Fissure Sealants: A Review of their Importance in Preventive Dentistry

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Abstract

Background: For the prevention of dental caries, fissure sealants application is recommended if pits and fissures are very deep and narrow, creating a physical barrier for the plaque's accumulation, in these specific anatomical areas of the tooth.

Aim: This review article about fissure sealant aims to address the main properties, indications, advantages and limitations of fissure sealants that are used in order to acquire knowledge about what is known today about this biomaterial and how and when it should be applied by clinicians.

Review Results: Studies have shown that fissure sealants applied both in clinics and in schools, are highly effective in preventing dental caries, reducing caries in pits and fissures up to 60% for 2 to 5 years after its implementation. The application of fissure sealants has specific indications, such as: newly erupted teeth, with deep fissures and clinically free of dental caries; patients who present physical and mental disabilities; adult patients that are under medical treatment that involves a significant decrease of the salivary flow. Several studies analyzed do not clarify which type of fissure sealant, if a resin-based or glass ionomeric fissure sealant, has higher retention rate and effectiveness.

Conclusion: The application of sealants is a recommended procedure to prevent or control dental caries. However, the relative effectiveness of different types of sealants has yet to be established.

Clinical Significance: Fissure sealants are recommended to be applied soon after tooth eruption, mainly at the level of the first permanent molars. However, health professionals should always take into account that fissure sealants, currently used, have limitations such as microleakage. Regular reassessment, in order to avoid the development of dental caries, on teeth with partial or total loss of fissure sealants is recommended.

Key Words: Fissure sealants, Primary prevention, Biomaterial, Oral health

Background

Pits and fissures on occlusal surfaces of permanent teeth are particularly susceptible to the development of dental caries [1-3]. This susceptibility is related with the physical size and individual morphology of pits and fissures, which can be considered as being "shelters" for microorganisms and make the hygiene procedures of these areas more difficult, allowing greater plaque retention [2,4-6]. For the prevention of dental caries, fissure sealants application is recommended if pits and fissures are very deep and narrow, creating a physical barrier for the plaque's accumulation, in these specific anatomical areas of the tooth [7-10]. Fissure sealants application in high susceptibility tooth decay areas is one of the primary preventive measures to minimize the risk, reducing its incidence in pits and fissures, preventing the need for more invasive dental fillings [11,12]. Like all biomaterials, the fissure sealant presents a range of chemical, physical and clinical characteristics that makes it an ideal biomaterial used in prevention measures that can benefit human health among the community.

This review article about the biomaterial fissure sealant aims to address the main properties, indications, advantages and limitations of fissure sealants that are used nowadays in order to acquire a higher level of knowledge about what is known today about this biomaterial and how and when it should be applied by clinicians and what can still be studied to improve this biomaterial by researchers.

Review results

To carry out this review article the search strategies included electronic databases, reference lists of articles, and selected textbooks. Articles and textbooks used in this study were mainly reached by using the following keywords: "fissure sealants", "primary prevention", "biomaterial", "oral health". "fissure sealant properties", "advantages / limitations of fissure sealants". By the end of the research, 53 scientific articles and 9 textbooks were used to explain important concepts as properties, indications and clinical protocol for fissure sealants application.

Resin-based sealants

There are three types of resin-based sealants: first generation, polymerized by ultraviolet radiation; second generation, auto-polymerized; and third generation, polymerized by visible light [11].

Fissure sealants were created in 1965, developing thus a new technique for primary prevention, called occlusal sealing [13]. This procedure involves the use of methyl-2-cyanoacrylate, which is mixed with poly (methylmethacrylate) and organic powder which is applied in the tooth's pits and fissures. Cyanoacrylate rapidly polymerizes upon exposure to moisture. With the development of biomaterials, sealants have suffered several changes and, nowadays, they include monomers of 2,2-bis(4-(2-hydroxy-3-methacryloxy-propyloxy)-phenyl) propane (Bis-GMA), activated chemical and photochemically. The Bis-GMA structure is presented in *Figure 1*.

Bis-GMA sealants' chemistry is the same as the composites used for dental restorations. The main difference between them is that bis-GMA sealant should be much more fluid, in order to allow a better penetration in pits and fissures, in conditioned enamel areas, retaining the sealant [14]. Three-parts of viscous bis-GMA are mixed with one part of diluent, such as methyl methacrylate or triethylene glycol, in order to obtain a

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reasonably low viscosity sealant. Alternatively, to obtain low viscosity, is the use of the diurethane dimethacrylate, whose structure can be seen in *Figure 2*. In certain circumstances, microparticles of silica or vaporized inorganic glass can be added in order to provide material rigidity and improve wear resistance [14]. In composite resins used in dental restorations, there are a higher percentage of microparticles, in order to form a lower viscosity level of material compared to the fissure sealants [14].

