Best Practices for Dental Sealants in Community Service-Learning

Jolanta Aleksejūnienė, D.D.S., M.Sc., Ph.D.; Mario A. Brondani, D.D.S., M.Sc., Ph.D.; Komkham Pattanaporn, D.D.S., M.P.H., Dr.P.H.; Vilma Brukiene, D.D.S., Ph.D.

Abstract: Community service-learning (CSL) in predoctoral dental education might be an effective tool for increasing sealant use by dentists—thus benefitting underserved children while facilitating students' learning of a clinical procedure in a real-life setting. This study reviewed the scientific literature on this topic in order to 1) evaluate the reasons for low sealant use among dentists, 2) consider important aspects of sealant use in community settings, and 3) identify best practices to use as guidelines for CSL regarding sealant use. As background, the MEDLINE database was searched with the key words "dental sealants" for human and laboratory studies in the English language. A total of 205 relevant articles were identified and overviewed. We found that the low use of sealants relate to dentists' orientation toward restorations rather than prevention, distrust in sealant treatment, lack of confidence in caries risk assessment, and concern about sealing over caries. The aspects to consider in the CSL projects are acquisition of knowledge and necessary skills of operators, cost-benefit approach to sealant placement, and meticulous sealant placement procedures, including the necessity for a short-term recall.

Dr. Aleksejūnienė is Assistant Professor, Department of Oral Health Sciences, Faculty of Dentistry, University of British Columbia; Dr. Brondani is Assistant Professor, Department of Oral Health Sciences, Faculty of Dentistry, University of British Columbia; Dr. Pattanaporn is Clinical Assistant Professor, Department of Oral Health Sciences, Faculty of Dentistry, University of British Columbia; and Dr. Brukiene is Assistant Professor, Institute of Odontology, Faculty of Medicine, Vilnius University, Vilnius, Lithuania. Direct correspondence and requests for reprints to Dr. Jolanta Aleksejūnienė, Faculty of Dentistry, University of British Columbia, 2199 Wesbrook Mall, Vancouver, British Columbia V6T11Z3, Canada; 604-822-7800 phone; 604-827-4448 fax; jolantaa@interchange.ubc.ca.

Occlusal caries constitutes more than two-thirds of the total caries in the permanent posterior teeth of Western children.[1] Systematic reviews have found strong evidence of sealant effectiveness on sound permanent posterior teeth in children and adolescents.[2] Although contemporary caries epidemiology supports sealant usage[3] as an effective method for prevention of occlusal caries,[4] sealant use by dentists has been limited.[4,5] There is also an inequality in sealant use as children most in need of sealants are at a disadvantage to receive them.[6] Obviously, a change in dental practice for preserving tooth structure should be initiated,[7] with more fissures sealed and fewer fissures restored than at current levels.[8]

Community service-learning (CSL) in predoctoral dental education might be an effective tool to initiate such change, as CSL teaches students to be socially responsible,[9] culturally competent, and aware of the determinants of health in underserved communities.[10,11] CSL fosters learning in unique ways because students not only learn clinical procedures in real-life settings, but they also experience the need for health care among those less fortunate than themselves.[12] Through CSL, patients receive benefits from the sealants (service component), and dental students receive appropriate education (learning component) that prepares them to provide sealants for their future patients.[13] Consequently, they will be more confident in sealant use as an effective caries prevention modality; and hopefully, as practitioners, they will be more willing than many current dentists to use this prevention modality with their patients. These future practitioners should also be able to be strong advocates for targeted school-based sealant programs in their communities and those nearby.

School-based programs generally target low-income children who are less likely than children from higher-income families to receive preventive services and to have a regular source of care.[14] Therefore, the CSL-based sealant projects should focus on underserved, high-risk children with lim-

ited access to dental care, as they are least likely to seek or obtain preventive as well as operative oral care.[7,15,16] Despite many high-risk children being eligible for dental insurance, many children are still unable to access or face great barriers in accessing dental care. Dental students should also serve as advocates for these children in accessing the dental care that is available for them. As part of the CSL and its preparation, students need to understand that our current systems do not ensure that children will receive timely restorations once they get cavities. It is important to consider that the ratio of restoration to sealant costs exceeds 12:1.[17] Therefore, a focus on sealants is justified by these children's lack of ongoing access to care and the higher likelihood that a cavity would not be restored promptly and the child would therefore be at risk of more morbidity as well as need for a larger filling or more extensive dental treatment. A clear distinction, however, has to be made regarding what is achievable in school-based programs vs. in a dental practice. Obviously, a better control of caries risk management, clinical procedures, choice of materials, patient recall, and compliance can be assured in a dental practice than in a school-based setting.

Therefore, our project aimed to support the efficient use of sealants by dental students in communities. To that end, it was important to identify important aspects and considerations for community-based dental education. Our specific aims were 1) to identify the reasons for low sealant use by dentists; 2) to consider possible modifiers of sealant success relevant to community projects; and 3) to suggest guidelines for sealant use in predoctoral dental community service-learning projects.

Materials and Methods

For this project, we conducted an overview of relevant research but not a systematic review since the focus was to identify all important aspects of sealant use or their limitations as it pertains to CSL provided by dental students. To make sure that none of the important aspects were missed, information acquisition from studies was not limited by stringent inclusion criteria or quality assessments.

The OVID MEDLINE bibliographic database was searched for English-language articles. As both population-based and laboratory studies were expected to provide useful information, the key words were not limited or too specific; rather, we used the generic term "dental sealants." The titles of 501 extracted articles were reviewed, and studies relevant to the present inquiry were identified. In this way, a total of 205 articles were reviewed that were of either direct or indirect relevance to our aims. The information from these studies formed the basis for the subsequent discussion.

