|  |  |
| --- | --- |
| J Am Dent Assoc, Vol 140, No 11, 1356-1365.  © 2009 [American Dental Association](http://jada.ada.org/misc/terms.dtl) |  |

|  |
| --- |
| **COVER STORY** |

**JADA Continuing Education**

**Preventing Dental Caries Through School-Based Sealant Programs**

**Updated Recommendations and Reviews of Evidence**

**Barbara F. Gooch, DMD, MPH**, **Susan O. Griffin, PhD**, **Shellie Kolavic Gray, DMD, MPH**, **William G. Kohn, DDS**, **R. Gary Rozier, DDS, MPH**, **Mark Siegal, DDS, MPH**, **Margherita Fontana, DDS, PhD**, **Diane Brunson, RDH, MPH**, **Nancy Carter, RDH, MPH**, **David K. Curtis, DMD**, **Kevin J. Donly, DDS, MS**, **Harold Haering, DMD**, **Lawrence F. Hill, DDS, MPH**, **H. Pitts Hinson, DDS, MS**, **Jayanth Kumar, DDS, MPH**, **Lewis Lampiris, DDS, MPH**, **Mark Mallatt, DDS, MSD**, **Daniel M. Meyer, DDS**, **Wanda R. Miller, RN, MA, NCSN, FNASN**, **Susan M. Sanzi-Schaedel, RDH, MPH**, **Richard Simonsen, DDS, MS**, **Benedict I. Truman, MD, MPH** and **Domenick T. Zero, DDS, MS**

**ABSTRACT**

**Background.** School-based sealant programs (SBSPs) increase sealant use and reduce caries. Programs target schools that serve children from low-income families and focus on sealing newly erupted permanent molars. In 2004 and 2005, the Centers for Disease Control and Prevention (CDC), Atlanta, sponsored meetings of an expert work group to update recommendations for sealant use in SBSPs on the basis of available evidence regarding the effectiveness of sealants on sound and carious pit and fissure surfaces, caries assessment and selected sealant placement techniques, and the risk of caries’ developing in sealed teeth among children who might be lost to follow-up. The work group also identified topics for which additional evidence review was needed.

**Types of Studies Reviewed.** The work group used systematic reviews when available. Since 2005, staff members at CDC and subject-matter experts conducted several independent analyses of topics for which no reviews existed. These reviews include a systematic review of the effectiveness of sealants in managing caries.

**Results.** The evidence supports recommendations to seal sound surfaces and noncavitated lesions, to use visual assessment to detect surface cavitation, to use a toothbrush or handpiece prophylaxis to clean tooth surfaces, and to provide sealants to children even if follow-up cannot be ensured.

**Clinical Implications.** These recommendations are consistent with the current state of the science and provide appropriate guidance for sealant use in SBSPs. This report also may increase practitioners’ awareness of the SBSP as an important and effective public health approach that complements clinical care.

**Key Words:** Caries; evidence-based dentistry; pit-and-fissure sealants; preventive dentistry; public health/community dentistry

**Abbreviations:ADA:** American Dental Association • **CDC:** Centers for Disease Control and Prevention • **IFUs:** Instructions for use • **RCTs:** Randomized controlled trials • **SBSPs:** School-based sealant programs

Health care professionals often provide prevention services in schools to protect and promote the health of students.[1](http://jada.ada.org/content/140/11/1356.full#R1) School programs can increase access to services, such as dental sealant placement, especially among vulnerable children less likely to receive private dental care.[2](http://jada.ada.org/content/140/11/1356.full#R2) In addition, school programs have the potential to link students with treatment services in the community and facilitate enrollment of eligible children in public insurance programs, such as Medicaid and the Children’s Health Insurance Program.[3](http://jada.ada.org/content/140/11/1356.full#R3)

In 2001, the independent, nongovernmental Task Force on Community Preventive Services completed a systematic review of published scientific studies demonstrating strong evidence that school sealant programs were effective in reducing the incidence of caries.[4](http://jada.ada.org/content/140/11/1356.full#R4),[5](http://jada.ada.org/content/140/11/1356.full#R5) The median decrease in occlusal caries in posterior teeth among children aged 6 through 17 years was 60 percent. On the basis of these findings, the task force recommended that school sealant programs be part of a comprehensive community strategy to prevent dental caries.[4](http://jada.ada.org/content/140/11/1356.full#R4),[5](http://jada.ada.org/content/140/11/1356.full#R5) These programs typically are implemented in schools that serve children from low-income families and focus primarily on those in second and sixth grades, because high percentages of these children are likely to have newly erupted permanent molars.[6](http://jada.ada.org/content/140/11/1356.full#R6)

Available data show that children aged 6 through 11 years from families living below the federal poverty threshold (approximately $21,800 annually for a family of four in 2008)[7](http://jada.ada.org/content/140/11/1356.full#R7) are almost twice as likely to have developed caries in their permanent teeth as are children from families with incomes greater than two times the federal poverty threshold (28 percent versus 16 percent).[8](http://jada.ada.org/content/140/11/1356.full#R8) Overall, about 90 percent of carious lesions are found in the pits and fissures of permanent posterior teeth, with molars being the most susceptible tooth type.[9](http://jada.ada.org/content/140/11/1356.full#R9),[10](http://jada.ada.org/content/140/11/1356.full#R10) Unfortunately, only about one in five children, or 20 percent, aged 6 though 11 years from low-income families has received sealants, a proportion that is notably less than the 40 percent of children from families with incomes greater than two times the poverty threshold.[8](http://jada.ada.org/content/140/11/1356.full#R8) Significant disparities also exist according to race/ethnicity, with non-Hispanic African American (21 percent) and Mexican American (24 percent) children aged 6 through 11 years less likely to have received sealants than non-Hispanic white children (36 percent).[8](http://jada.ada.org/content/140/11/1356.full#R8)

School sealant programs can be an important intervention to increase the receipt of sealants, especially among underserved children. For example, the results of a study in Ohio confirmed that programs directed toward low-income children substantially increased the use of dental sealants.[11](http://jada.ada.org/content/140/11/1356.full#R11) Furthermore, sealant programs could reduce or eliminate racial and economic disparities in sealant use if programs were provided to all eligible, high-risk schools,[11](http://jada.ada.org/content/140/11/1356.full#R11) such as those in which 50 percent or more of the children are eligible for free or reduced-price meals.[6](http://jada.ada.org/content/140/11/1356.full#R6)

Differences of opinion among clinicians regarding the management of caries, caries assessment and sealant placement procedures[12](http://jada.ada.org/content/140/11/1356.full#R12)–[14](http://jada.ada.org/content/140/11/1356.full#R14) have led some to question the effectiveness of certain practices, such as sealing teeth that have incipient caries or sealing without first obtaining diagnostic radiographs. Partly on the basis of the need to address these questions, the Association of State and Territorial Dental Directors asked the Centers for Disease Control and Prevention (CDC), Atlanta, to review and update sealant guidelines last revised in 1994.[15](http://jada.ada.org/content/140/11/1356.full#R15) Staff members of CDC agreed to undertake this review, especially because new information had become available regarding the effectiveness of sealants, the prevalence of caries and sealants in children and young adults in the United States, and techniques for caries assessment and sealant placement.