One of the best innovations, attained so far, in resin material that is used as a sealant, was the incorporation of sodium monofluorophosphate in the polymer matrix, acting as a "reservoir" of fluoride ions, which helps to prevent the development of demineralization that may develop dental caries [15]. The chemical structure of sodium monofluorophosphate is represented in *Figure 3*. The contact of fluoride ions with hydroxyapatite will generate fluorapatite on the enamel tooth surface, creating a greater resistance to demineralization and consequentially reducing significantly the risk of dental caries [16,17].

Bis-GMA first generation chemically activated was polymerized by an organic amine activator. The material is provided as a two package system: one containing bis-GMA and benzoyl peroxide as activator and another containing bis-GMA with a 5% organic amine accelerator. Both components are dispensed in droplets onto a suitable surface for viscous mixture and, after proper mixing, are applied directly on the tooth surface. Nowadays, we can still find autopolymerized fissure sealants in the market.

The polymerization process consists in the addition of a initiator (or activator) to a monomer, which is originally in a liquid state, that, after the establishment of covalent linkage (polymerization) creates a highly reticulated structure. The more suitable photopolymerization method used in dental medicine is the exposure to ultraviolet radiation [14]. Although it is an exothermic reaction, the clinical effects are minimal, because the material is placed in a limited volume. The reaction rate for all materials is temperature sensitive and the material polymerizates faster in the oral cavity (about 3 to 5 minutes) than in the mixing surface. Adding air during the mixing can be clinically manifested as surface irregularities, which may decolorize and retain plaque, drastically reducing the preventive effect of this material. To ensure optimal penetration of the material, the autopolymerized sealant must be quickly applied after mixing. A delay in its application can change the polymerization and induce failure in the material-tooth adhesion [18].

The most common sealant is the bis-GMA and it is photoactivated. Currently, the majority of them are photopolymerized, activated by diketones and an aliphatic amine. The sealant is applied in pits and fissures, with a suitable applicator. During the polymerization process, the light curing tip should be kept 1 to 2 mm from the surface and the sealant exposed to light for about 20 seconds. The sealants are applied in thin layers, allowing a depth polymerization with minimal exposure time, even for opaque materials. The benefit of using a photoactivated sealant is that the working time can be completely controlled by the health professional and according to the patient's behavior. This is particularly valuable when the sealant is applied in very young patients or if the patient does not cooperate [14].

Glass ionomer sealants

Glass ionomer sealants are essentially constituted by a powder-liquid mixture. The solid component consists of fluoralumine silicate glass, while the liquid component is composed by copolymers of polialcenoic acid, water and 2-hydroxyethyl methacrylate (HEMA). Glass ionomer sealants are autopolymerized once the mixture is carried out between the solid component (powder) and liquid component. Currently, we can also find photopolymerizable ionomer sealants [17,19]. The use of fissure sealants with a slow release of fluoride ions has been considered a way of maintaining a