Results and Discussion

The results and discussion are presented according to each of the aims of the study.

Aim 1: Reasons for Dentists' Low Sealant Use

Although sealants have been used to prevent occlusal caries for over thirty years,[18] the dental profession has not used them to their greatest advantage.[19] In general, the resistance of dentists to use sealants stemmed from several sources: dentists' orientation toward restorations rather than prevention,[20,21] distrust of the long-term benefits of sealant treatment,[22,23] perceived economic factors, lack of confidence in caries risk assessment, and concern about inadvertently sealing over caries.[7,22,24]

Concern about sealing over caries. Contemporary protocols for the treatment of dental caries support sealing over active noncavitated occlusal caries lesions.[21,25-27] However, dentists are still hesitant to seal where there is a suspicion of active caries,[19,20,28] despite the in vivo evidence that shows further progression of caries in the properly sealed carious lesions does not occur.[29-31] Viable organisms under proper sealants are reduced or eliminated,[32] and consequently both enamel and dentine caries are arrested.[30] A meta-analysis of six studies of sealant placement on teeth with noncavitated carious lesions found that sealants reduced by 71 percent the lesions that progressed.[21] Therefore, sealing caries should be considered as a better option than the alternatives such as dental neglect or extraction of teeth.[33] Evidence-based clinical recommendations for the use of pit-and-fissure sealants by a panel of the American Dental Association's Council on Scientific Affairs recommend placing them in children and adolescents on early (noncavitated) carious lesions.[34] Consequently, dental students should be informed about unnecessary concerns.

Long-term preventive effects of sealant treatment. It is difficult to predict accurately what

the long-term success of sealant treatment might be as a precise comparison among studies is impossible because various criteria and follow-up periods have been used to measure the success of sealants. Seemingly, the main attribute of success would be placement of sealants on a tooth at high risk. Maintenance over time is also important as even after ten or more years following sealant placement, high retention rates of sealants (80 percent to 90 percent) were achieved when recall was incorporated.[35-38] Moreover, even if fissure sealant programs serve only to delay rather than prevent the need for restorative care, there is still a substantial benefit to be gained,[39] since it has been shown that the half-life of restorations is considerably greater if the child is older than nine years when a restoration is placed.[40]

Caries risk assessments. The uneven distribution of dental caries among and within populations and the varying patterns of caries across tooth surfaces call for effective targeting of the available resources.[35] Thus, caries risk analysis of the patient, as well as the tooth, is essential in the planning process of sealant treatment.[22] Various aspects of risk assessment will be covered in subsequent sections.

Aim 2: Potential Modifiers of Sealant Success in Community Projects

A number of potential modifiers (risks) of the caries-preventive effect of fissure sealing have been suggested. In the context of CSL, patient-related risks, tooth-related risks, and operator- and procedure-related risks should be considered.

Patient-related factors. Similarly to other dental treatments, young and uncooperative patients might lead to a sealant failure.[25,41] Thus, proper patient management is a key for success in any treatment. Another important consideration is that the cost-effectiveness of any public health strategy for preventing caries can be improved by targeting high-risk children,[3,42] who otherwise receive limited care.[43] High-risk children usually have a low socioeconomic background, consume a cariogenic diet, and have plaque load, a low-fluoride intake, previous dental caries history, and infrequent dental visits.[3,44] The cost of providing sealants to every tooth in every child is beyond the means of most programs; therefore, cost-beneficial strategies for school-based programs should be considered.[45]

Pit-and-fissure sealants can be used effectively as part of a comprehensive approach to caries pre-

vention.[34] A study of high-risk Swedish adolescents demonstrated that less of a caries increment was found for those who had at least one sealant and for those who belonged to the fluoride varnish group.[46] A combined fluoride varnish application and sealant placement should be attempted in a CSL program because it may provide patients benefit and it gives students more clinical experience.

Tooth-related factors. Tooth location, eruption status, and fissure morphology have been related to sealant failures. That is, it has been demonstrated that sealants fail differently on different surfaces, or different sites, and sealant failure rates increase with multiple sealants.[47] Thus, the cost-effective use of sealants should involve selective sealant application on teeth and surfaces with the greatest caries risk.[22]

Regarding location, the caries preventive effect of sealants was demonstrated for permanent molars but not for premolars.[48] The higher success rate was demonstrated in first molars as compared to second permanent molars, while mandibular teeth and mesial sites retained sealants better than maxillary teeth or distal sites.[47,49] This might be due to direct vision, gravity flow of the resin, and generally well-defined pits and fissures in mandibular teeth.[49] The retention of sealants on occlusal surfaces was 2.8 times better than on buccal and palatal pits,[50] which have been identified as the two most frequent surfaces of sealant failures.[22] Clinicians tend to avoid sealing these surfaces due to the frustration of early sealant loss.[22] This clinical decision is not justified as a national survey found that buccal and palatal surfaces constitute a considerable part of the total caries, so caries in these surfaces should be prevented.[51]

Regarding eruption status, newly erupted immature tooth enamel is more permeable and more susceptible to caries attack because of its relatively high organic content.[41] This is especially true for erupting molars that are in the process of maturation.[19] Moreover, enamel is thinner in pits and fissures, which allows accelerated demineralization into the dentin. Eruption time for molars is longer than for premolars, and it takes 1.5 years for the first molars and up to 2.5 years for the second molars to fully erupt.[19] Not fully erupted teeth are at a particular risk for developing caries because the operculum covering the distal half of teeth during eruption allows for the retention of plaque and the initiation of the caries process before complete eruption.[52] Moreover, during the eruption time, the teeth are in infraocclusion to the occlusal plane of the existent deciduous teeth's occlusal plane, which prevents effective toothbrush-

ing.[19] Therefore, it is critical to protect newly erupted tooth surfaces to enhance overall tooth longevity. However, sealing not fully erupted teeth is difficult if the operculum of gingiva extends over the distal marginal ridge of the tooth, making isolation inefficient and potentially leading to a sealant failure.[53] However, the American Dental Association's Council on Scientific Affairs recommends universally applying sealants to children's and adolescents' permanent teeth when it is determined that the tooth, or the patient, is at risk of experiencing caries.[34]

