PIT AND FISSURE SEALANTS

Definition
A sealant is a clear or opaque plastic material that is applied to the pits and fissures of teeth where decay occurs most often. The purpose of the sealant is to provide a physical barrier to occlude pits and fissures and to protect them from bacteria and food. Because the sealant obliterates the deeper and more tortuous anatomy, it also facilitates oral hygiene efforts because the sealed tooth is easier to clean. Note Figure 1.

Sealants have been used in clinical practice for nearly 30 years. The first generation sealants were liquid resins placed on the tooth, then polymerized with an ultraviolet light. The ultraviolet light has been replaced today by chemically-cured materials or materials that are cured with a more safe and efficient source of light polymerization than ultraviolet light waves.

Figure 1  Fissure filled by sealant
Most sealants today are made of Bowen's formula called BIS-GMA, an acronym for a monomer that is the reaction product of bisphenol A and glycidyl methacrylate. This is the same material that comprises the matrix of composite resin filling materials. All sealants can be assigned to two basic categories according to the method of polymerization: (1) autopolymerizing or chemically-cured sealants, which are referred to also as second generation sealants and (2) photopolymerizing or light-cured sealants, which are referred to as third generation sealants.

Rationale
Why are sealants necessary? By nature of their anatomy, pit and fissure surfaces are stagnation sites that are difficult to clean and thus at higher risk for caries. As illustrated in Figure 2, in this magnification of an occlusal tooth surface cross-section, this deep and tortuous anatomy lends itself to the entrapment of food debris, plaque formation and bacterial growth. The illustration shows that the fissure is so small that a toothbrush bristle will not reach the depth of the fissure. Thus, even excellent home care efforts will not be successful in cleaning a deep fissure.

Another concern with pits and fissures is related to their susceptibility to fluoride protection. Research demonstrates that topical fluorides are less effective in protecting the pit and fissure surfaces than the smooth surfaces of enamel. This does not imply that fluorides are ineffective on pit and fissure surfaces; however, topical fluorides selectively benefit the smooth surfaces to a greater extent than pit and fissure surfaces and this difference is believed to be related to tooth anatomy.

The rationale for sealants is documented further by considering those surfaces that are most at risk for dental decay. Epidemiological investigations confirm that the occlusal surfaces alone account for well over 50% of the caries in children ages 6-18. This percentage is particularly dramatic when one considers that the occlusal surfaces represent only 12.5% of the tooth surfaces. To underscore the problem of pit and fissure decay further, recent studies show that over 90% of new carious lesions are confined to pits and fissures; thus, if sealants are used in all developmental fissures including facial pits and lingual fissures, significant decay reductions are possible.

Effectiveness of Sealants
Pit and fissure sealants were introduced to the profession in 1967 and their effectiveness was recognized by the ADA in 1971. Currently 10 different sealant materials are accepted by the ADA's Council on Scientific Affairs (JADA 127:353, 1996).

The best research methodology to assess sealant effectiveness is a half-mouth investigative approach wherein sealed teeth are compared to unsealed control teeth in the same mouth. This methodology was the foundation of the earliest sealant clinical trials. Once it became clear that sealants were effective, however, this research method had to be abandoned because it is unethical to deny treatment proven to be effective treatment from a control group in an investigation.

It is widely accepted today by both the research and practice communities that when sealants are totally retained on teeth, they will prevent caries. Therefore, sealant effectiveness is assessed today using sealant retention as a measure of effectiveness. Equations have been derived to calculate sealant effectiveness once retention is known. First generation sealants (ultraviolet-polymerized sealants) are vastly inferior to second (auto-polymerizing) and third generation (light-polymerizing) sealants. Second
and third generation sealants perform about the same.

There are several studies that have followed sealants for over 10 years and dozens of studies have spanned 5-7 years (Caries Res 27:77-82, 1993). The highest rate of sealant loss in clinical studies is always in the first year following placement, reflecting the extent that success depends on meticulous operator technique in placing the sealant. In general, at 5-7 years complete retention rates are around 50% in those studies where sealants have been placed and monitored yearly without repair or re-sealing. In those studies where sealants have received maintenance and retreatment, a half dozen different studies report 85-95% success in study periods of 7-10 years.

