

Pit and fissure sealant: review of the literature

Richard J. Simonsen, DDS, MS

Dr. Simonsen is associate dean, Arizona School of Dentistry and Oral Health, Mesa, Ariz.

Correspond with Dr. Simonsen at rsimonsen@ashs.edu

Abstract

For this literature review of pit and fissure sealant, 1,465 references were selected by a search for “sealants” on PubMed. References were limited to dental journals and papers in the English language. The search comprised papers from 1971 to October 2001. Additional papers of historical significance prior to 1971 were added from memory and from reference lists published in early papers. This paper reviewed the literature on pit and fissure sealants under the following subheadings: (1) laboratory studies, (2) clinical technique and tooth preparation, (3) etching time, (4) auxiliary application of pit and fissure sealant, (5) retention and caries prevention, (6) fluoride used with sealants and fluoride-containing sealant, (7) glass ionomer materials as sealants, (8) options in sealant: filled vs unfilled; colored vs clear; autocure vs light-initiated, (9) sealant placed over caries in a therapeutic manner, (10) cost effectiveness of sealant application, (11) underuse of pit and fissure sealant, (12) the estrogenicity issue, (13) use of an intermediate bonding layer to improve retention, (14) new developments and projections, and (15) summary and conclusions.

From a careful and thorough review of peer-reviewed publications on pit and fissure sealant, it is clear that sealants are safe, effective and underused (at least underused in the United States). Pit and fissure sealant is best applied to high-risk populations by trained auxiliaries using sealant that incorporates the benefit of an intermediate bonding layer, applied under the rubber dam or with some alternative short-term, but effective, isolation technique, onto an enamel surface that has been cleaned with an air polishing technique and etched with 35% phosphoric acid for 15 seconds. The dental profession awaits with enthusiasm, and some impatience, the incorporation of dentin-bonding technology into the development of a modern, more durable, resin-based sealant. (*Pediatr Dent.* 2002;24:393-414)

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The term pit and fissure sealant is used to describe a material that is introduced into the occlusal pits and fissures of caries-susceptible teeth, thus forming a micromechanically-bonded, protective layer cutting access of caries-producing bacteria from their source of nutrients.¹

Buonocore's classic study of 1955 marked the start of a major revolution in the clinical practice of dentistry.² The first clinical benefit from Buonocore's work was the introduction of the first dental pit and fissure sealant, Nuva-Seal (L.D. Caulk) in February 1971, along with its curing initiator, and ultraviolet light source, the Caulk Nuva Lite. However, it took several more years before the sealant technique, and other clinical innovations that have resulted from Buonocore's work, began to be adopted in clinical dentistry to any significant degree. Still now, more than 30 years

after the introduction of pit and fissure sealant to the dental market place, the profession has not embraced the procedure to the extent that available scientific data would expect.

For this literature review of pit and fissure sealant, 1,465 references were selected by a search for “sealants” on PubMed. References were limited to dental journals and papers in the English language. This is not to say that there may not be significant contributions on the subject in other languages, quite the contrary. It is merely an admission of the limitations of this paper. The search comprised papers from 1971 to October 2001. Additional papers of historical significance published prior to 1971 were added from memory and from reference lists published in some early papers.

While authors had previously attempted to find conservative ways of treating occlusal pits and fissures (such as Wilson who used zinc phosphate cement³ Bödecker who proposed enamel fissure eradication⁴ and Kline and Knutson who used ammoniacal silver nitrate to treat pits and fissures⁵), none achieved any great measure of success. An invasive operative procedure, the prophylactic odontotomy introduced in the 1920s,⁶ remained the treatment of choice for many clinicians well into the 1970s. But with Buonocore's visionary procedure came the ability, as he predicted in 1955, to successfully prevent caries by sealing pits and fissures with a bonded resin material. While the title of "father of bonding" has been claimed by some latter-day "Johnny-come-latelys," it clearly belongs to Michael Buonocore.

The focus of Buonocore's early work was the development of a sealant to prevent occlusal caries on posterior teeth.⁷ The first paper published on the subject of pit and fissure sealant was by Cueto and Buonocore in 1965.⁸ Gwinnett and Buonocore followed with a paper also in 1965⁹ and Cueto and Buonocore followed with an additional report in 1967.¹⁰ In their first study, Cueto and Buonocore used 50% phosphoric acid buffered with 7% zinc oxide as the etchant as well as a mixture of methylmethacrylate monomer with the powder from the much-used silicate cements as the sealant. After 1 year, the authors reported 87% caries reduction and 71% complete retention of the sealant material.¹⁰ Buonocore chose the acid from his knowledge of the industrial use of phosphoric acid in the etching of metal for the improved adhesion of paint.

By the mid-1970s, many early clinical studies showed excellent retention and great promise in terms of potential caries prevention.¹¹ It was recognized in the 1970s that one of the deficiencies of early sealant was the difficulty in assessing sealant presence with the clear resin materials used. Thus, in 1976, 3M Dental Products introduced the first colored sealant—Concise White Sealant, a chemically-cured material, white in color from the addition of titanium dioxide, that is still in the market as of 2001. Whether this 25-year duration marks the great longevity of a fine material, or a lack of innovation in development of new sealants (certainly as compared to the dentin bonding systems)—or perhaps a combination of both factors—is a matter of opinion. Recently, in 2001, both 3M (now 3M ESPE) and Ivoclar Vivadent introduced new sealants with color-changing capability. Whether there is any clinical benefit to color change, or if it is merely a cosmetic marketing tactic, remains to be seen.

By 1984, Burt could report that, "There is general agreement that first and second molars should be sealed as soon as possible after eruption because of their susceptibility to occlusal caries."¹² Soon afterwards, Graves and coauthors noted that, "The dental profession should shift its emphasis from the early restoration of fissured-surface defects to an expanded use of sealants for those with reduced decay and focus resources on a minority of the population with

high caries levels who receive limited care."¹³ In 1986, Eklund and Ismael noted that, "the value of sealants will be determined by the balance between high enough levels of potential caries on occlusal surfaces to give them something to prevent, and low levels of, or sufficiently delayed, proximal lesions to prevent the loss of the otherwise saved occlusal surface."¹⁴ Eccles, in 1989, noted that, "Fissure sealants should be used preventively for the caries-prone patient, and therapeutically for the suspect or early carious lesion. Where the caries has spread into dentine, as shown radiographically, then the sealant restoration¹⁵ [subsequently named the preventive resin restoration or PRR¹⁶⁻¹⁸] may be more suitable."¹⁹ There followed a confusing period in clinical dentistry in its approach to, and appreciation of, pit and fissure sealant. Clinicians seemed to be unsure whether to seal or not, whether to invasively prepare enamel or not prior to sealant application, and whether or not to resort to a preventive resin restoration. This uncertainty as to what is best in some situations, invasive or noninvasive treatment, still lingers today.

More recently, Burt has reported that, "Changes in the distribution of caries in economically developed nations over the last 15-20 years include: (1) an overall decline in prevalence and severity in child populations; (2) an increasingly skewed distribution, with most disease now found in a small number of children; and (3) concentration of caries in pit and fissure lesions . . . In the Scandinavian countries the prime population strategies are the regular use of fluoride toothpaste and public education that emphasizes oral hygiene."²⁰ Also, in the Scandinavian countries there is a considerably different approach to the use of sealant where a therapeutic, rather than preventive, approach is manifest in some countries.

There is only one report of an adverse reaction (allergy to resin) to a pit and fissure sealant in the literature.²¹

This paper will now review the literature on pit and fissure sealants under the following subheadings and a few selected references in each section will be discussed:

- laboratory studies;
- clinical technique and tooth preparation;
- etching time;
- auxiliary application of pit and fissure sealant;
- retention and caries prevention;
- fluoride used with sealants and fluoride-containing sealant;
- glass ionomer materials as sealants;
- options in sealant: filled vs unfilled; colored vs clear; autocure vs light-initiated;
- sealant placed over caries in a therapeutic manner;
- cost effectiveness of sealant application;
- underuse of pit and fissure sealant;
- the estrogenicity issue;
- use of an intermediate bonding layer to improve retention;
- new developments and projections;
- summary and conclusions.

Laboratory studies

In vitro studies published on sealant application procedures, looked initially at the effect of etching on the enamel surface^{22,23} and the optimal type and strength of acid for etching enamel.^{24,25} These studies supported the use of phosphoric acid in the strength range of 30%-40%. Most commercial sealants supplied to this day for pit and fissure sealants and other uses of the acid-etch technique utilize approximately 35% orthophosphoric acid.

Influence of acid type (phosphoric or maleic) on the retention of pit and fissure sealant was studied in an in vivo study. It was found that there was no statistically significant difference between the 2 groups (37% phosphoric and 10% maleic acid) in the 2 test periods, nor were there differences in the same group at the different periods.²⁶

It was also recognized early in the development of the technique that a clean dry (and free of saliva and water contamination) enamel surface was essential for a strong bond of the sealant to enamel. Tests with contaminated enamel yielded significantly lower bond strengths.²⁷ Efforts to alleviate the effects of saliva contamination with the use of the dentin bonding systems as demonstrated by Feigal will be discussed later.

While clinical studies have documented the protection of resin on enamel against development of caries, this was not shown experimentally until the work of Donly using an in vitro caries model. Placement of resin on an enamel surface was shown to inhibit enamel demineralization.²⁸

Other laboratory studies have been carried out on various aspects of tooth preparation prior to sealant application. These will be covered in later sections.

Clinical technique and tooth preparation

Many studies have looked at different methods of enamel surface preparation prior to acid etching and sealant application. The early application technique for pit-and-fissure sealant application consisted of cleaning the enamel surface to be treated with a pumice and water mixture using a rotary brush, either pointed or flat ended.

