

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:

- developmental status of the dentition;
- caries-risk assessment^{2,3};
- patient’s oral hygiene;
- anticipated parental compliance and likelihood of recall;
- 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 molars⁶⁻⁸, and caries in the primary dentition is highly predictive of caries occurring in the permanent dentition.³

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 two 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 one to two 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 three 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 three 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 methacrylate (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 to 90 percent of all caries in permanent posterior teeth and 44 percent 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 percent after one year and 58 percent after four 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 percent to 90 percent after 10 or more years.^{46,47}

Recommendations:

- 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.
- 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
- 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
- A low-viscosity hydrophilic material bonding layer, as part of or under the actual sealant, is recommended for long-term retention and effectiveness.²⁷
- 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:

- chemical bonding to both enamel and dentin;
- thermal expansion similar to that of tooth structure;
- biocompatibility;
- uptake and release of fluoride;
- 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 five 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 patients⁶⁸, uncooperative patients, or patients with special health care needs⁶⁹ 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 two-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 recommended⁷² as:

- luting cements;
- cavity base and liner;
- Class I, II, III, and V restorations in primary teeth;
- Class III and V restorations in permanent teeth in high risk patients or teeth that cannot be isolated;
- caries control with:
 - high-risk patients;
 - restoration repair;
 - ITR;
 - 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:

- Treat the surface of non-cavitated caries lesions with hydrochloric acid;
- Desiccate the surface with air then ethanol;

- Infiltrate, via capillary action over several minutes and two applications, an unfilled “fluid” resin to the extent of the dentino-enamel junction or slightly beyond;
- 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 one micron. Midsize resin particles range from one 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:

- Class I pit-and-fissure caries where conservative preventive resin restorations are appropriate;
- Class I caries extending into dentin;
- Class II restorations in primary teeth that do not extend beyond the proximal line angles;
- Class II restorations in permanent teeth that extend approximately one third to one half the buccolingual intercuspal width of the tooth;

- Class III, IV, and V restorations in primary and permanent teeth;
- strip crowns in the primary and permanent dentitions.

Contraindications:

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

- where a tooth cannot be isolated to obtain moisture control;
- in individuals needing large multiple surface restorations in the posterior primary dentition;
- 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 three-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 four 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 two years.¹¹ SSCs may be the better choice in patients with poor compliance and questionable long-term follow-up.⁸⁸

Recommendations:

Dental amalgam is recommended⁸⁹ for:

- Class I restorations in primary and permanent teeth;
- Class II restorations in primary molars where the preparation does not extend beyond the proximal line angles;
- Class II restorations in permanent molars and premolars;
- 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 intracoronary 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 four.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:

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

Fixed prosthetic restorations for missing teeth

A fixed prosthetic restoration replaces one 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 one or more missing teeth may be indicated to:

- establish esthetics;
- maintain arch space or integrity in the developing dentition;
- prevent or correct harmful habits; or
- improve function.^{103,104}

Removable prosthetic appliances

A removable prosthetic appliance is indicated for the replacement of one 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:

- maintain space;
- obturate congenital or acquired defects;
- establish esthetics or occlusal function; or
- facilitate infant speech development or feeding.¹⁰⁵⁻¹⁰⁷

