

## **5 APPLICATION OF PIT AND FISSURE SEALANTS IN SCHOOL BASED PREVENTIVE PROGRAMS**

Fissure sealants play an important role in caries prevention because they can protect the caries susceptible surfaces that are least benefited by fluoride, namely the occlusal pits and fissures. The evolving sealant technology with newer materials and improved qualities can now be transferred from the research setting to the practice environment. A major effort should be made to incorporate the use of sealants along with other primary preventive dentistry procedures such as plaque control, fluoride therapy and dietary advice. In this chapter the practical implications of the application of fissure sealants and their use in school based programs will be considered in greater detail. The sealant materials commonly utilised are the adhesive resins - the Bis-GMA resin derivatives and thus discussion will only be confined to the use of these materials.

## **5.1 CRITERIA OF PATIENT SELECTION FOR OCCLUSAL SEALING**

The selection of teeth for treatment should be done on an individual basis and is determined by the following factors:

1. The caries susceptibility of the individual occlusal surfaces
2. The general caries activity in the mouth
3. The length of time the tooth has remained caries free
4. The patients total preventive regime (Ripa 1975)

### **1. The caries susceptibility of the individual occlusal surfaces**

Different teeth have different susceptibility to caries in the mouth. Permanent molars are more susceptible to occlusal caries than bicuspids; primary secondary molars are more susceptible than primary first molars.

A two year study has been done on the occlusal caries incidence of permanent premolars and molars in Rochester, New York. All selected teeth had been judged clinically sound. During the two years, there was a gradual increase in occlusal caries in the first premolars to 21 per cent, and second premolars to 31 per cent. The caries incidence of the molars had risen sharply, with caries in 75 per cent of first molars and 84 per cent in second molars (Ripa 1975).

A tooth with shallow, well-coalesced pits and fissures is less likely to develop caries than a tooth with narrow and deep retentive pits and fissure. This has been dealt with in greater detail in chapter 2. As such only surfaces which are highly susceptible are usually sealed.

An additional basis to be considered here is the pattern of caries attack in different tooth types in a patient. Initial caries attack commonly occurs on the occlusal surface and seldom on the proximal surface, at least not until some years later. In such cases fissure sealing is likely to be beneficial. But if caries in a particular tooth type occurs most frequently in a proximal surface, then there would be little point in sealing the occlusal surfaces of these teeth, as they would often need an occluso-proximal restoration anyway (Graves, Burt 1975).

## **2. The general caries activity in the mouth**

If a child has several occlusal carious lesions it is a good precaution to seal the other teeth. The dental literature indicates a generally positive, but weak relationship between primary tooth caries and future permanent tooth caries (Klein, Birnstein, Chosack 1985). Thus a complete dmfs index may strengthen the assessment of permanent tooth caries risk.

A sealant should be indicated for an intact occlusal surface where the contralateral tooth surface is carious or restored. This is because teeth on opposite sides of the mouth are usually equally prone to caries (Harris, Simonsen 1987).

If there are many interproximal cavities in a mouth, sealants should only be used on non-carious teeth, if additional efforts are made to prevent interproximal decay.

Thus the previous caries experience of an individual is the determining factor in the dentist's clinical decision to seal the as yet noncarious, newly erupting teeth (Ripa 1975).

Some investigators believe the presence of dental plaque to be related to future dental caries. The more the plaque the greater the propensity for caries activity (Ashley, Wilson 1977; Klock 1984).

When there is an incipient lesion in the pit and fissure, the decision to seal would be a matter of professional judgement. Many investigators had encountered difficulties in accurately deciding whether or not caries was present in a fissure, using visual and tactile methods. There was often a variation in diagnosis made by different examiners and by the same examiner. Application of sealants have been shown to arrest the caries process. A clinical study by Mertz-Fairhurst, Schuster, Fairhurst (1986), revealed sealants arrested caries with a high degree of efficacy, as neither lesion depth nor microbiological counts progress under intact sealant. Sealants used this way are really used as noninvasive restorative materials.

### **3. Age of the tooth since its eruption**

Recently erupted teeth, especially molars, should be sealed as soon as possible since these teeth are known to be susceptible to decay. The two to three years immediately following tooth eruption is the period of greatest vulnerability to pit and fissure decay. Thus, the earlier the sealant is applied, the greater the degree of protection provided (Disney, Bohannan 1984).

Swango and Brunnelle (1983) stated that sealants should be placed as early as possible on permanent first and second molars. For children at high risk for pit and fissure caries, it was suggested by Dennison, Straffon and More (1990) that occlusal sealants be placed on incompletely erupted teeth. The potential for early failure is realised but the authors feel that with consistent recall and appropriate retreatment the problem can be overcome. Children who have a lower risk factor can have sealant application delayed for 2 to 6 months until eruption is complete which is estimated to be 2 to 6 months. However, this can pose to be a problem in a school based setting.

The risk of caries peaks two to four years after eruption and then declines (Going 1984). Conversely, if a tooth has been in the mouth for four or more years and has not developed occlusal decay, the chances of it developing decay are minimal, unless the child suddenly and dramatically changes his dietary or other oral health habits. Such teeth need not be treated (Ripa 1975). Since the liability to decay decreases with age, the need for occlusal sealing should decrease. Ripa (1985) recommended that sealants be limited principally to first molars that have been erupted for less than four years.

Ripa, Leske and Varma (1988) conducted a longitudinal study of the caries susceptibility of occlusal and proximal surfaces of first permanent molars of schoolchildren who were 10 to 13 years old and were reexamined annually for three years. The caries experience of the first permanent molars was recorded for up to ten years after their eruption. They found that there was a relatively constant rate of attack in occlusal surfaces of first molars up to ten years after their eruption. They concluded that the time the teeth had been in the mouth, some for 7 to 10 years, had no effect on the vulnerability of occlusal caries attack. The authors felt that if these results are substantiated by others, the recommendation that sealant use be limited principally to first molars that have been erupted for less than four years should be abandoned.

#### **4. The patients total preventive regime**

Occlusal sealing is usually one of the components of a multiple caries preventive approach. The effectiveness of a sealant is greatly reduced if a sealed tooth develops a proximal cavity and has to be restored with an occluso-proximal restoration. Therefore, topical fluoride applications, use of fluoride dentifrices, proper oral hygiene procedures and proper diet are important measures which should be carried out in conjunction with the application of sealants. Occlusal sealing was not recommended if community water fluoridation or other systemic fluoride supplementation, or topical fluoride application was not available (Ripa 1975). Cons, Pollard, Leske (1976), showed the use of sealants increased the effectiveness of water fluoridation by an additional 20 per cent. Horowitz (1980), reviewed the economics of

sealants and concluded that fissure sealants had a worthwhile contribution to make when used as an integral part of a total preventive regime. The combined benefits of pit and fissure sealants and weekly mouthrinsing with 0.2 per cent sodium fluoride were assessed by Ripa, Leske and Forte (1986). They concluded that the benefits of sealing and mouthrinsing are additive and the addition of sealants to a mouthrinsing program increases the number of children who continue to be caries free. Ripa, Leske and Forte (1987) completed a 2 year study of children in second and third grades to assess the effectiveness of 0.2 per cent fluoride mouth rinse used alone, as compared to a rinse, plus sealants. Twenty four occlusal lesions developed in the 51 rinse subjects, and only three in the 84 subjects receiving the rinse plus sealants. The conclusion was that caries could be almost completely eliminated by the use of these two preventive procedures.

Whenever a sealant is placed, a topical application of fluoride should follow if at all possible. In this way the whole tooth can be protected. However, in many public health programs, it is not possible to institute full-scale prevention programs, either because of lack of time or money. In such cases, at least the most vulnerable of all tooth surfaces is being protected and as such sealants can be indicated (Harris, Simonsen 1987).

The British Paedodontic Society (1987) issued a policy document describing the clinical guidelines for the application of fissure sealants. It is described below in Table 7.

**Table 7: Clinical guidelines for the application of fissure sealants.**  
**Source: British Paedodontic Society (1987).**

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*Patient Selection*

- (a) Children with special needs. For children with special needs, for example, for those who are medically compromised, mentally or physically handicapped, or from a disadvantaged social background who might be at high risk from developing extensive dental caries, fissure sealing of all surfaces should be considered.
- (b) Children with extensive caries in their primary teeth should have all permanent first molars sealed.