In one study comparing dry brushing with a rotary brush and paste, the tooth-cleaning technique of dry brushing with a toothbrush as a preparatory step in the sealant procedure yielded high clinical sealant retention at 12 months. This retention was comparable to that observed with rotary instrumentation. The results suggest that dry brushing by the operator may be an equivalent alternative to using a rotary brush and paste.²⁹

Various other cleaning methods have been tested—one of the best, if not the best, was the Prophy-Jet, an early air-abrasion system, more properly called an air polishing system, utilizing sodium bicarbonate particles instead of the more abrasive aluminum oxide particles common in today's air-abrasion systems. The tensile bond strength of sealants prepared with various techniques was measured in a study by De Craene et al.³⁰ Air polishing with the Prophy-Jet followed by acid etching produced the highest bond strength of all groups tested. A statistically significant higher mean

bond strength was found by De Craene et al after air polishing and acid etching compared to no cleansing prior to acid etching.

Similarly, in a study by Brockmann et al, air polishing combined with acid etching resulted in an improved surface for resin wetting as determined by the number of resin tags formed.³¹ The differences among the treatment groups were, however, not large enough to be statistically significantly different.

Another study on fissure preparation prior to sealant application found that the air-polishing system performed well. Fissure cleaning with an air-polishing unit produced a statistically significant increase in depth of penetration of sealant resin, and its use as a standard cleaning method before fissure sealing is recommended.³² Despite these positive studies, air polishing prior to etching never really became the standard for pit and fissure sealant application procedures, possibly due to the increase in equipment cost and complexity of the procedure.

A number of authors have looked at other more aggressive methods of fissure preparation prior to sealant application. Garcia-Godoy and de Araujo demonstrated that the Enameloplasty Sealant Technique (EST) allows a deeper sealant penetration and a superior sealant adaptation than the conventional sealant treatment without any mechanical enlargement of the fissures with a bur. It was reported that an increased surface area for sealant retention was readily evident in all samples treated with the EST.³³ Another trial supporting mechanical preparation prior to etching the enamel revealed the best sealant retention using a combination of cotton roll isolation and mechanical preparation of the occlusal surface.³⁴ Similarly, Xalabarde et al revealed a superior sealant adaptation to enamel when the enameloplasty technique was used.³⁵ At the same time, they also showed that there was no difference in penetration capabilities and adaptation between the filled and the unfilled sealants.

In the early years of air abrasion with aluminum oxide, some of the manufacturers claimed that roughening of the enamel surface with air abrasion could be a substitute for acid etching of enamel prior to sealant and other procedures. This claim could not be substantiated by independent studies which found that tensile bond strengths of resin composite to air-abraded, acid-etched enamel were significantly greater than were those to air-abraded, unetched enamel.³⁶ These data were confirmed by Kanellis et al, who noted that it does not appear that air abrasion without acid etching offers a significant advantage over traditional sealant placement methods and, in fact, appears to be inferior to the acid-etch technique for use in public health settings.³⁷ The claim of using air abrasion instead of acid etching was attractive from the clinical perspective, but it was merely a marketing ploy that failed when the data were examined.

Several other studies have addressed mechanical, or air, abrasion of pits and fissures prior to etching and sealant application.

In looking at microleakage of sealants after conventional, bur and air-abrasion preparation of pits and fissures, superior results were obtained when the tooth surfaces were prepared with a bur, while conventionally cleaned and air-abraded surfaces yielded similar results.³⁸

Another study showed that, based on in vitro shear bond strength values, air abrasion with 50 µm alumina is an effective pre-etch treatment for sealant placement and, when used with phosphoric acid treatment, significantly enhances the long-term bond of a sealant to enamel.³⁹

In another study, superior sealants were obtained when tooth surfaces were prepared by a bur, compared to air abrasion and conventionally prepared surfaces.⁴⁰

Occlusal fissures prepared with the #1/4 round bur and 2 air-abrasion methods demonstrated significantly better sealing than the control group and the other groups tested.⁴¹

Sealant penetration and retention were significantly improved by mechanical preparation compared to nonprepared fissures, and preparation with a tapered fissure diamond bur was superior to the round carbide bur.⁴²

Results of another study substantiated the use of resin sealants over glass ionomer sealants and invasive techniques over noninvasive techniques.⁴³

Finally, one study showed that enameloplasty reduces microleakage of pit and fissure sealants, especially when load is applied to teeth, irrespective of which bur is used to enlarge the fissure, (there are no statistically significant differences between the round and fissured diamond burs). It was shown that the application of occlusal force to the tooth produces significantly more microleakage, unless enameloplasty is performed.⁴⁴

In a normal preventive clinical practice, it is frequently the routine for the patient to be seen for a prophylaxis and fluoride treatment prior to the examination by the dentist. In cases where patients may be diagnosed after the fluoride treatment as needing a small touch-up sealant application to a partially missing sealant, it was of concern that the fluoride application could have rendered the enamel somewhat more resistant to an adequate acid-etching procedure. Studies, therefore, looked at the effect of various fluoride treatments on the subsequent etching of enamel.

Koh et al showed that topical fluoride treatment has no clinical effect on retention of pit and fissure sealants.⁴⁵ Brown and Barkmeier showed that 37% phosphoric acid treatment of intact enamel, or a combination of air abrasion with sodium bicarbonate or aluminum oxide followed by phosphoric acid, provides significantly higher bond strengths of a sealant material than air abrasion with sodium bicarbonate or aluminum oxide.⁴⁶

In a follow-up study, Koh et al, showed that exposure of enamel to NaF, SnF₂ or APF prior to placement of unfilled or filled sealants has no effect on in vitro bond strength between the enamel and the sealants.⁴⁷

Finally, Warren et al confirmed that sealant retention may not be adversely affected by a topical fluoride treatment applied immediately prior to placement.⁴⁸

All of these studies seem to confirm the logical assumption that it is unlikely that a topical fluoride treatment, applied immediately prior to acid etching for a sealant, would negatively affect the ability of phosphoric acid to provide an adequate etch of enamel.

Etching time

Buonocore initially used 85% phosphoric acid for 60 seconds for etching enamel.² Later, Gwinnett and Buonocore published a more detailed analysis of the effects of various acid strengths on enamel.⁹ Eventually, manufacturers and clinicians focused on 35% phosphoric acid applied for 60 seconds for the etching of permanent enamel. In the early 1970s, it was believed that, due to the “prismless” nature of primary enamel, it would require double the etching time of permanent enamel, and this became the standard clinical procedure.

Primary enamel has been described as “prismless” by Gwinnett.⁴⁹ However, there is no evidence of prismless enamel (which would require a longer etching time) on occlusal surfaces (it is mostly found in cervical regions). Despite this, early recommendations for etching primary enamel were for twice the then-accepted time for permanent enamel (120 seconds vs 60 seconds). The first report comparing the retention on primary molars of the 120-second etching time vs 60 seconds showed no difference in sealant retention.⁵⁰ A later report noted that, “Decreasing the etch time for primary molars has been found to decrease the chance of contamination, during etching. Additionally, the shorter etch time was far more acceptable to 3- and 4-year-old children.”⁵¹

For permanent enamel, shorter etching times (than the originally recommended 60 seconds) have been reported in later years. The findings demonstrate that the retention rates of fissure sealants using 20 seconds etching time are comparable to those reported with the more conventional 60 seconds.⁵²

It has also been shown that that the etching times for primary enamel can also be decreased over the times originally proposed. A short etch time of 15 seconds was found to be satisfactory for primary enamel.⁵³

Another study reported on the effect of different etching times on the retention of fissure sealants in second primary and first permanent molars. Etching times of 15, 30, 45 and 60 seconds were used. It was concluded that the different etching times do not appear to affect the retention of fissure sealants on the first permanent molars or second primary molars.⁵⁴

Some manufacturers have marketed drying agents for use with sealants and other uses of the acid etch technique. One clinical investigation assessed the retention of pit and fissure sealants with and without the use of a post-etching drying agent in pediatric dental patients. These results (with and without a drying agent) were not statistically significant based on the log-rank test.⁵⁵

Auxiliary application

It has been known for some time that a well-trained auxiliary is equally proficient at the application of pit and fissure sealant as a dentist. As long ago as the mid-1970s, Stiles et al, reported that there was “no difference in the retention of the sealant when applied by a dentist or a trained dental auxiliary.”⁵⁶ Ismail et al reported in an evaluation of the Saskatchewan dental program that about 79% of the sealants applied by dental therapists were retained 3 years after application.⁵⁷ Rock et al, noted that when resin was applied by a dental therapist, and all recall examinations were carried out by the same dentist, resin was fully retained on 77% of teeth at the end of 3 years.⁵⁸

In a study using Air Force dental technicians, sealant retention over a 2-year period was analyzed. The results suggest that pit and fissure sealants can be placed using dental auxiliaries in a cost-effective manner with a relatively high retention rate.⁵⁹

In a 5-year evaluation of fissure sealants applied by dental assistants, the dental assistants sealed the fissures without any additional assistance and none of them had any previous experience in fissure sealant application. In the opinion of Holst et al, sealing of fissures is a method well suited for delegation to dental assistants after proper education but should be followed up, as the success rate showed a great variation.⁶⁰

Retention and caries prevention

There are literally hundreds of reports documenting and discussing the retention of pit and fissure sealant. Apart from the early reports already mentioned, the first report over a significant period of time was Horowitz's landmark Kalispell study.⁶¹ In the 5-year report of this study,⁶² the authors reported 42% complete retention at 5 years. Horowitz also noted that teeth with sealant partially missing had a lower incidence of caries (7%) than paired unsealed control teeth that were not sealed (41% caries). Thus from the results of this pioneering clinical trial one can conclude that even partially sealed teeth are considerably less susceptible to caries than unsealed teeth. Horowitz concluded, “The findings of this study clearly show that when this pit and fissure sealant is retained, it is effective in preventing caries in sealed tooth surfaces.” Charbeneau et al, also commented on partially lost sealant noting that “sealant loss from a surface did not appear to initiate pit and fissure caries.”⁶³

Thylstrup and Poulsen looked at caries reduction and found a 70% reduction in caries over 1 year.⁶⁴ At 2 years, the caries reduction was 98% in sealed pairs where the material was fully retained.⁶⁵ A report on Nuva-Seal, the first sealant marketed, noted an 84% caries decrease over 1 year, and 53% 2 years after application.⁶⁶ The caries reduction was similar for primary and permanent enamel.