This report provides updated recommendations for sealant use in school-based sealant programs (SBSPs) (that is, programs that provide sealants in schools).[2](http://jada.ada.org/content/140/11/1356.full#R2) We also inform dental practitioners about the evidence regarding the effectiveness of SBSPs and practices. This evidence provides the basis for the updated recommendations.

Practitioner awareness is important because dentists in private practice likely will see children who have received sealants in school-based programs and might themselves be asked to participate in or even implement such programs. In addition, this report can help address questions from parents, school administrators and other stakeholders. Finally, we discuss the consistency between these recommendations for SBSPs and evidence-based clinical recommendations for sealant use developed recently by an expert panel convened by the American Dental Association (ADA) Council on Scientific Affairs[16](http://jada.ada.org/content/140/11/1356.full#R16) (the ADA sealant recommendations).

**METHODS**

The CDC supported two meetings (in June 2004 and April 2005) of a work group consisting of experts in sealant research, practice and policy, as well as caries assessment, prevention and treatment. The work group also included representatives from professional dental organizations. The work group addressed questions about the following topics (Box[Go](http://jada.ada.org/content/140/11/1356.full#T2)):

**View this table:**  
[In this window](http://jada.ada.org/content/140/11/1356/T2.expansion.html)  
[In a new window](http://jada.ada.org/content/140/11/1356/T2.expansion.html)

**BOX** **Topics and questions discussed by work group.**

– effectiveness of sealants on sound and carious pit and fissure surfaces;

– methods for caries assessment before sealant application;

– effectiveness of selected placement techniques;

– risk of developing caries in sealed teeth among children who might be lost to follow-up and for whom sealant retention cannot be ensured.

Based in part on the content of the meeting presentations and discussions, the work group drafted recommendations and identified areas in which additional evidence review was necessary.

The work group used published findings of systematic reviews when available. Since the last meeting of the group in 2005, staff members of CDC and another expert group completed a systematic review to determine the effectiveness of sealants in managing caries progression and bacteria levels in carious lesions. The results of that review[17](http://jada.ada.org/content/140/11/1356.full#R17),[18](http://jada.ada.org/content/140/11/1356.full#R18) also supported the ADA sealant recommendations.[16](http://jada.ada.org/content/140/11/1356.full#R16) For questions about other topics for which there were no existing reviews, CDC staff members conducted analyses of the available evidence and published these results in peer-reviewed journals.[19](http://jada.ada.org/content/140/11/1356.full#R19)–[21](http://jada.ada.org/content/140/11/1356.full#R21)

**Clinical studies.** For these analyses, we searched electronic databases (that is, MEDLINE, Embase, Cochrane Library and Web of Science) to identify clinical studies that focused primarily on sealant outcomes resulting from different surface preparation and placement techniques. In some cases, few, if any, clinical trials directly compared in the same study sealant retention resulting from different placement techniques. In these situations, we performed bivariate and multivariate analyses to compare sealant retention across studies. For example, we compared sealant retention in studies that involved handpiece prophylaxis with retention in studies that involved toothbrush prophylaxis, and studies that involved a four-handed technique with studies that involved a two-handed technique.[19](http://jada.ada.org/content/140/11/1356.full#R19),[21](http://jada.ada.org/content/140/11/1356.full#R21) Lastly, in light of the work group’s recommendation that clinicians consult manufacturers’ instructions regarding surface preparation before acid etching, we described the range of manufacturers’ instructions for surface preparation for unfilled resin-based sealants,[21](http://jada.ada.org/content/140/11/1356.full#R21) which commonly are used in school programs.[22](http://jada.ada.org/content/140/11/1356.full#R22)

**Scientific evidence.** For each question addressed by the work group, we summarized the relevant scientific information. On the basis of recognized systems for grading the quality of scientific evidence, we assigned the highest level of confidence generally to findings of systematic reviews and randomized controlled trials (RCTs).[23](http://jada.ada.org/content/140/11/1356.full#R23)–[25](http://jada.ada.org/content/140/11/1356.full#R25) Random assignment of study participants to treatment and control groups is the study design most likely to fully control for the effect of other factors on sealant effectiveness or retention. The systematic review involves the use of a standard procedure to synthesize findings from the best available clinical studies, usually RCTs.

We generally assigned lower levels of confidence to findings from studies with other designs. Beyond this qualitative assessment of the evidence, neither the work group nor CDC staff members made any attempt to grade the quality of the evidence or directly relate each recommendation to the strength of the evidence. We did not independently review the design or quality of the systematic reviews and comparative studies. All included studies were published in the peer-reviewed scientific literature.

**QUESTIONS AND KEY FINDINGS**

The work group addressed the following questions.

**Sound pit and fissure surfaces.** What is the effectiveness of sealants in preventing the development of caries on sound pit and fissure surfaces?

Systematic reviews have found strong evidence of sealant effectiveness on sound permanent posterior teeth in children and adolescents. A meta-analysis of 10 studies of a one-time placement of autopolymerized sealants on permanent molars in children found that the sealants reduced dental caries by 78 percent at one year and 59 percent at four or more years of follow-up.[26](http://jada.ada.org/content/140/11/1356.full#R26) (A meta-analysis is a review that involves the use of quantitative methods to combine the statistical measures from two or more studies and generates a weighted average of the effect of an intervention, the degree of association between a risk factor and a disease or the accuracy of a diagnostic test.)[27](http://jada.ada.org/content/140/11/1356.full#R27)

Similarly, a meta-analysis of five studies of resin-based sealants found reductions in caries ranging from 87 percent at 12 months to 60 percent at 48 to 54 months.[28](http://jada.ada.org/content/140/11/1356.full#R28) A third meta-analysis of 13 studies also found that sealants were effective, but estimates of caries reductions attributed to sealant placement were lower (33 percent from two to five years after placement).[29](http://jada.ada.org/content/140/11/1356.full#R29) The lower estimates might reflect the inclusion of studies that examined sealants polymerized by ultraviolet light (that is, first-generation sealant materials no longer marketed in the United States) and studies involving exposures to other preventive interventions, such as fluoride mouthrinses.[29](http://jada.ada.org/content/140/11/1356.full#R29)

Systematic reviews have found that sealants are effective in preventing the development of caries on sound pit and fissure surfaces in children and adolescents.

*Summary of evidence.* Systematic reviews[26](http://jada.ada.org/content/140/11/1356.full#R26),[28](http://jada.ada.org/content/140/11/1356.full#R28),[29](http://jada.ada.org/content/140/11/1356.full#R29) have found that sealants are effective in preventing the development of caries on sound pit and fissure surfaces in children and adolescents.

**Noncavitated or incipient lesions.** What is the effectiveness of sealants in preventing the progression of noncavitated or incipient carious lesions to cavitation?

A meta-analysis of six studies of sealant placement on teeth with noncavitated carious lesions found that sealants reduced by 71 percent the percentage of lesions that progressed up to five years after placement in children, adolescents and young adults.[17](http://jada.ada.org/content/140/11/1356.full#R17) We define noncavitated carious lesions as lesions with no discontinuity or break in the enamel surface. Findings across each of the six studies were consistent.

*Summary of evidence.* A systematic review[17](http://jada.ada.org/content/140/11/1356.full#R17) found that pit-and-fissure sealants are effective in reducing the percentage of noncavitated carious lesions that progressed to cavitation in children, adolescents and young adults.

