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REVISIÓN

Innovations in preventive dentistry: the impact of sealants

Innovaciones en odontología preventiva: el impacto de los sellantes

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ABSTRACT

Dental caries was highlighted as a multifactorial public health problem that affects people of all ages. Its prevalence was related to biological, behavioral and social factors. Dental pits and fissures were identified as anatomically vulnerable areas for caries development due to their complex morphology and difficult access for cleaning. To address this challenge, pit and fissure sealants emerged as a complementary preventive strategy to brushing and fluoride use.
Development
The evolution of sealants from early materials, such as cyanoacrylates, to more modern materials, such as light-cured resins and glass ionomer cements, was examined. These materials offered improvements in adhesion, fluoride release and resistance to microleakage. Placement techniques were also described, including ultrasonic procedures and ameloplasty, which optimized sealing efficiency in deep, narrow fissures. Despite the advances, challenges in its application were highlighted, such as proper tooth preparation and early diagnosis of incipient lesions.
Conclusions
Pit and fissure sealants proved to be an effective tool to reduce the risk of dental caries, especially in posterior teeth. However, their success depends on proper diagnosis, accurate techniques and compliance with periodic check-ups. The integration of this strategy in public health programs could contribute significantly to the promotion of oral health and disease prevention.or unstructured, no longer than 250 words; written in the past tense and in the third person singular.

Keywords: Dental caries; fissure sealants; preventive dentistry; dental materials; public health.

RESUMEN

Introducción
La caries dental se destacó como un problema multifactorial de salud pública que afecta a personas de todas las edades. Su prevalencia se relacionó con factores biológicos, conductuales y sociales. Las

fosas y fisuras dentales fueron identificadas como áreas anatómicamente vulnerables al desarrollo de caries debido a su morfología compleja y difícil acceso para la limpieza. Para abordar este desafío, los sellantes de fosas y fisuras emergieron como una estrategia preventiva complementaria al cepillado y al uso de flúor.
Desarrollo
Se examinó la evolución de los sellantes desde los materiales iniciales, como los cianoacrilatos, hasta los más modernos, como las resinas fotocuradas y los cementos de ionómero vítreo. Estos materiales ofrecieron mejoras en la adhesión, liberación de flúor y resistencia a la microfiltración. También se describieron técnicas de colocación, incluyendo procedimientos ultrasónicos y la ameloplastia, que optimizaron la eficacia del sellado en fisuras profundas y estrechas. A pesar de los avances, se resaltaron desafíos en su aplicación, como la preparación adecuada del diente y el diagnóstico temprano de lesiones incipientes.
Conclusiones
Los sellantes de fosas y fisuras demostraron ser una herramienta eficaz para reducir el riesgo de caries dental, especialmente en dientes posteriores. Sin embargo, su éxito depende de un diagnóstico adecuado, técnicas precisas y el cumplimiento de controles periódicos. La integración de esta estrategia en programas de salud pública podría contribuir significativamente a la promoción de la salud bucodental y la prevención de enfermedades o no estructurado, con una extensión no mayor a 250 palabras; redactado en pasado y en tercera persona del singular.

Palabras clave: Caries dental; sellantes de fisuras; odontología preventiva; materiales dentales; salud pública.

INTRODUCTION

Dental caries is one of the most significant health problems worldwide, affecting people of all ages and representing a constant challenge for dentistry and public health. This multifactorial phenomenon is influenced by biological, behavioral, social, and environmental factors and has been the subject of extensive studies that seek to understand and control its prevalence and severity. Among the preventive measures highlighted, pit and fissure sealants have emerged as a crucial tool in caries prevention, complementing traditional strategies such as tooth brushing and fluoride application.

Dental caries begins as a demineralization process that affects the hard structures of the tooth, progressing from microporosity formation to clinical cavitation. This process is closely related to the accumulation of bacterial plaque in anatomically vulnerable areas, such as the pits and fissures of posterior teeth. Due to their complex morphology and the difficulty of cleaning them effectively with a toothbrush, these areas create a favorable environment for the growth of cariogenic microorganisms, increasing susceptibility to caries' development.