References

1. Donly K. Pediatric Restorative Dentistry. Consensus Conference. April 15-16, 2002. San Antonio, Texas. *Pediatr Dent* 2002;24(5):374-6.
2. Anderson M. Risk assessment and epidemiology of dental caries: Review of the literature. *Pediatr Dent* 2002;24(5):377-85.
3. American Academy of Pediatric Dentistry. Policy on use of a caries-risk assessment tool (CAT) for infants, children, and adolescents. *Pediatr Dent* 2007;29(suppl):29-33.
4. Vargas CM, Crall JJ, Schneider DA. Sociodemographic distribution of pediatric dental caries: NHANES III, 1988-1994. *J Am Dent Assoc* 1998;129(9):1229-38.
5. Tinanoff N, Douglass J. Clinical decision-making for caries management in primary teeth. *J Dent Educ* 2001;65(10):1133-42.
6. O'Sullivan DM, Tinanoff N. Maxillary anterior caries associated with increased caries in other teeth. *J Dent Res* 1993;72(12):1577-80.
7. Greenwell AL, Johnsen D, DiSantis TA, Gerstenmaier J, Limbert N. Longitudinal evaluation of caries patterns from the primary to the mixed dentition. *Pediatr Dent* 1990;12(5):278-82.
8. Al-Shal TA, Erickson PR, Hardie NA. Primary incisor decay before age 4 as a risk factor for future dental caries. *Pediatr Dent* 1997;19(1):37-41.
9. Waggoner WF. Restorative dentistry for the primary dentition. In: Pinkham JR, Casamassimo PS, Fields HW Jr, McTigue DJ, Nowak AJ, eds. *Pediatric Dentistry: Infancy through Adolescence*. 4th ed. St. Louis, Mo: Elsevier Saunders; 2005:341-74.
10. Fuks AB, Heling I. Pulp therapy for the young permanent dentition. In: Pinkham JR, Casamassimo PS, Fields HW Jr, McTigue DJ, Nowak AJ, eds. *Pediatric Dentistry: Infancy through Adolescence*. 4th ed. St. Louis, Mo: Elsevier Saunders; 2005:577-92.
11. Holan G, Fuks AB, Ketzl N. Success rate of formosoresol pulpotomy in primary molars restored with stainless steel crowns vs amalgam. *Pediatr Dent* 2002;24(3):212-6.
12. Chappell RP, Eick JD. Shear bond strength and scanning electron microscopic observation of six current dentinal adhesives. *Quintessence Int* 1994;25(5):359-68.
13. Tjan AHL, Castelnuovo J, Liu P. Bond strength of multi-step and simplified-step systems. *Am J Dent* 1996;9(6):269-72.
14. Mason PN, Ferrari M, Cagidiaco MC, Davidson CL. Shear bond strength of 4 dentinal adhesives applied in vivo and in vitro. *J Dent* 1996;24(3):217-22.
15. Bordin-Aykroyd S, Sefton J, Davies EH. In vivo bond strengths of 3 current dentin adhesives to primary and permanent teeth. *Dent Mater* 1992;8(2):74-8.
16. García de Araujo FB, García-Godoy F, Issao M. A comparison of 3 resin bonding agents to primary tooth dentin. *Pediatr Dent* 1997;19(4):253-7.
17. Finger WJ, Balkenhol M. Practitioner variability effects on dentin bonding with an acetone-based one-bottle adhesive. *J Adhes Dent* 1999;(4)1:311-4.
18. García-Godoy F, Donly KJ. Dentin/enamel adhesives in pediatric dentistry. *Pediatr Dent* 2002;24(5):462-4.
19. American Dental Association. Bisphenol A and Dental Materials. Available at: "<http://www.ada.org/1766.aspx>". Accessed November 27, 2011.
20. US Food and Drug Administration. Bisphenol A (BPA). Available at: "<http://www.fda.gov/NewsEvents/PublicHealthFocus/ucm064437.htm>". Accessed November 27, 2011.
21. Fleisch AF, Sheffield PE, Chinn C, Edelstein BL, Landrigan PJ. Bisphenol A and related compounds in dental materials. *Pediatrics* 2010;126(4):760-8.
22. Simonsen RJ. Pit and fissure sealants. In: *Clinical Applications of the Acid Etch Technique*. Chicago, Ill: Quintessence Publishing Co, Inc; 1978:19-42.
23. Brown LJ, Kaste L, Selwitz R, Furman L. Dental caries and sealant usage in US children, 1988-1991: Selected findings from the third National Health and Nutrition Examination Survey. *J Am Dent Assoc* 1996;127(3):335-43.
24. National Center for Health Statistics, CDC. National Health and Nutrition Examination Surveys 1999-2004. Available at: "<http://www.cdc.gov/nchs/about/major/nhanes/nhanes99-02.htm>". Accessed June 9, 2008.
25. Llodra JC, Bravo M, Delgado-Rodriguez M, Baca P, Galvez R. Factors influencing the effectiveness of sealants: A meta-analysis. *Community Dent Oral Epidemiol* 1993;21(5):261-8.
26. Ahovuo-Saloranta A, Hijri A, Nordblad A, Worthington H, Makela M. Pit and fissure sealants for preventing dental decay in the permanent teeth of children and adolescents. *Cochrane Database Syst Rev* 2004(3):CD001830. 18E.
27. Feigal, RJ. The use of pit and fissure sealants. *Pediatr Dent* 2002;24(5):415-22.