Additional studies reported retention rates of 50% at 48 months;⁶⁷ 60% after 5 years;⁶⁸ 85% after 24 months;⁶⁹ 72% at 54 months;⁷⁰ 92% at 2 years;⁷¹ 63% after 23 months;⁷² 67% after 6 years;⁷³ 97% at 2 years;⁷⁴ 94% after 1 year in a

Guatemalan public health clinic;⁷⁵ Delton sealant in a Danish school dental service 40% after 6 to 7 years with caries reduction of 32% for girls and 25% for boys;⁷⁶ and 85% at 2 years.⁷⁷

A meta-analysis carried out by Llodra et al, showed that the overall effectiveness of autopolymerized resin was 71%, and the authors concluded that, “autopolymerizing sealants should be used.”⁷⁸ Ismail et al reported in an evaluation of the Saskatchewan dental program, that sealed teeth experienced 46% fewer carious lesions than unsealed teeth 4 years after the application of sealants.⁵⁷

The longest studies on pit and fissure sealant retention have been reported for 10 years or longer. Wendt and Koch reported on teeth sealed over a 10-year period (the title of their paper is somewhat confusing as it sounds like it is a 10-year study, but not all teeth were sealed for 10 years; teeth were sealed on an ongoing basis and the longest retentive period for any tooth was 10 years.) They found that after 8 years, about 80% of the sealed fissures showed total sealant retention and no caries. Another 16% of the sealed occlusal surfaces showed partial retention and no caries. After 10 years, only 6% of the sealed occlusal surfaces showed caries or restorations. The authors noted that the results underline that fissure sealing is an effective treatment and has a low failure rate.⁷⁹ A later follow-up noted that this long-term retrospective study indicates that a structured fissure sealing program is of great benefit for oral health.⁸⁰ Up to 20 years after sealant had been applied, a surprisingly high 65% showed complete retention, 22% partial retention without caries and 13% with caries or restoration in the occlusal fissures or buccal pits.⁸¹

Another long study by Romcke et al, showed an overall annual sealant success of 96% after 1 year and 85% after 8 to 10 years. The authors concluded that the results support the careful application of chemically-cured sealants under field conditions and the use of annual examination to allow minimal sealant maintenance.⁸²

A 15-year study of the single application of a colored (white) autopolymerizing pit and fissure sealant found 28% complete retention and 35% partial (noncarious) retention on permanent first molars. In a matched-pair analysis, carious or restored surfaces made up 31% of the surfaces in the sealed group and 83% in the unsealed group.⁸³ The author predicted that with routine maintenance, the 31% of sealed teeth that became carious could be reduced to nil if partially missing sealant was replaced at regular intervals.

The late Eva Mertz-Fairhurst completed several important studies in the area of pit and fissure sealant before her untimely passing. In a 1981 report,⁷⁰ she reported on the retention of Delton, probably the most popular sealant on the market, compared to the older ultraviolet light-initiated Nuva-Seal. While the Nuva-Seal was completely retained on 35% of all paired permanent molars, Delton was retained on 72%. Improved sealants and curing methods, along with a better understanding of the technique, was leading to improved retention rates compared to the original materials.

Mertz-Fairhurst concluded that “occlusal caries protection on permanent molars is assured if the sealant is completely retained on the tooth. Delton was 4 times more effective in providing protection against pit and fissure caries than Nuva-Seal.”

Stephen et al, reported that 25% of baseline unsealed surfaces were carious compared to 15% of those originally sealed, although for molars, the equivalent figures were 49% and 24%.⁸⁴

In a review, Weintraub reported that, based on the literature reviewed, following one application of autopolymerized or visible-light-cured sealant, the median percent effectiveness declines from 83% after 1 year to 55% after 7 years. Similarly, the median complete retention declines from 92% after 1 year to 66% after 7 years. Conversely, the median percent of sealed first molars becoming carious and/or restored increases from 4% after 1 year to 31% after 7 years. It was further noted that large differences in sealant effectiveness are not apparent between studies performed in fluoridated and fluoride-deficient communities.⁸⁵

Messer et al showed that, regardless of sealant retention, caries experience was low under partially retained or missing sealants (5%) and completely retained sealants (<1%).⁸⁶

Regarding retreatment, sealants placed in first permanent molars in 6-, 7- and 8-year-olds required more retreatment than those in older children. Those placed initially in second molars in 11 and 12 year olds required more reapplication than those placed in older children. It was concluded that sealants are a successful preventive procedure, but the failures of early-age placement leave some doubt as to the best time to place sealants.⁸⁷

Fluoride used with sealants and fluoride-containing sealant

Several studies have looked at the benefits of combining pit and fissure sealant application with fluoride treatment of one kind or another, or of adding fluoride to a sealant. In an evaluation after 4 years of the combined use of fluoride and dental sealants, the overall proportion of sealants retained on occlusal surfaces of first molars after an average of 2 years is 92%.⁸⁸ This study suggests that pit and fissure sealants confer additional caries-preventive benefits beyond those of fluoride therapy alone.

Early in the development of sealants, it was recognized that the addition of fluoride to a sealant, or perhaps to the enamel prior to sealant application, could have the potential benefit of additional caries protection. Reduced solubility of enamel without compromising the properties of the sealant were found in a study by Swartz et al.⁸⁹ However, no studies have documented a clinical benefit with fluoride-releasing resin sealant, and while one can contemplate the potential benefit, the short time duration of very low level fluoride release from resin sealant would raise doubts about whether any clinical benefit is likely. The addition of fluoride to resin sealant seems to be more of a

marketing benefit than a clinical benefit. Additionally, attempts to treat etched enamel with acidulated phosphate fluoride prior to sealant application resulted in reduction in bond strengths with all sealants tested.⁹⁰

In a 2-year clinical evaluation of a fluoride-containing fissure sealant, Helioseal-F, in young schoolchildren at risk for caries, a total of 431 fissure sealants were placed at baseline. Complete retention was found in 77% during the study period, while 22% were partially lost. Six sealants (1%) were completely lost.⁹¹

Another clinical evaluation of Helioseal F fissure sealant found after 1 year of clinical testing that a sealant containing fluoride-releasing particles did not show a significant difference in retention rate compared to an unfilled conventional sealant.⁹²

In an analysis of fluoride release from fissure sealants, Garcia-Godoy, Summitt and Donly found that all the fluoridated sealants tested released measurable fluoride throughout the test period in a similar pattern. However, the greatest amount of fluoride was released in the first 24 hours after mixing, and the fluoride release fell sharply on the second day and decreased slowly for the last days.⁹³

Two-year retention and caries rates of UltraSeal XT and FluoroShield light-cured pit and fissure sealants were assessed in a Canadian study. After 2 years, 74% of the sample was available for recall. The total retention rate was 96% for UltraSeal XT and 91% for FluoroShield. There were no new pit and fissure carious lesions over the 2 years of the study.⁹⁴

In a study comparing retention rates and caries increments between a fluoride-containing filled sealant (FluoroShield) and a conventional (not containing fluoride or filler) sealant (Delton) over 4 years in a regular biannual preventive program including topical gel application, the fluoride-containing filled sealant (FluoroShield) appeared to have a lower complete retention rate when compared with (Delton). However, total sealant loss and caries increment was similar in both groups.⁹⁵

Other studies have also shown equivalent retention with or without fluoride in the sealant. Vrbic showed that this similar retention pattern also applies to primary teeth. The retention of a fluoride-containing sealant on primary and permanent teeth 3 years after placement was assessed, and, in the primary molars, full retention was found in 95%, partial retention in 3% and loss of the sealant in 2% of the treated teeth. In the permanent molars, the corresponding rates were 96%, 3% and 1%, respectively. Thus, very good sealant retention was found 3 years after placement in both permanent and primary enamel, and there was no statistically significant difference in retention between primary and permanent molars.⁹⁶

Another 1-year clinical evaluation of the retention and quality of 2 fluoride-releasing sealants suggests that placement under rubber dam increases retention rate and sealant quality and may reduce material dependent factors that are considered a cause of sealant failures.⁹⁷

An *in vitro* analysis of fluoride release by pit and fissure sealant showed that sealant may provide additional protection against caries formation in cuspal incline enamel and smooth surfaces adjacent to sealed pits and fissures (although caries in such areas clinically is rare). Perhaps, more importantly, sealant may act as a fluoride reservoir with long-term release of fluoride into the immediately adjacent oral environment.⁹⁸ The key question remains that, while there is evidence for equal retention rates to conventional sealants and for *ex vivo* fluoride release and reduced enamel demineralization, further research is necessary to ensure the clinical longevity of fluoride sealant retention and to establish the objective of greater caries inhibition through the fluoride released in saliva and enamel.⁹⁹