Dental pits and fissures present a wide anatomical variability that directly influences their susceptibility to caries. They are classified into different types according to their shape, such as "V," "IK," "I," and "U," which determines the degree of access that preventive agents such as fluoride have. Deep and narrow fissures are particularly problematic, as they offer inaccessible refuges for mechanical cleaning and the action of chemical agents, favoring bacterial accumulation and the onset of the cariogenic process.

DEVELOPMENT

Dental caries is one of the most relevant problems in dentistry and public health. Currently, pit and fissure sealants represent one of the most effective preventive interventions in dentistry, accompanied by periodic controls, a good brushing technique, and frequency.

Dental caries is defined as a disease process that starts from the appearance of microporosities - as a result of demineralization - to the occurrence of cavitation. Therefore, there has been increasing concern about the role of primary and secondary prevention in detecting caries (1). According to Barrancos, “tooth morphology is characterized by the presence of pits and fissures in each tooth, which is unique in each occlusal face and each person. It was recorded that posterior teeth are more affected by caries because they present a favorable environment for accumulating microorganisms inside pits and fissures” (2).

The accumulation of these microorganisms does not depend on the cleaning performed by the person but on the depth that the toothbrush reaches inside the pits and fissures. These are considered anatomical faults of the tooth where there are large or small depressions depending on the variability of the tooth. Pits are depressions that are usually irregular in shape, mostly located on the occlusal side of the tooth. When the size of the fossa is large, it is called a central fossa in posterior teeth, and its importance lies in the continuous reception of the cusp of the antagonist during the chewing process. On the other hand, anterior teeth are located between the marginal ridges and the cingulum. The fissures are located at the bottom of the sulcus and extend into the dentin. Consequently, there will be a greater predisposition to dental caries because the microorganisms are out of reach of the toothbrush bristles and the chewing process, where their accumulation and metabolism will cause caries later on. Fissures can be classified as: “V” shaped - shallow and wide and therefore resistant to the development of dental caries-, “IK” shaped -simulating a bottle-, “I” shaped -deep, narrow, and with little accessibility, presenting a variation similar to the neck of a bottle- and “U” shaped -wide at the entrance and the base-, among others. The great variability of dental fissures in each tooth causes a great vulnerability to the development of caries because access to fluoride in that area is almost nil, and the enamel presents a high permeability. Depending on the depth of the fissure, the beginning of caries development is evaluated, how this development starts at the level of the sub-surface walls and moves towards the base of the fissure. In this context, the explorer is not recommended since it encourages the development of the lesion with further progression. In conclusion, the anatomy of these lesions cannot be recognized by examination or radiography.

History

At the Universidad Abierta Interamericana, numerous activities are carried out in which caries prevention is a priority, combining hygiene tasks, fluoride topical application, and pit and fissure sealants.

Since they are all very effective mass techniques - and although knowledge of cariology and sulcus morphology has advanced with the appearance of much more specific techniques -all of them imply more work time and less scope in the specific preventive technique. For this reason, although all possible protocolized techniques of pits and fissures are described in this work, the so-called ultrasonic technique was used as a measurement parameter over other materials used as sealants.

At the time of G. V. Black (1908), there were no effective methods for preventing early carious lesions. Prevention was essentially mechanical: healthy carious pits and fissures were included by moving them to so-called self-cleaning or relative immunity zones because it was believed that in these areas, bacterial accumulation was less likely to occur, and thus, an unjustified sacrifice of healthy tooth structure was made. At present, the prevention and treatment of dental caries should be based on the appropriate detection of caries in its earliest stages, i.e., it is not only a matter of detecting cavities but also early signs of demineralization and disease activity (3) (4) (5).

