Guideline on Pediatric Restorative Dentistry

Originating Committee
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Purpose
The American Academy of Pediatric Dentistry (**AAPD**) presents this guideline to assist the practitioner in the restorative care of infants, children, adolescents, and persons with special health care needs. The objectives of restorative treatment are to repair or limit the damage from caries, protect and preserve the tooth structure, reestablish adequate function, restore esthetics (where applicable), and provide ease in maintaining good oral hygiene. Pulp vitality should be maintained whenever possible.

Methods
This document is an update of the guideline last revised in 2007. This revision is based on current dental and medical literature related to restorative dentistry. An electronic search was conducted using PubMed® with the following parameters: Terms: "dental amalgam", "dental composites", "stainless steel crowns", "glass ionomer cements", "resin-modified glass ionomer cements", "dentin/enamel adhesives", "Bisphenol A", "resin infiltration", and "dental sealants"; Fields: all; Limits: within the last 10 years, humans, English, clinical trials. Papers for review were chosen from the resultant list of articles and from references within selected articles. When data did not appear sufficient or were inconclusive, recommendations were based upon expert and/or consensus opinion by experienced researchers and clinicians as well as consensus statements resulting from the expert literature review and evidence-based position papers presented at the 2002 AAPD "Pediatric Restorative Dentistry Consensus Conference" (Chicago, Ill.).[1]

Background
Restorative treatment is based upon the results of a clinical examination and is ideally part of a comprehensive treatment plan. The treatment plan shall take into consideration:

1. developmental status of the dentition;
2. caries-risk assessment[2,3];
3. patient's oral hygiene;
4. anticipated parental compliance and likelihood of recall;
5. patient's ability to cooperate for treatment.

The restorative treatment plan must be prepared in conjunction with an individually-tailored preventive program.

Caries risk is greater for children who are poor, rural, or minority or who have limited access to care.[4] Factors for high caries risk include decayed/missing/filled surfaces greater than the child's age, numerous white spot lesions, high levels of mutans streptococci, low socioeconomic status, high caries rate in siblings/parents, diet high in sugar, and/or presence of dental appliances.[5] Studies have reported that maxillary primary anterior caries has a direct relationship with caries in primary molars[6-8], and caries in the primary dentition is highly predictive of caries occurring in the permanent dentition.[5]

Restoration of primary teeth differs from restoration of permanent teeth, due in part to the differences in tooth morphology. The mesiodistal diameter of a primary molar crown is greater than the cervicoocclusal dimension. The buccal and lingual surfaces converge toward the occlusal. The enamel and dentin are thinner. The cervical enamel rods slope occlusally, ending abruptly at the cervix rather than being oriented gingivally and gradually becoming thinner as in permanent teeth.[9] The pulp chambers of primary teeth are proportionately larger and closer to the surface. Primary teeth contact areas are broad and flattened rather than being a small distinct circular contact point, as in permanent teeth. Shorter clinical crown heights of primary teeth also affect the ability of these teeth to adequately support and retain intracoronal restorations. Young permanent teeth also exhibit characteristics that need to be considered in restorative procedures, such as large pulp chambers and broad contact areas that are proximal to primary teeth.[9,10]

Tooth preparation should include the removal of caries or improperly developed or unsound tooth structure to establish appropriate outline, resistance, retention, and convenience form compatible with the restorative material to be utilized. Rubber-dam isolation should be utilized when possible during the preparation and placement of restorative materials.

As with all guidelines, it is expected that there will be exceptions to the recommendations based upon individual clinical findings. For example, stainless steel crowns (**SSCs**) are recommended for teeth having received pulp therapy. However, an amalgam or resin restoration could be utilized in a tooth having conservative pulpal access, sound lateral walls, and less than 2 years to exfoliation.[11] Likewise, a conservative Class II restoration for a primary tooth could be expanded to include more surface area when the tooth is expected to exfoliate within 1 to 2 years.

Recommendations

Dentin/enamel adhesives

Dentin/enamel adhesives allow bonding of resin-based composites and compomers to primary and permanent teeth. Adhesives have been developed with reported dentin bond strengths exceeding that of enamel.[12-14] In vitro studies have shown that enamel and dentin bond strength is similar for primary and permanent teeth.[7,8,11-16] The clinical success of adhesives allows for more conservative preparation when using composite restorative materials.