Another study looked at the effect of topical fluoride on the sealant material itself. The results of this *in vitro* study indicate that preventive therapies that combine use of topical fluorides and sealants may cause deterioration of filled sealants and glass-ionomer sealant material, but not unfilled sealants.¹⁰⁰

A comparison was carried out to assess the effectiveness of visible light fissure sealant (Delton) vs fluoride varnish (Duraphat) in a 24-month clinical trial. The percent effectiveness (percentage of saving from caries taking molars as analysis unit) at 24 months was greater in the sealed molars than in the varnished molars.¹⁰¹

Finnish researchers have looked carefully at treatment of high-risk groups with various combinations of intensive anti-caries therapies. Surprisingly, 2 studies came up with contradictory conclusions: Hausen et al, looked at children who were regarded as being at high risk of developing caries and randomized them into 2 groups. One group was offered intensive prevention consisting of preventive counseling, fluoride varnish applications, fluoride lozenges, sealants and chlorhexidine applications. The other group was provided the same basic prevention given to low-risk children (counseling and one fluoride varnish application per year). There was a negligible difference between the 2 groups which implies that intensive prevention treatments produced practically no additional benefit over routine prevention. This study concluded that, by offering all children only basic prevention, virtually the same preventive effect could have been obtained with substantially less effort and lower costs.¹⁰²

Varsio et al, came to a different conclusion, claiming that dentists should be encouraged to use standardized criteria, including data on caries state and eruption stage, in judging each patient's risk of caries to provide intensified caries-preventive treatment to those most in need.¹⁰³

Glass ionomer materials as sealants

The logical assumption that a material that releases fluoride, such as a glass ionomer cement, would provide an added benefit to the retentive blocking of the fissure by a resin sealant, has been tested many times with various glass ionomer materials, sometimes in direct comparison with

resin materials. There is no data that supports the use of glass-ionomer sealant in preference to resin sealant.

In 1996, the author reviewed the literature on glass-ionomer sealants for a symposium at the IADR meeting in Singapore. The conclusion was as follows:

“An objective assessment of the presently available scientific literature on the use of glass ionomer materials as pit and fissure sealants is not encouraging in terms of retention, but appears somewhat more positive for caries prevention. At the time of this writing [1996], the published literature indicates that retention for resin-based sealants is better than for glass ionomer sealants, but differences in caries prevention remain equivocal.”¹⁰⁴

Two studies published after the above review concluded that the resin-based sealant is not only superior in terms of retention, but also in caries prevention^{105,106} (in which, of course, retention plays a major role). Thus, traditional glass-ionomer cements have essentially been abandoned as fissure sealants since their retention is vastly poorer than the resin sealants. However, it has been speculated, if not shown to be of statistical significance, that the fluoride-releasing effect of the glass-ionomer materials may infer some caries protective effect even after the apparent loss of the material in the pits and fissures (this will be discussed further below).^{107,108}

Glass-ionomer (polyalkenoate) cements have documented high levels of fluoride release.¹⁰⁹ However, used as a pit and fissure sealant, the traditional glass-ionomer cements have shown very poor retention rates¹¹⁰⁻¹¹⁴ as well as leakage even when fully retained.¹¹⁵ One study suggested that etching of the enamel prior to application of the glass-ionomer sealant enhances bonding to enamel,¹¹⁶ but that is contrary to most manufacturers' instructions.

In a study reported by Boksmann et al, a comparison of the study's 6-month complete retention rates of 92% for Concise white light-initiated sealant and 2% for the Fuji III glass ionomer sealant, suggests, according to the authors, that the routine use of the Fuji III glass ionomer as a fissure sealant is unreliable.¹¹⁰ Torppa-Saarinen reported that after just 4 months, 75% of the Fuji III sealants were totally present, 22% partially lost and 3% totally lost.¹¹¹

Ovrebø found that not only is Fuji III poorly retained in the fissures, but that the material permits leakage even when it is fully retained.¹¹⁵

In the interesting study by Mejare and Mjör, 61% of the glass ionomer sealants were lost within 6-12 months and 84% after 30-36 months. Although total loss was recorded clinically for the majority of the glass ionomer sealants, some retained sealant was observed in the tooth replicas in 93% of them. The clinical evaluation of the resin-based sealants showed an average complete retention rate of 90% after 4.5-5 years. The corresponding figure with the replica technique was 58%. Caries was recorded in 5% (N=8) of the resin-based and in none of the glass ionomer sealed surfaces.¹⁰⁷ In the 8 surfaces with caries, 6 of the surfaces were registered after 6 to 12 months, which is probably too soon to

be certain caries was not present at sealant application time. This study is frequently quoted as “evidence” that, despite poor retention, glass-ionomer sealants are beneficial from a caries-prevention perspective. However, the small numbers do not allow such a conclusion to be drawn. As the authors themselves concluded, “Any conclusions about a possible long term caries-preventive effect [of glass-ionomer sealant] cannot be drawn from the present results.”

What is clear is that the caries-preventive effect of glass-ionomer sealant depends on both retention of the sealant and fluoride release.¹¹⁷ Williams et al, concluded that, “Polyalkenoate cements probably should be regarded as ‘fluoride depot’ materials rather than fissure sealants when used in this context.”¹¹⁸ Whether the development of the resin-modified glass-ionomer (RMGI) cements can challenge the resin sealants in terms of retention remains to be seen. But early indications are that the RMGI wears markedly more than the resin sealant¹¹⁹ even though higher fatigue bond strength has been reported for the RMGI sealant.¹²⁰ A 2-year report on the clinical performance of a RMGI sealant compared to a light-initiated, resin-based sealant showed 0% complete retention and 38% complete loss of the RMGI sealant, and 32% complete retention and 10% complete loss of the resin-based sealant.¹²¹

The poor retention rates of glass-ionomer sealants makes cost effectiveness a significant issue in considering their usage. Kervanto-Seppala et al in Finland showed that glass-ionomer sealants, whether resealed or not, cannot be as cost-effective as resin-based sealants, when the expense of placement in time (and thus costs) is used as the basis of efficacy.¹²² At 12 months, only 20% of the sealants were clinically evident.¹¹³

Hicks and Flaitz looked at caries-like lesion formation in occlusal enamel adjacent to a light-cured resin-modified glass ionomer utilized as a pit and fissure sealant and a conventional light-cured, fluoride-releasing sealant.¹²³ While both the resin-modified glass ionomer and fluoride-releasing sealant materials protected the pit and fissure enamel from caries development, the resin-modified glass ionomer reduced the extent of caries involvement in the adjacent unsealed occlusal incline enamel when compared with the resin sealant.

Seppa et al, suggested that fissures sealed with glass ionomer are more resistant to demineralization than control fissures, even after macroscopic sealant loss. This may be the result of the combined effect of fluoride released by glass ionomer and residual material in the bottom of the fissures.¹⁰⁸

A study that seems to be representative of what most researchers find in regards to the retention and caries-preventive effects of glass-ionomer sealants showed that the retention of glass-ionomer sealants is markedly inferior to the resin-based sealants. However, in this study, no difference in caries increment on the sealed surfaces was observed.¹¹²

Komatsu and co-investigators showed that with constant reapplication of the glass-ionomer sealant as it was lost, high

caries reduction rates could be obtained. In this study, the retention rate was maintained by sealant reapplication over three years. Caries reduction was 76% at 1 year, 70% at 2 years and 67% at 3 years. The authors concluded that reapplication is an acceptable procedure and seemed to improve caries reduction.¹¹⁷

One study showed better retention than most, although still a high proportion of the glass ionomer sealant was lost. After 3 years, 21% of the resin and 35% of the glass ionomer cement sealants were partially lost, and 0% and 38%, respectively, were totally lost. One tooth (1%) in the glass ionomer cement group and 3 teeth (4%) in the resin group developed caries.¹¹⁴

As a result of the poor retention of the glass-ionomer sealants, it has been suggested that polyalkenoate cements probably should be regarded as ‘fluoride depot’ materials rather than fissure sealants when used in this context.¹¹⁸ Additionally, other researchers have begun to look at other glass-ionomer materials, like the restorative materials, and the resin-modified glass-ionomer materials as sealant options. Looking at the Fuji sealant vs the restorative material after 4 months 46% of the Fuji IIIR sealant and 72% of the Fuji IXR used as a sealant showed complete retention. In conclusion, the glass ionomer *restorative* material showed to be more retentive than the equivalent sealant material.¹²⁴

Using a resin-modified glass ionomer as an occlusal sealant in a 1-year clinical study, the resin-modified glass-ionomer cement appeared to wear markedly.¹¹⁹ An interesting study from Norway comparing fissure sealing with a light-cured, resin-reinforced glass-ionomer cement (Vitrebond) and with a resin sealant, concluded that the resin-based sealant is superior to the glass-ionomer cement in preventing caries, and that the superior retention of the resin probably is an important factor in this result.¹⁰⁵

A 7-year study looked at retention of a glass-ionomer cement and a resin-based fissure sealant and effect on carious outcome. The aim of this study was to compare the retention and caries preventive efficacy of glass-ionomer (Fuji III; GIC) and light-cured resin-based (Delton; LCR) fissure sealants. On the sealed occlusal surfaces, 10% of GIC and 45% of LCR sealants were totally present and 9% of GIC and 20% of LCR sealants partially present. Twenty-three (24%) of the occlusal surfaces sealed with GIC and 16 (17%) of those sealed with LCR were carious or filled.¹⁰⁶

In another study, sealant retention failures requiring retreatment were 74% for the resin-modified glass-ionomer cement sealant and 11% for the resin-based sealant, with one instance of fissure caries being found for each material. The resin-modified glass-ionomer cement sealant showed a slight darkening from its initial placement, and was also more difficult to handle than the resin-based sealant.¹²⁵

