lower filled resins can be expected to shrink more. In Class I and Class II restorations this is quite important, for these restorations require good wear properties and minimal shrinkage upon polymerization is desired. Therefore, if a "flowable resin" is desirable to a dentist, a higher filled "flowable" should be used for Class I and II restorations.

Compomers

Compomers have become available more recently and are recommended for use as a pediatric dental restorative material.[73-75] Compomers are actually a cross between composite resin and glass ionomer cement and are officially termed polyacid-modified, resin-based composites.[76,77] An acid-base reaction takes place, although minimal, within the compomer material when the ion-leachable glass filler particles and dehydrated polyacid contained in the resin composite paste are exposed to water. Usually this water comes from saliva following restoration placement; therefore, visible-light polymerization is necessary to complete the setting reaction. Although an acid-base reaction, which is typical in the setting of glass ionomer cements, does not occur during the setting process of compomers, compomers do release fluoride and demonstrate adjacent tooth demineralization inhibition in vitro.[78] The fluoride release from compomers is less than that of glass ionomer cements and in vitro investigation indicates compomers are less effective to inhibit adjacent tooth demineralization than glass ionomer cements.[79]

The mechanical properties of tensile and flexural strength as well as wear resistance of compomers is superior to that of glass ionomers but less effective than those of resin composites.[76,80-82]

According to most manufacturers, enamel etching is not required for the placement of compomers. Compomers have shown relatively adequate adhesion to unetched enamel and dentin.[83-85] However, several laboratory studies have shown a higher bond strength and more intimate marginal adaptation of compomers when the enamel was acid-etched with 35% to 40% phosphoric acid.[84,86,87] Compomers are used in conjunction with methacylate primers that bond to enamel, dentin and compomer restorative material. Many of these primer bonding agents are acidulated and can etch enamel and dentin if utilized according to manufacturer instructions. Although the need for acid-etching has been discussed primarily from data associated with in vitro studies, the clinical relevance of acid-etching the enamel before the placement of compomers has not been clearly demonstrated.

Wear

The wear of resin composites was a major concern when the traditional resins were marketed. The large filler particle sizes (50 µm) and the lack of these particles becoming chemically integrated with the resin matrix were contributing factors to high wear rates. The bis-GMA resin matrix would begin to degrade, leaving unsupported filler particles exposed to masticating forces. The particles would become dislodged which was clinically expressed by high wear rates. As particles were ground smaller (1.5 µm), it became possible to incorporate a greater percentage of filler particles within the resin matrix and increase abrasion resistance. Likewise, a decrease in resin degradation and increase in abrasion resistance occurred when the glass filler particles were treated with silane. This silane treatment allowed filler particles to become chemically integrated within the resin matrix.

Although the contemporary resin composites have improved wear properties, they can still exhibit wear characteristics that are associated with occlusal contact attrition, resin matrix fracture, silane coupling agent hydrolysis, chemical erosion and the degree of polymerization.[88-104]

Currently, even smaller filler particle sizes (0.1-1 µm) are being incorporated into resins. Highly filled, small particle resins can exhibit the best wear characteristic.[32,105] Clinical trials have demonstrated contemporary resin composites to have acceptable wear characteristics which meet the standards of the ADA acceptable wear rate of no more than 50 µm per year and 250 µm over 5 years.[106,107] In fact, abrasive wear of many resin composites, as measured at restoration margins, is comparable to that of amalgam at 10 to 20 µm per year.[20,32,108]

Esthetics

One of the most favorable properties that resin-based composite restorations offer is excellent esthetics. Over the last 3 decades, there has been a tremendous improvement for color stability of composites. Resin degradation and the lack of particles to be bound within the resin polymer matrix led to discoloration of the original resin composites.[109] These factors have been addressed with great success and the extent of discoloration with contemporary resin composites is quite minor. Research has demonstrated that resin composite color does not significantly change from baseline to 10 years following restoration placement. Indeed, the color of resin restorations is a true advantage and can provide long-term patient satisfaction.[110]

Finishing and polishing

Following polymerization of the resin composite restorative material, the surface can be contoured to final restoration form with carbide or diamond finishing burs. The restoration surface can then be polished with sequential abrasive discs, abrasive rubber points and/or diamond abrasive paste. Polished restorations offer pleasing esthetics as well as comfort to the patient. After the final restoration contour form is achieved, a sealant material should be painted over the restoration. This is done for 2 basic reasons. First, the surface of the restoration achieves maximal polymerization because of the close proximity to the light polymerization source.[111] The surface of the resin composite restoration is altered when finishing and polishing, therefore the "new" final restoration surface should be polymerized to ensure it has reached maximum setting. The sealant or unfilled resin fills any microcracks within the surface of the resin, which may have been created during the finishing and polishing process.[112] More highly polymerized restorations have been shown to improve wear characteristics.[104]

Hypoplastic enamel

Children may present with teeth that reveal hypoplastic enamel, often the first permanent molar being affected. Hypoplastic enamel is difficult to bond to, partially due to the difficulty in adequately etching the enamel. Mild and moderately affected teeth can be treated with resin composite. The resin should extend to natural unaffected enamel to ensure adequate bonding. Dentin bonding adhesives can provide additional bond strength to the restoration. Severely hypoplastic teeth are subject to rapid caries development, and often it is necessary to plan treatment of full-coverage restorations in these circumstances.