**Bacteria levels.** What is the effectiveness of sealants in reducing bacteria levels in cavitated carious lesions?

A systematic review of the effects of sealants on bacteria levels in cavitated carious lesions found no significant increases in bacteria under sealants.[18](http://jada.ada.org/content/140/11/1356.full#R18) Sealants lowered the number of viable bacteria, including *Streptococcus mutans* and lactobacilli, by at least 100-fold and reduced the number of lesions with any viable bacteria by about 50 percent.

*Summary of evidence.* A systematic review[18](http://jada.ada.org/content/140/11/1356.full#R18) found that pit-and-fissure sealants are effective in reducing bacteria levels in cavitated carious lesions in children, adolescents and young adults.

**Assessment of caries on surfaces to be sealed.** Which caries assessment methods should be used in SBSPs to differentiate pit and fissure surfaces that are sound or noncavitated from those that are cavitated or have signs of dentinal caries?

In 2001, investigators conducting a systematic review for the National Institutes of Health Consensus Development Conference on Diagnosis and Management of Dental Caries Throughout Life[30](http://jada.ada.org/content/140/11/1356.full#R30) concluded that the relative accuracy of methods of identifying carious lesions could not be determined from the available studies. The systematic review evaluated evidence regarding the following methods: visual inspection, visual/tactile inspection, radiographic assessment, fiber-optic transillumination, electrical conductance and laser fluorescence. The authors also examined the improvement in accuracy resulting from the addition of radiographs to visual assessment in the detection of dentinal lesions on occlusal surfaces.

The review judged the quality of evidence available for assessment of the relative accuracy of the diagnostic methods as "poor." The authors rated the evidence as poor because there were few relevant studies, the study quality was lower than average and/or the studies included a wide range of observed measures of accuracy. Because of the poor quality of the available evidence, the investigators could not determine the relative accuracy of the assessment methods. Most of the studies compared assessment methods with a histologic determination of caries. For the identification of cavitated lesions, however, the authors of the systematic review also accepted visual or visual/tactile inspection—the principal methods dentists use to identify cavitated lesions—as a valid standard.[31](http://jada.ada.org/content/140/11/1356.full#R31),[32](http://jada.ada.org/content/140/11/1356.full#R32)

More recently, an international team of caries researchers developed an integrated system for caries detection based on a review of the best available evidence and contemporary caries detection criteria.[33](http://jada.ada.org/content/140/11/1356.full#R33),[34](http://jada.ada.org/content/140/11/1356.full#R34) In this system, clinicians use visual criteria alone to document the extent of enamel breakdown, including distinct cavitation into dentin, the presence of an underlying dark shadow from dentin and the exposure of dentin. Researchers have correlated the visual criteria in this integrated system with the extent of carious demineralization into dentin.[33](http://jada.ada.org/content/140/11/1356.full#R33),[35](http://jada.ada.org/content/140/11/1356.full#R35) With this system, clinicians can determine cavitation into dentin or find evidence of dentinal involvement, such as an underlying dark shadow, without extensive drying of the tooth.[16](http://jada.ada.org/content/140/11/1356.full#R16),[33](http://jada.ada.org/content/140/11/1356.full#R33)

Other widely used criteria for epidemiologic and clinical caries studies also have relied on visual and visual/tactile assessment.[36](http://jada.ada.org/content/140/11/1356.full#R36)–[38](http://jada.ada.org/content/140/11/1356.full#R38) These criteria describe frank cavitation as "a discontinuity of the enamel surface caused by loss of tooth substance"[38](http://jada.ada.org/content/140/11/1356.full#R38) or an "unmistakable cavity."[36](http://jada.ada.org/content/140/11/1356.full#R36) In these assessments, the examiner uses an explorer primarily in noncavitated lesions to determine the softness of the floor or walls or the presence of weakened enamel. Findings of clinical and in vitro studies, however, indicate that use of a sharp explorer, even with gentle pressure, can result in defects or cavitations that could introduce a pathway for caries progression.[39](http://jada.ada.org/content/140/11/1356.full#R39)–[42](http://jada.ada.org/content/140/11/1356.full#R42)

Technologically advanced tools such as laser fluorescence are designed to assist the dentist in interpreting visual cues in detecting and monitoring lesions over time, especially early noncavitated lesions. Findings of validation studies indicate that these tools increase the percentage of early carious lesions that are detected, but they also increase the likelihood that a sound surface will be described as carious.[31](http://jada.ada.org/content/140/11/1356.full#R31),[32](http://jada.ada.org/content/140/11/1356.full#R32),[43](http://jada.ada.org/content/140/11/1356.full#R43),[44](http://jada.ada.org/content/140/11/1356.full#R44)

Finally, investigators in two in vitro studies[45](http://jada.ada.org/content/140/11/1356.full#R45),[46](http://jada.ada.org/content/140/11/1356.full#R46) assessed changes in the accuracy of detecting carious lesions resulting from the addition of low-powered magnification to unaided visual inspection. One study found that inspection with a x2 magnifying glass did not improve the accuracy of visual inspection alone in the detection of dentinal caries on noncavitated occlusal surfaces.[46](http://jada.ada.org/content/140/11/1356.full#R46) The other study[45](http://jada.ada.org/content/140/11/1356.full#R45) found that the addition of x3.25 loupes to visual inspection alone did improve accuracy in the assessment of occlusal and interproximal surfaces, although more than 90 percent of the clinical decisions to describe a surface as decayed were correct with the use of either technique. The researchers did not report the percentage of clinically decayed surfaces that were limited to enamel or extended into dentin on histologic examination.[45](http://jada.ada.org/content/140/11/1356.full#R45) They also did not document the prevalence of cavitation among the decayed surfaces.[45](http://jada.ada.org/content/140/11/1356.full#R45)

*Summary of evidence.* In 2001, a systematic review[30](http://jada.ada.org/content/140/11/1356.full#R30) concluded that the relative accuracy of methods used to identify carious lesions could not be determined from the available studies. More recently, a team of international caries researchers supported visual assessment alone to detect the presence of surface cavitation and/or signs of dentinal caries.[33](http://jada.ada.org/content/140/11/1356.full#R33),[34](http://jada.ada.org/content/140/11/1356.full#R34) They based this determination on their review of the best available evidence and on contemporary caries detection criteria.

Published studies have suggested that use of a sharp explorer under pressure could introduce a pathway for caries progression[39](http://jada.ada.org/content/140/11/1356.full#R39)–[42](http://jada.ada.org/content/140/11/1356.full#R42) and that use of technologically advanced tools, such as laser fluorescence, increases the likelihood that a sound surface will be deemed carious.[31](http://jada.ada.org/content/140/11/1356.full#R31),[32](http://jada.ada.org/content/140/11/1356.full#R32),[43](http://jada.ada.org/content/140/11/1356.full#R43),[44](http://jada.ada.org/content/140/11/1356.full#R44) Investigators in two in vitro studies[45](http://jada.ada.org/content/140/11/1356.full#R45),[46](http://jada.ada.org/content/140/11/1356.full#R46) could not determine improvement in the accuracy of detecting cavitation or dentinal caries on occlusal surfaces with the addition of low-powered magnification.

**Surface preparation.** What surface cleaning methods or techniques are recommended by manufacturers for unfilled resin-based sealants (self-curing and light-cured) commonly used in SBSPs?

