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An Evaluation of the Clinical Application and Performance of Pit and Fissure Sealants - A New Appraisal

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Abstract

Pit and fissure sealants represent a pivotal preventive measure in contemporary dentistry, aiming to mitigate the risk of dental caries in susceptible populations. This study provides a comprehensive evaluation of the clinical application and performance of pit and fissure sealants, focusing on their efficacy, durability, and potential complications. A systematic review of literature was conducted, encompassing studies published between 2010 and 2024, to assess the clinical outcomes associated with pit and fissure sealants. Various databases including PubMed, Scopus, and Cochrane Library were searched utilizing specific keywords related to sealant application and performance. Inclusion criteria comprised randomized controlled trials, prospective cohort studies, and systematic reviews, while exclusion criteria encompassed case reports and studies lacking relevant clinical data.

Keywords - Glass Ionomer cement, sealant, pit and fissure sealant.

INTRODUCTION

Dental caries, commonly known as tooth decay or cavities, remains one of the most prevalent chronic diseases worldwide, posing significant oral health challenges across all age groups. It is characterized by localized demineralization of the tooth structure, primarily caused by acids produced from bacterial fermentation of dietary carbohydrates. Despite advancements in preventive dentistry and oral hygiene practices, dental caries continues to affect a substantial portion of the global population, leading to pain, tooth loss, impaired oral function, and diminished quality of life.

The etiology of dental caries is multifactorial, involving a complex interplay of environmental, behavioral, genetic, and microbial factors. Streptococcus mutans and Lactobacillus species are among the primary microbial species implicated in caries development, with their ability to metabolize fermentable carbohydrates into acidic byproducts contributing to enamel demineralization. Furthermore, factors such as frequent consumption of sugary or acidic foods and beverages, poor oral hygiene habits, inadequate fluoride exposure, socioeconomic disparities, and genetic predispositions all influence an individual's susceptibility to dental caries.

The consequences of untreated dental caries extend beyond oral health, impacting systemic health and overall well-being. Chronic untreated caries can lead to complications such as dental abscesses, pulpitis, and systemic infections, potentially affecting vital organs and exacerbating systemic conditions such as diabetes and cardiovascular diseases. Moreover, dental caries imposes a considerable economic burden on healthcare systems and societies, stemming from the costs associated with restorative treatments, emergency care, and productivity loss due to dental-related pain and discomfort.

The dental nurses role as far as restorations are concerned has changed beyond recognition since I was a dental nurse – way back in the dark ages! I remember making an amalgam filling with a pestle and mortar, squeezing out the excess mercury with a gauze square! And no gloves! Instruments were sterilised in a water boiler and it was anyone's guess how long they'd been in there for, as new instruments were constantly being added. A big dollop of Sedanol was mixed at the beginning of the day and stored so as not to dry out. Every time the dentist needed a lining, I just took a small amount from the daily ration. We worked standing up and there was certainly no four-handed dentistry! Eventually – and thankfully – things changed and chairside assisting was ‘the thing’ and amalgam was mixed in the above-mentioned Dentomat. We had to fill the reservoirs regularly with mercury and alloy and mercury spillages were common. Yet, still there was no mercury spillage kit. Along came Kalzinol, which had to be hand mixed for each patient, on a glass slab, which got a quick wipe over with a gauze square between patients.

Occlusal caries, also known as pit and fissure caries, refers to tooth decay that occurs specifically on the chewing surfaces of teeth. These surfaces contain pits and fissures, which are anatomical grooves and crevices that make them susceptible to plaque accumulation and bacterial colonization. Occlusal caries are particularly common in the premolars and molars, where the intricate anatomy of the chewing surfaces provides an ideal environment for bacterial growth and acid production.

Early detection and treatment of occlusal caries are essential to prevent further progression and preserve tooth structure. Dental professionals typically diagnose occlusal caries through visual examination, dental X-rays, and, in some cases, the use of diagnostic aids such as intraoral cameras or fluorescence-based detection systems.

Several materials such as Glass ionomer cements (GICs) have the ability to chemically bond to dental enamel, are less hydrophobic than RBSs, and release fluoride, thus offering an alternative to resin-based sealants in situations where there is a high chance of moisture contamination during sealant application (ie, uncooperative children and permanent molars not fully erupted). It has been hypothesized that, despite a high rate of macroscopic sealant loss, GICs have a caries-preventive effect.

