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Arch Basic Clin Res 2024; 6(3): 235-242 • DOI: 10.5152/ABCR.2024.24280

Review

Pit and Fissure Sealants

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Cite this article as: Akuç Taşan Ç, Ceran F. Pit and fissure sealants. *Arch Basic Clin Res.* 2024;6(3):235-242.

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ABSTRACT

Dental caries, a multifactorial chronic disease, affects a majority of the world's population and is regarded as the foremost global burden on oral health. Fluorides, while effective in reducing cavities on smooth enamel and cementum surfaces, are less effective in protecting occlusal pits and fissures, where the majority of cavities occur. Pits and fissures are highly susceptible to cavities due to their complex surface morphology, which promotes plaque retention. If they have a narrow and deep morphology, they are almost impossible to clean. Consequently, the prevalence of occlusal caries lesions on permanent posterior teeth exceeds that of caries on smooth surfaces. Systematic reviews and meta-analyses have determined that pit and fissure sealants, which form a physical barrier between the tooth surface and oral environment, are the most effective treatment option for preventing pit and fissure caries. In this review paper, the general characteristics of pit and fissure sealants, as well as their classification, materials used as sealants and current application techniques are evaluated.

Keywords: Dental sealant, pit and fissure sealant, preventive treatment, tooth decay

INTRODUCTION

Tooth decay is the most common chronic disease in childhood.[1] Pits and fissures on the occlusal surfaces of posterior teeth are more susceptible to caries development compared to smooth surfaces. This is primarily due to their complex morphology, which complicates dental hygiene, leading to greater plaque accumulation and, consequently, increased risk of caries formation.[2] Dental sealants and topical fluoride treatments are the two basic strategies for preventing these caries.[3] Enamel in pits and fissures does not benefit from the protective effects of fluorides to the same extent as enamel on smooth surfaces.[4] Pit and fissure sealants create a physical barrier that prevents the accumulation of microorganisms and food particles, thereby preventing the initiation and halting the progression of caries.[5,6] In 1978, Simonsen defined pit and fissure sealants as "a micro-mechanically bonded material that forms a protective layer that prevents cariogenic bacteria from accessing their food sources."[7] This definition does not encompass glass ionomer and resin-modified glass ionomer sealants, which bond chemically to the enamel.

Permanent first and second molars are the teeth with the highest caries prevalence. A study showed that permanent first molars with fissure sealants remained caries-free for up to 48 months compared to molars without fissure sealants.[8] The long-term effectiveness of pit and fissure sealants depends on their retention.[4] Many factors such as application technique, viscosity of fissure sealant materials, and light-curing conditions can cause fissure sealants to fail. Additionally, according to some studies in the literature, insufficient preparation may also cause failure of fissure sealants.[9,10] Reports indicate that the bonding capacity of fissure sealants may be weakened if topical fluoride gel is applied before fissure sealant placement.[11] Fluoride gels smooth the enamel surfaces of both primary and permanent teeth, which can reduce the bonding effectiveness of resin materials. Therefore, applying fluoride before placing pit and fissure sealants is generally not recommended.[12,13]

ANATOMY AND PHYSIOLOGY OF PIT AND FISSURES

Pits are defined as small point depressions found at the junction of developmental grooves or at their terminations,

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Received: June 7, 2024
Revision Requested: August 12, 2024
Last Revision Received: August 12, 2024
Accepted: August 19, 2024
Publication Date: October 15, 2024

while fissures are deep clefts located between adjacent cusps.[14,15] Pits and fissures that have high vertical walls and narrow bases are particularly susceptible to clefts developing caries.[16] Occlusal fissures are defined as wide or narrow funnels, narrowed hourglasses, inverted Y-shaped divisions, and irregularly shaped multiple intussusceptions.[17] The shape of pits and fissures are explained by using V, U, I and IK definitions.[18]

FEATURES OF PIT AND FISSURE SEALANTS

The aim of using pit and fissure sealants is to prevent the formation and halt the progression of caries lesions. An optimal fissure sealant material should exhibit biocompatibility, low viscosity, minimal solubility, aesthetic appeal, and provide clear visibility for reassessment.[18,19]

Glass ionomers and unfilled or lightly filled composite resins are the two basic types of materials used as pit and fissure sealants. While neither material is considered ideal, the selection depends on the specific requirements of the case. Within these categories, there are also subdivisions: Compomers and resin-modified glass ionomers.[20]

CLASSIFICATION OF PIT AND FISSURE SEALANTS

Pit and fissure sealants can be categorized based on the following characteristics:[21]

1. Polymerization type:

- First-generation pit and fissure sealants: Polymerize with ultraviolet light at a wavelength of 350 nm.
- Second-generation pit and fissure sealants: Chemically hardens on its own. It does not contain fillers. It can be transparent, opaque, or colored.
- Third-generation pit and fissure sealants: They polymerize with visible light at a wavelength of 430-490 nm. They can usually be white or transparent.
- Fourth-generation pit and fissure sealants: Fluoride is added to provide additional benefit.