Several factors should be noted relative to sealant effectiveness. While some studies show partially-retained sealants to be effective over a one or two year period, over the long-term partially-retained sealants are not effective. Accordingly, sealant maintenance is essential and this is probably the most difficult with adolescents who may be beyond the traditional risk period for caries. Unless these patients are monitored closely, sealants may serve only to delay the first restorations from childhood until adolescence. There are three other factors that weigh heavily in influencing sealant retention (Int Dent J 30:127-39, 1980). These include:

1. **Position of teeth in the mouth** — retention increases for more anterior teeth; retention is better in the mandible than the maxilla.
2. **Skill of the operator** — more skilled and/or clinically experienced operators produce better retention.
3. **Age of the patient** — the younger the child, the more difficult to maintain a dry field because of behavior and/or eruption status of teeth, resulting in poor retention.
4. **Soft tissue level and proximity to pits and fissures** — influences the probability of contamination of the enamel surface.

**Indications for Sealant Use**

Please review the decision tree for the management of questionable pits and fissures found later in this section. Consideration for sealing teeth should take into account the following factors:

(1) patient age  (4) fluoride environment and history
(2) oral hygiene status  (5) dietary habits
(3) family and individual  (6) tooth-type and morphology
history of dental caries

These factors may influence the decisions to seal or not to seal. More specific guidelines include:

1. Placement of sealants generally should be accomplished as soon as possible following the eruption of posterior teeth because this is the time when they have the greatest probability of decay. Thus, most indications for sealants will be for the child and adolescent patient population. However, sealant placement may be indicated at other times when a given child's caries risk status is modified. Examples might include changes in health status (i.e. xerostomia) or changes in oral hygiene status (i.e. compromised hygiene secondary to orthodontic appliances).
2. The placement of sealants should be limited to previously unrestored pits and fissures. All surfaces to be sealed should be scrutinized carefully for evidence of dentin caries. Radiographs should be examined carefully to rule out occlusal or proximal caries prior to the placement of pit and fissure sealants.
3. The surfaces of the tooth should contain pits and fissures susceptible to caries. Because they are more difficult to clean, deep and narrow pits and fissures are more susceptible to decay than wide and shallow pits. Usually primary teeth do not have deep pits and fissures, but they may be sealed if their anatomy makes them susceptible to decay. In brief, the judgement about whether a given tooth should be sealed is based strongly on the extent to which the tooth's fissures are coalesced.
4. A tissue flap (operculum) can interfere with the application procedure and lead to sealant loss or poor retention. For this reason the sealing of partially-emerged teeth is performed typically only on patients at high risk for caries development. When sealing partially erupted teeth, care must be taken to retract such tissue flaps with retraction cord, cotton pellets, or a rubber dam. Sometimes tissue flaps will make it necessary to defer placing the sealant until more eruption occurs. Occasionally, on maxillary molar teeth, half of the tooth will be erupted sufficiently to seal the mesial pit and the distal aspect can be sealed later, after further eruption. Sometimes local anesthesia is essential to provide comfortable sealant placement for emerging teeth.
5. Ideally, patients receiving sealants should be on some type of preventive fluoride program to reduce the risk of smooth surface caries.

**Sealant Application Technique**

1. **Isolation Techniques**: Prior to placing sealants, careful consideration should be given to the method of isolating the teeth because the maintenance of a dry field is absolutely essential to the success of
sealant retention. Maintaining a dry field of operation for sealant placement may be accomplished by two basic methods: (1) the use of cotton roll holders, cotton rolls and Dri-Angles® or (2) the use of the rubber dam.