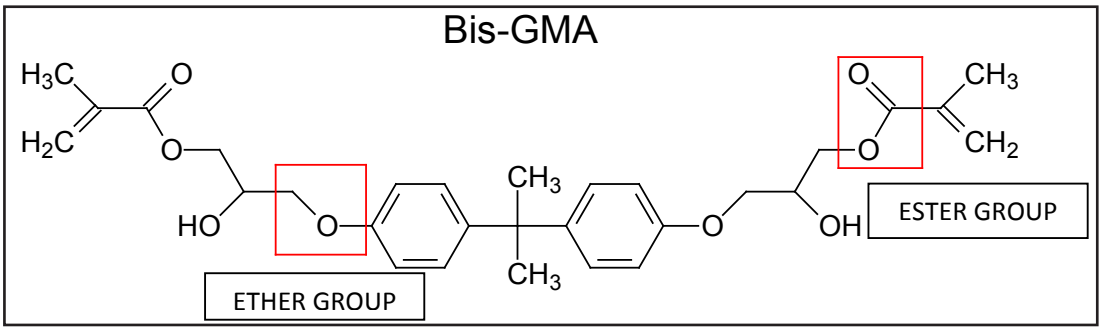

***Figure 1**. Molecular structure of Bis-GMA.*

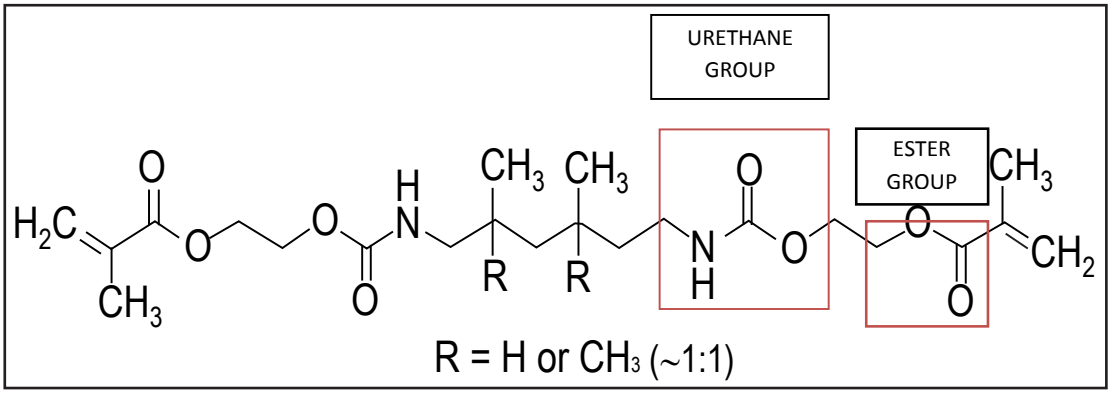

***Figure 2.** Molecular structure of diurethane dimethacrylate.*

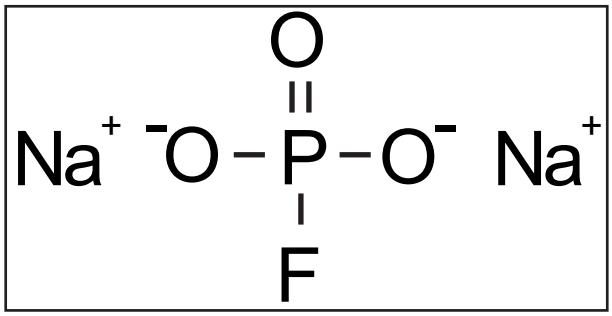

***Figure 3**. Molecular structure of sodium monofluorophosphate.*

high concentration of fluoride, at the surface, for a longer period than it is possible by applying topical therapies in gel [20]. As already mentioned, resin-based sealants release fluoride. However, several studies show that its liberation onto the surface of dental enamel is limited. Thus, glass ionomer sealants were created, allowing a longer release of fluoride ions, in order to reinforce enamel structure, which is considered an important factor in dental caries prevention [21,22].

Glass ionomer sealants are usually more viscous, making the penetration into the fissure depth more difficult. Their greater difficulty in penetrating deeper in those areas of the tooth, means that mechanical retention is not at the same level as the one observed in resin-based sealants with bis-GMA [19,23]. The glass ionomer sealants are also more friable and less resistant to occlusal wear [14,19]. Therefore, and according to clinical studies, the glass ionomer sealants exhibit significantly lower retention rates, but a higher accumulation of fluoride on the enamel surface, allowing a greater resistance to dental hard tissue demineralization [11,24,25].

Indications for use of fissure sealants

As stated before, fissure sealants are applied into pits and fissure surfaces of teeth, in order to create a physical barrier, which protects the sealed surface from decay. However, we can define other indications, in more specific situations, clinically evaluated as:

- Newly erupted teeth, with deep fissures and clinically free of dental caries;
- Patients who have motor disabilities that may present higher difficulty in accomplishing proper oral hygiene (special patients);
- Adult patients that are under medical treatment that involves a significant decrease of the salivary flow [14].

Several authors assess the need for sealants according to the intra-oral observation and oral hygiene [26]. Having this in consideration, we can propose the following classification:

Depending on the need for placement of fissure sealants, we consider that:

- In patients with low need, after an evaluation of pits and fissures depth in occlusal surface of permanent molars, the fissure sealant is applied if it is determine that, anatomically, there is a clinical indication to do so [7,26].
- In a patient with moderated need, priority should be given to erupted permanent molars, because there is a considerable level of susceptibility in developing tooth decay, being that risk increased in permanent molars [27].
- A patient with high need has a predisposition to develop tooth decay, so his molars and pre-molars should be sealed [7,26].