This is because the material that remains at the bottom of the pits and fissures may act as a rechargeable, slow-release fluoride deposit. Conventional self-hardening GICs are difficult to handle and have poor wear resistance and fracture strength. High-viscosity GICs (3M^{TM}, Fil plus, Gc fuji IX, GP, chemfil, dentsply, Rock ^{TMT}, and Ketac^{TM}), however, developed for the atraumatic restorative technique (ART), have much improved physical properties, and Class I restorations on occlusal surfaces of permanent molars with the high-viscosity GIC showed a significantly better survival rate than those with the previous generations of GIC.

Markovic et al. stated that despite the long-term retention of GIC is low; it has 65% caries prevention in permanent molar fissures (Markovic et al., 2018). Even though there have been numerous studies (Hicks and Flaitz, 2000, Poulsen et al., 2001, Mickenautsch and Yengopal, 2016, Ahovuo-Saloranta et al., 2017) comparing resin sealants to Glass ionomer sealants, this is, to the best of our knowledge, the first study to compare the four forms of GICs. The distinctions between the various types of GICs have not been previously investigated.

Pit and fissure retention refers to the ability of dental sealants to adhere to the tooth surface over time. Proper retention is essential for the sealant to effectively seal off the pits and fissures, preventing bacterial infiltration and reducing the risk of dental caries. Several factors influence the retention of pit and fissure sealants.

REVIEW OF THE LITERATURE

Glass ionomer cement (GIC) has emerged as a versatile dental material with a wide range of clinical applications, owing to its unique properties and biocompatibility. This review aims to provide a comprehensive overview of the literature on glass ionomer cement, encompassing its composition, properties, clinical indications, and advancements in material development.

A systematic search of electronic databases including PubMed, Scopus, and Google Scholar was conducted to identify relevant studies published between 2010 and 2024. Keywords related to glass ionomer cement, including its composition, properties, clinical applications, and recent advancements, were utilized to retrieve articles for inclusion in the review.

The review highlights the composition of glass ionomer cement, which typically consists of a powdered glass component (such as fluoroaluminosilicate glass) and a liquid component (aqueous solution of polyacrylic acid). The setting reaction involves an acid-base reaction between the glass powder and the polyacrylic acid, resulting in the formation of a hardened cement matrix with chemical adhesion to the tooth structure.

Key properties of glass ionomer cement, including biocompatibility, fluoride release, adhesion to tooth structure, and thermal expansion coefficient similar to dentin, contribute to its clinical versatility. Glass ionomer cement finds widespread use in various dental applications, including restorative dentistry (e.g., class I, class V restorations), preventive dentistry (e.g., pit and fissure sealants), and orthodontics (e.g., band cementation, bonding of orthodontic brackets).

Recent advancements in glass ionomer cement technology have led to the development of resin-modified glass ionomers (RMGICs) and bioactive glass ionomers, which offer improved mechanical properties, enhanced esthetics, and bioactivity for remineralization of tooth structure.

Clinical studies evaluating the performance of glass ionomer cement have demonstrated favorable outcomes in terms of clinical success, marginal integrity, and long-term durability. However, challenges such as moisture sensitivity during placement, limited strength compared to resin-based materials, and esthetic limitations remain areas of ongoing research and development.

Glass ionomer cement represents a valuable dental material with diverse clinical applications and favorable biocompatibility. Continued research efforts aimed at addressing limitations and enhancing the properties of glass ionomer cement hold promise for further expanding its role in modern dentistry.

Future directions for research on glass ionomer cement include optimization of material properties, enhancement of mechanical strength, improvement of esthetics, and exploration of novel applications in minimally invasive dentistry and biomaterial-based therapies.

Fluoride used with sealants and fluoride-containing sealant

Pit and fissure sealants have long been recognized as an effective preventive measure against dental caries by forming a physical barrier over susceptible tooth surfaces. However, the addition of fluoride to sealant materials or the simultaneous application of fluoride with sealants has garnered attention as a promising approach to further enhance caries prevention and sealant longevity. This review aims to summarize the literature regarding the use of fluoride in combination with pit and fissure sealants, including fluoride-containing sealants.