*Tooth selection*

- (a) Fissure sealants have the greatest benefit on the occlusal surfaces of permanent molar teeth. The sealing of primary molars is not normally advised.
- (b) Sealant should be applied as soon as the selected tooth has erupted sufficiently to permit moisture control and certainly within 2 years of eruption.
- (c) Any child with occlusal caries in one permanent first molar should have the remaining sound permanent first molars fissure sealed.
- (d) Occlusal caries affecting one or more permanent first molars indicates a need to seal the permanent second molars as soon as they have erupted sufficiently.
- (e) Teeth to be sealed should be free of approximal caries.

*Clinical circumstances*

- (a) When there is doubt about the integrity of an occlusal surface on clinical examination, bitewing radiographs should be taken. If no sign of dentine involvement can be seen radiographically, the surface should be sealed as a preventive measure and kept under close radiographic and clinical review.
  - (b) If early dentine involvement is suspected, the fissure should be investigated using small burs and a minimal composite restoration placed incorporating a fissure sealant to protect the rest of the occlusal surface.
  - (c) If extensive caries is discovered on investigation, a standard dental restoration should be inserted.
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Once the concept is accepted that all children are potential candidates for sealants, the decision whether to seal is no longer made at the patient level but at the tooth level. Simonsen (1984) suggested using sealants in patients judged to be at moderate risk to caries but not in caries free patients judged to be at low risk, or in patients with rampant caries with many proximal lesions. The National Institute of Health Consensus Conference (1984) suggested a high caries risk patient as any child with three or more decayed surfaces on primary and permanent teeth.

Ripa (1985) described tooth-oriented criteria for the use of sealants. A summary of this diagnostic criteria is shown in Table 8. These criteria are based primarily upon a visual-tactile inspection of the pits and fissures of teeth whose proximal surfaces are sound and upon other considerations described below. After the teeth are carefully examined, the pit and fissures should be diagnosed as either carious, questionable or sound.

**Carious** - carious pits and fissures must not be sealed. Frank caries is easily recognised as a break in the surface continuity of the enamel, with softness and usually with discolouration

**Questionable** - these are when a definitive diagnosis cannot be made easily. The tine of the explorer may *stick* in the pit and fissure, but there may be no softness at the tip of the explorer and no zone of white enamel demineralisation around the entrance of the pits and

margins of the fissure. However, if the explorer *sticks* it is also an area of increased retention of food and bacteria and may be definitely considered an increased caries-susceptible site. Such sites are ideal for sealant placement in order to truly prevent caries initiation. In children the thought *wait and see* is no longer applicable (Ripa 1985).

Sound - these deep pits and fissures should be sealed in a true preventive sense.

**Table 8: Tooth-oriented indications and contraindications for the use of pit and fissure sealants.***Source: Ripa (1985)*

Surface Diagnosis	Clinical Considerations	Do Seal	Do Not Seal
Carious	occlusal anatomy	if pits or fissures are separated by transverse ridge, a sound pit or fissure may be sealed	carious pits or fissures
Questionable	status of proximal surface(s)	sound	carious
	general caries activity	many occlusal lesions; few proximal lesions	many proximal lesions
Sound	occlusal morphology	deep, narrow pits and fissures	broad well-coalesced pits and fissures
	tooth age	recently erupted teeth	teeth caries-free for four years or longer
	status of proximal surface(s)	sound	carious
	general caries activity	many occlusal lesions; few proximal lesions	many proximal lesions

Newbrun (1992) and Elderton (1993) also advocated similar guidelines among the current and prospective strategies of preventing dental caries through the application of fissure sealants.

Elderton (1993) advocated that if an active carious lesion has been classified as shallow (involving just the enamel or superficial dentine), then the entirely non-invasive procedure of applying fissure sealant as a therapeutic treatment

to arrest the caries is the most efficacious method of management. If the active lesion is judged to be deeper than the superficial dentine, then an invasive restorative treatment should be done. The restoration can be combined with fissure sealant to form a *sealant restoration* or sometimes referred to as *preventive resin restoration*.

One of the early reservations about sealant application was that one may accidentally place sealant material over an existing carious lesion. Handelman (1982) showed that carious lesions covered with a fissure sealant for 2 to 5 years yielded bacterial cultures that were almost completely negative. Mertz-Fairhurst et al.(1986) have further demonstrated clinically in contralateral pairs of teeth with occlusal carious lesions that the sealed teeth were essentially bacteriologically inactive compared to the unsealed control carious lesions. Microbiological examination and culture of the residual carious material suggested a complete cessation of the carious process.

However dental school clinics customarily teach the policy of not sealing carious lesions. However, in dental practice very small incipient carious lesions may be sealed to arrest the carious progress, provided the patients are recalled at regular, 6 months intervals to assess retention.

## **5.2 METHOD OF APPLICATION**

The technique of sealant application is simple but one needs to pay meticulous attention to each of the steps involved for optimal success. Certain steps are more critical than others. Basic clinical methods for the use of conventional pit and fissure sealants have been consistent with only minor useful suggestions by different investigators.

The stepwise application of pit and fissure sealants may be described as follows:

1. Prophylaxis
2. Isolation and drying of the teeth
3. Acid etching of the surface
4. Washing and drying
5. Sealant placement
6. Final adjustment

### **1. Prophylaxis**

It has been shown that maximum bond strengths are obtained only when a prophylaxis is given prior to acid etching of teeth (Hardison 1983). The enamel surface is cleaned of cuticular deposits, plaque and food debris. This is usually done by means of using a prophylactic paste. The prophylactic paste advocated is a fluoride-free, oil-free pumice slurry to avoid contamination of the tooth surface. This can be applied with a rubber cup or brush using a slow speed handpiece. Both have been shown to be equally effective in

cleaning the fissured site (Taylor, Gwinnett 1973). Flavoured, oil- or glycerine-based, or fluoride-containing prophylaxis pastes have not been recommended since they adversely influence the etching of the enamel. The tooth is then thoroughly rinsed with an air-water spray, using the explorer tine to gently dislodge particles of the prophylaxis paste from the immediate orifice of the pits and fissures.

Miura, Nakagawa, Ishizaki (1973) demonstrated that a dental prophylaxis is important to achieve maximum bond strength between resin and enamel. Acid conditioning without a prophylaxis can result in only isolated areas of enamel etching. Relatively smooth enamel integument with occasional microorganisms, appears unaffected by acid action and subsequent application of resin to these surfaces may result in areas of smoothness on the fitting surface and only localised resin penetration.

## **2. Isolation and drying of the teeth**

This procedure is of extreme importance and is probably the most critical step with regard to the success or failure of the sealant. A dry field can be maintained in several ways. Rubber dam is the most effective means and its use is highly desirable but not absolutely essential. Other devices which can be used include cotton rolls, absorbent shields and saliva evacuators, the placement of bibulous pads over the opening of the parotid duct and saliva evacuators, can be used successfully. In one study in which retention was tested using a rubber dam versus cotton rolls, the sealant retention was approximately equal (Straffon, More, Dennison 1984). Under routine operating

conditions, cotton rolls with the use of high speed aspiration can provide a dry field. Another promising dry field isolating device that can be used for single operator operation, especially when used with cotton rolls, is the VAC ejector moisture control system by Whaledent International, New York. The major disadvantage of cotton rolls and other absorbers is that they may require frequent changing. The tooth surface should be thoroughly dried with warm, dry, oil-free air for approximately 10 seconds.

### **3. Acid etching of the surface**

Phosphoric acid in the range of 30 to 50 per cent, in either gel or solution form is used in all commercially available systems. It is applied using a small sponge, cotton pellet or a brush. The tooth enamel is etched for 60 seconds for permanent teeth and 90 seconds for deciduous teeth to ensure circulation of fresh acid to the enamel surface at all times, fresh acid should be continuously dabbed on the surfaces to be etched not rubbed. Care must be taken as the etching time progresses, to treat the surfaces gently and not to rub the cotton pellet or sponge on the surface during acid application, as this may damage the fragile enamel lattice work being formed (Gwinnett 1981; Nikiforuk 1985).