Studies have shown that fissure sealants applied both in clinics and in schools, are highly effective in preventing dental caries, reducing caries in pits and fissures up to 60% for 2 to 5 years after its implementation [28]. A reassessment of fissure sealants should be held annually, not exceeding 12 months between visits to the dentist, for children and adolescents at high risk of developing dental caries. However, it is appropriated a reassessment and reapplication of the sealant within 6 months, in particular cases of patients with high risk of developing dental caries and insufficient oral health behaviors [27] (Table 1).

Advantages and limitations of fissure sealant application

The application of sealants is a recommended procedure to prevent or control dental caries. Ahuvuo-Saloranta et al., by analyzing 16 randomized controlled clinical trials, verified that the fissure sealants application reduces the risk of developing dental caries in 78% on permanent first molars occlusal surfaces, after 2 years of being applied, and 60% after 4 years, when compared to unsealed occlusal surfaces [1]. A review article also developed by Ahovuo-Saloranta et al. confirms that sealing the occlusal surfaces of permanent molars in children and adolescents reduces caries up to 48 months when compared to no sealant [29].The efficiency of a sealant is associated with its retention [30].

It has been shown that sealants are 100% effective if they are fully retained on the tooth [31]. However, due to multiple risk factors, sealants can be degraded and suffer a partial or total loss.

***Table 1.** Classification of patients with indication of fissure sealant application.*

Patients with a low need for sealants	
Indications	Absence of new dental caries in the last year; Absence of dental caries in primary dentition; Absence of dental caries in permanent molars erupted; Good exposure to fluorides; Non-cariogenic diet; Good oral hygiene; Periodic reviews.
Patients with a moderated need for sealants	
Indications	A new dental carie in the last year; Dental caries in primary dentition; Some permanent molars affected by dental caries; Low exposure to fluorides; Cariogenic diet; Poor oral hygiene; Irregular reviews.
Patients with a high need for sealants	
Indications	Two or more new dental caries in the last year; People whose parents have high dental carie experience; Rampant dental caries; Medications that cause xerostomia; High cariogenic diet; Zero or nearly zero exposure to fluorides; Very poor oral hygiene.

Currently, it is known that sealants have a limited antibacterial effect due to their physical properties, but their duration is limited. In a study conducted by Matalon et al. it was found that antibacterial properties of glass ionomer sealants only last about 30 days. In this same study, it was found that resin-based sealants have even a lower antibacterial effect, after polymerization. The different antibacterial action, in glass ionomer and resin-based sealants, is due to the fact that the glass ionomer sealant has a greater fluoride release time [32].

Another important factor that may lead to sealants degradation and loss is the mouth´s pH constant variations, as well as the action of bacterial plaque and salivary enzymes, that can cause their chemical degradation [33]. This limitation explains the need for regular appointments to the dentist. Those appointments are recommended to be carried out every six months, in order to be performed sealants' regular assessments and check the patient's oral health [34].

Other studies demonstrate the effect of sealants wear due to chewing forces applied on the occlusal surfaces of the teeth. The constant force application on the sealant can lead to the material fracture and microleakage [35,36].

Studies conducted by Griffin et al., analyzed the risk of dental caries in teeth with partially or totally lost sealants when compared to those that have never been sealed. The authors concluded that both sealed teeth (with completely or partially lost sealants) showed no greater risk of developing decay, when compared to those which have never been sealed. These results were conflicting and suggest a heightened concern, because partially lost sealants may retain food debris and increase the risk of dental caries development [37].Thus, we conclude that, even in cases of fissure sealants total or partial loss, their application is recommended, since it is considered to be a good method for primary prevention in dental medicine.

The positive effects of fissure sealants are mainly:

i) Pits and fissures are mechanically sealed with a material resistant to acids;
ii) It prevents the development of Streptococcus mutans and other cariogenic microorganisms
iii) Allows better hygiene of pits and fissures.

Manipulation and application technique

Fissure sealants application is fairly easy, however there are a set of precautions that should be taken into account to avoid the risk of its partial or total loss. The clinical protocol recommended for placing sealant is the following:

Prophylaxis: Traditionally, cleaning should be performed with a rubber cup or a Robinson brush, using an appropriate prophylaxis paste as abrasive.

Isolation: It is a crucial step. A good isolation must be obtained to ensure the success of the procedure. It should be used a dental dam or, in some cases, cotton wool rolls for isolating the tooth oral mucosa can also be applied. Isolation is mainly intended to prevent the contamination with saliva during the sealants application.