MAIN POINTS

- Pit and fissure sealants are a common form of treatment used to prevent caries.
- There are various new developments in pit and fissure sealant materials and application steps. These include the use of bioactive smart materials, the enamel deproteinization technique, and the use of lasers in surface preparation.
- In this article, a comprehensive review of pit and fissure sealants is presented, and current developments are explained.

2. Filler content:

- Pit and fissure sealants that do not contain fillers: They have a more fluid structure.
- Pit and fissure sealants containing fillers: Stronger and more resistant to abrasion.
- Partial filler pit and fissure sealants.

3. Fluoride content:

- Containing fluoride
- Does not contain fluoride

4. Color:

- Colorful
- Transparent
- Opaque

5. Resin system:

- Bisphenol A-glycidyl methacrylate (Bis-GMA)
- Urethane Acrylate

INDICATIONS AND CONTRAINDICATIONS OF PIT AND FISSURE SEALANTS

Indications of pit and fissure sealants are listed as follows:[22]

- Newly erupted molars and premolars in patients at high risk of occlusal tooth decay,
- Teeth with deep and narrow pits and fissures that retain food particles,
- Teeth with caries on proximal surfaces,
- Patients who have both proximal and occlusal caries in primary teeth,
- Patients with a high caries risk.

It is recommended that pit and fissure sealants be applied at the age of 3-4 for primary molars, at the age of 6-7 for the first permanent molar teeth, and at the age of 11-13 for the second permanent molar and premolar teeth.[22]

Contraindications of pit and fissure sealants are listed as follows:[15]

- Teeth that remain decay-free for four or more years
- Shallow, wide, self-cleaning pits and fissures,
- Teeth without proximal surface caries,
- Individuals who have no previous experience with caries, and
- Patients with cooperation problems.[15]

ADVANTAGES AND DISADVANTAGES OF PIT AND FISSURE SEALANTS

Pit and fissure sealants are considered a minimally invasive method that seals pits and fissures to protect against tooth decay without causing harm to the tooth's structure.[23] The use of fluoride sealants can also provide protection to neighboring areas through the release of fluoride.[24] Sealants can be applied at the community level to prevent cavities.[25] It has been shown that after sealant application, teeth with complete or partial sealant loss do not have a higher risk of caries than teeth without any sealant. Additionally, two studies on the effectiveness of pit and fissure sealants concluded that pit and fissure sealants prevent the progression of dental caries. These findings show that pit and fissure sealants prevent bacteria from accessing fermentable substrates and inhibit their ability to demonstrate their cariogenic potential.[26]

The existence of moisture during the application of pit and fissure sealants hinders the sealant from properly adhering and bonding to the enamel surface. Therefore, the tooth must be completely dry during the procedure. This technical sensitivity is viewed as a disadvantage.[27] Other disadvantages of sealants include the possibility of sealing over hidden cavities or the sealant becoming dislodged over time, which can lead to caries developing beneath the sealants. These underlying cavities can continue to progress and become challenging for the dentist to diagnose.[21]

PIT AND FISSURE SEALANT MATERIALS

Resin-Based Pit and Fissure Sealants

Resin-based pit and fissure sealants are typically formulated with urethane or Bis-GMA. Diluents like triethylene glycol dimethacrylate (TEGDMA) and/or 2-hydroxyethyl methacrylate (HEMA) are added. There is a broad range of resin-based pit and fissure sealants available, from unfilled to partially filled, and in colors ranging from clear to white or other shades. These materials can be polymerized chemically or with visible light.[7]

Bis-GMA monomer is not hydrophilic enough to compete with water, despite having two hydroxyl groups.[28] Water in microscopic capillaries prevents the acrylic resin from completely penetrating the enamel surface. Therefore, contamination of eroded enamel with moisture during sealant application is the most frequently cited cause of sealant failure.[29] If etched enamel surfaces are contaminated with saliva before applying the sealant, proper bonding is impeded because the saliva clogs the micropores.[28,29]