2. **Preparation of Tooth:** An entire quadrant or a single tooth may be prepared for sealant application. A careful examination should be used to verify that there is no decay using careful lighting and illumination after air drying. The explorer should be used sparingly or with care because a sharp explorer can damage the fragile outer enamel morphology. There is good evidence that desiccation/illumination without an explorer examination may be superior to the use of the explorer as an adjunct to desiccation and illumination.

   The tooth is cleaned well (10-15 seconds) with a prophylaxis brush and a mixture of flour of pumice and water. It is important that the pumice mixture contain no oil or fluoride. Also, because fluoride renders the outer layer of enamel more resistant to demineralization or acid etching, fluoride treatment if indicated should be accomplished after the sealant is placed, not before. After the surfaces to be sealed have been cleaned thoroughly, they are washed well for 10-15 seconds and dried well for 10-15 seconds.

3. **Acid Conditioning of the Tooth:** The next step is the acid etching or acid conditioning procedure. This is the most critical step in the sealant application technique because the retention of the sealant depends on the proper acid conditioning of the tooth’s surface. Etching enhances the tooth’s receptivity to bonding with the sealant. During this critical step, meticulous maintenance of a dry tooth surface is essential for bonding to be successful.

   The tooth is etched with 30-50% solution or gel of unbuffered phosphoric acid. The etching time for children is 30 seconds for both primary and permanent teeth. Acid conditioning enhances enamel porosity, increases the surface area and further cleans the enamel surface. Acid conditioning should be limited to the tooth surfaces that will be sealed and care should be taken to keep the acid away from all soft tissues.

   After conditioning, the tooth is rinsed again with water for 10-15 seconds to remove the acid and its residues. Then the tooth is dried thoroughly for 10-15 seconds and examined carefully. The etched surface should not be disturbed with further instrumentation. If conditioning is adequate and the etch is good, the tooth will appear white, opaque and frosty. If the tooth does not have this appearance, it should be re-etched for another 30 seconds. Should saliva contact the tooth at any time during etching, the etching procedure should be repeated from the start. If saliva should contact the tooth after etching, re-rinse and dry the tooth and re-etch for 30 seconds. Reassess the tooth for the desired white, opaque frosty appearance. When a good etch has been achieved, the tooth is ready to be sealed.

4. **Special Consideration Regarding Tooth Isolation:** Rubber dam versus Dry-Angle® or cotton roll holder isolation? Research suggest that either method of isolation results in similar sealant retention rates. It is important to emphasize that retention depends heavily on the maintenance of a dry field during sealant placement.

   If restorative is planned for the quadrant in which teeth are to be sealed, a rubber dam should be used because the teeth will be isolated already with the rubber dam after administration of local anesthesia. Some clinicians prefer to always use the rubber dam to place sealants. By using a topical anesthetic around the gingival tissues of the nonanesthetized tooth to be clamped for the dam, the clamp can usually be placed comfortably. Topical anesthetic can be placed around the rubber dam clamp beaks to assist with this procedure. (For permanent molars, Ivory 14 or 14A clamps are excellent. For newly erupted permanent molars, an Ivory 8A is excellent. The SSW 27 clamp is the clamp of choice for primary molars.)

   If cotton roll/Dri-Angle® isolation is to be used, the tooth should be cleaned with the bristle brush and pumice, rinsed and dried. For maxillary teeth a Dri-Angle® is placed next to the tooth to be sealed. This both covers the parotid duct and isolates the tooth. The patient should be cautioned to stay open and to avoid licking the teeth. The mouth prop may be helpful. It is often helpful to use the mirror as a barrier between the tooth and tongue.

   In the mandibular arch, the use of the Dri-Angle® is usually unnecessary but may be helpful with some patients. After cleaning and rinsing the tooth, the cotton roll holder is placed prior to etching. The mirror is often a valuable aid in retracting the tongue away from the field of operation. In some instances the tooth may be kept dry by placing additional dry cotton rolls over the wet rolls. It may be necessary for the operator to use the mirror or fingers to retract the tongue and buccal vestibule while the assistant changes the cotton rolls.