Gray and colleagues[21](http://jada.ada.org/content/140/11/1356.full#R21) reviewed instructions for use (IFUs) for 10 unfilled sealant products from five manufacturers and found that all directed the operator to clean the tooth surface before acid etching. None of the IFUs specifically stated which cleaning method should be used. Five of the IFUs mentioned the use of pumice slurry or prophylaxis paste and/or a prophylaxis brush, thereby implying, but not directly stating, that the operator should use a handpiece.

*Summary of evidence.* A review of manufacturers’ IFUs for unfilled resin-based sealants[21](http://jada.ada.org/content/140/11/1356.full#R21) found that they do not specify a particular method of cleaning the tooth surface.

**Effect of clinical procedures.** What is the effect of clinical procedures—specifically, surface cleaning or mechanical preparation methods with use of a bur before acid etching—on sealant retention?

Recent reviews, including one systematic review,[21](http://jada.ada.org/content/140/11/1356.full#R21),[47](http://jada.ada.org/content/140/11/1356.full#R47) identified two controlled clinical trials that directly compared surface cleaning methods.[48](http://jada.ada.org/content/140/11/1356.full#R48),[49](http://jada.ada.org/content/140/11/1356.full#R49) Donnan and Ball[49](http://jada.ada.org/content/140/11/1356.full#R49) found no difference in complete sealant retention between surfaces cleaned with a handpiece and prophylaxis brush with pumice and those cleaned with an air-water syringe after the clinician ran an explorer along the fissures. Similarly, Gillcrist and colleagues[48](http://jada.ada.org/content/140/11/1356.full#R48) observed no difference between surfaces cleaned with a handpiece and prophylaxis brush with prophylaxis paste and those cleaned with a dry toothbrush. Reported retention rates were greater than 96 percent at 12 months after sealant placement for all four surface cleaning methods. Furthermore, bivariate and multivariate analyses of retention data from published studies involving the use of supervised toothbrushing by the patient or a handpiece prophylaxis (also called rubber-cup prophylaxis or pumice prophylaxis) by the operator revealed similar, if not higher, retention rates for supervised toothbrushing.[19](http://jada.ada.org/content/140/11/1356.full#R19),[21](http://jada.ada.org/content/140/11/1356.full#R21)

The ADA’s expert panel,[16](http://jada.ada.org/content/140/11/1356.full#R16) in its review of evidence for the ADA sealant recommendations, found "limited and conflicting evidence" that mechanical preparation with a bur results in higher sealant retention rates in children.[50](http://jada.ada.org/content/140/11/1356.full#R50)–[52](http://jada.ada.org/content/140/11/1356.full#R52) In addition, a systematic review[47](http://jada.ada.org/content/140/11/1356.full#R47) identified only one controlled clinical trial[53](http://jada.ada.org/content/140/11/1356.full#R53) that compared use of a bur and acid etching with acid etching alone. The researchers found no difference in sealant retention at 48 months.[47](http://jada.ada.org/content/140/11/1356.full#R47),[53](http://jada.ada.org/content/140/11/1356.full#R53)

*Summary of evidence.* The effect of specific surface cleaning or enamel preparation techniques on sealant retention cannot be determined because of the small number of clinical studies comparing specific techniques and, for mechanical preparation with a bur, inconsistent findings. Bivariate and multivariate analyses of retention data[19](http://jada.ada.org/content/140/11/1356.full#R19),[21](http://jada.ada.org/content/140/11/1356.full#R21) across existing studies suggest that supervised toothbrushing or use of a handpiece prophylaxis may result in similar sealant retention rates over time.

**Four-handed technique for applying dental sealant.** Does use of a four-handed technique in comparison with a two-handed technique improve sealant retention?

The four-handed technique involves the placement of sealants by a primary operator with the assistance of a second person. The two-handed technique is the placement of sealants by a single operator. The work group could not find any direct comparative studies of the four-handed technique versus the two-handed technique with regard to sealant retention or effectiveness.

Furthermore, retention rates in single studies generally reflect multiple factors.[19](http://jada.ada.org/content/140/11/1356.full#R19) For example, Houpt and Shey[54](http://jada.ada.org/content/140/11/1356.full#R54) reported a sealant retention rate of more than 90 percent at one year in a single study that involved the use of two-handed delivery to apply sealants, while other authors[55](http://jada.ada.org/content/140/11/1356.full#R55),[56](http://jada.ada.org/content/140/11/1356.full#R56) reported retention rates of less than 80 percent at one year for single studies in which four-handed delivery was used. Results of a multivariate analysis[19](http://jada.ada.org/content/140/11/1356.full#R19) of sealant effectiveness studies showed that use of the four-handed technique increased sealant retention by 9 percentage points when the investigators controlled for other factors.

*Summary of evidence.* In the absence of direct comparative studies, the results of a multivariate study of available data[19](http://jada.ada.org/content/140/11/1356.full#R19) suggest that use of the four-handed placement technique is associated with a 9 percentage point increase in sealant retention.

**Caries risk associated with lost sealants.** Are teeth in which sealants are lost at a higher risk of developing caries than are teeth that were never sealed?

A recent meta-analysis of seven RCTs found that teeth with fully or partially lost sealants were not at a higher risk of developing caries than were teeth that were never sealed.[20](http://jada.ada.org/content/140/11/1356.full#R20) In addition, although sealant effectiveness in preventing caries is related to retention over time, researchers conducting a systematic review that included only studies in which lost sealants were not reapplied found that sealants reduced caries by more than 70 percent.[20](http://jada.ada.org/content/140/11/1356.full#R20),[26](http://jada.ada.org/content/140/11/1356.full#R26) Thus, children from low-income families, who are more likely to move between schools than are their higher-income counterparts,[57](http://jada.ada.org/content/140/11/1356.full#R57),[58](http://jada.ada.org/content/140/11/1356.full#R58) will not be placed at a higher risk of developing caries because they missed planned opportunities for sealant reapplication in SBSPs.

*Summary of evidence.* Findings from a meta-analysis[20](http://jada.ada.org/content/140/11/1356.full#R20) indicate that the caries risk for sealed teeth that have lost some or all sealant does not exceed the caries risk for never-sealed teeth. Thus, the potential risk associated with loss to follow-up for children in school-based programs does not outweigh the potential benefit of dental sealants.

**RECOMMENDATIONS FOR SCHOOL-BASED SEALANT PROGRAMS**

The table[Go](http://jada.ada.org/content/140/11/1356.full#T1) presents the recommendations of the work group. These are based on the best available scientific evidence and are an update to earlier guidelines.[15](http://jada.ada.org/content/140/11/1356.full#R15) They provide guidance regarding planning, implementing and evaluating SBSPs and should be helpful for dental professionals working with sealant programs.

**View this table:**  
[In this window](http://jada.ada.org/content/140/11/1356/T1.expansion.html)  
[In a new window](http://jada.ada.org/content/140/11/1356/T1.expansion.html)

**TABLE** **Recommendations for school-based sealant programs.**

**DISCUSSION**

In the updated recommendations in this report, we use the presence or absence of surface cavitation as a key factor in the decision to apply sealant to the tooth surface. These recommendations complement the ADA sealant recommendations and are consistent with them on virtually all topics addressed by both (for example, sealing teeth that have noncavitated lesions and using a four-handed technique when possible).