Gouley (1974) recommended an etching time up to 2 minutes in a fluoridated water community. Primary teeth are also etched for 2 minutes. Ripa (1982) reviewed the literature and concluded that primary molars do not need more than the recommended 60 seconds etching time and that primary molars should be sealed using criteria similar to those for permanent tooth selection.

#### **4. Washing and drying**

The acid is removed by rinsing with a continuous jet of water for 30 seconds, especially for the gel etchant. This is important because inadequate removal of reaction products from acid etching will significantly reduce the sealant retention. After washing the etched surface is dried thoroughly with a jet of oil-free air for 10 seconds.

If a rubber dam is not used, care should be taken to avoid saliva contamination from drenched cotton rolls and saliva which could contaminate the etched surface. At this stage it is essential that no saliva be allowed to contaminate the etched-enamel surface. If saliva comes into contact with the etched-enamel surface, a poor bond or no bond at all, will result. If the etched surface becomes contaminated with saliva, much of the etched surface becomes occluded with a biofilm. Gwinnett and Ripa (1982) found potassium and chloride in the elemental analysis of a sealant in their study due to contamination of saliva. The wetting characteristics of enamel with respect to the resin are drastically changed and the appearance of the fitting surface appears smooth. If this occurs, the clinical procedure should be stopped and the etching phase repeated in its entirety, prior to any attempt at bonding a resin material. The etched enamel surface will take on a frosted white appearance.

## 5. Sealant placement

The sealant material should be applied to the etched surface with a fine brush, a mini sponge or an applicator provided by the manufacturer and it should be allowed to flow in over the prepared surface. Place an adequate amount of sealant to cover all the fissures on the occlusal surface. A thin layer should be carried up buccal and lingual inclines of the occlusal surface in order to seal supplementary fissures. There should be sufficient bulk of material to accommodate loss from abrasion associated with intercuspation of the opposing tooth.

Dennison, Straffon and More (1983) studied the relation of material thickness and retreatment. The sealant thickness was divided into three categories. The thinnest sealants required 50 per cent retreatment after 18 months, whilst thicker coatings required 23 per cent and 30 per cent retreatment respectively depending on their relative thickness.

With light cured sealants curing is initiated by exposing the sealant to visible light or U-V light for 20-30 seconds. With chemical cured sealants, working time varies from 1-2 minutes and it takes 3 to 5 minutes for polymerisation.

There is likely to be an *air-inhibited* sticky layer on the surface of the polymerised sealant. This sticky layer is sometimes diagnosed incorrectly as incomplete polymerisation of the sealant. It can be wiped off with a cotton pellet. This is the unreacted monomer.

## **6. Final adjustments**

An attempt should be made by the operator to dislodge the sealant with the tip of an explorer. If the sealant is properly placed it will not dislodge. If it does, the whole procedure should be repeated again without omitting any steps.

The surface is also explored for exposed pits and fissures and voids in the material. If necessary, apply additional sealant material without the need for any additional etching. Gross excess of sealant has to be removed using a round carbide or diamond bur but small discrepancies in occlusal interference especially of unfilled resin will wear off the teeth (Hicks 1988). This is very important for the comfort of the patient, and if not corrected, may interfere with the long-term prognosis of the sealant's retention.

### **Recall**

Sealants should be checked at every recall visit. Consequently, the opaque sealants offer an advantage in checking their retention. If sealants are found to be partially lost, they should be reapplied.

Silverstone (1975) has shown that with early loss of sealants, the remaining enamel surface is less soluble than adjacent sound enamel to the acids in the mouth. This is due to the retention of tags of sealant which have penetrated deep into the enamel surface. However, in a large number of clinical studies, a large number of treated surfaces losing sealant have become carious. This is due to the multifactorial nature of dental caries and other predisposing

factors. Thus it is prudent to reexamine sealed teeth every 6 months or a year, for early detection of sealant loss. This, however, does not suggest that loss of sealant predisposes the uncovered surface because it is at no greater risk of carious attack than its contralateral control surface.

Straffon and Dennison (1988) did a study on sealant loss and retreatment at regular intervals of 6 months for 7 years, on children between the ages of 6 and 8 years, in an undergraduate paedodontic clinic. The highest period of sealant loss and of greatest retreatment was at 6 months. This high early failure rate indicates a potential isolation problem with probable contamination of the application site after the enamel was etched. It therefore, appears critical to evaluate and maintain an isolated operating field and to emphasise early patient recall to retreat potential failures.

Gwinnett and Ripa (1982) examined the fitting surface of failed sealants recovered immediately after placement, and 14 of which had failed after several months in the mouth by scanning electron microscopy. Large areas of the fitting surfaces were smooth, with only localised regions showing evidence of contact with etched enamel. Those fitted surfaces exposed to the oral environment showed structures resembling microorganisms. These observations strongly suggest:

1. contamination of etched enamel surfaces after etching but prior to sealant application or
2. inadequate dental prophylaxis prior to etching the enamel surface

They emphasised the importance of proper isolation methods and careful technique of application.

### **5.3 PERSONNEL INVOLVED IN SEALANT APPLICATION**

In a dental office sealant application is usually done by the dentist. However, the application of sealants is one dental service which many investigators feel can be delegated to adequately trained dental auxiliaries. The meticulous technique necessary is perhaps a disadvantage, but the skill level is not unusually high and all members of the dental team including dentists, hygienists or assistants can be trained to apply fissure sealants.

Leake and Martinello (1976) assessed the ability of 2 teams - one led by a dentist, the other by a dental hygienist - to apply sealants. Both teams had a 2-day orientation and technique course on the use of the materials. Application was performed on the first permanent molars of Canadian school children. Of 376 teeth treated by the hygienist/assistant team and available for recall after four years, 89 per cent had lost all sealant while only 9 per cent were completely covered. Of 464 teeth treated by the dentist/assistant team, 69 per cent had lost all sealant while 29 per cent remained completely covered. The investigators could not account for the marked difference in sealant retention achieved by the two teams. Nevertheless, Leake and Martinello (1976) concluded that with a longer training program, more experience and greater care the success achieved in sealant application by hygienists should approach that achieved by dentists.

The results of Leske, Pollard and Cons (1976) support the conclusion that the level of clinical experience of the operator can influence the outcome. Three years after sealant application, the team led by the hygienist with five years of clinical experience produced the highest percentage, 43 per cent of completely covered teeth; the teams led by the recent dental graduates produced retention levels of 32 and 27 per cent, while the team led by the hygienist with the least clinical experience had a retention rate of 25 per cent. It was felt that the clinical experience of the first hygienist, in both intraoral procedures and patient management techniques, constituted an important factor for the successful accomplishment of a technique whose application is extremely critical.

In a public health program, delegation to dental auxiliaries is desirable for cost effectiveness and to provide maximum delivery of dental services. This will be further discussed in the review of some school based sealant programs later in this chapter.

#### **5.4 COST ANALYSIS**

The cost associated with sealant application is principally related to the salary of the individual performing the treatment, supplies, equipment and so on. It increases directly with the level of professional education of the operator. Dental hygienists, assistants and trained auxiliaries can be used to place sealants.

Cost effectiveness analysis involves a series of analytical and mathematical procedures to aid in the selection of the most effective method from among various alternative approaches. This process involves not only dollars but subjective judgements as to the quality of the result. The objective is not necessarily to select the least costly method of rendering a service, but to select that method which is optimal in terms of attaining its goal without undue cost (Dunning 1986).

Haupt and Shey (1983) outlined six variables that should be examined to determine the cost effectiveness of pit and fissure sealants. These include:

1. Caries prevalence
2. Longevity of material
3. Number of teeth being sealed
4. Time for the procedure
5. Type of operator
6. Equipment cost

Few attempts have been made to assess cost effectiveness. Horowitz (1980) reported on a program in which approximately 100,000 teeth had been treated with only five per cent loss at six months. The cost of placing each caries-inhibiting sealant was estimated as \$12.25, this sum approaching that of a single restoration and is performed by a dentist.