5. **Sealant Placement:** The sealant procedure to be discussed first will be the light-polymerization or light-cured (LC) system. This LC system is the one in use throughout the dental school clinics and at
many extramural sites. Using the LC system, the sealant material is placed on all susceptible pits and fissures and a few seconds are allowed for the material to flow into the deep pits and fissures. The sealant may be carried to the tooth with a customized application dispenser used for the Delton® material. Alternately, a small brush or plastic instrument may be used to spread the sealant material smoothly on the tooth. The sealant is cured with the light source according to the manufacturer’s recommendations and generally this will be at minimum a 20-second cure time for each surface that is being sealed.

The older sealant systems rely upon a catalyst and base mixture to form a self-cured or autopolymerized sealant. Autopolymerized sealant systems are still relied upon in some extramural clinics where expensive curing lights are not available. One of the tried and true products on which many rely is autopolymerized Delton®. This sealant system requires mixing a catalyst and base to form an unfilled BIS-GMA resin. One drop of base and one drop of catalyst are dispensed into the mixing well and mixed together for 15 seconds. The sealant is carried to the tooth with a customized application dispenser used for the Delton® material. Alternately, a small brush or plastic instrument may be used to spread the sealant material smoothly on the tooth. The sealant should not be painted back and forth on the tooth surface because this may cause air bubbles to be trapped in the fissures. In placing the sealant, it is important that all pits and fissures be covered thoroughly with the sealant material.

The resin tags of a sealant penetrate the etched and porous enamel, resulting in a mechanical, interlocking bond. This resin tag phenomenon is the critical feature for sealant retention. The necessity of a dry operation field is essential because contamination of the etched enamel with saliva or water will lead to bond failure.

The mixing time is 15 seconds; the working time for placement is 45 seconds; the polymerization or setting time starts in 60 seconds. It is critical that the sealant be applied within 60 seconds; otherwise, the polymerization process will be disturbed and resin bond to enamel may be compromised. Another 60 seconds are necessary for complete polymerization. Thus, a total time of 120 seconds is required from start to finish.

6. **Checking the Polymerized Sealant:** After complete polymerization, any resin flash and ledges of sealant that extend beyond etched enamel should be removed with a sharp scaler, curette, or carbide finishing bur. An explorer should be used to examine the sealant after it has polymerized. Aggressive attempts to remove the sealant should be used to ensure that the bonding is successful. If the sealant has been placed properly in only the deep pits and fissures, occlusal adjustment will be unnecessary. Still, the occlusion should be examined for high spots and the sealant may be adjusted with round carbide finishing bur.

7. **Sealant Maintenance at Recall Appointment:** The sealant should be checked at subsequent recall appointments to evaluate its retention. The effectiveness of pit and fissure sealants is increased by monitoring and maintaining the intact sealant. If the sealant has been lost or only partially retained, more sealant can be added by repeating the steps in the application technique already described. It is not necessary to remove residual sealant before reapplication. Any sealant material could be used to repair a partially retained sealant.

**EXAMINATION OF VARIOUS MODIFICATIONS IN SEALANT TECHNIQUE**

Many modifications have been suggested in the technique-related aspects of sealants use. While not all inclusive, this list explores some options.

(1) **Options for Tooth Preparation**

- No tooth preparation
- Preparation with only a toothbrush
- Rubber cup with pumice slurry
- Rotation brush with pumice slurry
- Hydrogen peroxide "bubble-out"
- Enameloplasty with a bur or burs
- Prophy-jet® or Cavi-jet® unit preparation
- Air Abrasion Preparation

Most of the work in this area has been done *in vitro*. (For a review see Main C. *et al.* Surface treatment studies aimed at streamlining fissure sealant application. *J Oral Rehabil* 1983;10:307-17). Almost all clinical trials have relied upon brush/pumice preparation. One that did not is reported by Donnan MF and Ball IA: A double-blind clinical trial to determine the importance of pumice prophylaxis on fissure sealant retention (*Brit Dent J* 1988;165:283-86). While several methods show promise, the preponderance of evidence supports the brush/pumice preparation and this method has become the standard against which all others are judged. This technique also is inexpensive and easy
to use and thus it represents our current teaching philosophy.