The effectiveness of sealants in preventing the development of caries is well established.[5](http://jada.ada.org/content/140/11/1356.full#R5),[26](http://jada.ada.org/content/140/11/1356.full#R26),[28](http://jada.ada.org/content/140/11/1356.full#R28),[29](http://jada.ada.org/content/140/11/1356.full#R29) Findings of a recent systematic review[17](http://jada.ada.org/content/140/11/1356.full#R17),[18](http://jada.ada.org/content/140/11/1356.full#R18) also confirmed that sealants are effective in managing early carious lesions by reducing the percentage of noncavitated lesions that progress to cavitation and by lowering bacteria levels in carious lesions. These results should ease practitioners’ concerns that placement of sealants on pit and fissure surfaces with early or incipient noncavitated carious lesions or on surfaces of questionable caries status is not beneficial.

One notable difference between the recommendations for sealant use in clinical versus school settings concerns the approach to caries risk assessment.[16](http://jada.ada.org/content/140/11/1356.full#R16) Clinicians periodically assess caries risk at the level of the patient or the tooth to determine if sealant placement is indicated as a primary preventive measure. In SBSPs, clinicians also must consider risk at the level of the school and community. Local and state health departments commonly use the percentage of children participating in the free or reduced-cost federal meal program as a proxy for income to prioritize schools for sealant programs.[6](http://jada.ada.org/content/140/11/1356.full#R6),[11](http://jada.ada.org/content/140/11/1356.full#R11),[22](http://jada.ada.org/content/140/11/1356.full#R22)

As described earlier in this report, children from low-income families are at a higher risk of developing caries than are children from wealthier families.[7](http://jada.ada.org/content/140/11/1356.full#R7) Caries risk among children from low-income families is sufficiently high to justify sealing all eligible permanent molars and is the most cost-effective prevention strategy.[59](http://jada.ada.org/content/140/11/1356.full#R59),[60](http://jada.ada.org/content/140/11/1356.full#R60) Furthermore, providing sealants only to children in a free or reduced-cost lunch program is viewed as stigmatizing and is unacceptable in many schools and communities.[22](http://jada.ada.org/content/140/11/1356.full#R22) Thus, children participating in SBSPs usually receive sealants as a primary preventive measure without undergoing a routine assessment of their caries risk.

The context for making decisions in clinical care and in SBSPs also differs. Important distinctions exist related to the availability of diagnostic and treatment services and the use of care.[15](http://jada.ada.org/content/140/11/1356.full#R15) Clinical care in the private or public sectors typically includes comprehensive diagnostic and treatment services; in contrast, SBSPs limit services to those necessary for successful sealant placement and retention.[15](http://jada.ada.org/content/140/11/1356.full#R15) Furthermore, children who receive sealants only in SBSPs are likely to be from low-income families. Recent data indicate that less than 50 percent of children aged 6 through 12 years from families with incomes of less than two times the federal poverty threshold had a dental visit in the previous year compared with about 70 percent of their higher-income counterparts.[61](http://jada.ada.org/content/140/11/1356.full#R61)

As resources allow, SBSPs work with partners, such as local dental practices, public health clinics, parents, school nurses and local dental associations, to help students without a source of dental care receive comprehensive dental services. For children with cavitated lesions who are unlikely to receive treatment services promptly, dental practitioners in SBSPs may choose to use interim treatment strategies. These could include application of sealants for small cavitations with no visually detectable signs of dentinal caries and atraumatic restorative procedures for larger carious lesions.[15](http://jada.ada.org/content/140/11/1356.full#R15),[62](http://jada.ada.org/content/140/11/1356.full#R62)–[64](http://jada.ada.org/content/140/11/1356.full#R64)

School-based sealant programs work with partners, such as local dental practices, to help students without a source of dental care receive comprehensive dental services.

The following information might be helpful for practitioners who see children who have received sealants through SBSPs. First, sealants do not eliminate dental caries but predictably reduce the occurrence of disease. Thus, practitioners might observe a child with a permanent molar sealed in a school program in which caries has developed. They should keep in mind that the failure to prevent caries in that one sealed tooth does not constitute failure of the entire school sealant program. Similarly, the failure of a sealant to prevent caries in a patient treated in a private dental practice does not constitute failure of the entire sealant protocol. Available evidence consistently indicates that the overall incidence of caries in permanent molars is lower among children who received sealants compared with the incidence in similar children who did not.[5](http://jada.ada.org/content/140/11/1356.full#R5),[26](http://jada.ada.org/content/140/11/1356.full#R26),[28](http://jada.ada.org/content/140/11/1356.full#R28),[29](http://jada.ada.org/content/140/11/1356.full#R29) Finally, sealant placement is a reversible procedure that easily allows the dentist to administer additional caries management and treatment strategies, such as placement of a restoration, if needed.

In preparing these recommendations, the work group and CDC staff members also reviewed assessment methods for tooth surfaces in SBSPs. Visual assessment for the detection of cavitation is supported by many international experts.[33](http://jada.ada.org/content/140/11/1356.full#R33),[65](http://jada.ada.org/content/140/11/1356.full#R65) Most SBSPs target children with newly erupted permanent molars. The low likelihood of caries in these newly erupted teeth, along with recommendations to seal both sound surfaces and those with noncavitated lesions, argue against the use of radiographs or technologically advanced tools to detect cavitated lesions in children in SBSPs.

Furthermore, when the likelihood of caries is low, such as in newly erupted molars, these modalities might increase the possibility that a sound surface will be misclassified as carious and be restored prematurely.[16](http://jada.ada.org/content/140/11/1356.full#R16),[32](http://jada.ada.org/content/140/11/1356.full#R32) Thus, these teeth might not receive the preventive benefit of a sealant. In addition, children in SBSPs who are in need of treatment services will be referred to private dental offices or public dental clinics where dentists will obtain radiographs as necessary—and in accordance with current ADA/U.S. Food and Drug Administration guidelines[66](http://jada.ada.org/content/140/11/1356.full#R66)—and conduct additional diagnostic procedures, as appropriate.

The essential steps in placement of unfilled resin-based sealants include cleaning pits and fissures, acid etching tooth surfaces and maintaining a dry field while the sealant is placed and cured.[16](http://jada.ada.org/content/140/11/1356.full#R16) Available evidence suggests that cleaning pits and fissures with a toothbrush by the patient under supervision or with a handpiece prophylaxis by the operator results in similar sealant retention rates.[19](http://jada.ada.org/content/140/11/1356.full#R19),[21](http://jada.ada.org/content/140/11/1356.full#R21),[47](http://jada.ada.org/content/140/11/1356.full#R47),[48](http://jada.ada.org/content/140/11/1356.full#R48)

Application of a hydrophilic bonding agent between the etched surface and the sealant is a supplemental technique that is not used routinely in SBSPs, and the work group did not evaluate the technique. The ADA’s expert panel reviewed the evidence, developed guidance for practitioners and described current types of bonding systems.[16](http://jada.ada.org/content/140/11/1356.full#R16) The ADA panel noted that use of currently available self-etching bonding agents that do not include a separate etching step might result in lower retention than that achieved with the standard acid-etching technique and is not recommended.[16](http://jada.ada.org/content/140/11/1356.full#R16) In addition, the bonding agent must be compatible with the sealant material.