When comparing the 2-year clinical performance of an experimental resin-modified glass-ionomer cement sealant (K-512=Fuji III LC), K-512 showed 0% complete retention, 62% partial retention, and 38% complete loss (nil retention). The corresponding percentages for Delton were 32%, 58% and 10%, respectively. There was 1 instance of

fissure caries for K-512 and 3 for Delton. Sealants deemed to need retreatments because retention failures were 62% for K-512 and 34% for Delton. The K-512 sealants continued to darken over the study, many becoming slightly darker than the sealed teeth.¹²¹

Retention and caries prevention of Vitremer (resin-modified glass ionomer) and Ketac-bond (conventional glass ionomer) used as occlusal sealants were assessed. The total retention rates for Vitremer after 6 and 12 months were 59% and 36%, respectively. For Ketac-Bond, the total retention rates were 24% and 15%, respectively. No dental caries was recorded during the 12 months for both experimental groups. When effectiveness was measured by sealant retention, there was a significant difference between Vitremer and Ketac-Bond after 6 ($P<.01$) and 12 months ($P<.05$). When effectiveness was measured by caries prevention, no significant difference was found between experimental groups, even when the sealants were partially or totally lost. There was no development of carious lesions after 1-year placement of sealants, but there was a significant difference between experimental and control groups.¹²⁶

Another study has confirmed the retention and caries-prevention data seen in many other studies. This study compared the retention and the caries-preventive effect of a glass-ionomer material developed for fissure sealing (Fuji III) and a chemically polymerized resin-based fissure sealant (Delton). A split-mouth, randomized design using contralateral teeth was used. After 3 years the glass-ionomer sealant was completely lost in almost 90% of the teeth compared to less than 10% of the resin sealed teeth. After 3 years, the relative risk of a tooth sealed with glass-ionomer sealant over that of a tooth sealed with resin sealant was 3.38 (95% CL: 1.98; 5.79). This finding was consistent over type of tooth. The glass-ionomer sealant tested in this study had poorer retention and a less caries-protective effect than the resin-based sealant used.¹²⁷

The poor retention of glass-ionomer sealants probably precludes them from use as sealants, particularly in lieu of evidence of superior caries prevention despite the poor retention. In an attempt to improve the retention, one study suggested that etching prior to application enhances the bonding of glass-ionomer sealant to fissure enamel.¹¹⁶

It can be concluded that glass-ionomer sealants, whether resealed or not, cannot be as cost-effective as resin-bonded sealants when the expense of placement in time (and thus cost) is used as the basis of efficacy.¹²²

Options: filled vs unfilled; colored vs clear; autocure vs light-initiated

There are a wide variety of sealants available, from unfilled to partially filled and from clear to white or other color. These materials can be polymerized chemically by mixing the components or initiated by visible light. The early ultraviolet (UV) light-initiating system has been discontinued, but the chemical (the first available along with the UV system) and the visible light-cure initiated materials have been available since the early 1970s.

Filled vs unfilled

Penetration, an important yet poorly recognized factor in sealant application and retention, is inversely proportional to the viscosity. Thus, it could be reasoned that an unfilled resin will penetrate deeper into the fissure system, and, therefore, perhaps be better retained.

In a study comparing unfilled and filled sealant as well as gel or liquid etchant after the same time in the mouth, an unfilled light-cured resin was significantly better retained than a filled light-cured resin. The use of etchant in gel form was as effective as liquid etching.⁵⁸ Another study looked at microleakage of sealants after conventional, bur and air-abrasion preparation of pits and fissures, and found that the unfilled sealant was superior to the filled sealant.³⁸

In a study of 58 children, half were sealed with PrismaShield (a filled sealant) (DENTSPLY Caulk, Milford, DE), and the others with the unfilled Concise White Sealant (3M ESPE, St. Paul, Minn), by a community dental service hygienist. In comparing PrismaShield and Concise after 2 years, 81% of PrismaShield sealant was completely retained, compared with 88% of the unfilled Concise White Sealant.¹²⁸

In addition to the aforementioned disadvantage of lack of equivalent penetration of the filled sealants (or flowable resins, as they are also called), another disadvantage is occlusal adjustment. Unfilled sealant will abrade rapidly, probably within 24 to 48 hours, if it is left in occlusion with an opposing cusp tip.¹ Filled sealant, however, will require occlusal adjustment included as a routine part of the application procedure, which not only increases the time and cost of the procedure, but also may not allow all auxiliaries who can apply sealant, to carry out the occlusal adjustment. Tilliss et al, showed that with a filled sealant, nearly all subjects experience a perceptible occlusal change and most are unable to abrade the interferences to a comfort level. These results indicate that the occlusion should be routinely verified and, if necessary, adjusted immediately after placement of a filled sealant.¹²⁹ Requiring occlusal adjustment as a routine part of the application of pit and fissure sealant would have a devastatingly negative effect on the numbers of children sealed.

Colored vs clear

In March of 1977, the first colored sealant (3M's Concise White Sealant) was introduced to the US market. There are clear advantages to a color as long as it is esthetically acceptable. It is easier to see the sealant during application, and it is much faster to assess retention with a white sealant than with a clear sealant at later time intervals. Also, documentation of retention is much easier over long time periods with a colored sealant.⁸³ Some have argued against use of an opaque color as it precludes continual examination of the sealed fissure. However, the studies that have examined the application of sealant over carious pits have not indicated any cause for concern when applying sealant to an incipient lesion or a stained fissure. The recent trend to invasively

examine all stained fissures does not appear to recognize the early studies on sealing over carious lesions.

The latest trend in marketing sealant is to incorporate a color change in either the curing phase (Clinpro, 3M ESPE, St. Paul, Minn) or in the polymerized phase (Helioseal Clear Chroma, Ivoclar Vivadent, Amherst, NY). While the Helioseal material, which changes color from clear to green when exposed to a visible light has some clinical utility, particularly on subsequent follow-up examinations when clear sealant is very hard to see, it is hard to understand any benefit to dentist or patient of the Clinpro material that changes color from pink to white on polymerization. One really cannot argue that it is easier to see opaque pink than opaque white, and there really has never been a need for any kind of polymerization indicator for light-initiated curing systems. Thus, the usefulness of the color change technology, the skeptical may argue, remains a perceived marketing benefit. It is unfortunate that the impressive technological achievements of companies in the restorative dentin bonding and resin-modified glass-ionomer material areas, has not been transferred to the preventive dentistry material field.

Rock carried out an interesting study assessing the utility of clear vs colored (opaque) sealant. The combined identification error rate for opaque resin was only 1%, while for clear resin it was 23%. Significant differences were also found in the accuracy with which the 3 dentists identified each type of resin. The most common error was to identify the presence of clear resin on an untreated tooth.¹³⁰ This study raises significant questions about the accuracy of studies done with clear resin.

Autocure vs light-initiated

Autopolymerizing resins generally performed better than the early ultraviolet light-initiated resin sealant—84% complete retention at 2 years compared to 75% in one study.¹³¹ When the visible light-initiated resins were introduced and compared to the autopolymerizing sealant, no significant difference was found in retention over 31 months.¹³²

De Craene and coworkers showed that a visible light-cured sealant (Helioseal) appears to be as good as the self-cured sealants and better than the UV light-cured products.³⁰ Thus, both self-cured and visible light-cured materials should provide equal clinical effectiveness in terms of both retention and caries prevention.

Sealant over caries

Handelman, in 1972, was the first to report on the interesting aspect of application of sealant over caries.¹³³ Clearly, since our diagnostic methods for assessing pit and fissure caries have been up to this time basically an educated guess, we must be placing sealants almost routinely over undetected incipient lesions. To determine if placement of sealant over undetectable incipient lesions was harmful, it was necessary to apply sealant over diagnosed lesions and study the effects. Handelman's preliminary report was followed by another report in 1973.¹³⁴ In his 2-year analysis, Handelman

noted that, "Preliminary clinical and radiographic findings suggest that there was not progression of the carious lesions."¹³⁵ Soon other studies confirmed Handelman's initial findings.¹³⁶ Going et al, noted that "these data confirm and extend previous observations that a limited number of cultivable organisms persist in some lesions, but their numbers are few, and they do not appear capable of continuing the destruction of tooth structure."¹³⁷

Eva Mertz-Fairhurst and many coworkers carried out a landmark study of the effects of sealing caries. Multiple publications culminated in 10-year data.¹³⁸ Mertz-Fairhurst's 10-year study evaluated bonded and sealed composite restorations placed directly over frank cavitated lesions extending into dentin vs sealed conservative amalgam restorations and conventional unsealed amalgam restorations. The results indicate that both types of sealed restorations exhibited superior clinical performance and longevity compared with unsealed amalgam restorations. Also, the bonded and sealed composite restorations placed over the frank cavitated lesions arrested the clinical progress of these lesions for 10 years.

It has been well known for some time that the occlusal pits and fissures provide an ideal ecological niche for the microflora of the oral cavity. It has been speculated early that sealing of pits and fissures could have an effect on the overall count of *Streptococcus mutans* in the oral cavity.¹³⁹ The continuous effect of pit and fissure sealing on *S mutans* presence in situ was studied by Mass et al. Their data suggested that sealants enable a prolonged reduction of *S mutans* presence in situ, indicating an additional prevention effect, by reducing one source of dissemination.¹⁴⁰ However, Carlsson et al, suggest that preventive pit and fissure sealing with a resin based material does not affect salivary *mutans streptococci* levels.¹⁴¹

The author has been unable to document the claim from some advocates of invasive exploration of apparently caries-free, or minimally carious, fissures that bacteria that remain viable within the confines of a sealed fissure after sealant application (and assuming good clinical technique with all fissures sealed) can continue to produce acid from nutrients supplied from within the dentinal tubules. This claim appears specious at this time.