(2) Isolation Techniques
Rubber dam isolation
Cotton roll holder/Dri-Angle® isolation
Antisialogogue treatment

The literature supports isolation by any means. Good moisture control rather than the particular method used is the critical issue for success.

(3) Acid Application Issues
Brush application
Sponge application
Cotton pellet application
Acid agitation versus no agitation
Etch solution versus etch gel

Frequent acid replenishment is believed to be desirable but there are no data on this topic. Gels and solutions appear to work equally well but gels need more thorough post-etch rinsing.

(4) Etch Time Considerations
One minute etch
Less than one minute etch

Scores of long-term clinical trials have relied upon a 60-sec etch time. Recently many manufacturers and clinicians have recommended a 15-sec etch time. While the 15-sec etch time may be appropriate for etching certain surfaces (e.g., smooth surfaces) or certain types of enamel (e.g., adult enamel), there are no clinical studies examining a 15-sec etch for sealants in children. Two clinical trials in children have examined a 20-sec etch time (Eidelman E, Shapira J, Houpt M). The retention of fissure sealants using a 20-sec etching time: three-year follow-up. ASDC J Dent Child 1988;55: 119-20 and Stephen et al. Retention of a filled fissure sealant using a reduced etch time: a two-year study in 6 to 8-year children. (Br Dent J 1982; 1553:232-3). Our current recommendation calls for a 30-second etch time for primary and permanent teeth prior to sealant placement.

(5) Method of Placement
There is no data-driven support for any particular method. To avoid voids, care should be taken to avoid the incorporation of tiny air bubbles within the sealant. Care should be taken not to apply too much sealant material. This will result in peripheral ledges and high occlusion.

(6) What Type of Sealant to Place?
Generation 1 Sealant (photo-cured via UV light)
Generation 2 Sealant (auto or chemically-cured)
Generation 3 Sealant (photo-cured via visible light)
Unfilled versus filled sealant
Tinted versus non-tinted versus opaque sealant
Nonfluoride versus fluoride-containing sealant
BIS-GMA versus non BIS-GMA sealant

The Generation 1 Sealants are no longer available because they were found in long-term clinical trials to be much less effective than the Generation 2 and 3 products. There are no significant differences in Generation 2 and 3 products although in many long-term studies the auto-polymerized materials show slightly better, but not statistically significantly better performance. Recently there has been some speculation that this improvement might be related to the concept that auto-cured sealant gain better pit/fissure penetration than the photo-cured materials, which in some instances may be polymerized on command before they ooze fully into the depths of the pits and fissure. Accordingly, when using photo-cured sealants it may be beneficial prior to photo-curing to allow a few seconds for the material to flow into the depths of the tooth's fissures.

Theoretically one would anticipate that filled sealants would undergo less wear and abrasion than unfilled sealants but clinical trials do not support this expectation; indeed, long-term studies show no differences in these two material-types. This material selection choice is largely one of the clinician's personal choice.

The use of tinted versus non-tinted versus opaque sealants is another in which the clinician's choice rules the day because long-term clinical trials do not support any given material. Some clinicians feel that they can see colored sealants better; others prefer clear because they want to be able to"see and monitor"stained fissures underneath the sealants. In the past, some white colored opaque sealants have been found
to be more brittle than their clear counterparts and this is thought to be related to the additives that make
the sealant material white in color. Some clinician still claim that opaque sealants are more brittle but this
property has not been supported with data.

There has been considerable excitement in recent years over fluoride-containing sealants and products
on the market have been documented in laboratory studies to "release fluoride"; however, the clinical
outcomes of fluoride-containing sealants have not been documented.