Allergic reaction

Presently, as supported by information presented at the NIH-NIDR Risk Assessment Consensus Conference for restorative materials, resin composites are not considered to increase the risk of toxicity or hypersensitivity.[113] Degradation of resin composites is so minimal that there is no evidence that the placement of these materials as restoratives is problematic.[114]

Research directions

Although contemporary resin-based composites have vastly improved from the original marketed composites, there is potential for further improvement. Ideally, resin should have very minimal or no shrinkage upon polymerization. Future resin composites will have this issue addressed, resulting in composites that exhibit minimal shrinkage. Complete polymerization is an important factor and further research should focus on obtaining maximal polymerization.

Technique sensitivity during resin-based composite placement is perhaps the greatest disadvantage of their utilization. Difficulty in isolating teeth to control moisture and differences between materials marketed makes successful restoration placement problematic. Properties of the material should continually address these problems. Minimal long-term clinical data is available for resin-based composite restorations, particularly in primary anterior teeth. Further clinical trials can provide valuable information.

Finally, dentists must be made aware of the clinical technique for material utilization. Educating dentists about factors that are critical for restoration success will be of benefit for both the profession and patients.

Recommendations

The dental literature supports the use of resin-based composite with the following indications and contraindications:

Indications

For all resin-based composite restorations, teeth must be adequately isolated to prevent saliva contamination. The dental literature supports the use of highly filled resin-based composites in the following situations:

1. small pit and fissure caries where conservative preventive resin restorations are indicated in both the primary and permanent dentition;
2. occlusal surface caries extending into dentin;
3. Class II restorations in primary teeth that do not extend beyond the proximal line angles;
4. Class II restorations in permanent teeth that extend approximately one-third to one-half the buccolingual intercuspal width of the tooth;
5. Class V restorations in primary and permanent teeth;
6. Class III restorations in primary and permanent teeth;
7. Class IV restorations in primary and permanent teeth;
8. strip crowns in the primary and permanent dentitions.

Contraindications

The dental literature supports that resin-based composites not be used in the following situations:

1. where a tooth cannot be isolated to obtain moisture control;
2. individuals needing large multiple surface restorations in the posterior primary dentition;
3. high-risk patients that have multiple caries and/or tooth demineralization, exhibit poor oral hygiene and compliance with daily oral hygiene, and when maintenance is considered unlikely.

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Abstract of the Scientific Literature

Traumatic Dental Injuries and Quality of Life in Children

The impact of traumatic injuries on the dental, periodontal and facial tissues has been studied extensively. On the other hand, the psychological influence of traumatic oral and facial injuries in children has not been thoroughly examined. With the purpose of assessing the sociodental impact of untreated fractured anterior teeth in children, this study included a cross-sectional survey of 3,702 Brazilian schoolchildren aged 9 to 14 years. From the total population, 448 had traumatized permanent anterior teeth; from these, 88 presented untreated enamel and dentin fractures. The study group included 68 children and a matching control group. An oral examination and an oral impact on daily performances (OIDP) index was used to evaluate the children's physical, psychological and social activities: eating, enjoying food, speaking, tooth cleaning, sleeping and relaxing, smiling, laughing, showing teeth without embarrassment, maintaining usual emotional state without being irritable, carrying major social role or work and enjoying contact with people. The findings of the study indicated that children with untreated fractured teeth had a statistically significant higher overall OIDP value. In relation to the OIDP components, only speaking and pronouncing clearly was found not to have a significant difference between the groups; the most significant differences were found in smiling, laughing and showing teeth without embarrassment and in maintaining an emotional state without being irritable.

Comments: While the physical effect of oral and facial traumatic injuries in children has been extensively examined, this study claims to be the first one that thoroughly covers their behavioral aspect. In fact, this study provides significant information on the negative effect of untreated enamel and dentin fractures on the daily behavior and self-image of children. Considering that behavior is one of the most significant aspects of pediatric dentistry, this change in research attitude should be widely adopted and emulated for other aspects of pediatric dentistry. **EBG**

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Cortes MIS, Marcenes W, Sheiham A. Impact of traumatic injuries to the permanent teeth on the oral health-related quality of life in 12- to 14-year-old children. *Community Dent Oral Epidemiol.* 2002;30:193-198.

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