Cost effectiveness

The issue of the cost effectiveness of sealants has not been addressed by many studies. At the 10-year point of a 15-year study, it was found that it is 1.6 times as costly to restore the carious lesions in the first permanent molars in an unsealed group of 5- to 10-year-old children living in a fluoridated area than it is to prevent, with a single application of pit and fissure sealant, the greater number of lesions observed if pit and fissure sealant is not utilized.¹⁴²

Of course, in areas of low caries rates, the cost effectiveness of applying pit and fissure sealant en masse is questionable. However, the benefit of preventing a lesion, rather than having a restoration placed and then continually

replaced as necessary, is not one measured in dollars and cents. However, the level of dental caries in any population should be monitored closely because a successful program of prevention, and thus a substantial decline in caries prevalence, could diminish the economic argument for sealants.

Burt noted that cost-effectiveness of sealants would be enhanced by: (1) using trained auxiliaries to apply sealant to the fullest extent allowed by law, (2) applying the most recently developed sealants in which retention rates appear to be most favorable, and (3) their application in areas where proximal caries is low.¹²

In another study using a preliminary cost-comparison model, it was projected over a 40-month period that the cost of initiating a universal molar sealant policy in a population would be 92 cents per year per student greater than the cost of restoring occlusal caries in the presence of sound proximal surfaces.¹⁴³

Underuse

It has been documented for decades that sealants are safe, effective and underused. The latest data available, indicates that in the United States, only 15% of children ages 6 to 17 have dental sealants.¹⁴⁴ Another report indicates just 10% of the sample had sealants on their permanent molars.¹⁴⁵

Why this underusage of a proven preventive material occurs is hard to explain. Dentists continue to identify lack of insurance coverage for sealant application as a major barrier to patients receiving the service.¹⁴⁶ Chapko promoted the 2-stage, or opinion-leader, model of diffusion and suggested that new technologies can be promoted by first influencing dentists who consistently adopt early.¹⁴⁷ However, Farsi concluded that continuing education courses were more likely to change dentists' knowledge than attitude and behavior.¹⁴⁸

Cohen et al concluded that professional organizations should take a more active role in promoting sealants to dentists, that professional organizations and governmental agencies should increase efforts to inform patients/consumers of the benefits of sealants, that guidelines for sealant use should be developed, that state boards should permit the delegation of sealants to trained auxiliaries, and that sealant manufacturers should make more of an effort to advertise and promote sealants.¹⁴⁹ In another paper, Cohen suggested that the best combination of variables predicting sealant use were preventive orientation, opinion about sealants and patient influence.¹⁵⁰ A study by Lang et al, suggested that dental personnel may strongly influence dissemination of information about, and utilization of, pit and fissure sealants.¹⁵¹

Romberg and coworkers noted that variables significantly associated with sealant use included availability of insurance, ability to delegate sealant procedures and patient income and acceptance.¹⁵²

In a Colorado study, it was shown that a relatively high percentage of Colorado dentists are utilizing sealants on a frequent basis. Major reasons for limited usage or

nonutilization of sealants relates to lack of insurance coverage and concern regarding sealing in of caries.¹⁵³

Attitudes towards certain procedures are frequently born in dental school. In another report, Cohen noted that the students' projected sealant use in practice was explained best by the combination of student attitudes toward sealants and their evaluation of the overall preventive orientation of their dental school.¹⁵⁴

One of the concerns with adding sealant coverage to third-party dental programs was the concern about overtreatment. Corbin et al, looked at the effect of third-party plans and showed that sealants can be added to third-party dental programs with little overall risk of inappropriate use or abuse.¹⁵⁵ Newbrun noted that dental sealants, which are highly effective in protecting pits and fissures when applied soon after the teeth erupt, will be more widely used in the future when insurance plans will pay for prevention.¹⁵⁶ In the 10 years that have passed, little increase in usage has been ascertained.

Selwitz and others, in an analysis of 16 factors thought to be related to sealant presence, revealed that parents were more likely to obtain dental sealants for their children if dentists or their staffs recommended them, if the parents were knowledgeable about dental sealants, if the parents were more highly educated and if the parents had dental insurance coverage. Yet, they were surprised to discover that parents were less likely to obtain dental sealants for their children if they heard about them from mass media. The latter finding was unexpected and may have been influenced by conflicting or negative opinion expressed by some dental practitioners through mass media or other channels of communication.¹⁵⁷

It remains a clear and disappointing fact that, despite the proven benefits, pit and fissure sealant treatment is offered to just a small percentage of the at-risk population.

Estrogenicity issue

A recent study on the estrogenicity of resin-based dental composites and sealants by Olea and coworkers in Granada, Spain, started a controversy that resulted in considerable confusion and doubt in the minds of many dentists and consumers alike about the safety of pit and fissure sealant.¹⁵⁸ Concern was raised about the safety of monomers leached out of these materials.

Dental resin composite materials and pit and fissure sealants have a similar basic composition, which can include bis-glycidyl dimethacrylate (Bis-GMA), urethane dimethacrylate (UDMA) and triethylene-glycol dimethacrylate (TEGDMA). Bisphenol-A (BPA) is not a direct ingredient of dental sealants; it is a chemical that appears in the final product only when the raw materials fail to fully react.¹⁵⁹ The conversion of monomers during the curing process of a sealant is incomplete, thus residual monomers can leach out of the cured resin. Findings that a portion of the polymerizable groups in dental resins have failed to react during polymerization have led many researchers to investigate

the possible leaching of these unbound molecules into different solvents.¹⁶⁰ Several studies have noted that the rate of elution of components from dental resin is rapid initially, but slows significantly over time.¹⁶¹⁻¹⁶⁴

The Olea study confirmed the estrogenicity of BPA and also implicated bisphenol-A dimethacrylate (BIS-DMA) as an estrogenic factor. Furthermore, the investigators detected these monomers in the saliva of human subjects 1 hour after sealants had been placed, although they had not found these monomers in the subjects' saliva before the sealants had been placed.¹⁵⁸

After the Olea study created quite a stir in the lay press, other researchers looked into the issue in more detail. They questioned what was released from the sealants in use and what the adverse effects were. Hamid and Hume found that bisphenol-A release could not be detected from any of the 7 sealants tested, and their results call into question earlier concerns expressed about possible adverse effects of bisphenol-A released from resin sealants.¹⁶⁵ Similarly, Nathanson and coworkers found that none of the tested sealants was shown to have released BPA; however, the investigators identified other eluted components that should be investigated for their biological effects.¹⁶⁶

Soderholm and Mariotti discussed whether Bis-GMA-based resins in dentistry are safe. Their review revealed that short-term administration of Bis-GMA and/or bisphenol-A in animals or cell cultures can induce changes in estrogen-sensitive organs or cells. However, considering the dosages and routes of administration and the modest response of estrogen-sensitive target organs, the authors conclude that the short-term risk of estrogenic effects from treatments using bisphenol A-based resins is insignificant. While long-term effects need to be investigated further, commonly used dental resins should not be of concern to the general public.¹⁶⁷ Other studies have not found any problems with the sealants.

BPA released orally from a dental sealant may not be absorbed or may be present in nondetectable amounts in systemic circulation. The concern about potential estrogenicity of sealant may be unfounded.¹⁶⁸

Another study showed BPA was not detected in American-made sealants, and BPA-DM was detectable in only a few. In addition, the surface layer of the sealant can be treated to reduce the possibility of unpolymerized BPA-DM being left on the tooth. The authors believe it is important to reassure parents that their children are less likely to be exposed to BPA from sealants than from the ingestion of soft drinks or canned food.¹⁶⁹

Recently, it was reported that BPA was released from one fissure sealant (Delton) into saliva causing estrogenic activity *in vitro*. It was concluded that the results reported in the literature may be attributed to the Bis-DMA-content of the fissure sealant tested (Delton). No BPA-release is expected under physiologic conditions from fissure sealants based on Bis-GMA if pure base monomers are used.¹⁷⁰

Minute amounts of BPA, considerably lower than previously reported, were detected in saliva samples collected immediately after, but not at 1 hour and 24 hours after placement of Delton LC fissure sealant. BPA was not detected after placement of Visio-Seal fissure sealant.¹⁷¹

Data suggests that the estrogenicity of the 2 proprietary sealants was associated with BPA-DMA rather than with BPA.¹⁷²

Bisphenol-A can be released from dental materials, however the leachable amount would be less than 1/1000 of the reported dose (2 µg/kg body weight/day) required for xenoestrogenicity *in vivo*.¹⁷³

A suggestion for clinicians who wish to minimize patients' exposure to the uncured components in the oxygen-inhibited layer of sealants would be to use a mild abrasive, such as pumice, either on a cotton applicator or in a prophyl cup on the sealant surface after sealant polymerization.¹⁷⁴

As the JADA Special Report ended, even though the potential deleterious effects of BPA and its degradation products are well-documented,¹⁷⁵⁻¹⁷⁸ no reports of adverse health effects have been attributed to the leached components of dental sealants. It is therefore questionable whether these materials indeed are leached out of dental sealants in quantities that can pose a health hazard.¹⁶⁰

While further study of an issue of potential concern is always recommended, it would appear from the numerous studies quoted previously, save the original Olea study, that parental concern about the estrogenicity of sealants is unfounded based on the presently-available evidence. It should also be remembered that none of the dental sealants that carry the ADA Seal release detectable BPA.¹⁷⁹

Use of an intermediate bonding layer

It was recognized early in the development of the acid etch technique that isolation was a key to the success of the clinical sealant procedure. Salivary contamination, unless washed off thoroughly (and as some would do, reetch the area) leads to significantly reduced bond strengths.²⁷ The study by Thomson et al, noted that the strength of the bond between sealant and saliva-contaminated-and-washed enamel (168 ± 14 kg/cm²) is not found to be significantly different from the bond strength to uncontaminated enamel (174 ± 11 kg/cm²). Unwashed contaminated enamel gives significantly reduced bond strength (68 ± 11 kg/cm²).