Glass Ionomer-Based Pit and Fissure Sealants

Glass ionomer cements are utilized as dental sealants, and studies in the literature indicate that they exhibit retention rates comparable to traditional dental sealants. However, their physical and mechanical properties are noted for insufficient wear resistance and susceptibility to easy loss.[30] In addition, glass ionomer sealants are fragile. If they break, they can expose the pits and fissures underneath them to the intraoral environment and cause new caries to form.[30]

Glass ionomer cements are frequently used in atraumatic restorative treatments (ART). ART involves removing soft or demineralized tooth tissue with only a hand instrument and then restoring the tooth with an adhesive restorative material such as glass ionomer cement. This technique is defined as a temporary restorative treatment approach for caries prevention.[31]

ART is commonly employed globally as a method to relieve infection and pain.[32] Interim therapeutic restoration (ITR) is a dental restoration method frequently used in contemporary United States dental practice, especially for young patients, uncooperative patients, or those with special healthcare needs.[31] It refers to the procedure carried out to halt further decalcification and progression of caries when cavity preparation and/or placement of conventional dental restorations is not immediately possible and needs to be delayed. Interim therapeutic restorations are particularly valuable in regions facing a shortage of dentists.[31]

Resin Modified Glass Ionomer-Based Pit and Fissure Sealants

Resin-modified glass ionomer cements are a hybrid restorative material consisting of 80% glass ionomer cement and 20% resin-based hybrid restorative material.[33] It was developed to overcome the existing problems of conventional glass ionomer cements such as moisture sensitivity and poor physical properties. While developing this material, glass ionomer cement properties such as flour release, recharge properties, and chemical adhesion were also retained.[34] With the development of adhesive system technology, it is one of the most up-to-date materials that have become more widely used.[35] Resin-modified glass ionomer cements exhibit physical and mechanical properties that fall between conventional glass ionomer cements and composite resins. Their main advantages are both physical and chemical bonding to the tooth and high recharge properties. In addition, these materials have the advantages of increased surface hardness and prolonged working time. The powder component of resin-modified glass ionomer cements consists of fluoroaluminosilicate glass powders, while the liquid component contains HEMA, methacrylate groups, tartaric acid, polyacrylic acid, and 8% water.[36] As a disadvantage, they are less biocompatible than conventional glass ionomer cements due to the residual monomer (HEMA).[37]

Researchers using resin-modified glass ionomer cements as fissure sealants have noted that the material wears out shortly after application.[38] Some clinical studies indicate that resin-modified glass ionomer cement used as a sealant has a lower retention rate compared to resin-based sealants, although the difference in caries increase appears to be minimal.[39]

On the other hand, in another study, resin-modified glass ionomer cement used as a pit and fissure sealant showed better retention than resin-based dental sealant.[40] They found that all types of fissure sealants showed comparable marginal sealing ability. The study suggests that etching pits and fissures with phosphoric acid may help minimize microleakage associated with resin-modified glass ionomer cement.

Flowable Composites

Flowable composites were introduced in the 1990s (specifically in 1996). Despite having filler sizes comparable to hybrid composites, they had lower filler content than traditional composite resins.[41] Flowable composites were initially indicated at the beginning for marginal repair of different materials such as amalgam, composite, crown porcelain, or for lining before composite restoration, splinting teeth, and cementation of porcelain veneers. Furthermore, flowable composites were utilized as pit and fissure sealants in addition to their other applications.[41,42,43] Conventional composites were not good sealants on their own because they cannot easily penetrate fissures due to their relatively high viscosity. Thus, flowable composites, which are low-viscosity versions of traditional composites, were employed as fissure sealants due to their excellent wetting ability, sufficient flow characteristics, and adequate wear and fracture resistance.[43]

PROTECTIVE RESIN RESTORATIONS

In cases where pits and fissures contain minimal caries, a more conservative, modified preparation approach is recommended. The caries-affected tissue is restored using composite filling materials after minimal removal of tooth structure, and sealants are applied to close non-carious fissures.[44]

There are three types of protective resin restorations, which vary depending on the size and depth of the carious lesion:[16]

- Type A: This refers to pits and fissures where decay is confined to the enamel layer.
- Type B: This refers to small and limited incipient lesions that extend into the dentin.
- Type C: This refers to deep caries necessitating extensive dentine preparation.