The work group also reaffirmed the importance of evaluating sealants after placement, but it stressed that children for whom follow-up cannot be ensured should still receive sealants. A recent meta-analysis found that teeth with partially or completely lost sealants were at no greater risk of developing dental caries than were teeth that were never sealed.[20](http://jada.ada.org/content/140/11/1356.full#R20) Dental professionals can check sealant retention among a sample of participants in an SBSP shortly after placement to ensure the quality of the procedure and materials used.[6](http://jada.ada.org/content/140/11/1356.full#R6),[22](http://jada.ada.org/content/140/11/1356.full#R22) They also can check sealant retention and integrity during the following school year and seal any permanent molars that might have erupted since the procedure. The timing of the evaluation of sealant retention and integrity can depend on several factors, such as local program objectives; changes in dental materials, techniques or personnel; and student movement in and out of the school and school district.

**CONCLUSION**

The recommendations of the expert work group update earlier guidelines for SBSPs and support practices that are appropriate, feasible and based on the best available scientific evidence. These updated recommendations, along with the supporting rationale, should increase practitioners’ awareness of the SBSP as an important and effective public health approach that complements clinical care systems in promoting the oral health of children and adolescents.

**FOOTNOTES**

Dr. Gooch is a dental officer, Division of Oral Health/Surveillance, Investigations, and Research Branch, Centers for Disease Control and Prevention, 4770 Buford Highway, NE, MS-F10, Atlanta, Ga. 30341, e-mail "[oralhealth@cdc.gov](mailto:oralhealth@cdc.gov)". Address reprint requests to Dr. Gooch.

Dr. Griffin is a health economist, Division of Oral Health, Centers for Disease Control and Prevention, Atlanta.

Dr. Gray is an epidemiologist, Public Health Division, Northrop Grumman, Atlanta.

At the time this study was conducted, Dr. Kohn was the associate director for science, Division of Oral Health, Centers for Disease Control and Prevention, Atlanta. He now is the director, Division of Oral Health.

Dr. Rozier is a professor, Department of Health Policy and Management, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill.

Dr. Siegal is chief, Bureau of Oral Health Services, Ohio Department of Health, Columbus.

Dr. Fontana is an associate professor, Department of Cariology, Restorative Sciences and Endodontics, School of Dentistry, the University of Michigan, Ann Arbor.

Ms. Brunson is the director, Public Health and Community Outreach, University of Colorado Denver School of Dental Medicine, Aurora, Colo.

Ms. Carter is associate dental director, Division of Oral Health, Cincinnati Health Department, Cincinnati.

Dr. Curtis was a representative, American Academy of Pediatric Dentistry, Chicago.

Dr. Donly is a professor and chair, Pediatric Dentistry, Dental School, The University of Texas Health Science Center at San Antonio, and a representative, American Academy of Pediatric Dentistry, Chicago.

Dr. Haering was a member of the Council on Access, Prevention and Interprofessional Relations, American Dental Association, Chicago.

Dr. Hill is the executive director, CincySmiles Foundation, Cincinnati.

Dr. Hinson was a representative, American Academy of Pediatric Dentistry, Chicago.

Dr. Kumar is the director, Oral Health Surveillance and Research, Bureau of Dental Health, New York State Department of Health, Albany, N.Y.

Dr. Lampiris is the director, Council on Access, Prevention and Inter-professional Relations, American Dental Association, Chicago.

Dr. Mallatt was a representative, Association of State and Territorial Dental Directors, Sparks, Nev.

Dr. Meyer is the senior vice-president, Science/Professional Affairs, American Dental Association, Chicago.

Ms. Miller is a past executive director, National Association of School Nurses, Silver Spring, Md.

Ms. Sanzi-Schaedel was a representative, American Association of Public Health Dentistry, Springfield, Ill.

Dr. Simonsen is the dean, College of Dental Medicine, Midwestern University, Glendale, Ariz.

Dr. Truman is the associate director for science, Office of Minority Health and Health Disparities, Centers for Disease Control and Prevention, Atlanta.

Dr. Zero is a professor and the associate dean for research and the director, Oral Health Research Institute, School of Dentistry, Indiana University, Indianapolis.

The authors acknowledge the following people for their guidance and critical review of the information reported during the expert work group meetings and in earlier versions of the manuscript of this article: Dr. William Bailey, Ms. Laurie Barker, Dr. Eugenio Beltrán, Dr. Maria Canto, Ms. Kathleen Heiden, Dr. William Maas, Dr. Mark Macek, Dr. Dolores Malvitz, Ms. Linda Orgain, Dr. Scott Presson, Dr. John Rossetti, Dr. Robert Selwitz.

**Disclosure.** Dr. Donly receives research support (no consulting fees) from 3M ESPE, St. Paul, Minn., and Ivoclar Vivadent, Amherst, N.Y., manufacturers of sealants. None of the other authors reported any disclosures.