In 1955, the acid etching technique was introduced. Buonocore predicted that this technique would be used to seal spots and fissures for caries prevention and, in 1965, suggested using a sealant with agents capable of bonding to the tooth structure.

The procedure of Resin Preventive Restorations (RPR) evolved from the use of spot and fissure sealants to preventive dentistry. This procedure was first described by Simonsen in 1977.

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From the technique proposed by Buonocore in 1955, different research has been developed, and a large number of products have been created for the sealing of occlusal pits and fissures, using the adamantine conditioning technique and light curing for the most recent materials (3).

Occlusal sealants were developed by Cueto and Buonocore (1965) specifically to prevent caries in the pit and fissure region and be very effective.

The cost-benefit of using sealants over other treatment modalities has been well established. However, only 11 to 15 % of American children have received this treatment in the United States.

Another study conducted by Seif (1996) on 12-year-old children from different socioeconomic strata in Caracas, Venezuela, showed similar figures, with sealants used only in the high socioeconomic stratum.

In turn, Leverett and collaborators (1983) have studied the cost and profitability of treatment with sealants -including the replacement of the lost sealant- versus treatment with amalgam and concluded that sealants are not justified in patients with inactive caries but that they are very profitable in patients with active caries (5) (6) (7).

Different research has been developed using the technique proposed by Buonocore (1955), and many products for sealing occlusal pits and fissures have been created using the adamantine conditioning technique and light curing for the most recent materials.

Barrancos and Barrancos (2) found different types of materials used as sealants and, from there, modified BIS-GMA resins were used, with or without filler (currently used with filler), glass ionomer - taken with greater importance for its fluoride release - and zinc polycarboxylates, whose advantage lies in their greater adhesion strength to enamel than to dentin. The pit and fissure sealant has fluidity as its main characteristic to be able to penetrate the pit and/or fissure, depending on the molecules it contains, and to be able to achieve an effect of transformation from liquid to solid using a polymerization process, since in the solid state it guarantees the barrier effect on the occlusal face concerning the oral environment.

There is a varied classification of materials. According to the presence of fluoride, sealants are classified into those that have fluoride in their composition and those that do not. In the case of the first group, once the material is placed on the surface of pits and fissures, the release of the fluoride ion will begin, complementing the purpose of sealing pits and fissures. They can also be classified according to the presence or absence of fillers. Those sealants contain filler particles in their composition, which magnifies their hardness and reduces excessive wear in the mouth due to friction with their antagonist and/or food. Unfilled sealants do not contain filler particles; this provides better retention and less microleakage. Finally, we classify sealants according to the type of color: white sealants have pigments that give them a white or yellowish appearance (most sealants are included in this group), which makes them easily visible in periodic check-ups; transparent sealants allow us to observe the tissue surrounding the sealant in place, but it is difficult to observe it in subsequent check-ups, remaining almost imperceptible. Finally, the chromatic sealants present a coloration different from the one they will present after being submitted to a light device or when entering a polymerization state. The operator should handle the tooth since the natural color of the tooth will not be confused with the conventional sealant (6).

When sealants are used as a therapeutic alternative, microconservative restorative procedures are performed, which promote the preservation of the tooth structure and not its unnecessary removal, such as the use of remineralization, using various materials and methods such as fluoride varnishes, topical applications of sodium fluoride, aminotetrafluoride (ATF), chlorhexidine rinses, among others.

Over the years, it has been demonstrated that complementing fluoride with a sealing technique significantly reduces and prevents caries rates.

History of materials used as sealants:

Cyanoacrylates

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They were created in 1940 as surgical adhesives and constituted the first sealant materials for caries prevention in dental practice in the sixties. Their instability in the mouth and their relative toxicity were the negative properties that caused their replacement.

Polycarboxylates

These materials were proposed as occlusal sealing agents promptly. Although they achieved an acceptable adaptation, they had the disadvantage of disintegration in the oral environment due to their solubility index.