There are successful long-term reports on protective resin restorations. In this promising restoration type, the results of a 9-year study showed that 55% of protective resin restorations were fully preserved, 25% had partial pit and fissure sealer loss, and 20% had complete pit and fissure sealer loss. Caries developed in 25% of the teeth where sealant loss occurred, while 88% of the restored surfaces remained free from caries nine years after treatment.[45]

In another study by Walker et al., protective resin restorations were placed in patients aged 6 to 18 years and followed for up to 6.5 years. It was found that 83% of the restorations did not need further intervention. Among those requiring intervention, 37% needed treatment solely due to the loss of integrity of the pit and fissure sealant, while 21% required treatment due to the development of a proximal lesion.[46]

Many studies have concluded that protective restorations yield positive long-term outcomes. Conservative cavity preparation combined with protective sealing is regarded as a successful approach in treating decayed teeth suitable for protective resin restorations.[47]

APPLICATION STEPS OF PIT AND FISSURE SEALANTS

Tooth surface for the sealant to hold:

- Have maximum surface area,[48]
- Must exhibit deep, irregular pits and fissures,[49]
- Must be clean, and[50]
- Ideally be dry and free from saliva at the time of sealant application, which is crucial for most sealant materials.

These are considered four important steps for successful seal placement.[51]

Increasing the Surface Area

Pit and fissure sealants do not bond directly to the tooth surface. Retention is achieved with adhesive applications. Increasing the surface area is achieved by etching pits and fissures with phosphoric acid at a concentration of 30% to 50%.[48,50,52]

Depth of Pit and Fissure

Wide and shallow fissures provide a less favorable surface for sealant retention than deep and irregular fissures. The deeper the fissures, the more the sealant is protected from the shear forces generated during chewing movements.[53]

Surface Cleaning

Methods employed to clean the tooth surface before placing sealants include air drying, polishing with pumice, brushing with fluoride-free toothpaste, and, in certain instances, the use of hydrogen peroxide or a laser.[54]

Pit and fissure sealants' long-term durability even without any prophylaxis was reported in the literature.[7] Regardless of the cleaning method chosen, it is crucial to remove all heavy stains, debris, and plaque from the occlusal surface using acid etching or other appropriate methods before applying pit and fissure sealants.[55]

Preparing the Tooth for Sealant Application

- After isolating the teeth, thorough drying is essential.
- Following the manufacturer's etching time instructions is crucial; typically, an enamel etching time of 20 to 30 seconds is recommended.[51]
- After etching, the enamel should be rinsed for 10-20 seconds and then dried for approximately 10 seconds. The dried enamel surface should exhibit a dull, chalky, white, or frosty appearance.[28]

Drying the Tooth Surface

Fissure sealants are hydrophobic materials and require the teeth to be dry during placement. Saliva is more detrimental than water because its organic components create a barrier between the tooth and the sealant. When applying air to the tooth surface, it must be ensured that the air stream is free of moisture. Moisture can be monitored by directing the air into the cold mouth mirror; any condensation indicates moisture. Neglecting this step can lead to variability in fissure sealant retention between operators.[7]

Application of Pit and Fissure Sealant

Light-curing or self-polymerizing pit and fissure sealants should first be placed in fissures at maximum depth. After the fissures are adequately closed, they should be advanced to the approximal edges.[7]

If gaps are observed in the fissures after applying pit and fissure sealants, additional sealant can be added without requiring further abrasion. After curing, an oily residue forms on the surface of the sealant. This residue consists of monomers that do not react on the surface and should be cleaned with gauze. If any fractures occur after the application of the dental sealant and require repair, it is recommended to repeat the initial etching and drying procedures. All light-curing and self-curing sealants can easily bond to each other because they belong to the same chemical family, Bis-GMA.[56]

Evaluation of the Permanence of Pit and Fissure Sealants

The retention of applied pit and fissure sealants should be assessed using the edge of a probe without applying excessive force. If the sealant does not exhibit adequate retention, the pit and fissure sealant placement procedure should be repeated. If two attempts are unsuccessful, it is advisable to postpone sealant application until remineralization has occurred and the patient is compliant with the procedure.[7]

Placement of Pit and Fissure Sealant on Caries Lesion

There are studies showing that pit and fissure sealants are effective in stopping non-cavitated caries.[57,58] A systematic review indicates that the likelihood of halting or reversing non-cavitated occlusal caries with pit and fissure sealants is 2-3 times higher compared to no treatment.[59] Similarly, a 44-month clinical study shows that non-cavitated caries can be stopped with pit and fissure sealants.[60] There are studies showing that pit and fissure sealants also stop non-cavitated caries at the dentin level, similar to enamel caries.[61] In addition, there are studies on solid surfaces and fissure sealants. Pit and fissure sealants placed on carious surfaces show similar survival rates.[62] Therefore, it is concluded that pit and fissure sealants are effective in stopping non-cavitated caries.