Etching: The most commonly used for this purpose is the 37% phosphoric acid, which is available in the market as a gel. The acid should be in contact with the tooth surface for about 30 seconds, creating microporosities on enamel, in order to assure the sealant retention in fissures [38].

Acid Removal: Several authors recommend washing the tooth surface for approximately one minute. However, some studies have shown that one minute is as effective as 20 seconds regarding to bond strength and microleakage risk. Nevertheless, the washing should be long enough to allow all acid removal. After washing, the enamel must be completely dry, showing in the whole extension of etching an opaque white appearance [20].

Application: The sealant should be applied on any surface susceptible to caries formation. The polymerization of the material should be performed as soon as possible. In liquid form, sealants manage a greater penetration in enamel microporosities and higher resin *tags,* when there is a longer exposure of to the tooth surface. After polymerization, the sealant should be assessed using a probe to check the existence of air bubbles, or irregularities [20].

Several studies demonstrate the importance of preparing the enamel surface of pits and fissures, to reduce the risk of microleakage, by improving the sealant penetration. This preparation consists in a slight abrasion on the enamel surface with a diamond bur, to improve the sealant retention and, consequently, reduce the risk of its partial or total loss [39].A study developed by Singh et al. revealed that invasive techniques increase the tensile bond strengths of sealants as compared to non- invasive techniques and that the use of a bonding agent as an intermediate layer between the tooth and fissure sealant is beneficial for increasing the bond strength [40].

However, other studies consider that the improvement in sealant retention is not statistically significant during the mechanical preparation of the enamel surface. Thus, we can also consider that performing a more invasive procedure with the removal of tooth tissue, before the sealant application, is not recommended [27]. When applying a fissure sealant, one should have a particular attention to its placement. It is essential that the tooth is completely free from saliva moisture present in the oral cavity. To do so, it is important to isolate the tooth, to ensure that the sealed surface is going to be as dry as possible [20].

With bonding agent *versus* without bonding agent

One of the most studied issues is if a bonding agent should be placed before the sealant, in order to ensure its better retention, on tooth enamel, being considered an intermediate step between etching and sealant application.

The application of a bonding agent gives the possibility of obtaining a better adhesion of a biomaterial to a dental surface. It consists in the application of a biomaterial that will have a role of interface between a specific material for dental restorations and the dental tissue (enamel and/or dentine) [41].

Various articles show that its placement is advantageous [42]. Moreover, several studies demonstrate that, if on one hand it is beneficial in terms of retention, on the other hand, given the extra cost that comes from the use of an adhesive system, there are no statistically significant gains in the application of adhesives [31,43].

A study by Ansari and Hashemi concluded that the enamel surface needs to be completely free of humidity, due to the existing saliva in the oral cavity. If these conditions are guaranteed, there is no need for an adhesive system before

sealant application, because it will not significantly improve polymer retention in tooth enamel [44].

However, other studies, such as Beauchamp et al. and Askarizadeh et al., reported that in situations where complete lack of saliva contamination on the enamel surface is not possible, placing a bonding agent after etching can lead to more prolonged sealant retention [45,46].

Focusing on existing literature, we found that its use will depend on the existing conditions in oral cavity and the way the health professional is able to make the isolation, avoiding saliva contamination and the sealant failure.

Presently, concerning adhesive placement prior to sealants, there are some schools that are for its use and others that are against it. It continues to be a non-consensual subject and only longitudinal studies with a more representative sample and periodical reevaluations can give more conclusive results [27].

Discussion

Several studies have been conducted in order to compare the different materials used as fissure sealants and to verify if there are advantages or not in placing an adhesive system. A study developed by Deery et al., confirmed that regarding the material used, it is known today that there are no significant differences between the use of resin-based and ionomeric-based sealants [47].

When we want to compare materials, it should be taken in account the environment in which that material is applied and the complementarity that both exhibit. Other studies have demonstrated that the resin-based sealants` retention is significantly better than the one of the glass ionomeric sealants in a non-moisture environment [48-51].

An in vivo study, with 80 children, conducted by Bargale et al., showed that resin-based sealants provided better retention, in permanent molars, than the glass ionomer ones, after a six and twelve months reassessment [52]. The highest risk of retention loss occurs with glass ionomer sealants, which increase and hence the risk of microleakage and dental caries formation.