Regarding fissure morphology, deep fissure morphology might be an obstacle for good adhesion, and it has been related to less sealant penetration[54] than a shallow fissure morphology.[55] Shallow fissures may be more likely to be thoroughly cleaned and etched than deep fissures.[56] To overcome the problems of deep constricted fissures, a mini-invasive technique for the placement of sealants has been employed.[57] However, in the context of contemporary knowledge, the rationale for the mini-invasive technique needs to be reevaluated for the following reasons. First, evidence is at least inconsistent: although a few studies have found that mechanical preparation of the fissures improved retention compared to sealants placed on non-prepared fissures,[58-61] other studies found only a slight improvement or no improvement in sealant retention.[57,61] Second, assurance that hidden occlusal caries is detected is unnecessary, as evidence shows arrested caries under properly placed sealants.[20,30,62-64] Moreover, changing technologies and an improved understanding of the caries process emphasize disease prevention and conservation of tooth structure over operative intervention.[34]

Operator- and sealant placement-related factors. For projects in which suboptimal conditions may occur, it is important to employ the most practical and pragmatic approach, concomitantly securing the quality of sealant treatment. The success of the sealant treatment will be determined by an operator's skill, preparation for the sealant placement, choice of materials, proper field isolation, and quality assurance in steps of the sealant placement.[65]

Sealants have been shown to be a cost-effective method that can be easily applied by skilled dentists and dental hygienists.[66] Reviewing the literature, it becomes clear that success is mainly determined by the skill of the operator.[67] For example, long-term sealant effectiveness has been found to be equal or even better when sealants were placed by trained dental assistants or auxiliaries.[65,68,69] The outcome of sealant use has also been found to be successful when dental students placed sealants.[70,71] Consequently, with proper education and acquisition of necessary skills, dental students should be successful in placing sealants.

The maintenance of sealants is important,[71,72] as they might fail even under the best circumstances.[22] Patient recall in CSL programs is important as students are just acquiring the necessary clinical skills, so sealants placed by students may be lost at a higher rate than the ones placed by experienced practitioners. Thus, the recall is a necessity when students are providing the service. At the same time, more experienced practitioners may consider recall after sealant placement unnecessary and not cost-beneficial.

A systematic review found that, with single (no recall) sealant applications, the relative risk reduction (RRR) varied from 4 percent to 54 percent, and for repeated applications (recall included) the RRR ranged from 69 percent to 93 percent.[72] Sealant retention decreases gradually, i.e., a 5 to 10 percent failure rate per year might be expected.[22,73] Thus, in order to ensure maximum caries prevention, sealants should undergo evaluation,[62] when loss of material, exposure of voids in the material, and potential for caries development are regularly assessed.[74] The length of the recall should be sufficient as a continued susceptibility of pit-and-fissure caries up to nine years after eruption,[75] and clinically significant changes in uncovered fissures have been demonstrated.[22] The need for reapplication of sealants is usually highest during the first year after the sealant placement.[74,76,77] Three-month, six-month, and annual recalls have been used,[35,78] but the specific length of the recall should be based on the individual risk.[78]

The difficult clinical decision to make is when sealants are only partially lost[79] as there is no consistent evidence about when to replace partially lost sealants. Some studies have suggested that any considerable "partial loss" of sealant leaves a tooth equally susceptible to caries as an unsealed control tooth,[70] while others report that partial retention has a lower caries rate than non-sealed teeth or missing sealant teeth.[7] Other studies have found that partial retention and missing sealants showed no difference with caries preventive effects.[80] Consequently, additional studies are needed to determine when to reseal partially lost sealants and what is the optimal time for the patient recall and to identify factors that will enable practitioners to target children with the highest degree of caries susceptibility for more frequent examination.[71] Until more evidence is acquired, all lost and partially lost sealants should be replaced.[81]

Patient management and proper field isolation are the two most important considerations for sealant success. One of the guidelines in sealant placement is to clean the surfaces with a prophy pumice prior to sealant placement.[61] Given that a pumice prophylaxis does not significantly increase sealant bond strength[82] and that this paste has been found in significant quantities in sealed fissure spaces,[83] which may reduce retention of sealants,[84] alternative cleaning methods should be considered. It has been demonstrated that cleaning the debris from the teeth by gently running a blunt explorer through the fissures and subsequently forcefully rinsing with water resulted in retention rates comparable to those achieved when teeth were cleaned by a prophy pumice.[85] Moreover, the retention of sealants after cleaning with a toothbrush was at least as high as the one associated with a handpiece prophylaxis.[84,86] It appears that different cleaning methods produce similar results and toothbrushing, which is already commonly used in school-based dental sealant programs,[87] requires the least equipment and time.[61] For CSL projects, simple toothbrushing should be prioritized over other cleaning methods. This practical and simplified approach is cost-beneficial and enables programs to serve more children.