The effect of pit and fissure sealants in preventing cavitated caries is a topic of debate. One clinical study shows continued caries progression for initial and moderate caries sealed with sealants at a 24-month follow-up.[63] Pit and fissure sealants were found to effectively arrest micro-cavity caries in permanent molars during a 2-year follow-up period.[64] However, another study concluded that while pit and fissure sealants can halt non-cavitated caries, they may not be effective in stopping micro-cavitated caries.[65]

INNOVATIONS IN PIT AND FISSURE SEALANTS AND APPLICATIONS

Recently, new developments have been seen in the pit and fissure sealant application stages. One of these is the enamel deproteinization technique. In this technique, it is thought that not all of the organic residues on the enamel surface can be removed by pickling, so removing these organic residues with different agents before pickling can reduce microleakage and increase penetration ability.[66] In a study conducted in 2022 using 170 caries-free human third molars, the effect of the use of NaOCl, Brix 3000 gel containing papain enzyme, Papacarie Duo gel containing papain enzyme, and bromelain enzyme complex solution for deproteinization on the microleakage scores and penetration ability of fissure sealants before etching the enamel surface with phosphoric acid was evaluated. A decrease in microleakage rate was observed in teeth treated with Brix 3000 gel before acid etching. There was no difference in microleakage in teeth deproteinized with NaOCl, Papacarie Duo gel, and bromelain. While the teeth treated with Brix 3000 gel and Papacarie Duo gel showed improvement in terms of penetration, no improvement was detected in the group deproteinized with NaOCl and bromelain solution.[66] Considering this study, the enamel deproteinization technique seems promising and needs future long-term studies.

Another development in pit and fissure sealant applications is the introduction of lasers as an alternative surface preparation technique.[67] It is reported that the classical method of acid etching and fissure sealant application has disadvantages such as loss of enamel layer, differences in the depth of etching, easy contamination of the etched surface, improper washing and drying, and negative effects on bond durability.[68] Lasers eliminate all these disadvantages. The use of erbium lasers (2780-2940nm) is suggested for the preparation of pits and fissures.[67] The advantages of laser systems in fissure sealant applications can be listed as minimizing washing, isolation, and technical sensitivity, having an antibacterial effect, and providing a caries-resistant modification in dental tissue.[69] Considering all these, it is thought that lasers may replace acid etching, which is a step of pit and fissure sealant application.

According to a recent study on dental sealant applications in 2024, the use of 'bioactive' smart materials has come to the agenda instead of using resin or glass ionomer-containing 'passive' materials as pit and fissure sealants.[70] Smart Burs, Smart GIC, Smart Composite, Smart Dentin Replacement, and Smart Impression Materials are some of the smart materials.[71] Smart materials show significant changes when exposed to external stimuli such as temperature, humidity, stress, pH, electric or magnetic fields. The application of "bioactive" smart materials is considered a very promising technology with the potential for greater durability and higher efficacy over long periods of time.[72] More comprehensive long-term studies on the use of bioactive smart materials in dentistry are needed.

CONCLUSION

Besides utilizing fluoride and maintaining regular oral hygiene, one of the most significant preventive measures against caries formation is the application of pit and fissure sealants. Sealing of pits and fissures is recognized as an effective method to prevent and stop caries. The positive effects of the application of the enamel deproteinization technique before the acid etching stage in pit and fissure sealant application on microleakage and penetration ability seem promising. In addition, it has been suggested that lasers may replace the traditional acid etching stage and that smart materials should be preferred instead of traditional materials for the sealing of pits and fissures. More long-term studies on all these issues are needed.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – F.C.; Design – Ç.A.T.; Supervision – F.C.; Resources – Ç.A.T.; Materials – F.C.; Data Collection and/or Processing – Ç.A.T.; Analysis and/or Interpretation – F.C.; Literature Search – Ç.A.T.; Writing Manuscript – F.C.; Critical Review – Ç.A.T.; Other – F.C.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: The authors declared that this study has received no financial support.

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