All sealants are comprised of BIS-GMA constituents. In 1996 a study from Spain reported that the
BIS-GMA material in sealants might be leached from BIS-GMA containing sealants and absorbed into
the body (Olea, N et al. Estrogenicity of resin based composites and sealants used in dentistry
Environmental Health Preventive 1996;104:298-305). Because BIS-GMA has been found to mimic
estrogenic activity in vitro, concerns have been expressed that sealants might mimic the female estrogen
hormone. The ADA Statement on this article is as follows: “The article entitled, ‘Estrogenicity of Resin-
Based Composites and Sealants Used in Dentistry’ is interesting but all estrogenic activities that have
been observed in this paper are in a laboratory cell-culture environment. Whether this observation can be
reproduced in clinical trials is questionable. Estrogenic potential may or may not survive the acid
environment in the gastrointestinal tract after swallowing. The amount of leachable materials still needs
to be quantified. The biological implication of this observation needs to be further elucidated. Until more
data can be cumulated, the ADA cannot at this time draw definitive conclusions from this observation”
(3/5/96).

(7) Are there differences in sealant technique for primary versus permanent teeth?

Some clinicians suggest a longer etch time and/or mechanical preparation of the tooth prior to
sealing primary molars. Theory and one clinical trial argue for no tooth preparation and a 60-sec etch
time. (See Ripa LW. "Sealant retention in primary teeth: A critique of clinical and laboratory
studies." J Pedod 1979;3:279). Our current teaching philosophy embraces the 30-sec etch time prior to
sealing primary teeth.

PREVENTIVE VERSUS THERAPEUTIC SEALANTS

Since their introduction to the profession in the mid-1970's, pit and fissure sealants have been
advocated only for the use of caries prevention and their use for carious lesions has not been advocated.
Because pit and fissure caries is not always easy to detect, the use of sealants on questionable carious pits
and fissures has always been controversial. It is widely accepted that most pits and fissures are inoculated
with mutans streptococci or other caries-causing microorganisms, so many argue that sealants should not
be placed over questionable lesions. At the same time, the criteria for sealing those pits and fissures that
are susceptible to an explorer catch has also come into question; indeed there is considerable evidence
that the use of a sharp explorer may mislead clinicians or do harm. Several studies conclude that good
illumination and air drying are superior to use of the explorer. Use of the explorer has been challenged
because of the potential to damage fragile enamel that has the potential to remineralize; furthermore, there
is evidence the explorer may act to inoculate previously uninfected pits and fissures in the other
quadrants.

There have been several excellent clinical trials to examine the effect of sealing carious lesions.
Although the primary issue has been to determine the effect of sealing over incipient carious lesions,
several clinical trials have examined sealing over frank caries (for review, see Swift ET "The Effect of
Sealing Over Caries: A Review" JADA 1988;116:700-04). Findings from these studies have been
impressive and collectively they have shown a decided decrease in the numbers of viable microorganisms
in lesions under intact sealants. Furthermore, caries progression appears negligible. These benefits seem
to result mainly from the sealant’s ability to block nutrients from bacteria within the carious lesions. In
addition, the acid-etching process and the inherent reparative ability of dentin may be involved to some
extent. In brief, acid-etching probably kills most microorganisms within its reach and dentin is
amendable to repair via pulpam nutrients.

In early 1994 a National Workshop on Guidelines for Sealant Use developed guidelines for the use of
pit and fissure sealants in public and private programs (see proceedings published in the J Pub Hlth Dent
1995;55(5):263-73). These guidelines are illustrated in the Sealant Decision-Tree on the next page. They
recommend the sealing of enamel caries rather than the restoration of enamel caries. This concept was
endorsed by the American Dental Association (JADA 1995;126:185, Special Supplement, June) and it
represents the current teaching philosophy in our department.

For purposes of nomenclature and patient record documentation any sealant placed on questionable or
frank enamel caries will be recorded as a therapeutic sealant. The conventional sealant placed for
preventive purposes will be recorded as a sealant. For purposes of ADA coding, all sealants will be
coded as 01351.
Decision Tree for Pit and Fissure Treatment