Sealant application involves strict attention to detail and dry field isolation throughout the procedure.[65,88] Although practitioners admit that rubber dam isolation is best,[61] they do not use this type of isolation[77] (i.e., a survey of over 1,000 pediatric dentists found that they preferred cotton roll isolation over a rubber dam[24]). For CSL projects, obvious disadvantages of the rubber dam isolation are discomfort during a dam clamp placement, the need for a local anesthetic, difficulty in placing a clamp onto a partially erupted tooth, and an increase in the cost and need for sterilization of the armamentarium.[61] Moreover, clinical studies comparing isolation using either a rubber dam or a cotton roll found no differences in sealant retention and caries;[50,59,89] thus, proper isolation with cotton rolls should be adequate in sealant placement.[65] The choice of cotton roll over rubber dam isolation will also lead to better patient management and saves time.[61] To ensure the quality of the cotton roll isolation and of overall performance in sealant placement in community settings, four-handed dentistry is needed,[61,90] so students should work in pairs.

Various etching modalities have been evaluated for sealant use, in which both liquid and gel etchants showed sufficient penetration, resulting in similar bond strength and clinical retention.[61,91-93] For community projects, the gel etchant should be chosen as it allows easy control.[60] The fifteen- or twenty-second etching and twenty-to-thirty-second rinse of etchant[61] ensure sufficient bond strength[94] and resistance to microleakage.[95]

Various materials have been extensively used and evaluated as fissure sealants, but only principal differences between these materials will be discussed.

The rationale for using glass ionomer (GI) sealants was based on the fact that they are not as sensitive to moisture as resin-based (RB) sealants and that GI sealants release fluoride.[72] However, the retention rates of GI sealants are low.[65,96-99] Resin-based sealants are widely used because of their demonstrated track record and high retention rates.[25,65,100]

Clinical studies have found that the presence or absence of fillers has virtually no effect on the clinical outcomes of resin-based sealants.[39] At the same time, experimental studies have demonstrated that low viscosity (unfilled) sealants penetrated better, whereas high viscosity (filled) sealants did not penetrate enough to ensure a good marginal seal.[39,101] Another important consideration is that filled sealants necessitate occlusal adjustment.[102] The time necessary for the occlusal adjustment is clearly not desirable in community projects because a smaller number of children will receive sealants.[65] For that reason, unfilled sealants, which are already most commonly used in school programs,[65] will also be a good choice for community projects. A systematic review concluded that no studies documented a clinical benefit with fluoride releasing resin sealant; thus, the preference for the fluoride sealant is just a matter of choice.[103]

The advantages of colored sealants vs. clear sealants are that colored ones are visible, i.e., they are easier to assess during both the application and follow-up procedures.[65] Moreover, the identification error rate for the colored resin sealants has been found to be considerably less than for the clear resin sealants.[104] On the other hand, the argument against colored sealants has been that they preclude visual examination for caries of the sealed fissure.[65] This argument has been clearly disproven by evidence that well-sealed caries underneath properly placed sealants does not progress.[34]

Comparable bond strengths and retention rates between autopolymerizing (chemically cured) and light-cured sealants have been reported.[39,105-108] Self-etch adhesives raised a particular interest in research as they do not require rinsing or changing of cotton

rolls;[109] thus, if effective, these materials might be desirable for application under field conditions. However, a closer look at studies shows that at present the use of self-etch adhesives is not justified: the bonding of available self-etching adhesives to enamel is inferior to that achieved with total etch systems.[110,111] Moreover, in saliva-contaminated sites, self-etch adhesives or etching were equally unacceptable as the total failure rate was around 60 percent for both materials.[112] This means that, in saliva contamination, RB sealants with or without etching are ineffective,[113] so self-etch adhesives cannot be recommended either for clinical or community sealant projects.

Saliva contamination before sealant placement is the most commonly reported reason for sealant failure.[42] Saliva contamination is also hard to avoid in a young patient,[114] so the protective effect of bonding materials in saliva-contaminated surfaces was of particular research interest. Although one laboratory study found that sealant retention is possible on wet surfaces if a bonding agent is used between enamel and sealant,[88] clinical trials have found that using bonding agent does not increase retention rate.[115,116] Moreover, the use of bonding agents increases both the time and the cost of the sealant application; thus, this option should be carefully weighed before adopting it,[65] particularly for community projects in which both cost-benefit and time are important considerations.

Overall, the evidence supports sealant use in community projects given that the operator has the necessary skills and knowledge, teeth and surfaces at risk either sound and/or with noncavitated caries are sealed, the steps of sealant placement procedure are meticulously followed, and at least one recall is in place.

Aim 3: Guidelines for Sealant Use in Community-Based Dental Education

The following guidelines are suggested in applying practical and pragmatic principles, thus securing quality assurance in both treatment and follow-up procedures.

Prior to the implementation of a community sealant program
- In order to acquire the necessary knowledge and understanding, students should receive a thorough didactic preparation with the following themes: infection control, management of a child patient, caries risk assessment and management, factors related to sealant success and failure, and sealants maintenance.
- In order to acquire good operational skills for the CSL program, students should practice both field isolation and a meticulous sealant application technique under the supervision of experienced operators (e.g., dental hygienists and trained auxiliaries). Students are allowed to place sealants in the community sites only after the necessary skills have been acquired.

Preparation for the sealant implementation
- In order to increase the cost-effectiveness of sealant use and benefit underserved populations, children from low socioeconomic areas should be chosen, and all pits and fissures of their permanent molars should be sealed.[2]
- The best age for sealant placement should be between seven and ten years. Prior to sealant placement, children should be prescreened for their caries risk and behavior management. Only cooperative children, whose eruption status of permanent molars allows for proper field isolation with cotton rolls, should be selected for a CSL sealant program.
- Given difficulties inherent in patient management under suboptimal conditions and a lack of experience in behavior management, uncooperative children should be referred to a dental practitioner who has the necessary patient management skills.