Adhesive systems currently follow either a "total-etch" or a "self-etch" technique. Total etch technique requires 3 steps. It involves use of an etchant to prepare the enamel while opening the dentinal tubules, removing the smear layer, and decalcifying the dentin. After rinsing the etchant, a primer is applied that penetrates the dentin, preparing it for the bonding agent. The enamel can be dried before placing the primer, but the dentin should remain moist. A bonding agent then is applied to the primed dentin. A simplified adhesive system that combines the primer and the adhesive is available. Because the adhesive systems require multiple steps, errors in any step can affect clinical success. Attention to proper technique for the specific adhesive system is critical to success.[17]

Recommendations:

The dental literature supports the use of tooth bonding adhesives, when used according to the manufacturer's instruction unique for each product, as being effective in primary and permanent teeth in enhancing retention of restorations, minimizing microleakage, and reducing sensitivity.[18]

Bisphenol A and dental materials

Bisphenol A (**BPA**) is widely used in the manufacturing of many consumer plastic products and can become part of dental sealants and composites in 3 ways: as a direct ingredient, as a by-product of other ingredients in dental sealants and composites that may have degraded [eg, bisphenol A glycidyl metha-crylate (bis-GMA) and bisphenol A dimethacrylate (bis-DMA)], and as a trace material left-over from the manufacturing of other ingredients used in dental sealants and composites.[19] The most significant window of potential exposure to BPA is immediately following the application of resin-based dental sealants and composites. Based on current evidence, the US Food and Drug Administration (**FDA**) and the American Dental Association (**ADA**) do not believe there is a basis for health concerns relative to BPA exposure from any dental material and have concluded that any low-level of BPA exposure that may result from dental sealants and/or composites poses no known health threat.[19,20]

Recommendations

Measures can be taken to reduce potential BPA exposure from dental materials. Techniques are directed at removing the residual monomer layer immediately after placement of dental sealants and composites. Recommendations include rubbing the newly applied dental sealant or composite with pumice on a cotton roll and thoroughly rinsing with water using an air-water syringe or having the patient rinse for 30 seconds and spit after the dental procedure. Also, use of rubber dam isolation would further limit potential exposure.[21]

Pit and fissure sealants

Sealant has been described as a material placed into the pits and fissures of caries-susceptible teeth that micromechanically bonds to the tooth preventing access by cariogenic bacteria to their source of nutrients.[22]

Pit and fissure caries account for approximately 80-90% of all caries in permanent posterior teeth and 44% in primary teeth.[23,24] Sealants reduce the risk of caries in those susceptible pits and fissures. Placement of resin-based sealants in children and adolescents have shown a reduction of caries incidence of 86% after 1 year and 58% after 4 years.[25,26] Before sealants are placed, a tooth's caries risk should be determined.[27] Any primary or permanent tooth judged at risk would benefit from sealant application.[27] The best evaluation of caries risk is done by an experienced clinician using indicators of tooth morphology, clinical diagnostics, caries history, fluoride history, and oral hygiene.[27] Sealant placement on teeth with the highest risk will give the greatest benefit.[27] High-risk pits and fissures should be sealed as soon as possible. Low-risk pits and fissures may not require sealants. Caries risk, however, may increase due to changes in patient habits, oral microflora, or physical condition, and unsealed teeth subsequently might benefit from sealant application.[27]

With appropriate diagnosis and monitoring, sealants can be placed on teeth exhibiting incipient pit and fissure caries.[28] Studies have shown arrested caries and elimination of viable organisms under sealants or restorations with sealed margins.[29-31] Surveys have shown that pediatric dentists often incorporate enameloplasty into the sealant technique.[32] In vitro studies have shown enameloplasty may enhance retention of sealants.[33-36] However, short-term clinical studies show enameloplasty as equal to but not better than sealant placement without enameloplasty.[37,38]

Isolation is a key factor in a sealant's clinical success.[39] Contamination with saliva results in decreased bond strength of the sealant to enamel.[39] In vitro and in vivo studies report that use of a bonding agent will improve the bond strength and minimize microleakage.[40,41] Fluoride application immediately prior to etching for sealant placement does not appear to affect bond strength adversely.[42,43]

Sealants must be retained on the tooth and should be monitored to be most effective. Studies have shown glass ionomer sealant to have a poor retention rate.[44,45] Studies incorporating recall and maintenance have reported sealant success levels of 80% to 90% after 10 or more years.[46,47]

Recommendations:

1. Sealants should be placed into pits and fissures of teeth based upon the patient's caries risk, not the patient's age or time lapsed since tooth eruption.
2. Sealants should be placed on surfaces judged to be at high risk or surfaces that already exhibit incipient carious lesions to inhibit lesion progression. Follow-up care, as with all dental treatment, is recommended.[27]
3. Sealant placement methods should include careful cleaning of the pits and fissures without removal of any appreciable enamel. Some circumstances may indicate use of a minimal enameloplasty technique.[27]
4. A low-viscosity hydrophilic material bonding layer, as part of or under the actual sealant, is recommended for long-term retention and effectiveness.[27]

5. Glass ionomer materials could be used as transitional sealants.[27]

Glass ionomer cements

Glass ionomers have been used as restorative cements, cavity liner/base, and luting cement. The initial glass ionomer materials were difficult to handle, exhibited poor wear resistance, and were brittle. Advancements in glass ionomer formulation led to better properties, including the formation of resin-modified glass ionomers. These products showed improvement in handling characteristics, decreased setting time, increased strength, and improved wear resistance.[45-49] Glass ionomers have several properties that make them favorable to use in children:

1. chemical bonding to both enamel and dentin;
2. thermal expansion similar to that of tooth structure;
3. biocompatibility;
4. uptake and release of fluoride;
5. decreased moisture sensitivity when compared to resins.

Glass ionomers are hydrophilic and tolerate a moist, not wet, environment, whereas resins and adhesives are affected adversely by water. Because of their ability to adhere, seal, and protect, glass ionomers often are used as dentin replacement materials.[50-52] Glass ionomer has a coefficient of thermal expansion similar to dentin.

Resin-modified glass ionomers have improved wear resistance compared to the original glass ionomers and are appropriate restorative materials for primary teeth.[53-57] In permanent teeth, resin-based composites provide better esthetics and wear resistance than glass ionomers. Glass ionomer and resin "sandwich technique" was developed on the basis of the best physical properties of each.[58] A glass ionomer is used as dentin replacement for its ability to seal and adhere while covered with a surface resin because of its better wear resistance and esthetics.

Fluoride is released from glass ionomer and taken up by the surrounding enamel and dentin, resulting in a tooth that is less susceptible to acid challenge.[59-61] Studies have shown that fluoride release can occur for at least 5 years.[62,63] Glass ionomers can act as a reservoir of fluoride, as uptake can occur from dentifrices, mouthrinses, and topical fluoride applications.[64,65] This fluoride protection, useful in patients at high risk for caries, has led to the use of glass ionomers as a luting cement for SSCs, space maintainers, and orthodontic bands.[66,67]

Other applications of glass ionomers where fluoride release has advantages are for interim therapeutic restorations (**ITR**) and the atraumatic/alternative restorative technique (**ART**). These procedures have similar techniques but different therapeutic goals. ITR may be used in very young patients[68], uncooperative patients, or patients with special health care needs[69] for whom traditional cavity preparation and/or placement of traditional dental restorations are not feasible or need to be postponed. Additionally, ITR may be used for caries control in children with multiple open carious lesions, prior to definitive restoration of the teeth.[70] ART, endorsed by the World Health Organization and the International Association for Dental Research, is a means of restoring and preventing caries in populations that have little access to traditional dental care and functions as definitive treatment.

These procedures involve the removal of soft tooth tissue using hand or slow-speed rotary instruments with caution to not expose the pulp when caries is deep. Leakage of the restoration can be minimized if unsound tooth structure is removed from the periphery of the preparation. Following preparation, the tooth is restored with an adhesive restorative material, such as self-setting or resin-modified glass ionomer cement.[69,70] This technique has been shown to reduce the levels of oral bacteria (eg, mutans streptococci, lactobacilli) in the oral cavity.[67,69] Success is greatest when the technique is applied to single- or small 2-surface restorations.[57,71] Inadequate cavity preparation with subsequent lack of retention and insufficient bulk can lead to failure.[69]

Recommendations:

Glass ionomers can be recommended[72] as:

1. luting cements;
2. cavity base and liner;
3. Class I, II, III, and V restorations in primary teeth;
4. Class III and V restorations in permanent teeth in high risk patients or teeth that cannot be isolated;
5. caries control with:
   a. high-risk patients;
   b. restoration repair;
   c. ITR;
   d. ART.

Resin Infiltration

The objective of resin infiltration is to halt progression of small proximal carious lesions by surrounding them with polymerized unfilled resin. This technique uses a specialized matrix interproximally in order to:

1. Treat the surface of non-cavitated caries lesions with hydrochloric acid;
2. Desiccate the surface with air then ethanol;
3. Infiltrate, via capillary action over several minutes and 2 applications, an unfilled "fluid" resin to the extent of the dentino-enamel junction or slightly beyond;
4. Polymerize the resin with light.