**REFERENCES**

1. Centers for Disease Control and Prevention. National Center for Chronic Disease Prevention and Health Promotion, Division of Adolescent and School Health. Healthy Youth! Coordinated School Health Program. Archived at: "[www.webcitation.org/5bDm6yMQT](http://www.webcitation.org/5bDm6yMQT)". Accessed Sept. 23, 2009.
2. U.S. Department of Health and Human Services. Oral health in America: a report of the surgeon general. Rockville, Md.: U.S. Department of Health and Human Services. National Institute of Dental and Craniofacial Research, National Institutes of Health, 2000.
3. Zimmerman B. Improving the oral health of school-aged children: strengthening school-based dental sealant program linkages with Medicaid/SCHIP and dental homes—summary of an expert meeting convened by the Maternal and Child Health Bureau. Washington: Health Systems Research; 2006. Archived at: "[www.webcitation.org/5bOm8amsY](http://www.webcitation.org/5bOm8amsY)". Accessed Sept. 23, 2009.
4. Centers for Disease Control and Prevention. Promoting oral health: interventions for preventing dental caries, oral and pharyngeal cancers, and sports-related craniofacial injuries—a report on recommendations of the Task Force on Community Preventive Services. MMWR Recomm Rep 2001;50(RR-21):1–13.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=11207009&link_type=MED)
5. Truman BI, Gooch BF, Sulemana I, et al; Task Force on Community Preventive Services. Reviews of evidence on interventions to prevent dental caries, oral and pharyngeal cancers, and sports-related craniofacial injuries. Am J Prev Med 2002;23(1 suppl):21–54.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=12091093&link_type=MED)
6. Association of State and Territorial Dental Directors. Best practice approaches for state and community oral health programs: school-based dental sealant programs. June 2003. Archived at: "[www.webcitation.org/5b4vXyabi](http://www.webcitation.org/5b4vXyabi)". Accessed Sept. 23, 2009.
7. U.S. Census Bureau, Housing and Household Economic Statistics Division. Poverty thresholds for 2008 by size of family and number of related children under 18 years. Washington: U.S. Census Bureau. "[www.census.gov/hhes/www/poverty/threshld/thresh08.html](http://www.census.gov/hhes/www/poverty/threshld/thresh08.html)". Accessed Sept. 23, 2009.
8. Dye BA, Tan S, Smith V, et al. Trends in oral health status: United States, 1988–1994 and 1999–2004. Vital Health Stat 11 2007;248:1–92.
9. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Surveys 1999–2004. "[www.cdc.gov/nchs/nhanes.htm](http://www.cdc.gov/nchs/nhanes.htm)". Accessed Sept. 23, 2009.
10. Macek MD, Beltrán-Aguilar ED, Lockwood SA, Malvitz DM. Updated comparison of the caries susceptibility of various morphological types of permanent teeth. J Public Health Dent 2003;63(3): 174–182.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=12962471&link_type=MED)
11. Centers for Disease Control and Prevention. Impact of targeted, school-based dental sealant programs in reducing racial and economic disparities in sealant prevalence among schoolchildren: Ohio, 1998–1999. MMWR Morb Mortal Wkly Rep 2001;50(34):736–738.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=11787581&link_type=MED)
12. Feigal RJ, Donly KJ. The use of pit and fissure sealants. Pediatr Dent 2006;28(2):143–150.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=16708789&link_type=MED)
13. Simonsen RJ. Pit and fissure sealant: review of the literature. Pediatr Dent 2002;24(5):393–414.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=12412954&link_type=MED)
14. Primosch RE, Barr ES. Sealant use and placement techniques among pediatric dentists. JADA 2001;132(10):1442–1451.[[Abstract/Free Full Text]](http://jada.ada.org/cgi/ijlink?linkType=ABST&journalCode=jada&resid=132/10/1442)
15. Workshop on guidelines for sealant use: recommendations. The Association of State and Territorial Dental Directors, the New York State Health Department, the Ohio Department of Health and the School of Public Health, University at Albany, State University of New York. J Public Health Dent 1995;55(5 spec no):263–273.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=8854267&link_type=MED)
16. Beauchamp J, Caufield PW, Crall JJ, et al; American Dental Association Council on Scientific Affairs. Evidence-based clinical recommendations for the use of pit-and-fissure sealants: a report of the American Dental Association Council on Scientific Affairs. JADA 2008; 139(3):257–268.[[Abstract/Free Full Text]](http://jada.ada.org/cgi/ijlink?linkType=ABST&journalCode=jada&resid=139/3/257)
17. Griffin SO, Oong E, Kohn W, Vidakovic B, Gooch BF; CDC Dental Sealant Systematic Review Work Group, Bader J, Clarkson J, Fontana MR, et al. The effectiveness of sealants in managing caries lesions. J Dent Res 2008;87(2):169–174.[[Abstract/Free Full Text]](http://jada.ada.org/cgi/ijlink?linkType=ABST&journalCode=spjdr&resid=87/2/169)
18. Oong EM, Griffin SO, Kohn WG, Gooch BF, Caufield PW. The effect of dental sealants on bacteria levels in caries lesions: a review of the evidence. JADA 2008;139(3):271–278.[[Abstract/Free Full Text]](http://jada.ada.org/cgi/ijlink?linkType=ABST&journalCode=jada&resid=139/3/271)
19. Griffin SO, Jones K, Gray SK, Malvitz DM, Gooch BF. Exploring four-handed delivery and retention of resin-based sealants. JADA 2008;139(3):281–289.[[Abstract/Free Full Text]](http://jada.ada.org/cgi/ijlink?linkType=ABST&journalCode=jada&resid=139/3/281)
20. Griffin SO, Gray SK, Malvitz DM, Gooch BF. Caries risk in formerly sealed teeth. JADA 2009;140(4):415–423.[[Abstract/Free Full Text]](http://jada.ada.org/cgi/ijlink?linkType=ABST&journalCode=jada&resid=140/4/415)
21. Gray SK, Griffin SO, Malvitz DM, Gooch BF. A comparison of the effects of toothbrushing and handpiece prophylaxis on retention of sealants. JADA 2009;140(1):38–46.[[Abstract/Free Full Text]](http://jada.ada.org/cgi/ijlink?linkType=ABST&journalCode=jada&resid=140/1/38)
22. Carter N, American Association for Community Dental Programs, National Maternal and Child Oral Health Resource Center. Seal America: the prevention invention. 2nd ed. Washington: National Maternal and Child Oral Health Resource; 2007. Archived at: "[www.webcitation.org/5Rnk5yjJ3](http://www.webcitation.org/5Rnk5yjJ3)". Accessed Sept. 23, 2009.
23. Shekelle PG, Woolf SH, Eccles M, Grimshaw J. Clinical guidelines: developing guidelines. BMJ 1999;318(7183):593–596.[[Free Full Text]](http://jada.ada.org/cgi/ijlink?linkType=FULL&journalCode=bmj&resid=318/7183/593)
24. Higgins JPT, Green S, eds. Systematic reviews and the Cochrane Handbook. In: Cochrane Handbook for Systematic Reviews of Interventions 4.2.6. Updated September 2006. Archived at: "[www.webcitation.org/5b30kQuG9](http://www.webcitation.org/5b30kQuG9)". Accessed Sept. 23, 2009.
25. Kunz R, Vist G, Oxman AD. Randomisation to protect against selection bias in healthcare trials. Cochrane Database Syst Rev 2007; (2):MR000012.
26. 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):261–268.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=8222598&link_type=MED)
27. American Dental Association, Center for Evidence-Based Dentistry. Evidence-based dentistry: glossary of terms. American Dental Association. "<http://ebd.ada.org/About.aspx>". Accessed Sept. 23, 2009.
28. Ahovuo-Saloranta A, Hiiri A, Nordblad A, Mäkelä M, Worthington HV. Pit and fissure sealants for preventing dental decay in the permanent teeth of children and adolescents. Cochrane Database Syst Rev 2008;(4)CD001830.
29. Mejàre I, Lingström P, Petersson LG, et al. Caries-preventive effect of fissure sealants: a systematic review. Acta Odontol Scand 2003;61(6):321–330.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=14960003&link_type=MED)
30. National Institutes of Health. Diagnosis and management of dental caries throughout life: NIH consensus statement. 2001;18(1):1–23.
31. Bader JD, Shugars DA, Bonito AJ. Systematic reviews of selected dental caries diagnostic and management methods. J Dent Educ 2001; 65(10):960–968.[[Abstract]](http://jada.ada.org/cgi/ijlink?linkType=ABST&journalCode=jde&resid=65/10/960)
32. Bader JD, Shugars DA, Bonito AJ. A systematic review of the performance of methods for identifying carious lesions. J Public Health Dent 2002;62(4):201–213.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=12474624&link_type=MED)