Feigal came up with the novel concept that hydrophilic bonding materials that contain water, may, when applied under a sealant, minimize the bond strength normally lost when a sealant is applied in a moist environment. Bonding agent under sealant on wet contamination yielded bond strengths equivalent to the bond strength obtained when sealant was bonded directly to clean, etched enamel. Bonding agent used without contamination yielded bond strengths significantly greater than the bond strength obtained when using sealant alone without contamination.

When the saliva was air dried onto the surface, there was no significant difference in bond strengths whether or not a bonding agent was used under the sealant.¹⁸⁰

Retention and microleakage have shown improvement when a bonding agent is used: A 2-year clinical study comparing sealants done with intentional salivary contamination shows that sealant retention is possible on wet enamel if a bonding agent is used between enamel and sealant.¹⁸¹ An *in vitro* study investigated the effect of Scotchbond Dual Cure bonding agent on microleakage of sealant bonded to saliva-contaminated enamel. Placement of Scotchbond between the sealant and enamel reduced microleakage of sealants applied under conditions of salivary contamination.¹⁸² Another study shows that single-bottle bonding agents protect sealant survival, yielding half the usual risk of failure for occlusal sealants and one-third the risk of failure for buccal/lingual sealants.¹⁸³

In primary teeth, the effect of bonding agents on the microleakage and bond strength of sealant has been studied. The use of enamel-dentin bonding agents under sealant in moisture-contaminated conditions gave better results than applying sealant alone onto noncontaminated teeth.¹⁸⁴

The microleakage of a universal adhesive used as a fissure sealant was tested. The results suggest that OptiBond (Kerr) may be used by itself as a pit and fissure sealant instead of the combination of adhesive plus sealant.¹⁸⁵

Scotchbond Multi-Purpose (3M ESPE) and All-Bond 2 (Bisco), enhanced the vertical penetration of the sealant, particularly in deep fissures. It was proposed by Symons et al, that the dentinal adhesive systems may improve the retention rate of sealants in deep fissures particularly if the fissure is not completely dry prior to resin placement.¹⁸⁶

While most of the data of the above studies seems to favor the use of a layer of bonding agent as part of the sealant procedure, Boksman carried out a clinical trial of sealants with and without bonding agent and found no benefit to the use of the bonding agent. The retention rates for the sealants were 77% for Concise with Scotchbond 2, 84% for Concise with no bonding agent; 77% for Prisma Shield with Universal Bond; and 77% for Prisma Shield with no bonding agent. Results of this study indicated that the use of a bonding agent prior to the application of a pit and fissure sealant does not increase the retention rate.¹⁸⁷

Use of a bonding agent would tend to increase the time (and the cost) of the sealant application procedure and thus should be carefully weighed before adoption. While not all studies agree, it seems appropriate to speculate that the modern bonding agents could improve sealant retention. The basic pit and fissure sealant of 2002 varies little from the sealant of the 1970s. Meanwhile dentin bonding systems have gone through multiple generations of improvements over the past almost 20 years since the introduction of the original Scotchbond Dual-Cure Dental Adhesive in 1983. It is not hard to imagine that some of this increased knowledge of retention and bonding could be of benefit to

sealants. The sealant of the future may not need to be applied with an intermediate bonding agent, but the sealant itself should encompass some of the benefits inherent in the latest bonding systems—benefits of penetration, wetting and novel delivery systems that minimize steps and thus minimize the chance for clinical errors.

New developments and projections

From the above review of the available evidence on pit-and-fissure sealant, it is clear that, while sealants are a proven, safe and effective preventive material, certain improvements could be made to the clinical technique to the delivery system and the chemical makeup of the sealant material.

As noted in the section on clinical technique and tooth preparation, mechanical preparation of the fissured surface appears to be beneficial to retention and microleakage.^{41-44,188}

Generally, shorter etching times than the originally proposed 60 seconds for permanent enamel and 120 seconds for primary enamel—times as short as 15 seconds—have been found to be just as effective as the longer times.^{189,190} Sol et al, also looked at cleaning methods and found that use of a sodium bicarbonate air polishing system resulted in a statistically significant higher retention of sealant.¹⁸⁹

Penetration of sealant is, in the author's opinion, a key factor in improving sealants of the future. Irinoda et al showed that a low viscosity sealant penetrates better and forms a resin impregnated layer with enamel, whereas the higher viscosity sealants tested did not penetrate enough to ensure that the acid-etched enamel was infiltrated sufficiently by the sealant to ensure good marginal seal.¹⁹¹ This finding runs contrary to the manufacturers' tendency today to promote filled sealants or flowable materials for sealant application. There is no evidence that these filled sealants will be better, and what evidence there is, tends to show that they will not be retained as well.^{38,58} Barnes et al, on the other hand, found that viscosity and flow characteristics have no effect on sealing ability or void formation.¹⁹² The effect of a sealant that penetrates better than conventional sealants would be interesting to study over the long term clinically. The author's best prediction is that the sealant that penetrates the best, with all other factors remaining equal, is the sealant that will be retained the longest and, therefore, is the sealant that will prevent the initiation, or the spread, of caries the longest.

Etchant penetration goes hand-in-hand with sealant penetration. If we are to use penetrating agents within sealants, then we also must provide a way to etch the fissure walls as deeply as possible. The present trend of using self-etching adhesives may well be of enormous benefit if applied to pit and fissure sealant. In one study, none of the commercially available etchants studied were able to penetrate farther than 17% of the total fissure depth in the fissure model. A surfactant-containing etchant was tested and showed complete penetration within about 1 minute and had a significantly lower surface tension and contact angle than the other

products tested. Only the surfactant-containing etchant could produce a retentive pattern on the entire wall enamel of the fissure with the exception of locations blocked by debris and plaque. Surfactant-containing etchants with a low viscosity can penetrate completely into fissures and can produce an increased retentive and wettable surface which significantly increased sealant penetration into deep fissures.¹⁹³

If sealants are gradually lost over time (as all sealants are to some degree), they should be repaired when deficient if they are to be effective.¹⁹⁴

Argon laser curing has been looked at by some researchers. In one study, it was noted that argon laser polymerization provides further caries protection against a cariogenic challenge over that afforded by fluoride-releasing sealants.¹⁹⁵ In an earlier (1993) study, Hicks and coworkers found that argon laser-curing of sealant material may enhance the caries resistance of the enamel forming the enamel-resin interface and result in a reduction in caries formation adjacent to sealants.¹⁹⁶

Er:YAG laser irradiation was not found to be a positive pretreatment for enamel surfaces to be sealed.¹⁹⁷ It was observed that treating the enamel surface exclusively by Er:YAG laser resulted in the highest degree of leakage. Additionally, use of the Er:YAG laser with subsequent acid-etching did not lessen microleakage at the enamel-sealant interface when compared with an acid-etched group.

The results suggest that complementing either air-abrasion or Er:YAG laser irradiation with a subsequent acid-conditioning did not lessen microleakage at the enamel-sealant interface when compared with an acid-etched group. It was also observed that treating the enamel surface exclusively by Er:YAG laser resulted in the highest degree of leakage.¹⁹⁷

Another study concluded that carbon dioxide laser conditioning is a viable alternative to acid etching for fissure sealing.¹⁹⁸

There is an interesting dichotomy in how sealants are used in different parts of the world. In the United States, the trend today seems to be to use far more caution in applying sealant to questionable areas (cariou or not). It seems that the oxymoronic invasive diagnosis is the order of the day, with aluminum oxide air abrasion and small burs leading the way. In other parts of the world, sealants are not applied until caries is diagnosed visually (without invasive treatment). There it is recognized that well-applied sealants will prevent spread of an incipient lesion, as the literature shows. Why this is so hard to get across in the United States is hard to fathom.

Clearly, our powers of diagnosis are limited, particularly where pit and fissure caries is concerned. Innovative new diagnostic tools such as the DIAGNOdent (KaVo) promise objective, rather than subjective, diagnosis of pit and fissure caries.^{199,200} In a recent paper, Takamori et al, expanded the use of the laser fluorescence system into

detecting caries under sealants—an intriguing use indeed. They showed that this laser diagnosis system (DIAGNOdent) makes it easy to detect the existence of caries under a pit and fissure sealant during a routine checkup.²⁰¹ However, the technique did not work on white sealants and the opacity of the titanium dioxide, may be the confounding factor at play.

The philosophical discussion then revolves around whether the subjectively caries-free fissures should be cleaned and sealed or aggressively (invasively) opened (enameloplasty) prior to sealing with small burs or aluminum oxide abrasive systems, or whether the fissures should be left untreated or, perhaps, preventively treated with application of a fluoride varnish. The relatively viscous fluoride varnishes would, however, not penetrate the fissures to an ideal degree.