28. Handelman SL, Buonocore MG, Heseck DJ. A preliminary report on the effect of fissure sealant on bacteria in dental caries. *J Prosthet Dent* 1972;27(4):390-2.
29. Handelman SL, Washburn F, Wopperer P. Two-year report of sealant effect on bacteria in dental caries. *J Am Dent Assoc* 1976;93(5):967-70.
30. Going RE, Loesche WJ, Grainger DA, Syed SA. The viability of microorganisms in caries lesions five years after covering with a fissure sealant. *J Am Dent Assoc* 1978;97(3):455-62.
31. Mertz-Fairhurst EJ, Adair SM, Sams DR, et al. Cario-static and ultraconservative sealed restorations: Nine-year results among children and adults. *ASDC J Dent Child* 1995;62(2):97-107.
32. Primosch RE, Barr ES. Sealant use and placement techniques among pediatric dentists. *J Am Dent Assoc* 2001;132(10):1442-51.
33. Wright GZ, Hatibovic-Kofman S, Millenaar DW, Braverman I. The safety and efficacy of treatment with air-abrasion technology. *Int J Paediatr Dent* 1999;9(2):133-40.
34. Chan DC, Summitt JB, García-Godoy F, Hilton TJ, Chung KH. Evaluation of different methods for cleaning and preparing occlusal fissures. *Oper Dent* 1999;24(6):331-6.
35. Geiger SB, Gulayev S, Weiss EI. Improving fissure sealant quality: Mechanical preparation and filling level. *J Dent* 2000;28(6):407-12.
36. Zervou C, Kugel G, Leone C, Zavras A, Doherty EH, White GE. Enameloplasty effects on microleakage of pit-and-fissure sealants under load: An in vitro study. *J Clin Pediatr Dent* 2000;24(4):279-85.
37. Le Bell Y, Forsten L. Sealing of preventively enlarged fissures. *Acta Odontol Scand* 1980;38(2):101-4.
38. Shapira J, Eidelman E. Six-year clinical evaluation of fissure sealants placed after mechanical preparation: A matched pair study. *Pediatr Dent* 1986;8(3):204-5.
39. Beauchamp J, Caufield PW, Crall JJ, Donly K, Feigal R, Gooch B. Evidence-based clinical recommendations for the use of pit-and-fissure sealants. *J Am Dent Assoc* 2008;139(3):257-67.
40. Hebling J, Feigal RJ. Use of one-bottle adhesive as an intermediate bonding layer to reduce sealant microleakage on saliva-contaminated enamel. *Am J Dent* 2000;13(4):187-91.
41. Feigal RJ, Hitt JC, Splieth C. Sealant retention on salivary contaminated enamel: A two-year clinical study. *J Am Dent Assoc* 1993;124(3):88-97.
42. Koh SH, Chan JT, You C. Effects of topical fluoride treatment on tensile bond strength of pit and fissure sealants. *Gen Dent* 1998;46(3):278-80.
43. Warren DP, Infante NB, Rice HC, Turner SD, Chan JT. Effect of topical fluoride on retention of pit-and-fissure sealants. *J Dent Hyg* 2001;75(1):21-4.
44. Boksmán L, Gratton DR, McCutcheon E, Plotzke OB. Clinical evaluation of a glass ionomer cement as a fissure sealant. *Quintessence Int* 1987;18(10):707-9.