Simonsen (1989) calculated a basic cost comparison for two matched pair groups under the assumption that they were a representative sample of the original group of 200 patients between the ages of 5 and 15 years, who received pits and fissure sealants in Bloomington, Minnesota, a fluoridated area, in 1976. At the 10 year recall, 12 of the original complete pairs were available for analysis. Each patient had all four first permanent molars sealed in one appointment. He calculated that the individual cost per child per year for sealing and resealing missing sealant was \$11.22. The cost to restore the carious surface in the unsealed group was \$17.67 per child per year. These costs were calculated with the assumption that the application is done by a dentist not an auxiliary. Thus, the cost of applying a single application of pit and fissure sealant to a group of children and reapplying sealant one time to all missing areas that occurred over a 10 year period is approximately two thirds (0.63) the cost of treating the caries that occurred in the matched group of unsealed children over the same 10 year period.

Another example of cost effectiveness analysis was done by Calderone and Mueller (1983). In the 1981-82 school year, five dental hygienists and dental assistant teams applied sealants in 24 New Mexico communities in America. This program cost \$24,235.26 with proper allowance for salaries, travel, maintenance, amortised equipment and supplies. The cost per child was \$7.41 and the cost per tooth was \$1.59. Hardison (1983) reported the direct cost for a one-time sealant application in a community health program in Tennessee at \$1.20 per tooth and \$8.02 per child. Sealant costs in these two programs were comparable and contained evidence of being cost effective.

The cost of providing sealants in the first year of the National Preventive Dentistry Demonstration Project in the United States of America was \$22.82 per child per year. It costs about \$8 to \$9 to seal a tooth and maintain that seal per year (Klein, Bohannan, Bell, Disney, Foch, Graves 1985). One reason for the inflated sealant costs was that they were applied indiscriminately to all sound posterior teeth.

The cost benefit ratio is expressed in monetary units and takes the form of a ratio obtained by dividing the benefit by the cost of achieving it.

The formula is as follows:

$$\text{Cost benefit ratio} = \frac{(\text{cost of care without program}) - (\text{cost of care with program})}{(\text{cost of program})}$$

Any ratio larger than 1 indicates that the program will at least pay its own way, while any program with a ratio less than 1 will lose money. No such number

can be accepted without estimating intangibles (Dunning 1986). The intangible benefits to the dental health of the individual which is achieved by keeping the occlusal surface caries-free is overlooked in such considerations. In addition, it is assumed that a cariously involved tooth can be restored and that the restoration requires no maintenance. In reality, some teeth may be so cariously involved that extraction may be necessary, and even if an amalgam restoration can be placed its serviceability is often limited to about 5 years (Elderton 1983).

### **Sealant versus amalgams**

This is not an equitable comparison since sealants are used to prevent occlusal lesions, and amalgam is used to treat occlusal lesions that could have been prevented. However, it is necessary, as one of the major obstacles to more extensive use of sealants has been the belief that amalgams, and not sealants are a permanent restoration and they can be placed in less time.

Straffon and Dennison (1988) showed that the average cumulative time required to place and maintain a sealant for 7 years was 10 minutes and 45 seconds; an amalgam restoration required 14 minutes and 26 seconds.

Dennison and Straffon (1981) compared the lifespan of sealant and amalgam and the time for initial material application and maintenance. After four years of investigation, the reported sealants took 29 per cent less time and were 100 per cent effective.

Many studies have also been accomplished to determine the longevity of an amalgam restoration. Clinical studies assessing the longevity of amalgam restorations have found only 47 per cent of the restorations to be acceptable after a 5 year period in adults (Hamilton, Moffa, Ellison 1981). Elderton (1983) found that for routine amalgam and synthetic restoration placed in adults, the median survival time was 51 months. With children, the median survival time for amalgam restorations prior to replacement is dependent upon the age of the child at the time the restoration was placed (Walls, Wallwork, Holland, Murray 1985). The 5 year survival rate for occlusal amalgam restorations prior to replacement has been shown to be 30 per cent for children 5-7 years of age, 43 per cent for children 7-9 years of age, 61 per cent for children 9-11 years of age, and 63 per cent for adolescents 11-15 years of age.

This is comparable to the sealant retention rates after 5 years as shown in Table 5 in Chapter 3. The sealant retention ranges from 67 per cent to 19 per cent. The major difference between the two is that with sealant placement a preventive technique has been utilised, whereas amalgam placement represents a restorative technique in which tooth structure is lost. In fact, it has been shown that with replacement of a defective amalgam restoration, the periphery of the cavity preparation increases by 38 per cent, resulting in even greater loss of tooth structure (Elderton 1976). With sealant loss, reapplication of sealant material may be accomplished allowing for continued caries protection and maintenance of an intact tooth.

Even if longevity merits were equal, the sealant has the advantage of being painless to apply, aesthetic, as well as emphasising the highest objective of the dental profession, namely prevention.

Public health programs are supported by public funds and must be used to the best advantage of the people served. The value of a successful sealant should not be costed in terms of clinical time and material alone, since the technique is atraumatic and presents the young patient with a painless procedure free from local anaesthesia and the use of terrifying high speed equipment. Furthermore, no tooth damage occurs and even if the sealant should fail, its replacement is rapidly achieved without further tissue destruction. Furthermore, a better aesthetic appearance, the self-esteem of having a caries-free mouth and maintenance of an intact tooth surface are additional benefits to be considered, both by the dentist and patient.

Ripa (1985) suggested the following guidelines which would reduce the cost of sealant application. They are:

1. Delegating sealant treatment to auxiliary personnel where legally permitted
2. Selecting commercial products that have the most favourable retention rates and using only American Dental Association accepted products
3. Following meticulous application procedure in order to maximise the longevity of the sealants and minimise the number of reapplications

## **5.5 REVIEW OF SOME SCHOOL BASED SEALANT PREVENTIVE PROGRAMS**

Fissure sealants have been advocated in public health programs and they have been utilised in some school based dental programs. Some of these school based programs have been selected from the literature for discussion.

The number of children eligible for sealants is greater in school based programs than in community health centres. Advantages of a school based pit and fissure sealant program include:

1. Accessibility to eligible sealant applicants
2. Integration with and reinforcement of dental health education
3. Introduction of dental health care to children in a friendly non-threatening way

Furthermore, school based sealant programs may increase the oral health status of the community and decrease the school absenteeism due to dental problems (McCormack-Brown, Clark, McDermott 1989).

### **The New Mexico Sealant Program**

This fissure sealant application program for New Mexico school children in America was started in September 1979. The aim of this service project was to replace the school based dental treatment services that had begun in 1954. In 1978, seven dentists were employed full time to deliver basic restorative dental services to New Mexico school children in underserved areas of the state. With the inception of the sealant activity, the treatment activity was slowly phased out by December 1985, six years later (Calderone, Davis 1987).

The **targeting mechanisms** of the program are as follows:

1. Limiting sealant program participation to schools that serve areas with at least optimal levels of fluoride, or that participate in a school based mouth-rinse program
2. Offering sealants only to children in the second or sixth grades in the selected schools. It was found that too many of the permanent posterior teeth were unerupted or partially erupted for first or fifth grade students.
3. Sealing only permanent posterior teeth without tissue tags, caries or restorations
4. Sealing bicuspid teeth only in conjunction with permanent molar teeth

### **Methods and Materials**

Sealants are applied in the schools, using portable dental equipment. They are applied to erupted permanent posterior teeth, according to written protocols and procedures by the Dental Health Program dentists, by dental

hygienists under general supervision. The staff uses a four-handed, half-mouth technique, in which the right side or left side of the student's mouth is isolated for the sealant application procedure (Calderone, Davis 1987). In addition this program is combined with a fluoride mouth rinse program or an adequate level of fluoride in the drinking water of the participants. The sealant material utilised is Delton (Johnson & Johnson) throughout the program.

## **Results**

In the second year of the sealant activity, retention rates have been calculated each year by each person applying sealants for the students who had received sealants the previous year. Artificial light, mouth mirror, and explorer are used to examine the occlusal surfaces of erupted permanent posterior teeth.

Recordings are made for:

1. Retained sealant - when the occlusal surface is completely covered with sealant
2. *Partially lost* - when only a portion of the occlusal surface is covered with sealant
3. *Lost sealant* - when there is no sign of previously applied sealant

Recordings for decayed and filled teeth are also made. Decay is recorded if a sharp explorer can penetrate through an occlusal pit or fissure with a feeling of softness at the base. If there is doubt as to the penetration and softness, the tooth is not recorded as being decayed, but rather recorded as needing a new sealant and would, therefore be sealed. Since this program is a service program, not a clinical trial, no attempt is made to calibrate the examiners in the application of the criteria, particularly the criterion for occlusal caries.