Sealant placement procedures
- A portable operatory and the necessary infection control environment are created in the school setting.
- Prior to the sealant placement, children receive a supervised toothbrushing, and the sealant placement procedure is explained to the child following the tell-show-do strategy.
- During the sealant placement, students work in pairs. One student takes care of the field isolation with cotton rolls supplemented by portable water and a suction system, and the other student performs the steps of the sealant placement procedure.
- A fifteen-second etching with a colored 35 percent phosphoric acid gel should be applied onto all susceptible pits and fissures of the tooth and extended up to the cuspal inclines well beyond the anticipated margin of the sealant. A fifteen-second rinsing after the etching should be employed, and the quality of etching should always be assessed during the tooth drying. If the field is contaminated after the etching, the etching should be reapplied, followed by rinsing and drying.

- Light-cured unfilled opaque sealants should be prioritized over auto-cured filled sealants, and sealants should cover fissures sufficiently, but not excessively, in order to avoid occlusal discrepancies and patient discomfort. Given only unfilled sealants are used, occlusal adjustments are not necessary.
- To optimize caries prevention, a flouride varnish may be applied after sealant placement.[117]

Recall procedure
- In CSL sealant programs, sealant retention should be evaluated after one year.
- To maximize the learning experience, the recall is performed by the same students who placed the sealants a year ago. All missing or partially missing sealants should be replaced at a recall appointment.
- If a child will be further followed in the dental practice, the recall frequency should be individualized and based upon the child's caries risk situation.

Acknowledgments

REFERENCES

1. Task Force on Community Preventive Services. Promoting oral health: interventions for preventing dental caries, oral and pharyngeal cancers, and sport-related craniofacial injuries. MMWR 2001;50(RR21):1–13.
2. Gooch B, Griffin SO, Gray S. Preventing dental caries through school-based sealant programs: updated recommendations and reviews of evidence. J Am Dent Assoc 2009;140(11):1356–65.
3. Adair SM. The role of sealants in caries prevention programs. J Calif Dent Assoc 2003;31(3):221–7.
4. Zadik Y, Bechor R. Hidden occlusal caries: challenge for the dentist. N Y State Dent J 2008;74(4):46–50.
5. Cohen LD. Pit and fissure sealants: an underutilized preventive technology. Int J Technol Assess Health Care 1990;6(3):378–91.
6. Dye BA, Tan S, Smith V, Levis BG, Barker LK, Thorton-Evans G, et al. Trends in oral health status: United States 1988–1944 and 1999–2004. National Centre for Health Statistics. Vital Health Stat 2007;11:248.
7. Ismail AI, Gagnon P. A longitudinal evaluation of fissure sealants applied in dental practices. J Dent Res 1995;74(9):1583–90.
8. Ismail AI. Clinical diagnosis of precavitated carious lesions. Community Dent Oral Epidemiol 1997;25(1):13–23.
9. Olney CA, Livingston JE, Fisch S, Talamantes MA. Becoming better health care providers: outcomes of a primary care service-learning project in medical school. J Prev Interv Community 2006;32(1–2):133–47.
10. Brondani MA, Clark C, Rossoff L, Aleksejūnienė J. An evolving community-based dental course on professionalism and community service. J Dent Educ 2008;72(10):1160–8.
11. Rubin RW, Rustveld LO, Weyant RJ, Close JM. Exploring dental students' perceptions of cultural competence and social responsibility. J Dent Educ 2008;72(10):1114–21.
12. Lalumandier JA, Victoroff KZ, Thuernagle O. Early clinical experience for first-year dental students. J Dent Educ 2004;68(10):1090–5.
13. Griffen AL, Vig PS. What is the scientific basis for oral health care? Pediatr Dent 1997;19(2):131–3.
14. Oral health in America: a report of the surgeon general. Rockville, MD: National Institute of Dental and Craniofacial Research, National Institutes of Health, U.S. Department of Health and Human Services, 2000:166–8.
15. Dasanayake AP, Li Y, Philip S, Kirk K, Bronstein J, Childers NK. Utilization of dental sealants by Alabama Medicaid children: barriers in meeting the year 2010 objectives. Pediatr Dent 2001;23(5):401–6.
16. Dasanayake AP, Li Y, Kirk K, Bronstein J, Childers NK. Restorative cost savings related to dental sealants in Alabama Medicaid children. Pediatr Dent 2003;25(6):572–6.
17. Griffin SO, Griffin PM, Gooch BF, Barker LK. Comparing the costs of three sealant delivery strategies. J Dent Res 2002;81(9):641–5.
18. Gooch BF, Truman BI, Griffin SO, Kohn WG, Sulemana I, Gift HC, et al. A comparison of selected evidence reviews and recommendations on interventions to prevent dental caries, oral and pharyngeal cancers, and sports-related craniofacial injuries. Am J Prev Med 2002;23 (1 Suppl):55–80.
19. Antonson SA, Wanuck J, Antonson DE. Surface protection for newly erupting first molars. Compend Contin Educ Dent 2006;27(1):46–52.
20. Mertz-Fairhurst EJ, Adair SM, Sams DR, Curtis JW, Ergle JW, Hawkins KI, et al. Cariostatic and ultraconservative sealed restorations: nine-year results among children and adults. ASDC J Dent Child 1995;62(12):97–107.
21. Griffin SO, Oong E, Kohn W, Vidakovic B, Gooch BF, Bader J, et al. The effectiveness of sealants in managing caries lesions. J Dent Res 2008;87(2):169–74.
22. Feigal RJ. Sealants and preventive restorations: review of effectiveness and clinical changes for improvement. Pediatr Dent 1998;20(2):85–92.
23. Liebenberg WH. The fissure sealant impasse. Quintessence Int 1994;25(11):741–5.
24. Primosch RE, Barr ES. Sealant use and placement techniques among pediatric dentists. J Am Dent Assoc 2001;132(10):1442–51.
25. Feigal RJ. The use of pit and fissure sealants. Pediatr Dent 2002;24(5):415–22.
26. Hevinga MA, Opdam NJ, Frencken JE, Bronkhorst EM, Truin GJ. Can caries fissures be sealed as adequately as sound fissures? J Dent Res 2008;87(5):495–8.
27. Welbury R, Raadal M, Lygidakis NA. EAPD guidelines for the use of pit and fissure sealants. Eur J Paediatr Dent 2004;5(3):179–84.
28. Paterson RC, Blinkhorn AS, Paterson FM. Reported use of sealant restorations in a group of general practitioners in the west of Scotland. Br Dent J 1990;169(1):18–22.