In some European countries, particularly the Scandinavian countries, routine application of pit and fissure sealant to caries-free teeth is seen as overtreatment. This approach is supported by the study of Heller et al. "Initially sound tooth surfaces were unlikely to become decayed in 5 years, and did not benefit greatly from the application of sealants. Within the limitations of this study, there were clear efficiencies in sealing incipient, but not sound, surfaces. The targeting of teeth with incipient caries for sealants is therefore recommended."²⁰² Others would prefer to investigate the surfaces prior to sealing. The results support the practice of opening up questionably carious fissures and removing caries (if present) before sealing.²⁰³

In this philosophy of conservative pit and fissure management, the effect would be to leave all caries-free fissures unsealed until there is evidence of caries and only *then* seal the fissures. This is apparently an effort to minimize overtreatment of teeth that would never become carious and thus conserve valuable resources and manpower. However, in so doing, many teeth will become carious before sealing, and this becomes an ethical dilemma. Is it ethical to allow a disease to occur before instituting proven, effective preventive procedures?

Applying sealant to small carious lesions is certainly justifiable—the literature is clear on this subject^{133,138} However, when the sealant wears down and a fissure that was previously sealed becomes partially uncovered and the oral fluids are free once again to migrate down the fissure under the sealant, and thus possibly interact with the bacteria in the dormant carious lesion once again, the caries process would once again become active. Depending on when the sealant is reapplied, the resulting damage could be limited or severe. It would seem to me to be more prudent to seal caries susceptible, caries-free teeth and, once caries is diagnosed, to remove the caries and place a preventive resin restoration.^{15,18} Of course, if dental professionals had etchants and sealants, or a combined self-etching adhesive sealant that penetrates to the base of all fissures, this would be of lesser concern.

It has been suggested that sealants should be a targeted treatment for just the high risk patients. Graves et al, stated in 1986, that "the dental profession should shift its emphasis from the early restoration of fissured-surface defects to an expanded use of sealants for those with reduced decay and focus resources on a minority of the population with high caries levels who receive limited care."¹³

Soderholm made an interesting argument in his discussion on the epidemiology of dental caries and how this affects prevention: "When a high-risk patient is identified, auxiliary personnel could place sealants and recall the patient for a new visual inspection 6 months later. If caries is suspected at that time, the patient could be sent to a dentist for additional treatment. To offset the negative effects caused by overutilization of sealants, their usage should be divided into 2 categories. First, a preventive option should be available, and the fee for use of sealants in this option should be lower compared to the fees used today. By using specially trained auxiliary personnel to place such sealants, the fee could be kept reasonably low. Second, a sealant treatment option that targets treatment of incipient lesions also should be available. The fee for such a treatment should be close to that of the traditional occlusal restoration, and the application should be by a dentist. By using such a fee structure based on market forces, one would expect that sealant usage would increase among patients suffering from early carious lesions, while the usage of preventive sealants would remain the same or decline. This utilization pattern for dental sealants would contribute to improved efficiency of sealant usage in the treatment of dental caries, particularly at a time when caries frequency is declining. The improved efficiency could release dental care resources that should be used to target risk groups with improved education in dental health. By using such a strategy, the long-term effect would be not only the placement of fewer restorations, but an improvement in dental health among adolescents and adults."²⁰⁴

Chewing gum containing xylitol has been shown to prevent caries to a similar degree as sealant. Alanen et al, found that sealants and xylitol chewing gum are equal in caries prevention. After 5 years, no statistically significant differences between the sealant and xylitol groups were found.²⁰⁵

The use of combinations of preventive techniques, such as fluoride-containing varnishes, chewing gum containing xylitol or agents that stimulate remineralization of demineralized enamel and sealants, in a multipronged attack should be studied further.

Croll has developed perhaps the most innovative application of a pit and fissure sealant technique to date. He described a method of placing a reinforced resin-bonded sealant. He applies a dentinal bonding agent to etched enamel (or uses the new self-etching adhesives) and compresses a posterior composite into the fissures. "When the beneficial properties of resin-bonded sealants are combined with those of preventive resin restorations, the outcome is perhaps the 'quintessential sealant.'"²⁰⁶

Summary

This paper has reviewed the scientific literature under the following subheadings:

- laboratory studies;
- clinical technique and tooth preparation;
- etching time;
- auxiliary application of pit and fissure sealant;
- retention and caries prevention;
- fluoride used with sealants and fluoride-containing sealant;
- glass ionomer materials as sealants;
- options in sealant: filled vs unfilled; colored vs clear; autocure vs light-initiated;
- sealant placed over caries in a therapeutic manner;
- cost effectiveness of sealant application;
- underuse of pit and fissure sealant;
- the estrogenicity issue;
- use of an intermediate bonding layer to improve retention;
- new developments and projections;
- summary and conclusions.

Almost 1500 references involving pit and fissure sealant, or other ancillary techniques, were reviewed and the following conclusions can be drawn from the available scientific evidence. The etching agent of choice for pit and fissure sealant application is 35%-37% orthophosphoric acid. The clinical technique for pit and fissure sealant application involves strict attention to detail and perfect isolation for maintenance of a dry field. Dry brushing, rotary brushing with pumice paste, air polishing and air abrasion have all been used to clean the enamel surface prior to etching. Air polishing appears to offer the best surface preparation technique. Etching time has shortened over the years to 15 seconds for both permanent and primary enamel. Trained auxiliaries are equally competent at sealant application. Pit and fissure sealant is well documented in terms of retention and caries prevention.

Fluoride-containing sealants have not shown superiority to regular sealant. In regards to using sealant as one component in an intensive preventive program, one study found that basic prevention leads to virtually the same preventive effect as intensive prevention treatments, while another found that providing intensive prevention to high-risk populations was a benefit. Glass-ionomer sealants have failed miserably in comparison to resin-based sealants, showing very poor retention. The major benefit of resin sealants, that of excellent retention and thus physical blocking of the fissure system, appears much more important for caries prevention than the transient benefit of fluoride release over the short time glass-ionomer sealants are retained. Even though some claim remnants of the glass-ionomer sealant may inhibit caries for longer time periods, this does not compensate for the poor retentive properties of the material.

Unfilled sealants perform better than filled sealants. Colored or clear resin sealant is much a matter of personal preference. However, it has been shown that the ability to

assess retention properly in colored sealants is much less error prone than with clear sealants. Use of a color should not interfere with the potential for laser fluorescent diagnosis of caries under a sealant. This may eventually become a valuable adjunct procedure in the follow-up routine of sealants placed years earlier, and thus the opaque white sealant may not be ideal.²⁰¹

Autocured sealant appears to have equivalent documentation of performance compared to visible-light-cured sealant. The data is unequivocal that sealant can safely be placed over incipient caries and that the lesion will remain dormant as long as the sealant eliminates contact of the oral fluids (and thus the nutrient source) with the cariogenic bacteria. The claim from some advocates of aggressive invasive exploration of apparently caries-free or minimally carious fissures—that bacteria remaining viable within the confines of a sealed fissure can continue to produce acid from nutrients from the dentinal tubules—is unsubstantiated.

Pit and fissure sealant can be regarded as cost effective or not cost effective depending on the study design and results (primarily the retention of the sealant). It seems that even if the data show that sealant treatment is more costly than restoring surfaces that would have become carious in the absence of sealant, one must remember the intangible benefits of preventing disease and preventing loss of tooth structure. Application of sealant, from a maximally cost-effective view, is best applied to high-risk patients. While safe and effective and (according to some studies) cost-effective, sealants are an extremely underused preventive treatment. Various rationalizations have been proposed to explain the incongruity of the underuse of a known successful preventive treatment.

One study raised concern about the safety of monomers leaching out of one particular sealant. Other more recent studies have refuted this concern, and the present scientific position, as expressed by the American Dental Association, is that parental concern about the alleged estrogenicity of sealants is unfounded based on the presently available evidence. The use of an intermediate bonding layer, or the incorporation of the benefits of the advances of the past decade in dentin bonding agents into newly formulated pit-and-fissure sealants, is perhaps the most exciting new potential development for the future of pit-and-fissure sealant materials. The use of a caries-detecting laser fluorescence system as a routine baseline caries-assessment aid prior to sealant application, and more recently as a follow-up observation, deserves further study.

Pit and fissure sealant is best applied to high-risk populations by trained auxiliaries using sealant that incorporates the benefit of an intermediate bonding layer applied under the rubber dam or with some alternative short-term, but effective, isolation technique, onto an enamel surface that has been cleaned with an air-polishing technique and etched with 35% phosphoric acid for 15 seconds. The dental profession awaits with enthusiasm, and some impatience, the incorporation of dentin-bonding technology into the development of a modern, more durable, resin-based sealant.

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ABSTRACT OF THE SCIENTIFIC LITERATURE



PERIODONTOPATHIC BACTERIA IN CHILDREN OF DIFFERENT ETHNIC BACKGROUNDS

Several etiologic and facilitating factors are involved in the establishment of gingival and periodontal diseases, one of them being the ethnic origin. The purpose of this study was to determine: (1) the frequency of periodontopathic bacteria in the saliva of young individuals of different race/ethnicity; (2) the risk factors for periodontopathic bacteria salivary occurrence. One hundred fifty children and adolescents between the ages of 4 and 16 attending a children's dental center were included in the study. The findings of the study indicated that salivary occurrence of periodontopathic bacteria was related to the length of time the parents had lived in the United States, education level of the mother, length of time since the last dental visit and gender, but apparently not related to ethnicity per se.

Comments: Periodontopathic bacteria are transmissible among family members, and children seem to acquire them predominantly from their parents. Furthermore, they may eventually lead to periodontal diseases. Based on this study, the environmental factors may have a more definitive influence than genetic predisposition on the oral colonization by periodontal pathogens. These findings may lead to interesting methods for the prevention and modification of periodontal diseases. **EBG**

Address correspondence to Dr. Casey Chen, DEN 4335, USC School of Dentistry, Division of Primary Oral Health Care, Los Angeles, CA 90089 (email: ccchen@hsc.usc.edu).

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