The occlusal surfaces of all erupted permanent posterior teeth are examined and recorded each year that a student participates. In this way, a record of decayed, missing and filled (DMF) occlusal surfaces is maintained for each participant. The data is surface- and tooth-specific.

The sixth grade children in 1984-85 and continuing each subsequent year were divided into two groups:

Group A - sixth grade participants who had received sealants in the first, second, or third grade as previous participants in the sealant program.

Group B - sixth grade participants who had never before participated in the sealant program, and therefore had never before received sealants.

Both groups of sixth grade students were receiving some fluoride benefit from either fluoridated water or fluoride mouthrinsing programs. The data collected for the 1984-85 school year and 1985-86 school year is illustrated below in Table 9.

**Table 9: Comparison of occlusal surfaces of first permanent molars in sixth grade children**  
**a 1984-1985**  
**b 1985-1986**  
**Source: Calderone and Davis (1987)**

Year a.1984-85		Number (Per cent) of Occlusal Surfaces			
Total	Decayed (D)	Missing (M)	Filled (F)	Total DMF	
Group A*	1,767	22 (1.2)	0 (0.0)	86 (4.9)	108 (6.1)
Group B†	7,497	318 (4.3)	35 (0.5)	2,270 (30.3)	2,623 (35.0)

  

Year b.1985-86		Number (Per cent) of Occlusal Surfaces			
Total	Decayed (D)	Missing (M)	Filled (F)	Total DMF	
Group A*	2,019	16 (0.8)	3 (0.2)	94 (4.7)	113 (5.6)
Group B†	12,633	416 (3.3)	61 (0.5)	2,914 (23.1)	3,391 (26.9)

\*Had teeth sealed in first, second or third grade

†Teeth never before sealed

In 1984-85, the DMF rate for the occlusal surfaces of first permanent molars was 6.1 per cent of occlusal surfaces previously sealed, 35 per cent of occlusal surfaces not previously sealed. In 1985-86, the comparable DMF rates were 5.6 per cent and 26.9 per cent.

The combined complete and partial retention rate for sealants six years after placement was 77.82 per cent. The five-year combined retention rate was 89.16 per cent. The one year combined retention rate was 96.5 per cent. There was an increase of over 10 per cent in retention rates from 1979-80 to 1980-81 when there was a change from a two-handed to a four-handed application, refinement of the technique and the acquired skills of the operators (Calderone, Davis 1987).

**Costs**

The cost per child was \$7.41 and the cost per tooth was \$1.59 (Calderone, Mueller 1983). The average time for sealant application was nine minutes, 25 seconds. A savings of 20 per 100 teeth was found (Calderone, Davis 1987).

**Conclusion**

The author proposed the following as a result of analysis of program data:

1. The prevalence of decay on the occlusal surfaces of the first permanent molar teeth in sixth grade students who had sealants placed in the first, second or third grade was five fold less than that of sixth grade restoration recipients who did not have sealants placed. A savings of 20 per 100 teeth was found
2. Sealants can be applied effectively in a school setting, using portable dental equipment

Based on the results provided, pit and fissure sealants have been shown to be an effective adjunct to other ongoing decay-preventive procedures and should be included in the preventive public health programs.

### **The Saskatchewan Health Dental Plan**

The Saskatchewan Health Dental Plan in Canada is a publicly funded program, providing diagnostic, preventive and treatment services to children aged five to sixteen throughout Saskatchewan. Children aged five to thirteen receive their dental care from operating dental auxiliaries and their dental assistants working in school clinics. Most older children receive their care in private offices. Pit and fissure sealants were adopted in the program in 1981 with the aim of reducing the number of one surface restorations placed on permanent molar teeth (Lewis 1985).

The **target guidelines** for the program are as follows:

Sealants were to be placed on:

1. Permanent teeth only
2. Teeth on *watch* because of potentially carious pits and fissures that would become carious within a year. Teeth which although not frankly carious would otherwise have had the pits and/or fissures restored with amalgam.

Sealants were not to be placed on:

1. Deciduous teeth
2. Sound teeth with *shallow* occlusal surfaces, or on teeth that had been erupted for over three years
3. Frankly carious teeth having a lesion with a soft floor and/or undermined enamelled walls
4. Teeth that were likely to need restoration interproximally within the next year (Lewis 1985; Whyte, Leake, Howley 1987; Ismail, King, Clark 1989).

## **Methods and Materials**

Sealants were applied in school dental clinics. These consist of a basic one-chair dental operatory for the dental therapist. The two person team works under indirect supervision of a dentist. The material used was Delton (Johnson & Johnson), a chemically polymerised fissure sealant. The sealants were placed without rubber dam. The expanded duty auxiliaries had been formally trained in restorative, surgical and preventive services.

## **Results**

There was a 19.6 per cent reduction in one surface amalgam restorations over the three years (Lewis 1985). Caries prevalence (deft + DMFT) declined 45 per cent from 6.55 in 1973 to 3.63 in 1984 and the proportion of decayed teeth in the index declined from 0.76 to 0.37 (Disney 1985).

## **Costs**

A single visit cost is made by estimating only dental therapist and assistant costs. An estimate of 24 minutes treatment time per child represents a period equal to sealing two quadrants. The estimated cost per visit was C\$13 and for 2 visits per year C\$25.98. These figures do not include the capital and dentist supervision costs (Disney 1985).

## **Conclusion**

There was a major improvement in dental health among school age children, over a ten year period the proportion of met treatment needs had doubled and the cumulative disease experience had declined by half in six year olds (Disney 1985).

Whyte, Leake and Howley (1987) did a two-year follow up of the 11,000 sealants in first permanent molars and reported the following:

1. The overall clinical success rate, which included the sound plus resealed teeth after one year was 98.7 per cent, and after 2 years 97 per cent
2. Sixty eight per cent of the resealings were provided in the first year, a finding possibly related to isolation problems in younger age groups
3. 8.4 per cent of maxillary teeth compared to 5.1 per cent mandibular molars required resealing one or more times. However the clinical success rate was the same in both arches; 97 per cent.
4. Differences in the rate of resealing are apparent among age groups. Among five-, six-, and seven-year olds, an average of 6.2 per cent received resealings; among 8- to 15-year olds, 3.3 per cent.
5. The overall success rate (sound plus resealed) ranged from 95.9 per cent in the high caries group (deft - DMFT score >8) to 97.8 per cent in the low caries group (deft - DMFT = 0 - 2).
6. A significantly lower rate of success was shown in the children with high initial caries rates. However, the difference in the rate of success between the high and low caries groups was only 1.9 per cent.

Ismail, King and Clark (1989) also evaluated the Saskatchewan sealant program through a longitudinal study and came to the conclusions below:

1. About 79 per cent of the sealants were retained three years after application. Sealed teeth experienced 46 per cent less caries than unsealed teeth four years after the application of sealants
2. Sealants saved 10.4 teeth per 100 permanent teeth from becoming either decayed or filled within a period of four years. The placement of fissure sealants has contributed to a 20-30 per cent decline in the number of one surface amalgam restorations placed in children. The lower estimated number of saved teeth compared to the New Mexico plan of 20 teeth per 100 permanent teeth may have resulted from the higher prevalence of dental caries on occlusal and smooth surfaces in Saskatchewan children

**Clinic based sealant program - Guam**

The children in Guam, a fluoride-deficient island, had a high caries prevalence. The DMFS scores in children aged six through 14 were 5.35. In 1976 a school based fluoride mouthrinse program was initiated involving children in grades kindergarten through eight in weekly rinses with 0.2 per cent neutral sodium fluoride. A clinic based sealant program was added in 1984 to the fluoride mouthrinse program. Community water fluoridation was not established until 1986 (Sterrit, Frew 1988).

**Criteria of patient selection**

All permanent molars and pit and fissure sites were sealed, except those that were:

1. Restored
2. Carious with undermining of enamel adjacent to the site

The pit and fissure sites included lingual pits of maxillary incisors and occlusal surfaces of bicuspid. Incipient and frank lesions were also sealed on permanent teeth because of the parental apathy towards their children's care and the high prevalence of extraction and endodontic treatment needs among school-aged children.