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. Mertz-Fairhurst EJ, Schuster GS, Fairhurst CW. Arresting caries by sealants: results of a clinical study. J Am Dent Assoc 1986;112(2):194–7.

31. Mertz-Fairhurst EJ, Curtis JW Jr, Ergle JW, Ruegge-berg FA, Adair SM. Ultraconservative and cariostatic sealed restorations: results at year 10. J Am Dent Assoc 1998;129(1):55–66.

32. Oong EM, Griffin SO, Kohn W, Gooch BF, Caufield P. The effect of dental sealants on bacteria levels in caries lesions: a review of the evidence. J Am Dent Assoc 2008;139(3):271–8.

33. Ismail AI. Reactor paper: minimal intervention techniques for dental caries. J Public Health Dent 1996;56(3):155–60.

34. Beauchamp J, Caufield P, Crall J, Donly K, Feigal R, Gooch B, et al. Evidence-based clinical recommendations for the use of pit-and-fissure sealants. J Am Dent Assoc 2008;139(3):257–7.

35. Hovuo-Saloranta A, Hiiri 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.

36. Jodkowska E. Efficacy of pit and fissure sealing: long-term clinical observations. Quintessence Int 2008;39(7):593–602.

37. 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.

38. Simonsen RJ. Retention and effectiveness of dental sealant after 15 years. J Am Dent Assoc 1991;122(10):34–42.

39. Barrie AM, Stephen KW, Kay EJ. Fissure sealant retention: a comparison of three sealant types under field conditions. Community Dent Health 1990;7(3):273–7.

40. Walls AW, Wallwork MA, Holland IS, Murray JJ. The longevity of occlusal amalgam restorations in first permanent molars of child patients. Br Dent J 1985;158(4):133–6.

41. Roberson T, Heymann H, Swift EJ. Sturdevant's art and science of operative dentistry. 4th ed. St. Louis, MO: Mosby, 2002.

42. Azarpazhooh A, Main PA. Pit and fissure sealants in the prevention of dental caries in children and adolescents: a systematic review. J Can Dent Assoc 2008;74(2):171–7.

43. Graves RC, Bohannan HM, Disney JA, Stamm JW, Bader JD, Abernathy JR. Recent dental caries and treatment patterns in U.S. children. J Public Health Dent 1986;46(1):23–9.

44. Dorantes C, Childers NK, Makhija SK, Elliott R, Chafin T, Dasanayake AP. Assessment of retention rates and clinical benefits of a community sealant program. Pediatr Dent 2005;27(3):212–6.

45. Kumar JV, Wadhawan S. Targeting dental sealants in school-based programs: evaluation of an approach. Community Dent Oral Epidemiol 2002;30(3):210–5.

46. Kallestal C. The effect of five years' implementation of caries-preventive methods in Swedish high-risk adolescents. Caries Res 2005;39(1):20–6.

47. Morgan MV, Adams GG, Campain AC, Wright FA. Assessing sealant retention using a Poisson frailty model. Community Dent Health 2005;22(4):237–45.

48. Heyduck C, Meller C, Schwahn C, Splieth CH. Effectiveness of sealants in adolescents with high and low caries experience. Caries Res 2006;40(5):375–81.

49. Deery C, Fyffe HE, Nugent ZJ, Nuttall NM, Pitts NB. A proposed method for assessing the quality of sealants: the CCC Sealant Evaluation System. Community Dent Oral Epidemiol 2001;29(2):83–91.

50. Francis R, Mascarenhas AK, Soparkar P, Al-Mutawaa S. Retention and effectiveness of fissure sealants in Kuwaiti school children. Community Dent Health 2008;25(4):211–5.

51. Brown LJ, Selwitz RH. The impact of recent changes in the epidemiology of dental caries on guidelines for the use of dental sealants. J Public Health Dent 1995;55(5):274–91.

52. Carvalho JC, Ekstrand KR, Thylstrup A. Dental plaque and caries on occlusal surfaces of first permanent molars in relation to stage of eruption. J Dent Res 1989;68(5):773–9.

53. Dennison JB, Straffon LH, More FG. Evaluating tooth eruption on sealant efficacy. J Am Dent Assoc 1990;121(5):610–4.

54. Duangthip D, Lussi A. Effects of fissure cleaning methods, drying agents, and fissure morphology on microleakage and penetration ability of sealants in vitro. Pediatr Dent 2003;25(6):527–33.

55. Symons AL, Chu CY, Meyers IA. The effect of fissure morphology and pretreatment of the enamel surface on penetration and adhesion of fissure sealants. J Oral Rehabil 1996;23(12):791–8.

56. Grewal N, Chopra R. The effect of fissure morphology and eruption time on penetration and adaptation of pit and fissure sealants: an SEM study. J Indian Soc Pedod Prev Dent 2008;26(2):59–63.