45. Forss H, Saarni UM, Seppä L. Comparison of glass ionomer and resin-based fissures sealants: A 2-year clinical trial. *Community Dent Oral Epidemiol* 1994;22(1):21-4.
46. Simonsen RJ. Retention and effectiveness of dental sealant after 15 years. *J Am Dent Assoc* 1991;122(10):34-42.
47. Romcke RG, Lewis DW, Maze BD, Vickerson RA. Retention and maintenance of fissure sealants over 10 years. *J Can Dent Assoc* 1990;56(3):235-7.
48. Mitra SB, Kedrowski BL. Long-term mechanical properties of glass ionomers. *Dent Mater* 1994;10(2):78-82.
49. Douglas WH, Lin CP. Strength of the new systems. In: Hunt PR, ed. *Glass Ionomers: The Next Generation*. Philadelphia, Pa: International Symposia in Dentistry, PC; 1994:209-16.
50. Quackenbush BM, Donly KJ, Croll TP. Solubility of a resin-modified glass ionomer cement. *ASDC J Dent Child* 1998;65(5):310-2, 354.
51. Kerby RE, Knobloch L, Thakur A. Strength properties of visible light-cured, resin-modified glass ionomer cements. *Oper Dent* 1997;22(2):79-83.
52. Croll TP. Visible light-hardened glass-ionomer cement base/liner as an interim restorative material. *Quintessence Int* 1991;22(2):137-41.
53. Welbury RR, Shaw AJ, Murray JJ, Gordon PH, McCabe JF. Clinical evaluation of paired compomer and glass ionomer restorations in primary molars: Final results after 42 months. *Br Dent J* 2000;189(2):93-7.
54. Vilkinis V, Hörsted-Bindslev P, Baelum V. Two-year evaluation of Class II resin-modified glass ionomer cement/composite open sandwich and composite restorations. *Clin Oral Investig* 2000;4(3):133-9.
55. Rutar J, McAllan L, Tyas MJ. Three-year clinical performance of glass ionomer cement in primary molars. *Int J Paediatr Dent* 2002;12(2):146-7.
56. Donly KJ, Segura A, Kanellis M, Erickson RL. Clinical performance and caries inhibition of resin-modified glass ionomer cement and amalgam restorations. *J Am Dent Assoc* 1999;130(10):1459-66.
57. Croll TP, Bar-Xion Y, Segura A, Donly KJ. Clinical performance of resin-modified glass ionomer cement restorations in primary teeth. A retrospective evaluation. *J Am Dent Assoc* 2001;132(8):1110-6.
58. Wilson AD, McLean JW. Laminar restorations. In: *Glass Ionomer Cement*. Chicago, Ill: Quintessence Publishing Co; 1988:159-78.
59. Tam LE, Chan GP, Yim D. In vitro caries inhibition effects by conventional and resin-modified glass ionomer restorations. *Oper Dent* 1997;22(1):4-14.
60. Scherer W, Lippman N, Kalm J, LoPresti J. Antimicrobial properties of VLC liners. *J Esthet Dent* 1990;2(2):31-2.
61. Tyas MJ. Cariostatic effect of glass ionomer cements: A 5-year clinical study. *Aust Dent J* 1991;36(3):236-9.
62. Forsten L. Fluoride release from a glass ionomer cement. *Scand J Dent Res* 1977;85(6):503-4.