Occlusal surfaces of bicuspid teeth were sealed when they were in the same quadrant as a permanent molar selected for sealant treatment. Teeth with partially lost sealant were routinely resealed during the annual clinic visits.

**Methods and materials**

Children in grades one through eight were bussed to one of two public health dental clinics. Two dentists assisted and supervised 17 expanded function dental auxiliaries in the provision of the preventive services. At the start of the program, Delton Clear Sealant (Johnson & Johnson) was used, but was substituted by Delton Tinted (Johnson & Johnson) for ease of detection of the sealant at follow-up examinations.

The evaluation of the Guam sealant program was done in a sequential cross-sectional comparison by Sterrit and Frew (1988). Mean DMFS scores for children were determined in 1984 at the initiation of sealant treatments and compared to scores for similar aged children obtained from a follow-up survey completed two years later. Ages of the children in the studies ranged from 6 to 14 years.

**Results**

Retention rates for sealants at the first year follow up were 94 per cent overall. After 2 years of the sealant program for children, the 1986 survey results confirmed the program's effectiveness. Total DMF surface scores declined by 2.43 DMF surfaces per child from 5.35 DMFS to 2.92 DMFS. Thus the DMFS scores decreased 45 per cent and the entire reduction in DMFS scores occurred on pitted and grooved surfaces.

**Conclusions**

Another analysis of the data to evaluate both the fluoride mouthrinse program of 8 years duration and the 2 year combination of fluoride mouthrinsing and pit and fissure sealant application was done by Sterritt, Frew, Rozier, Brunelle (1990).

Overall DMFS counts declined after 8 years of fluoride mouthrinsing and after an additional 2 year of the combination program with sealant application and fluoride mouthrinsing. Overall DMFS declined from 7.06 at baseline to 5.27 in 1984 and 2.93 in 1986. Table 10 displays actual and percentage differences in DMFS scores per child according to age and interventions. Except for 12 year olds, reductions were greater after just 2 years of fluoride mouthrinsing plus sealants than in the previous 8 years of fluoride mouthrinsing alone (1976-1984). After fluoride mouthrinsing alone overall mean DMFS per child was 1.79 surfaces lower compared to baseline, or 0.22 DMFS per year, while after fluoride mouthrinsing with sealants overall mean scores were 2.34 lower, or 1.17 DMFS per child per year. This annual reduction was more than 5 times greater than that with fluoride mouthrinsing alone.

**Table 10: Actual and percentage differences in DMFS scores according to age and year intervals.**

**Source: Sterrit, Frew, Rozier, Brunelle (1990)**

Age	FMR years 1976 to 1984		FMR + S years 1984 to 1986		All years 1976 to 1986	
	Actual	%	Actual	%	Actual	%
6	0.03	2.9	0.62	62.6	0.65	63.7
7	0.45	2.1	1.33	76.9	1.78	81.7
8	1.01	27.3	2.06	76.6	3.07	83.0
9	0.93	18.1	3.01	71.3	3.94	76.5
10	1.87	29.8	2.39	54.3	4.26	68.0
11	2.20	29.7	1.72	33.1	3.92	53.0
12	4.64	40.3	2.90	42.1	7.55	65.4
13	1.36	13.1	3.18	35.2	4.54	43.7
14	3.20	22.9	3.89	36.2	7.09	50.8
Total	1.79	25.4	2.34	44.4	4.13	58.5

FMR - fluoride mouth-rinsing

S - sealant application

The authors felt that a change in program emphasis from one of treatment to prevention has been shown to be effective in reducing dental decay. Most importantly, instead of treatment to a small number of children each year virtually the entire population of children in grades kindergarten through eight were provided with sealant applications and topical fluorides.

No cost analysis of the program is given by the authors.

### **The National Preventive Dentistry Demonstration Program**

The National Preventive Dentistry Demonstration Program (NPDDP) was conducted in five fluoridated and five nonfluoridated sites in the United States of America. Each school was classified to one of five preventive regimens or the sixth *control* regimen (Weintraub 1989). These regimens are shown in Table 11. Children in the *comprehensive* and *clinic* regimens received sealants and prophylaxis/fluoride gel at both the fluoridated and non fluoridated sites, whereas children in the *modified comprehensive* regimen received sealants only at the fluoridated sites. Two longitudinal cohorts were followed, one cohort of children initially in Grades 1 or 2, the other of children initially in Grade 5. The DMFS increments after four years by surface type are represented in Table 12. The regimens that included sealants all showed significant favourable differences in occlusal DMFS increments compared to controls and all showed smaller absolute increments than those obtained in non-sealant regimens (Klein, Bohannon, Bell, Disney, Foch, Graves 1985; Weintraub 1989).

**Table 11: The NPDDP - Assignment of treatment procedures to regimens at nonfluoridated and fluoridated sites.**  
**Source: Weintraub (1989)**

Regimen	Nonfluoridated Sites		Fluoridated Sites	
	Clinic	Classroom	Clinic	Classroom
Comprehensive	Sealants, prophylaxis/gel	Rinse/tablet, education	Sealants, prophylaxis/gel	Rinse, education
Modified comprehensive	Prophylaxis/gel	Rinse/tablet, education	Sealants	Rinse, education
Clinic	Sealants, prophylaxis/gel		Sealants, prophylaxis/gel	
Classroom		Rinse/tablet, education		Rinse, education
Modified classroom		Education		Education
Longitudinal comparison				

**Table 12: The NPDDP - Mean four-year clinical DMFS increments on occlusal surface by regimen, cohort and fluoridation status.**  
**Source: Weintraub (1989)**

Procedure	Nonfluoridated		Fluoridated	
	Cohort 1 + 2	Cohort 5	Cohort 1 + 2	Cohort 5
Comprehensive	0.48	1.01	0.39	0.38
Modified comprehensive	1.31	2.15	0.46	0.70
Clinic	0.64	1.06	0.47	0.51
Classroom	1.32	2.77	1.31	2.21
Education	1.62	2.84	1.49	2.23
Control	1.73	2.61	1.32	2.04

Cohort 1+2 - children in grades 1 and 2

Cohort 5 - children in grade 5

Among the regimens that included sealants in fluoridated and nonfluoridated sites, the fluoridated areas showed smaller DMFS increments. All the regimens with sealants included some form of fluoride treatment. The children received a fluoride gel and/or fluoride mouthrinse in both fluoridated and nonfluoridated areas. Although the comprehensive regimen resulted in the smallest increments, there was little absolute difference in occlusal increment with or without the classroom procedures, namely, education and fluoride mouthrinse, if the clinic procedures, namely sealants, prophy/gel were included (Klein et al. 1985; Weintraub 1989).

### **Costs**

The annual average cost of maintaining a child in a sealant or prophy/gel program was estimated to be \$22.82. About 10 teeth were sealed per child in four years. Thus it cost about \$8 to \$9 to seal a tooth and maintain that seal (Klein et al. 1985). One of the problems encountered by the NPDDP, which was designed to determine the costs and effectiveness of several types and combinations of generally accepted school based preventive procedures when applied to all children, was that sealants were applied to all children regardless of need. Thus the results obtained inflated sealant costs.

### **Conclusion**

Sealants were more effective in fluoridated areas than nonfluoridated areas. The application of sealants was the only school based procedure that was consistently effective in reducing decay. Little additional benefit was obtained

if sealants were combined with the classroom procedures, and a greater benefit was observed in the grade 5 cohort than the grade 1+2 cohort when sealants were combined with the prophy/gel procedure. However, the average *direct* cost of providing sealants as part of a school based program (about \$23 per child per year if not provided in conjunction with fluoride prophy/gel applications) was far more than the *total* cost of restoring the 0.25 to 0.50 surfaces that sealants prevented from becoming decayed per year (at \$19.92 per restoration) (Klein et al. 1985).

A comparison of the costs of a school based sealant program with the cost of restoring the surfaces that would have become carious without such a program, would have to consider several variables that were not quantified in this research. The perceived value of a sound tooth relative to one that has been restored, the discounted value of funds spent to prevent a future problem, and the expected life of a restoration and a sealant were not quantified in this research.