57. De Craene GP, Martens C, Dermaut R. The invasive pit-and-fissure sealing technique in pediatric dentistry: an SEM study of a preventive restoration. ASDC J Dent Child 1988;55(1):34–42.

58. Le BY, Forsten L. Sealing of preventively enlarged fissures. Acta Odontol Scand 1980;38(2):101–4.

59. 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):23–5.

60. 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.

61. Waggoner WF, Siegal M. Pit and fissure sealant application: updating the technique. J Am Dent Assoc 1996;127(3):351–61.

62. Going RE, Loesche WJ, Grainger DA, Syed SA. The viability of microorganisms in carious lesions five years after covering with a fissure sealant. J Am Dent Assoc 1978;97(3):455–62.

63. Kramer PF, Zelante F, Simionato MR. The immediate and long-term effects of invasive and noninvasive pit and fissure sealing techniques on the microflora in occlusal fissures of human teeth. Pediatr Dent 1993;15(2):108–12.

64. Leverett DH, Handelman SL, Brenner CM, Iker HP. Use of sealants in the prevention and early treatment of carious lesions: cost analysis. J Am Dent Assoc 1983;106(1):39–42.

65. Simonsen RJ. Pit and fissure sealant: review of the literature. Pediatr Dent 2002;24(5):393–414.

66. Kervanto-Seppala S, Lavonius E, Pietila I, Pitkaniemi J, Meurman JH, Kerosuo E. Comparing the caries-preventive effect of two fissure sealing modalities in public health care: a single application of glass ionomer and a routine resin-based sealant programme—a randomized split-mouth clinical trial. Int J Paediatr Dent 2008;18(1):56–61.

67. Kim J, Shin CH, Park K. Long-term evaluation of sealants applied with an invasive technique. Int Dent J 2008;58(6):323–8.

68. Holst A, Braune K, Sullivan A. A five-year evaluation of fissure sealants applied by dental assistants. Swed Dent J 1998;22(5–6):195–201.

69. Ismail AI, King W, Clark DC. An evaluation of the Saskatchewan pit and fissure sealant program: a longitudinal follow-up. J Public Health Dent 1989;49(4):206–11.

70. Mertz-Fairhurst EJ, Fairhurst CW, Williams JE, la-Giustina VE, Brooks JD. A comparative clinical study of two pit and fissure sealants: 7-year results in Augusta, GA. J Am Dent Assoc 1984;109(2):252–5.

71. Gale TJ, Hanes CM, Myers DR, Russell CM. Performance of sealants applied to first permanent molars in a dental school setting. Pediatr Dent 1998;20(5):341–4.

72. Mejare I, Lingstrom P, Petersson LG, Holm AK, Twetman S, Kallestal C, et al. Caries-preventive effect of fissure sealants: a systematic review. Acta Odontol Scand 2003;61(6):321–30.

73. National Institutes of Health. Consensus development conference statement on dental sealants in the prevention of tooth decay. J Am Dent Assoc 1984;108(2):233–6.

74. Dennison JB, Straffon LH, Smith RC. Effectiveness of sealant treatment over five years in an insured population. J Am Dent Assoc 2000;131(5):597–605.

75. Chestnutt IG, Schafer F, Jacobson AP, Stephen KW. Incremental susceptibility of individual tooth surfaces to dental caries in Scottish adolescents. Community Dent Oral Epidemiol 1996;24(1):11–6.

76. Tianviwat S, Chongsuvivatwong V, Sirisakulveroj B. Loss of sealant retention and subsequent caries development. Community Dent Health 2008;25(4):216–20.

77. Gray GB, Paterson RC. Management of fissure caries in the community dental services using sealant restorations: a field trial. Eur J Prosthodont Restor Dent 1998;6(1):33–40.

78. Wang NJ, Holst D. Individualizing recall intervals in child dental care. Community Dent Oral Epidemiol 1995;23(1):1–7.

79. Gray GB. An evaluation of sealant restorations after 2 years. Br Dent J 1999;186(11):569–75.

80. Chestnutt IG, Schafer F, Jacobson AP, Stephen KW. The prevalence and effectiveness of fissure sealants in Scottish adolescents. Br Dent J 1994;177(4):125–9.

81. Deery C, Fyffe HE, Nugent Z, Nuttall NM, Pitts NB. Integrity, maintenance, and caries susceptibility of sealed surfaces in adolescents receiving regular care from general dental practitioners in Scotland. Int J Paediatr Dent 1997;7(2):75–80.

82. Main C, Thomson JL, Cummings A, Field D, Stephen KW, Gillespie FC. Surface treatment studies aimed at streamlining fissure sealant application. J Oral Rehabil 1983;10(4):307–17.

83. Burrow JF, Burrow MF, Makinson OF. Pits and fissures: relative space contribution in fissures from sealants, prophylaxis pastes, and organic remnants. Aust Dent J 2003;48(3):175–9.

84. Kolavic GS, Griffin SO, Malvitz DM, Gooch BF. A comparison of the effects of toothbrushing and handpiece prophylaxis on retention of sealants. J Am Dent Assoc 2009;140(1):38–46.

85. Donnan MF, Ball IA. A double-blind clinical trial to determine the importance of pumice prophylaxis on fissure sealant retention. Br Dent J 1988;165(8):283–6.

86. 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):254–6.

87. Siegal MD, Lalumandier JA, Farquhar CL, Bouchard JM. School-based and school-linked public health dental sealant programs in the United States, 1992-93. Columbus, OH: Association of State and Territorial Dental Directors, 1997.

88. Feigal RJ, Hitt J, Splieth C. Retaining sealant on salivary contaminated enamel. J Am Dent Assoc 1993;124(3):88–97.

89. Straffon LH, Dennison JB, More FG. Three-year evaluation of sealant: effect of isolation on efficacy. J Am Dent Assoc 1985;110(5):714–7.