The technique proscribed by the manufacturer, including the use of a rubber dam, must be strictly followed. A different version of the product is available to repair early carious lesions in the form of white spots gingival to orthodontic brackets (after removal of brackets) when plaque removal was less than ideal.

Recommendations:

Resin infiltration has been introduced as a treatment option for small interproximal carious lesions in permanent (and, in some circumstances, primary) teeth.[73]

Resin-based composites

Resin-based composite is an esthetic restorative material used for posterior and anterior teeth. There are a variety of resin products on the market, with each having different physical properties and handling characteristics based upon their composition. "Resin-based composites are classified according to their filler size, because filler size affects polishability/esthetics, polymerization depth, polymerization shrinkage, and physical properties."[74] Microfilled resins have filler sizes less than 0.1 micron. Minifilled particle sizes range from 0.1 to 1 micron. Midsize resin particles range from 1 to 10 microns. Macrofilled particles range from 10 to 100 microns. The smaller filler particle size allows greater polishability and esthetics, while

larger size provides strength. Hybrid resins combine a mixture of particle sizes for improved strength while retaining esthetics. Flowable resins have a lower volumetric filler percentage than hybrid resins. Highly-filled, small particle resins have been shown to have better wear characteristics.[75-77]

Resin-based composites allow the practitioner to be conservative in tooth preparation. With minimal pit and fissure caries, the carious tooth structure can be removed and restored while avoiding the traditional "extension for prevention" removal of healthy tooth structure. This technique of restoration with preventive sealing of the remaining tooth has been described as a preventive resin restoration.[78]

Resins require longer time for placement and are more technique sensitive than amalgams. In cases where isolation or patient cooperation is compromised, resin-based composite may not be the restorative material of choice.

Recommendations[79]*:*

Indications:

Resin-based composites are indicated for:

1. Class I pit-and-fissure caries where conservative preventive resin restorations are appropriate;
2. Class I 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 III, IV, and V restorations in primary and permanent teeth;
6. strip crowns in the primary and permanent dentitions.

Contraindications:

Resin-based composites are not the restorations of choice in the following situations:

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

Amalgam restorations

Dental amalgam has been used for restoring teeth since the 1880s. Amalgam's properties (eg, ease of manipulation, durability, relatively low cost, reduced technique sensitivity compared to other restorative materials) have contributed to its popularity. Esthetics and improved tooth-color restorative materials, however, have led to a decrease in its use. Dental amalgam has been reviewed and studied extensively for its safety and effectiveness. The ADA's Council on Scientific Affairs has concluded that "based on available scientific information, amalgam continues to be a safe and effective restorative material" and that "there currently appears to be no justification for discontinuing the use of dental amalgam".[80] The FDA places encapsulated amalgam in the same class of devices as most other restorative materials, including resin-based composites, and maintains its position that amalgam is a safe and effective restorative option for patients.[80]

The durability of amalgam restorations has been shown in numerous studies.[81-83] Studies of defective restorations have indicated that operator error plays a significant role the restoration's durability.[84,85] For example, in Class II restorations where the proximal box is large and the intercuspal isthmus is narrow, the restoration is stressed and can result in fracture. In primary teeth, studies have shown that 3-surface mesial-occlusal-distal (MOD) restorations can be placed but that SSCs are more durable.[86,87] In primary molars, the patient's age can affect the restoration's longevity.[72-76] In children age 4 or younger, SSCs had a success rate twice that of multisurface amalgams.[81]

The decision to use amalgam should be based upon the needs of each individual patient. Amalgam restorations often require removal of healthy tooth structure to achieve adequate resistance and retention. Glass ionomer or resin restorative materials might be a better choice for conservative restorations, thereby retaining healthier tooth structure. SSCs are recommended for primary teeth with pulpotomies. Yet, a Class I amalgam could be appropriate if enamel walls can withstand occlusal forces and the tooth is expected to exfoliate within 2 years.[11] SSCs may be the better choice in patients with poor compliance and questionable long-term follow-up.[88]

Recommendations:

Dental amalgam is recommended[89] for:

1. Class I restorations in primary and permanent teeth;
2. Class II restorations in primary molars where the preparation does not extend beyond the proximal line angles;
3. Class II restorations in permanent molars and premolars;
4. Class V restorations in primary and permanent posterior teeth.