Analysis of the study's baseline data and DMFS increment scores indicated that a small number of children, 20 per cent, accounted for a disproportionately large number of the decay, 60 per cent. These findings, together with the high cost of the preventive procedures, led to a preliminary investigation of the utility of targeting preventive care on high risk children. Klein et al.(1985) noted that the program was not designed to identify children likely to have the highest DMFS score increments. Even if a successful

prediction system of targeting children were available, several factors would still have to be considered in assessing the utility of a school based targeting program. Such factors would include:

1. The cost of identifying high risk children
2. The relative effectiveness of the preventive procedures with high-risk versus typical risk children
3. The difficulties of reaching the targeted children during the school day
4. Ethical problems about delivering preventive care to only a small segment of the eligible population have also to be considered

(Klein et al.1989)

Although sealants prevented 23 to 65 per cent of the decay that occurred in the longitudinal control group, this percentage translated to just one to two carious surfaces prevented in four years. This is about the same amount of decay that was prevented by community water fluoridation, although sealants only affected pit and fissure surfaces. With the limited resources available for preventive care and the finding that a small percentage of children have most of the decay suggest that research is needed to assess the feasibility of developing a program that could accurately identify high risk children and effectively target care on them (Klein et al.1989).

In a public health program, an important consideration for the initiation and continued operation of any preventive program is its efficiency or practicality, and cost effectiveness.

Many of the earlier field studies carried out in public health settings to assess the real life effectiveness of sealants gave equivocal findings (Leake, Martinello 1976; Lennon, O'Mullane, Taylor 1984). Leake and Martinello (1976), did a study of the evaluation of sealant application in a public health setting in Ontario. Lennon, O'Mullane and Taylor (1984), in a more recent clinical trial in 11 community dental clinics in England, applied sealants on all sound surfaces of first permanent molars. Both studies were not efficient compared with placement of amalgam restorations. Fissure sealing programs were abandoned after an initial trial.

However, the school based dental preventive New Mexico and Saskatchewan programs among others, give further evidence as to the use of fissure sealants as an additional component of their programs which provide complete dental care to eligible children. They show effectiveness of sealants under less than ideal field conditions. There was a major improvement in dental health among school age children over an 8-10 year period, the proportion of met treatment needs had doubled and the cumulative disease experience had declined by half in six year olds (Disney 1985).

Seemingly, the success of sealant application in a public health program may depend on the use of a targeting strategy rather than a blanket treatment to all children. The use of the patient and tooth selection criteria have been shown to be practical in evaluating the success of a fissure sealant program especially in schools. There is a great need for methods that will permit better

targeting of individuals at high risk to oral disease. With the possible development of valid and reliable methods to predict caries development in children, the criteria for targeting high caries risk children will be based on caries prediction rather than the number of decayed tooth surfaces found at the time of the examination.

The use of sealants, at the present time, relates more to preventive philosophy and to a desire to preserve tooth structure by preventing or delaying the need for restorative treatment than to clear-cut cost effective benefits. This highly effective primary preventive technique can be easily combined with present school programs with a relatively little additional requirement for time, personnel, money and material. The use of this proven approach could bring the annual incidence of caries down to a point where all those experiencing disease could be treated. This could greatly improve the oral health status of all school children.

## 6 SUMMARY AND CONCLUSIONS

Pits and fissures are surfaces most prone to dental caries when compared to the other tooth surfaces due to their morphological characteristics, which predispose them to fissure caries (Nagano 1961; Hicks, Flaitz 1986). Fissure caries do not usually begin at the bottom of fissures but frequently occur bilaterally along the walls of the fissure (Hicks, Flaitz 1986). In spite of a widespread use of fluorides, the beneficial action of fluoride is least in this type of caries as shown by the epidemiological findings in several countries (Brunelle, Carlos 1982; Fejerskov et al. 1982; Brown 1982; Johnson 1988). Occlusal surfaces constitute 12 per cent of the total number of tooth surfaces, yet it is found that they are eight times more vulnerable than the smooth surfaces.

Occlusal caries represents a disease process that has an early onset. Pit and fissure caries accounts for 90 per cent of all lesions in first permanent molars as shown among elementary children from a fluoridated community (Borhannan et al. 1984; Ripa 1985).

Pit and fissure sealants act as physical barriers preventing oral bacteria and dietary carbohydrates from aggregating within the pits and fissures. Numerous materials have been tested for fissure sealing. Conventional fissure sealant materials, the Bis-GMA derivatives and glass-ionomer cements have been used successfully in clinical trials.

The Bis-GMA derivatives permit mechanical obturation of pits and fissures for caries prevention. The use of an acid solution to etch the enamel surface is an essential prerequisite for the successful bonding of resin to enamel (Silverstone 1975). The concentration of phosphoric acid packaged with commercially available resin systems falls in the range of 30-50 per cent , and a one minute etch time provides sufficient time for the acid to penetrate, and lift off organic pellicles and dissolve thin calcified deposits not removed by prophylaxis (Buonocore 1975; Silverstone 1975). Presently, an etch time of 15-20 seconds is recommended by the manufacturers of the commercially available sealant systems. When an adhesive resin is applied on the etched enamel surface, it penetrates into the porosities created by etching, forming comb-like structures or tags. This forms a mechanical lock on polymerisation.

The bonding of glass-ionomer cements to enamel is of a chemical rather than a mechanical nature. The glass-ionomer cement is a highly ionic polymer. The interaction between apatite in enamel and polyacrylic acid in the cement produces polyacrylate ions which then form strong ionic bonds with the surface calcium and phosphate ions of apatite in enamel (Wilson et al. 1983; Wilson, McLean 1988). The glass-ionomer cements have the ability to bond chemically to enamel. They also have the ability to actively release fluoride into the surrounding enamel. However, the glass-ionomer cements have been found to have poor physical properties.

The mechanical bonds of adhesive resins are found to be stronger than the molecular bonds of glass-ionomer cements as shown by the retention rates of glass-ionomer cements which generally appear lower than the adhesive resins (Shimokobe et al. 1986; Boksman et al. 1987; Williams, Winter 1981). Thus the Bis-GMA materials remain the materials of choice for the prevention of pit and fissure caries.

The current adhesive resins available are either autopolymerised or light cured. The present generation of these products have undergone technological development over the years and offer the clinician numerous choices of material selection. The visible light cured filled resins are theoretically rated superior as compared to both the light cured unfilled and self cured unfilled resins. The filled resins are also preferred because of their greater wear resistance (Wei 1988). Coloured sealants have the added advantage of easier placement and detection especially at the recall examination.

Clinical and laboratory trials have been conducted to test the properties and effectiveness of the Bis-GMA pit and fissure sealants. The following factors, penetration of sealant, microleakage, sealant wear, occlusal caries reduction and retention, have been considered:

1. Penetration of sealant

It is shown that wide fissures are more often completely penetrated by the sealant material than constricted fissures. Thus in deep and narrow fissures, microorganisms might be left in the deep fissures beneath the sealant (Taylor, Gwinnett 1973; Powell, Craig 1978).

## 2. Microleakage

All fissure sealant materials tested show dye penetration in laboratory studies

## 3. Sealant wear

Wear of sealant occurs with time in the oral cavity. There are no statistically significant differences in clinical wear rates between filled and unfilled resins or between autopolymerised and U-V polymerised sealants (Jensen et al. 1985). Maxillary teeth exhibit a greater amount of sealant loss than mandibular teeth for all parameters, volume, area and depth (Conry et al. 1990).

## 4. Occlusal caries reduction

Ripa (1985) found an average occlusal caries reductions of 82, 68, 65, 43, 36, 40 and 34 per cent from one through seven years after sealant application. This is for studies that applied sealants only once. The chemically cured sealants provide superior caries protection than the U-V light cured sealant (Mertz-Fairhurst et al. 1984). The effectiveness of fissure sealant is similar in fluoridated or non fluoridated communities.

## 5. Sealant retention

Most studies show a retention of 70 to 99 per cent after one to two years of sealant application. The average retention figures from one to seven years after sealant application are 80, 71, 58, 51, 43, 54 and 49 per cent respectively (Ripa 1985). The efficacy of sealants depends upon their retention and marginal integrity. Partial sealant loss sometimes occurs, but heightened resistance to occlusal caries is maintained, apparently, because resin tags

continue to occlude the pits and fissures. There is no evidence to suggest that partial or total sealant loss increases the susceptibility of the occlusal surface to caries attack.