90. Griffin SO, Jones K, Gray SK, Malvitz DM, Gooch BF. Exploring four-handed delivery and retention of resin-based sealants. J Am Dent Assoc 2008;139(3):281–9.

91. Guba CJ, Cochran MA, Swartz ML. The effects of varied etching time and etching solution viscosity on bond strength and enamel morphology. Oper Dent 1994;19(4):146–53.

92. Hardison JR. The use of pit-and-fissure sealants in community public health programs in Tennessee. J Public Health Dent 1983;43(3):233–9.

93. Rock WP, Weatherill S, Anderson RJ. Retention of three fissure sealant resins: the effects of etching agent and curing method—results over 3 years. Br Dent J 1990;168(8):323–5.

94. Summitt JB, Chan DC, Burgess JO, Dutton FB. Effect of air/water rinse versus water only and of five rinse times on resin-to-etched-enamel shear bond strength. Oper Dent 1992;17(4):142–51.

95. Summitt JB, Chan DC, Dutton FB, Burgess JO. Effect of rinse time on microleakage between composite and etched enamel. Oper Dent 1993;18(1):37–40.

96. Pereira AC, Pardi V, Mialhe FL, Meneghim MC, Ambrosano GM. A 3-year clinical evaluation of glass-ionomer cements used as fissure sealants. Am J Dent 2003;16(1):23–7.

97. Chadwick BL, Treasure ET, Playle RA. A randomised controlled trial to determine the effectiveness of glass ionomer sealants in pre-school children. Caries Res 2005;39(1):34–40.

98. Mejare I, Mjor IA. Glass ionomer and resin-based fissure sealants: a clinical study. Scand J Dent Res 1990;98(4):345–50.

99. Aranda M, Garcia-Godoy F. Clinical evaluation of the retention and wear of a light-cured pit and fissure glass ionomer sealant. J Clin Pediatr Dent 1995;19(4):273–7.

100. Beiruti N, Frencken JE, van't HMA, van Palenstein Helderman WH. Caries-preventive effect of resin-based and glass ionomer sealants over time: a systematic review. Community Dent Oral Epidemiol 2006;34(6):403–9.

101. Irinoda Y, Matsumura Y, Kito H, Nakano T, Toyama T, Nakagaki H, et al. Effect of sealant viscosity on the penetration of resin into etched human enamel. Oper Dent 2000;25(4):274–82.

102. Tilliss TS, Stach DJ, Hatch RA, Cross-Poline GN. Occlusal discrepancies after sealant therapy. J Prosthet Dent 1992;68(2):223–8.

103. Walker J, Floyd K, Jakobsen J. The effectiveness of sealants in pediatric patients. ASDC J Dent Child 1996;63(4):268–70.

104. Rock WP, Potts AJ, Marchment MD, Clayton-Smith AJ, Galuszka MA. The visibility of clear and opaque fissure sealants. Br Dent J 1989;167(11):395–6.

105. Houpt M, Fuks A, Shapira J, Chosack A, Eidelman E. Autopolymerized versus light-polymerized fissure sealant. J Am Dent Assoc 1987;115(1):55–6.

106. Shapira J, Fuks A, Chosack A, Houpt M, Eidelman E. Comparative clinical study of autopolymerized and light-polymerized fissure sealants: five-year results. Pediatr Dent 1990;12(3):168–9.

107. Sveen OB, Jensen OE. Two-year clinical evaluation of Delton and Prisma-Shield. Clin Prev Dent 1986;8(5):9–11.

108. Wright GZ, Friedman CS, Plotzke O, Feasby WH. A comparison between autopolymerizing and visible-light-activated sealants. Clin Prev Dent 1988;10(1):14–7.

109. Fuks AB, Kupietzky A. Assessment of two curing systems in a self-etching primer/adhesive sealant: a preliminary study for a clinical trial. Eur Arch Paediatr Dent 2007;8(3):171–4.

110. Hara AT, Amaral CM, Pimenta LA, Sinhoreti MA. Shear bond strength of hydrophilic adhesive systems to enamel. Am J Dent 1999;12(4):181–4.

111. Kanemura N, Sano H, Tagami J. Tensile bond strength to and SEM evaluation of ground and intact enamel surfaces. J Dent 1999;27(7):523–30.

112. Seemann R, Kluck I, Bizhang M, Roulet JF. Secondary caries-like lesions at fissure sealings with Xeno III and Delton: an in vitro study. J Dent 2005;33(5):443–9.

113. Silverstone LM, Hicks MJ, Featherstone MJ. Oral fluid contamination of etched enamel surfaces: an SEM study. J Am Dent Assoc 1985;110(3):329–32.

114. Feigal RJ, Musherure P, Gillespie B, Levy-Polack M, Quelhas I, Hebling J. Improved sealant retention with bonding agents: a clinical study of two-bottle and single-bottle systems. J Dent Res 2000;79(11):1850–6.

115. Boksman L, McConnell RJ, Carson B, Cutcheon-Jones EF. A 2-year clinical evaluation of two pit and fissure sealants placed with and without the use of a bonding agent. Quintessence Int 1993;24(2):131–3.

116. Pinar A, Sepet E, Aren G, Bolukbasi N, Ulukapi H, Turan N. Clinical performance of sealants with and without a bonding agent. Quintessence Int 2005;36(5):355–60.

117. Splieth C, Forster M, Meyer G. Additional caries protection by sealing first molars compared to fluoride varnish applications in children with low caries prevalence: 2-year results. Eur J Paediatr Dent 2001;2(3):133–8.