63. Swartz ML, Phillips RW, Clark HE. Long-term fluoride release from glass ionomer cements. *J Dent Res* 1984;63(2):158-60.
64. Forsten L. Fluoride release and uptake by glass ionomers and related materials and its clinical effect. *Biomaterials* 1998;19(6):503-8.
65. Donly KJ, Nelson JJ. Fluoride release of restorative materials exposed to a fluoridated dentifrice. *ASDC J Dent Child* 1997;64(4):249-50.
66. Donly KJ, Istre S, Istre T. In vitro enamel remineralization at orthodontic band margins cemented with glass ionomer cement. *Am J Orthod Dentofacial Orthop* 1995;107(5):461-4.
67. Vorhies AB, Donly KJ, Staley RN, Wefel JS. Enamel demineralization adjacent to orthodontic brackets bonded with hybrid glass ionomer cements: An in vitro study. *Am J Orthod Dentofacial Orthop* 1998;114(6):668-74.
68. Wambier DS, dos Santos FA, Guedes-Pinto AC, Jaeger RG, Simionato MR. Ultrastructural and microbiological analysis of the dentin layers affected by caries lesions in primary molars treated by minimal intervention. *Pediatr Dent* 2007;29(3):228-34.
69. Mandari GJ, Frencken JE, van' t Hof MA. Six year success rates of occlusal amalgam and glass ionomer restorations placed using three minimal intervention approaches. *Caries Res* 2003;37(4):246-53.
70. Dulgergil DT, Soyman M, Civelek A. Atraumatic restorative treatment with resin-modified glass ionomer material: Short-term results of a pilot study. *Med Princ Pract* 2005;14(3):277-80.
71. Ersin NK, Candan U, Aykut A, Oncag O, Eronat E, Kose T. A clinical evaluation of resin-based composite and glass ionomer cement restorations placed in primary teeth using the ART approach: Results at 24 months. *J Am Dent Assoc* 2006;137(11):1529-36.
72. Berg JH. Glass ionomer cements. *Pediatr Dent* 2002;24(5):430-8.
73. Paris S, Hopfenmuller W, Meyer-Lueckel H. Resin infiltration of caries lesions: An efficacy randomized trial. *J Dent Res* 2010;89(8):823-6. Epub 2010 May 26.
74. Burgess JO, Walker R, Davidson JM. Posterior resin-based composite: Review of the literature. *Pediatr Dent* 2002;24(5):465-79.
75. Pallav P, de Gee AJ, Davidson CL. The influence of admixing microfiller to small-particle composite resins on wear, tensile strength, hardness and surface roughness. *J Dent Res* 1989;68(3):489-90.
76. Robertson TM, Bayne SC, Taylor DF, Sturdevant JR. Five-year clinical wear analysis of 19 posterior composites [abstract No. 63]. *J Dent Res* 1988;67:120.
77. Bayne SC, Taylor DF, Wilder AD, Heymann HO, Tangen CM. Clinical longevity of 10 posterior composite materials based on wear [abstract No. 630]. *J Dent Res* 1991;70:344.
78. Simonsen RJ. Preventive resin restorations: Three-year results. *J Am Dent Assoc* 1980;100(4):535-9.
79. Donly KJ, García-Godoy F. The use of resin-based composite in children. *Pediatr Dent* 2002;24(5):480-8.
80. American Dental Association Council on Scientific Affairs. Statement on Dental Amalgam, Revised 2009. Chicago, Ill.; 2009. Available at: "<http://www.ada.org/1741.aspx>". Accessed June 26, 2012.
81. Levering NJ, Messer LB. The durability of primary molar restorations: I. Observations and predictions of success of amalgams. *Pediatr Dent* 1988;10(2):74-80.
82. Hunter B. Survival of dental restorations in young patients. *Community Dent Oral Epidemiol* 1985;18(5):285-7.
83. Holland IS, Walls AW, Wallwork MA, Murray JJ. The longevity of amalgam restorations in deciduous molars. *Br Dent J* 1986;161(7):255-8.
84. Dahl DE, Ericksen HM. Reasons for replacement amalgam dental restorations. *Scand J Dent Res* 1978;86(5):404-7.
85. Roberts JF, Sheriff M. The fate on survival of amalgam and preformed crown molar restorations placed in a specialist paediatric dental practice. *Br Dent J* 1990;169(8):237-44. Erratum in *Br Dent J* 1990;169(9):285.
86. Waggoner WF. Restorative dentistry for the primary dentition. In: Pinkham J, Casamassimo PS, Fields HW Jr, McTigue DJ, Nowak AJ, eds. *Pediatric Dentistry: Infancy Through Adolescence*. 4th ed. St. Louis, Mo: Elsevier/Saunders; 2005:341-74.
87. Randall RC, Vrijhoef MA, Wilson NH. Efficacy of preformed metal crowns vs amalgam restorations in primary molars: A systematic review. *J Am Dent Assoc* 2000;131(3):337-43.
88. Seale NS. Stainless steel crowns in pediatric dentistry. In: Pinkham J, Casamassimo PS, Fields HW Jr, McTigue DJ, Nowak AJ, eds. *Pediatric Dentistry: Infancy Through Adolescence*. 4th ed. St. Louis: Elsevier/Saunders; 2005:361-2.
89. Fuks AB. The use of amalgam in pediatric dentistry. *Pediatr Dent* 2002;24(5):448-55.
90. Seale NS. The use of stainless steel crowns. *Pediatr Dent* 2002;24(5):501-5.
91. Randall RC. Preformed metal crowns for primary and permanent molar teeth: Review of the literature. *Pediatr Dent* 2002;24(5):489-500.
92. Waggoner WF. Restoring primary anterior teeth. *Pediatr Dent* 2002;24(5):511-6.
93. Oueis H, Atwan S, Pajtas B, Casamassimo P. Use of anterior veneered stainless steel crowns by pediatric dentists. *Pediatr Dent* 2010;32(5):413-6.
94. Roberts C, Lee JY, Wright T. Clinical evaluation of and parental satisfaction with resin-faced stainless steel crowns. *Pediatr Dent* 2001;23(1):28-31.
95. Shah PV, Lee JY, Wright T. Clinical success and parental satisfaction with anterior preveneered primary stainless steel crowns. *Pediatr Dent* 2004;26(5):391-5.
96. Champagne CE, Waggoner WF, Ditmyer MM, Casamassimo PS, MacLean JK. Parental satisfaction with preveneered stainless steel crowns for primary anterior teeth. *Pediatr Dent* 2007;29(6):465-9.