Polyurethanes

Other adhesive materials, called polyurethanes, were developed as occlusal sealing agents. They initially created good expectations due to their demonstrated ability to release fluoride in a sustained manner and their high degree of permeability. Polyurethanes are the reaction product of a diisocyanate with a high molecular weight glycol, using chloroform as solvent. The polymers used have been the reason for the failure to achieve the expected results.

Diacrylates

At the end of the 1960s, a viscous resin called BISGMA was developed based on a monomer formed by the reaction of BIS-phenol A and glycidyl methacrylate. Bowen created this formula, and it is still in use today. The results obtained are considered satisfactory.

Urethane Dimethacrylates

Although diacrylates are the most commonly described sealing materials, since they continue to be used over time, it should be noted the existence of other sealing agents called urethane dimethacrylates that currently provide identical possibilities in terms of adaptation and durability as those that respond to the BIS-GMA form.

Vitreous Ionomer Cements

The trend is to use glass ionomer cement of a certain fluidity as a fissure sealant.

Fluidity as sealants for pits, points, grooves, and fissures. According to Boksman, these cements have excellent properties, characterized by the adhesion between ions -since they chemically bond to the enamel- and by the incorporated fluoride acting on this tissue. However, the main disadvantages related to their application would be the degree of viscosity that distinguishes them and prevents penetration into the depth of a fissure and premature detachment of the occlusal enamel, which, according to some authors, could be due to their brittle nature.

The conditions that the sealing material should have are:

Low surface tension and sufficient fluidity (accompanied by other necessary requirements on the solid that constitutes the walls of the capillary, in this case, the walls of the fissure, i.e., the dental enamel). The liquids that meet this condition are organic liquids, i.e., those made up of molecules. Once this liquid has filled the space, it must become a solid since it must remain (ideally permanently) in the space and in contact with the oral environment. From the latter, it can be deduced that the molecules that make up this liquid must be capable of reacting with each other by joining through a polymerization process since this determines the transformation into a solid (if the degree of polymerization is sufficient).

In conclusion, the material to be used, generally called pit and fissure sealant, must be constituted by a liquid of molecules capable of polymerizing (monomers). To achieve this without resorting to the combination of molecules with different functional groups capable of reacting with each other (condensation or ring-opening reactions), these molecules must be of vinylic type (with double bonds) so that, with the action of an appropriate initiator, an addition polymerization reaction (by the opening of these double bonds) and the subsequent transformation, once placed in the space to be filled, can take place. In addition, the final solid should be stable in the mouth (not attackable by the medium, not soluble or degradable). Usually, the molecule used in the formulation of the sealant has not one but two double bonds. Thus, the polymerization is made with crossed chains, and a thermosetting organic material

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is obtained (and relatively rigid in "normal" temperature conditions, which allows it to be categorized as a "resin" within the organic materials) that better guarantees the desired characteristic (5).

Indications

Dental sealants present indications that will limit their use. These are variable and depend on the characteristics of each patient. For example, in teeth with complete eruption, non-remineralized, wide, and/or deep pits, fissures, incipient caries, and enamel defects such as hypoplasia and/or hypomineralization.

Sealants will be contraindicated when in the pits and fissures where the brush reaches its full depth, wide cavitated lesions are observed, with evident caries, or when the dental eruption has not been completed. The tooth presents previous restorations and/or interproximal caries.

Before placing these sealants, a good diagnosis is necessary since there are several parameters in the sealing technique.

The surface to be treated must be perfectly clean and dry for our treatment to be effective.

They are contraindicated in cavitated teeth, in people with high caries rates, and in those who do not comply with periodic controls -as this could be counterproductive-. They are also not recommended for partially erupted teeth.

About the technique of sealant placement, the most important conditions for achieving adhesion are adequate isolation and satisfactory etching. If fissures with very narrow anatomies are detected, an annuloplasty with a round bur to increase the contact surface or an ultrasonic technique can be performed.