Regarding the release of fluoride ions, we now know that ionomer sealants present a greater release time compared to resin sealants. It is essential to adjust the type of material, depending on its properties, and patient needs.

By the studies carried out, we can also see that there is a complementarity between the resin-based sealants and glass ionomer ones, concerning their clinical application and benefits for the patient [11].

Nevertheless, we must be aware that some studies show that resin-based sealants have no better retention than the glass ionomer sealants. As an example, the study carried out by Fracasso et al., demonstrates that both glass ionomer and resin-based presented a satisfactory degree of penetration into fissures, however, glass ionomer sealant proved to have a better behavior in microleakage test, when compared with the resin sealant [53].

A key problem of fissure sealants is microleakage, a few time after their application. This microleakage may lead to bacterial plaque accumulation, which in contact with enamel, can turn into a carious lesion [54]. It would be important to assess the effectiveness of an antimicrobial agent in preventing the bacterial plaque accumulation and subsequent development of dental caries.

It would be a relevant issue, to compare the bacterial inhibition in resin-based and in glass ionomer sealants, when associated with the same antibacterial. In future, the study of this biomaterial shall minimize the negative effects of microleakage and this situation can only be achieved through the combination of other components to the polymer matrix used.

There are several studies concerning the application of an antibacterial agent in fissure sealants. A study by Li et al. demonstrated that the incorporation of the antibacterial metacriloxiletil ethyl dimethyl ammonium chloride monomer (DMAE-CB) influences the antibacterial properties after photopolymerization. This conclusion was confirmed through analysis of the antibacterial effect in growth of bacterial strain *Streptococcus mutans*, being verified an inhibitory effect on bacterial growth [55]. In this study, it was found that the combination of an antibacterial agent in sealants did not affect their chemical and physical properties and there is no greater risk of microleakage. Some studies have been demonstrating the antibacterial beneficial combination between a bactericidal and/or bacteriostatic and an adhesive system, without changing their physical and chemical properties [56].

Other studies showed that the use of fluoride on dental surfaces, when contacting with the fissure sealant or even incorporated into the biomaterial, may increase their antibacterial effect [15,18,56-58]. A study undertaken by Matalon et al. showed that rinsing with a mouthwash fluoride, for two weeks, allows a greater replacement of the sealant antibacterial properties [59].

So we can verify that the association between an antimicrobial agent (with specific characteristics) with several biomaterials used in clinical practice of dental medicine, can increase an inhibitory effect on the growth of bacterial strains, in this case, Streptococcus mutans [55,57].

Conclusion

The use of fissure sealants as a key primary prevention method is well documented and it is scientifically proved to have good results. Dental sealants were introduced to help prevent dental caries in the pits and fissures, mainly in the occlusal tooth surfaces. Sealants act to prevent the growth of bacteria that can lead to dental caries. There is evidence to suggest that fissure sealants are effective in preventing caries in children and adolescents when compared to no sealants. Therefore, this biomaterial should continue to be used to prevent dental caries, especially among younger people. The most adequate biomaterials to seal pits and fissures should present good dental surface retention, simple application method, biocompatibility, low viscosity in order to obtain better penetration of the biomaterial in narrow fissures and low solubility in the oral cavity [60].

It is necessary to develop more laboratory and clinical researches, in order to improve this biomaterial, for the population's benefit and to reduce the most frequent pathology worldwide – dental caries. The relative effectiveness of different types of sealants has yet to be established, mainly because there is still not clarified which type of fissure sealant,

if a resin-based or glass ionomeric fissure sealant, has higher retention rate and effectiveness.

Clinical Significance

- The several sealants brands of fissure sealants available are considered by clinicians to be ideal biomaterials used in primary prevention. However, as already mentioned, all polymers with biomaterial properties used in clinical practice have limitations that may bring into question the patient's welfare and his oral health.
- The earlier the application, the more effective it is. Therefore, in children, fissure sealants are recommended to be applied soon after tooth eruption, mainly at the level of the first permanent molars.
- Fissure sealants are considered to be an effective and economical method for dental caries primary prevention, so they were integrated in oral health programs [11,61,62].
- Fissure sealants that have the best requisites that exist nowadays and are commercialized in the market are resin-based and ionomeric-based fissure sealants.
- However, health professionals should always take into account that fissure sealants (both resin-based and ionomeric-based) and other dental materials, currently used, have limitations. One major limitation is related to microleakage. Thus, it is important a careful application and regular reassessment, in order to avoid the development of dental caries, on teeth with sealant partial or total loss.

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