Stainless steel crown restorations

Stainless steel crowns are prefabricated crown forms that are adapted to individual teeth and cemented with a biocompatible luting agent. "The SSC is extremely durable, relatively inexpensive, subject to minimal technique sensitivity during placement, and offers the advantage of full coronal coverage."[90]

SSCs have been indicated for the restoration of primary and permanent teeth with caries, cervical decalcification, and/or developmental defects (eg, hypoplasia, hypocalcification), when failure of other available restorative materials is likely (eg, interproximal caries extending beyond line angles, patients with bruxism), following pulpotomy or pulpectomy, for restoring a primary tooth that is to be used as an abutment for a space maintainer, or for the intermediate restoration of fractured teeth.

In high caries-risk children, definitive treatment of primary teeth with SSCs is better over time than multisurface intracoronal restorations. Review of the literature comparing SSCs and Class II amalgams concluded that, for multisurface restorations in primary teeth, SSCs are superior to amalgams.[91] SSCs have a success rate greater than that of amalgams in children under age 4.[83]

The use of SSCs also should be considered in patients with increased caries risk whose cooperation is affected by age, behavior, or medical history. These patients often receive treatment under sedation or general anesthesia. For patients whose

developmental or medical problems will not improve with age, SSCs are likely to last longer and possibly decrease the frequency for sedation or general anesthesia with its increased costs and its inherent risks.

SSCs can be indicated to restore anterior teeth in cases where multiple surfaces are carious, where there is incisal edge involvement, following pulp therapy, when hypoplasia is present, and when there is poor moisture control.[92] One study suggests that "extent of caries" is the main factor that influences pediatric dentists' choice to use anterior veneered SSCs.[93] Where esthetics are a concern, the facing of SSCs can be removed and replaced with a resin-based composite (open-faced technique). Another option when esthetic concerns predominate is primary SSCs with preformed tooth-colored veneers. Although these veneered crowns can be more difficult to adapt (due to their limited crimping area) and are subject to fracture or loss of the facing, in some cases veneered SSCs possess a major advantage over conventional SSCs due to their superior esthetics and high parental satisfaction.[94-98]

Recommendations:

1. "Children at high risk exhibiting anterior tooth caries and/or molar caries may be treated with SSCs to protect the remaining at-risk tooth surfaces.
2. Children with extensive decay, large lesions, or multiple-surface lesions in primary molars should be treated with SSCs.
3. Strong consideration should be given to the use of SSCs in children who require general anesthesia."[90]

Labial resin or porcelain veneer restorations

A resin or porcelain veneer restoration is a thin layer of restorative material bonded over the facial or buccal surface of a tooth. Veneer restorations are considered conservative in that minimal, if any, tooth preparation is required. Porcelain veneers usually are placed on permanent teeth.

Recommendations:

Veneers may be indicated for the restoration of anterior teeth with fractures, developmental defects, intrinsic discoloration, and/or other esthetic conditions.[99]

Full-cast or porcelain-fused-to-metal crown restorations

A cast or porcelain-fused-to-metal crown is a fixed restoration that employs metal formed to a desired anatomic shape or a metal substructure onto which a ceramic porcelain veneer is fused. The crown is cemented with a biocompatible luting cement.

Recommendations:

Full-cast metal crowns or porcelain-fused-to-metal crown restorations may be utilized in permanent teeth that are fully erupted and the gingival margin is at the adult position for:

1. teeth having developmental defects, extensive carious or traumatic loss of structure, or endodontic treatment;
2. as an abutment for fixed prostheses; or
3. for restoration of single-tooth implants.[100-102]

Fixed prosthetic restorations for missing teeth

A fixed prosthetic restoration replaces 1 or more missing teeth in the primary, transitional, or permanent dentition. This restoration attaches to natural teeth, tooth roots, or implants and is not removable by the patient. Growth must be considered when using fixed restorations in the developing dentition.

Recommendations:

Fixed prosthetic restorations to replace 1 or more missing teeth may be indicated to:

1. establish esthetics;
2. maintain arch space or integrity in the developing dentition;
3. prevent or correct harmful habits; or
4. improve function.[103,104]

Removable prosthetic appliances

A removable prosthetic appliance is indicated for the replacement of 1 or more teeth in the dental arch to restore masticatory efficiency, prevent or correct harmful habits or speech abnormalities, maintain arch space in the developing dentition, or obturate congenital or acquired defects of the orofacial structures.

Recommendations:

Removable prosthetic appliances may be indicated in the primary, mixed, or permanent dentition when teeth are missing. Removable prosthetic appliances may be utilized to:

1. maintain space;
2. obturate congenital or acquired defects;
3. establish esthetics or occlusal function; or
4. facilitate infant speech development or feeding.[105-107]

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