Techniques

Conventional occlusal sealing: This technique involves the shortest working time; the occlusal surface is cleaned with a brush soaked in pumice stone, carrying the sealant material in a K file for greater penetration into pits and fissures.

Occlusal sealing with the opening of pits, points, grooves, and/or fissures is performed by physical-mechanical means. This group includes the various methods of opening or slightly widening fissures, which, following the progression of the disease, generate microcavities that can be positioned in the enamel, in the amelogenin junction, or in the dentin. The rationale for the use of fissure-opening occlusal sealing techniques is to:

To achieve the removal of the fissure contents and the prismatic layer to promote the action of 37% phosphoric acid in the depth of the defects and thus create micropores in the lateral walls of the defects and increase the adaptation of the sealant, decreasing marginal leakage.

Avoid sealing amelogenin or dentine subsurface lesions that are impossible to diagnose.

Ultrasonic or sonic techniques: K-type files are used. ISO-06 standard, adapted to ultrasonic cleaners.

Microcavities are obtained, including an area free of interocclusal counts within the mucosal space. Subsequently, the conditioning technique is performed, and a sealing agent, preferably light-curing, is applied.

Opening technique with troncoconical fistulotomy drills: The drills used are special for this technique; they measure 100um in their active tip against 250um of a quarter tip.

Small cylindrical stones: The microcavities are prepared with extra-fine diamond stones of very small diameter at the end and truncated cone or biconcave shape. They are subsequently sealed.

Ameloplasty: Ameloplasty is usually considered a technique or procedure that consists of remodeling or widening occlusal structural defects through very small rotary instrumentation. This maneuver is performed only on the adamantine tissue and converts the occlusal surfaces into smooth, polished, easily cleaned areas.

The current concept of the procedure called "annuloplasty" would be interrelated with the solution of the problem determined by subsurface occlusal caries lesions with different depths in the dental structures and the impossibility of diagnosing them through conventional techniques. Ameloplasty can be

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defined as the technique that consists of the “opening or shaping” of the cariogenic structural defects of the enamel of an occlusal face or a marginal ridge using appropriate rotary instrumentation or other procedures. The technical purpose is to transform an area of non-cleanliness into an area of cleanliness and access to mechanical brushing to receive a sealing agent when the enlarged sulcus is very deep, fissured, or corresponds to a patient with high cariogenic activity (5).

Indications for Ameloplasty

When non-clean areas, such as pits and deep grooves, with active plaque evidenced by colorimetric methods, there is no evidence of cariogenic activity in other dental elements.

When grooves or supplementary defects are observed on marginal ridges or cuspid sloping planes, which, if included in cavity preparation, would imply the weakening of fundamental structures for a stabilized occlusion, which are not always easy to restore (5).

Pit and fissure sealants have the following functions:

They mechanically seal the pits and fissures with an acid-resistant resin or ionomer.

By sealing the pits and fissures, they suppress the habitat of streptococcus mutans and other microorganisms.

And other microorganisms.

They facilitate cleaning these surfaces by physical methods such as tooth brushing and chewing.

There are currently two forms or types of commercially available pit and fissure sealants:

Self-curing

Self-curing (resin-based or ionomer-based).

Type of materials used to seal pits and fissures:

Sealant

Glass ionomer

Flowable resin: Composite Flow

A sealant application must remain intact for a long period. If a complete seal is not obtained or the sealant is lost, even in a small area, the potential for the sealant to act as an anti-cariogenic agent is jeopardized. Continued leakage increases the potential for caries.