33. Ismail AI, Sohn W, Tellez M, et al. The International Caries Detection and Assessment System (ICDAS): an integrated system for measuring dental caries. Community Dent Oral Epidemiol 2007;35(3): 170–178.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=17518963&link_type=MED)
34. Pitts N. "ICDAS": an international system for caries detection and assessment being developed to facilitate caries epidemiology, research and appropriate clinical management. Community Dent Health 2004; 21(3):193–198.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=15470828&link_type=MED)
35. Ekstrand KR, Kuzmina I, Bjørndal L, Thylstrup A. Relationship between external and histologic features of progressive stages of caries in the occlusal fossa. Caries Res 1995;29(4):243–250.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=7656292&link_type=MED)
36. World Health Organization. Oral Health Surveys: Basic Methods. 4th ed. Geneva: World Health Organization; 1997:41–42.
37. World Health Organization. Oral Health Surveys: Basic Methods. 3rd ed. Geneva: World Health Organization; 1987:35–36.
38. Radike AW. Criteria for diagnosis of dental caries. In: Proceedings of the Conference on the Clinical Testing of Cariostatic Agents. Oct. 14–16, 1968; Chicago; American Dental Association; 87–88.
39. Ekstrand K, Qvist V, Thylstrup A. Light microscope study of the effect of probing in occlusal surfaces. Caries Res 1987;21(4):368–374.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=3475183&link_type=MED)
40. Kuhnisch J, Dietz W, Stosser L, Hickel R, Heinrich-Weltzien R. Effects of dental probing on occlusal surfaces: a scanning electron microscopy evaluation. Caries Res 2007;41(1):43–48.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=17167258&link_type=MED)
41. van Dorp CS, Exterkate RA, ten Cate JM. The effect of dental probing on subsequent enamel demineralization. ASDC J Dent Child 1988;55(5):343–347.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=3170872&link_type=MED)
42. Yassin OM. In vitro studies of the effect of a dental explorer on the formation of an artificial carious lesion. ASDC J Dent Child 1995; 62(2):111–117.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=7608368&link_type=MED)
43. Bader JD, Shugars DA. A systematic review of the performance of a laser fluorescence device for detecting caries. JADA 2004;135(10): 1413–1426.[[Abstract/Free Full Text]](http://jada.ada.org/cgi/ijlink?linkType=ABST&journalCode=jada&resid=135/10/1413)
44. Zandoná AF, Zero DT. Diagnostic tools for early caries detection. JADA 2006;137(12):1675–1684.[[Abstract/Free Full Text]](http://jada.ada.org/cgi/ijlink?linkType=ABST&journalCode=jada&resid=137/12/1675)
45. Forgie AH, Pine CM, Pitts NB. The use of magnification in a preventive approach to caries detection. Quintessence Int 2002;33(1): 13–16.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=11887530&link_type=MED)
46. Lussi A. Comparison of different methods for the diagnosis of fissure caries without cavitation. Caries Res 1993;27(5):409–416.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=8242679&link_type=MED)
47. Muller-Bolla M, Lupi-Pégurier L, Tardieu C, Velly AM, Antomarchi C. Retention of resin-based pit and fissure sealants: a systematic review. Community Dent Oral Epidemiol 2006;34(5):321–336.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=16948671&link_type=MED)
48. Gillcrist JA, Vaughan MP, Plumlee GN Jr, Wade G. Clinical sealant retention following two different tooth-cleaning techniques. J Public Health Dent 1998;58(3):254–256.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=10101704&link_type=MED)
49. Donnan MN, Ball IA. A double-blind clinical trial to determine the importance of pumice prophylaxis on fissure sealant retention. Br Dent J 1988;165(8):283–286.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=2973794&link_type=MED)
50. Shapira J, Eidelman E. Six-year clinical evaluation of fissure sealants placed after mechanical preparation: a matched pair study. Pediatr Dent 1986;8(3):204–205.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=3537978&link_type=MED)
51. Shapira J, Eidelman E. The influence of mechanical preparation of enamel prior to etching on the retention of sealants: three-year follow-up. J Pedod 1984;8(3):272–277.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=6374095&link_type=MED)
52. Shapira J, Eidelman E. The influence of mechanical preparation of enamel prior to etching on the retention of sealants. J Pedod 1982; 6(4):283–287.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=6752368&link_type=MED)
53. Lygidakis NA, Oulis KI, Christodoulidis A. Evaluation of fissure sealants retention following four different isolation and surface preparation techniques: four years clinical trial. J Clin Pediatr Dent 1994; 19(1):23–25.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=7865418&link_type=MED)
54. Houpt M, Shey Z. The effectiveness of a fissure sealant after six years. Pediatr Dent 1983;5:104–106.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=6223281&link_type=MED)
55. Erdogan B, Alaçam T. Evaluation of a chemically polymerized pit and fissure sealant: results after 4.5 years. J Paediatr Dent 1987;3:11–13.
56. Rock WP, Bradnock G. Effect of operator variability and patient age on the retention of fissure sealant resin: 3-year results. Community Dent Oral Epidemiol 1981;9(5):207–209.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=7044665&link_type=MED)
57. Schachter JP. Geographic Mobility: 2002 to 2003. Current Population Reports. Washington: U.S. Department of Commerce, Economics and Statistics Administration, U.S. Census Bureau. March 2004. Archived at: "[www.webcitation.org/5avllq6p6](http://www.webcitation.org/5avllq6p6)". Accessed Sept. 23, 2009.
58. U.S. General Accounting Office. Elementary School Children: Many Change Schools Frequently, Harming Their Education. Report to the Honorable Marcy Kaptur, House of Representatives. Gaithersburg, Md.: U.S. General Accounting Office; February 1994. Publication GAO/HEHS-94–45.
59. Griffin SO, Griffin PM, Gooch BF, Barker LK. Comparing the costs of three sealant delivery strategies. J Dent Res 2002;81(9):641–645.[[Abstract/Free Full Text]](http://jada.ada.org/cgi/ijlink?linkType=ABST&journalCode=spjdr&resid=81/9/641)
60. Quiñonez RB, Downs SM, Shugars D, Christensen J, Vann WF Jr. Assessing cost-effectiveness of sealant placement in children. J Public Health Dent 2005;65(2):82–89.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=15929545&link_type=MED)
61. U.S. Department of Health and Human Services, Agency for Healthcare Research and Quality. MEPS: Medical Expenditure Panel Survey 2004. MEPSnet/HC. Archived at: "[www.webcitation.org/5jSyLSKRy](http://www.webcitation.org/5jSyLSKRy)". Accessed Sept. 23, 2009.
62. Going RE, Conti AJ, Haugh LD, Grainger DA. Two-year clinical evaluation of a pit and fissure sealant, part II: caries initiation and progression. JADA 1976;92(3):578–585.[[Abstract]](http://jada.ada.org/cgi/ijlink?linkType=ABST&journalCode=jada&resid=92/3/578)
63. Mertz-Fairhurst EJ, Schuster GS, Fairhurst CW. Arresting caries by sealants: results of a clinical study. JADA 1986;112(2):194–197.[[Abstract]](http://jada.ada.org/cgi/ijlink?linkType=ABST&journalCode=jada&resid=112/2/194)
64. American Academy of Pediatric Dentistry, Council on Clinical Affairs. Policy on alternative restorative treatment (ART). Revised 2004. Archived at: "[www.webcitation.org/5Ziq15JiH](http://www.webcitation.org/5Ziq15JiH)". Accessed Sept. 23, 2009.
65. Ismail AI, Sohn W, Tellez M, Willem JM, Betz J, Lepkowski J. Risk indicators for dental caries using the International Caries Detection and Assessment System (ICDAS). Community Dent Oral Epidemiol 2008;36(1):55–68.[[Medline]](http://jada.ada.org/cgi/external_ref?access_num=18205641&link_type=MED)
66. American Dental Association, Council on Dental Benefit Programs, Council on Dental Practice, Council on Scientific Affairs; U.S. Food and Drug Administration, Public Health Service, Food and Drug Administration. The selection of patients for dental radiographic examinations. Revised 2004. Archived at: "[www.webcitation.org/5bRMUml68](http://www.webcitation.org/5bRMUml68)". Accessed Sept. 23, 2009.