The results of these long term evaluations strongly suggest that sealants are capable of long term retention and caries prevention. The difference between retention of autopolymerised or visible light polymerised sealants is of no statistical significance (Shapira et al. 1990).

The effective use of fissure sealants requires meticulous attention to the technique of application, especially moisture control. Contamination with saliva affects the retention of the sealant considerably. Thus the most important factors in determining sealant success are:

1. A thorough prophylaxis of the tooth surface with a fluoride-free, oil-free pumice slurry, to avoid contamination of the tooth surface
2. Adequate etching of the tooth surface with phosphoric acid
3. Thorough post-etch washing
4. Maintaining a contaminant-free and moisture-free enamel surface before placement of the sealant. Use of cotton rolls with high speed aspiration have shown equal effectiveness with a chemically polymerised resin as compared to the use of rubber dam
5. Placement of sealant with adequate time allowed for complete polymerisation

Saliva contamination is the single most important reason that accounts for the largest percentages of sealant failures. If contaminated by an exposure to saliva, the tooth surface should be re-etched, prior to any attempt at sealant placement.

The principal intraoral factors which affect the operators ability to sufficiently dry a tooth are the position of the tooth in the mouth and its degree of eruption (Ripa 1985). Studies have reported better sealant retention and effectiveness rates on premolars as compared to permanent molars, for mandibular teeth as compared to maxillary teeth and in older children as compared to 6-7 year olds.

The retention figures of most clinical trials carried out can be expected to be even more effective where reapplication of any lost material is a routine procedure. Thus the efficiency of pit and fissure sealants can be considerably increased by the reapplication of sealant when noticed defective during recall appointments. The highest retreatment rates occur at six months (Straffon, Dennison 1988).

The glass-ionomer cements have not been able to match the adhesive resins in their retentive capacity over long term clinical trials. They, thus remain as alternatives and have not superseded the Bis-GMA derivatives as superior fissure sealant materials.

Many large scale community based or school based sealant programs have already produced convincing evidence that a fissure sealant program can be highly efficacious in a public health setting. A school based sealant program can be incorporated as an adjunct to an ongoing preventive program such as plaque control, fluoride therapy, and dietary advice. It can be instituted in the same facility with only little need for additional equipment or materials. The school based programs reviewed produced the following favourable results:

1. Sealants can be applied effectively in a school setting, using portable dental equipment
2. A change in program emphasis from one of treatment to prevention through incorporation of pit and fissure sealants has been shown to be effective in significantly reducing dental decay
3. Instead of treatment to only a small number of children per year, a far greater number of children can be provided with sealant applications and topical fluorides
4. The dental hygienist-assistant teams using a *four handed* technique were successful in achieving the desired results, comparable to results obtained from other clinical trials
5. Greater benefits were obtained when sealants were used in combination with fluoride mouthrinse programs

The combined complete and partial retention rate for sealant six years after placement was 78 per cent in the New Mexico Sealant Program (Calderone, Davis 1987). In the Saskatchewan Health Dental Plan, about 79 per cent of

the sealants were retained three years after application. Sealed teeth experienced 46 per cent less caries than unsealed teeth, four years after sealant application (Ismail et al.1989). In the clinic based sealant program in Guam, effectiveness of the program is described as the reduction in the total DMFS scores by 45 per cent and the entire reduction occurred in pits and fissures (Sterrit, Frew 1988). Comparable results of sealant effectiveness were found in the NPDDP in the United States of America and sealants were more effective in fluoridated than non fluoridated areas (Klein et al.1985).

Among preventive dental programs, fissure sealant programs are the most expensive, when compared to water fluoridation and other self-applied fluorides. However, they are inexpensive when compared to a restoration. Horowitz (1980), reported the cost of placing each sealant as \$12.25, the sum approaching that of a single restoration performed by a dentist. However, by 1989, Simonsen (1989), found that the cost of applying a single application of pit and fissure sealant to a group of children, and reapplying sealant one time to all missing areas that occurred over a 10 year period, is approximately two thirds (0.63) the cost of treating the caries that occurred in the matched group of unsealed children over the same 10 year period.

However, the cost effectiveness of fissure sealants is frequently questioned. The factors which affect the economics of fissure sealing on large scale school programs can be summarised as follows:

### 1. Materials and equipment

The retention rates obtained with the autopolymerising and visible light activated materials are equivalent (Ripa 1985), although with the latter, additional outlay is required to purchase a light source. In school based programs use of autopolymerising materials is advocated. As both material and operator costs have to be borne again each time reapplication of sealant is required, the durability of a material will have a major influence upon the success of the technique

### 2. Operator cost and technique of application

It has been proven that adequately trained auxiliaries and hygienists are able to attain equivalent retention rates to qualified dentists (Leake, Martinello 1976; Leske et al. 1976). Their employment in a fissure sealing program has been advocated as a means of reducing costs. Well defined written protocols and procedures by the supervising dentists should be developed prior to the program and there should be adequate training of the auxiliary personnel especially in their ability to obtain adequate moisture control during sealant placement

### 3. Patient and tooth selection

Fissure sealants are unlikely to be economically viable if applied to teeth that are not liable to become carious, therefore, selection of which teeth to seal is of major importance. Seemingly, the success of sealant application in a public health program may depend on the use of a targeting strategy rather than a blanket treatment

Some guidelines for tooth selection for sealant placement can be summarised as follows:

1. Fissure sealants have the greatest benefit on the occlusal surfaces of teeth with narrow and deep retentive pits and fissures and these are the most vulnerable teeth to dental caries
2. Sealants should be applied as soon as the teeth have erupted sufficiently to permit moisture control and within 2-3 years of eruption
3. If the caries activity in a mouth is high, presence of several occlusal carious lesions on primary or permanent teeth, it is a good precaution to seal the other permanent teeth as they erupt

The use of these guidelines has shown to be practical in most school based sealant programs. However there is a need for methods that will permit better targeting of children at high risk to oral disease. With the possible development of valid and reliable methods to predict caries development in children, the criteria for targeting will be based on caries prediction rather than the number of decayed tooth surfaces found at the time of examination.

#### 4. Monitoring and reapplication

Most sealant failures occur within 6 months of their placement (Straffon, Dennison 1988), therefore recalls for sealant retention should be made relatively soon afterwards. The optimal time has yet to be evaluated. However

this may increase the percentage effectiveness, but will incur greater costs. In school based programs, monitoring and reapplication of sealants is more economical if integrated with the patient's regular dental care rather than by means of a special fissure sealing program

#### 5. Combination with other preventive methods

The effectiveness of sealants is greatly reduced if they are placed on teeth which eventually succumb to interproximal caries. If fissure sealants are employed in combination with other preventive measures their benefit can be maximised. Cons et al.(1976), showed that the use of sealants increased the effectiveness of water fluoridation by an additional 20 per cent. Ripa et al.(1987), concluded that the benefits of sealing and mouth rinsing are additive and the addition of sealants to a mouthrinsing program increases the number of children who continue to be caries free.

Sealants can also halt the carious process after it has begun, so they can also be used as a form of treatment for early lesions before cavitation has occurred. When sealant is placed over an incipient carious lesion, caries does not progress provided the sealant remains intact. Sealant if retained, has shown to arrest caries as neither lesion depth nor microbiological counts progress under intact sealant (Mertz-Fairhurst et al.1986). Sealant used in this way is really a noninvasive restorative material.

Sealants undoubtedly have a place in the caries preventive program of community based or school based programs and when their use is combined with effective use of fluorides, the combination can prevent dental decay entirely in children. The use of sealants, at the present time, relates more to a preventive philosophy to preserve tooth structure by preventing or delaying the need for restorative treatment than to clear-cut cost effective benefits. Sealants should be incorporated into existing school based programs when financial considerations allow.

Future development of fissure sealants should be made with improvements in cost, ease of application, and durability in the oral environment. The routine use of fissure sealants under optimal conditions should virtually eliminate fissure caries and preserve most posterior dentition intact into adulthood.

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