The main quality of any sealant material is its adhesion to the enamel surface. It is important to know if a product has the characteristic of preventing microleakage or, in any case, if it allows minimal microleakage compared to another. Microleakage introduces saliva, fluids, substances, and bacteria found in the mouth into the enamel-sealant complex due to the lack of adhesion between the sealant and the enamel surface. Microleakage causes multiple consequences: because there is a direct channel between the sealant and the enamel surface, caries, pulp lesions, and/or hypersensitivity could occur. These consequences result from poor adaptation of the material and lack of adhesion. Some main causes of microleakage are the absence of marginal sealing in the tooth and the obturation material. This will be due to different reasons such as, for example, a poorly adapted restoration where the lack of seal produces the expulsion of the material, a bad preparation of the cavity, or, in cases where we see sealants, it could be a bad ameloplasty, a bad manipulation and application of the material by the dentist. It will also be produced by using obturator material in poor or outdated condition or by a deformation of the restoration caused by the act of chewing that usually produces forces when the tooth comes into contact with its antagonist.

Pain is the first manifestation of microleakage, provided there is pulp vitality, and caries would represent the most important phenomenon due to contamination during application and/or product failure. The presence of caries in these cases is undetectable since when the symptoms are present, it is observed that the caries process.

The presence of caries in these cases is undetectable since when symptoms are present, it is observed that the carious process is in an advanced stage and not in the initial stage as expected.

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On the other hand, when the operator detects the microleakage, a new restoration will be made to prevent the progression of the carious lesion -as long as the surrounding structure is healthy.

When opting for one or the other material, we understand that the vitreous ionomer can continuously release fluoride, representing a clear advantage over microfiltration.

On the other hand, the resinous sealant will have the benefit that, being a chromatic sealant, it will allow better handling of the material when applying it, longer working time, and better distribution. As light-cured, it will become white - keeping it differentiated from the enamel - and can be examined in future controls. The choice of material will also depend on the type of patient with whom the professional is working. Since most patients with pit and fissure sealants are children and/or adolescents, there is not much time to perform the treatment due to the behavior they tend to take in the dental office.

Therefore, the dentist will be in charge of evaluating which type of material to use and will base this decision on the fewer steps required for the application, an advantage present in glass ionomer.

The purpose of this in vitro research is to evaluate the presence or absence of marginal microleakage in premolars and third molars from the use of three different types of materials - sealers, glass ionomer, and composite flow - taking into account the benefits for the practitioner who, depending on the circumstances, will keep this information in mind.

CONCLUSIONS

Dental caries represents a persistent and multifactorial public health problem, particularly prominent in the pits and fissures of posterior teeth due to their anatomical complexity. The scientific evidence reviewed underlines the importance of preventive approaches, such as pit and fissure sealants, which have proven effective tools for mitigating caries risk in these vulnerable areas.

The evolution of techniques and materials used in sealants, from early cyanoacrylates to light-cured resins and glass ionomer cement, reflects the effort to maximize the effectiveness and durability of these interventions. Advances in current materials, such as fluoride-releasing glass ionomer and chromatic sealants, have allowed for better enamel adhesion, greater microleakage resistance, and more appropriate handling in subsequent controls. However, limitations in their application, such as adequate tooth surface preparation and the need for precise isolation, are critical aspects that practitioners must consider to ensure treatment success.

The studies reviewed also highlight the influence of anatomical variability in pits and fissures on susceptibility to caries, showing that deep and narrow fissures present a higher risk. Techniques such as angioplasty and ultrasonic procedures have emerged as complements to improve accessibility and effectiveness of sealing, allowing a better adaptation of materials in difficult access areas.

On the other hand, it has been pointed out that there is a need for clear criteria for the indication of sealants, prioritizing their use in patients with high caries risk and teeth with anatomical characteristics prone to the development of lesions. This, coupled with the importance of early diagnosis and integrating preventive measures such as topical fluoridation and plaque control, underscores the comprehensive approach needed to address dental caries effectively.

In conclusion, pit and fissure sealants remain a fundamental preventive strategy in modern dentistry, especially when combined with other preventive and diagnostic interventions. Although challenges related to the application and durability of the materials persist, technological advances and ongoing research allow their use to be optimized, significantly reducing caries prevalence in vulnerable populations. Implementing these strategies should be a priority in public health programs aimed at oral health promotion and disease prevention.

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CONFLICT OF INTEREST

None.