97. MacLean JK, Champagne CE, Waggoner WF, Ditmyer MM, Casamassimo PS. Clinical outcomes for primary anterior teeth treated with veneered stainless steel crowns. *Pediatr Dent* 2007;29(5):377-81.
98. Leith R, O'Connell AC. A clinical study evaluating success of 2 commercially available veneered primary molar stainless steel crowns. *Pediatr Dent* 2011;33(4):300-6.
99. Horn HR. Porcelain laminate veneers bonded to etched enamel. *Dent Clin North Am* 1983;27(4):671-84.
100. Simonsen R, Thompson V, Barrack G. *Etched Cast Restorations: Clinical and Laboratory Techniques*. Quintessence Publishing; Chicago Ill.; 1983.
101. Creugers NHJ, van't Hof MA, Vrijhoef MMA. A clinical comparison of 3 types of resin-retained cast metal prostheses. *J Prosthet Dent* 1986;56(3):297-300.
102. McLaughlin G. Porcelain fused to tooth: A new esthetic and reconstructive modality. *Compend Contin Educ Dent* 1984;5(5):430-5.
103. Thompson VP, Livaditis GJ. Etched casting acid etch composite bonded posterior bridges. *Pediatr Dent* 1982;4(1):38-43.
104. Wood M, Thompson VP. Anterior etched cast resin-bonded retainer: An overview of design, fabrication, and clinical use. *Compend Contin Educ Dent* 1983;4(3):247-56, 258.
105. Winstanley RB. Prosthodontic treatment of patients with hypodontia. *J Prosthet Dent* 1984;52(5):687-91.
106. Abadi BJ, Kimmel NA, Falace DA. Modified overdentures for the management of oligodontia and developmental defects. *ASDC J Dent Child* 1982;49(2):123-6.
107. Nayar AK, Latta JB, Soni NN. Treatment of dentinogenesis imperfecta in a child: Report of a case. *ASDC J Dent Child* 1981;48(6):453-5.