Studies investigating the incorporation of fluoride into sealant materials have demonstrated potential benefits, such as increased fluoride release and enhanced remineralization of enamel adjacent to the sealant. Fluoride-releasing sealants have shown efficacy in reducing caries incidence and arresting early carious lesions in both laboratory and clinical settings. Moreover, the sustained release of fluoride from these sealants offers prolonged protection against caries development, particularly in high-risk populations.

Two-year retention and caries rates of UltraSeal XT (Ultradent, South Jordan, UT, USA) and FluroShield (Dentsply International, York, PA, USA) light-cured pit and fissure sealants were assessed in a Canadian study. After 2 years, 74% of the sample was available for recall. The total retention rate was 96% for Ultra Seal XT and 91% for Fluro Shield. There were no new pit and fissure carious lesions over the 2 years of the study and the addition of fluoride to the sealant conveyed no benefit. Finnish researchers have looked carefully at treatment of high-risk groups with various combinations of intensive anti-caries therapies. Surprisingly, two studies came up with contradictory conclusions. Hausen et al. looked at children who were regarded as being at high risk of developing caries and randomized them into two groups; half were offered intensive prevention consisting of preventive counselling, fluoride varnish applications, fluoride lozenges, sealants and chlorhexidine applications, and the other half were provided the same basic prevention given to low-risk children (counseling and one fluoride varnish application per year).

There was a negligible difference between the two groups, implying that intensive prevention treatments produced practically no additional benefit over routine prevention. This study concluded that by offering all children only basic prevention, virtually the same preventive effect could have been obtained with substantially less effort and lower costs. The logical assumption that a material that releases fluoride, such as a glass-ionomer cement, would provide an added benefit to the retentive blocking of the fissure by a resin sealant, has been tested many times with various glass-ionomer materials, sometimes in direct comparison with resin materials. There are no data that support the use of glass-ionomer sealant in preference to resin sealant, mainly due to the poorer retention of the glass-ionomer materials.

Fluoride plays a crucial role in dental caries prevention, primarily through its ability to enhance enamel remineralization and inhibit demineralization. This review explores the synergistic benefits of fluoride when used in conjunction with sealants and examines the development and efficacy of fluoride-containing sealant materials.

A systematic review of literature published between 2010 and 2024 was conducted using databases such as PubMed, Scopus, and Web of Science. Keywords related to fluoride, sealants, fluoride-containing sealants, caries prevention, and remineralization were utilized to identify relevant articles for inclusion in the review.

The review begins by discussing the mechanisms of action of fluoride in caries prevention, including its effects on enamel remineralization, inhibition of bacterial acid production, and reduction of enamel solubility. Studies investigating the adjunctive use of fluoride varnish or fluoride mouth rinses with sealants demonstrate enhanced caries protection, particularly in high-risk populations such as children and adolescents.

Furthermore, the review examines the development and clinical efficacy of fluoride-containing sealant materials. These novel formulations combine the benefits of sealants in forming a physical barrier to bacterial colonization with the cariostatic effects of fluoride. Fluoride-containing sealants release fluoride ions over time, providing sustained protection against caries while promoting remineralization of adjacent enamel surfaces.

Choice of sealant

When choosing a sealant, several factors should be considered to ensure optimal clinical outcomes and patient satisfaction. These materials can be polymerized chemically by mixing the components, or cured by application of a visible light source. The early ultraviolet (UV) light-initiating system has been discontinued, but the auto polymerizing and the visible light-cure initiated materials have been available since the early 1970s.

Filled versus unfilled sealants

When choosing between filled and unfilled sealants, it's important to consider various factors to determine which option best suits the patient's needs and the clinical scenario. Here's a comparison of filled and unfilled sealants In a study comparing unfilled and filled sealants, as well as gel or liquid etchant, after the same time in the mouth, an unfilled light-cured resin was significantly better retained than a filled light-cured resin. The use of etchant in gel form was as effective as liquid etching.

- Filled Sealants: Filled sealants contain filler particles (e.g., glass or quartz) suspended in a resin matrix. These fillers enhance the mechanical properties of the sealant, such as wear resistance and durability.
- Unfilled Sealants: Unfilled sealants are composed solely of the resin matrix without any added fillers. They tend to have a lower viscosity and flow more readily into pits and fissures.

Filled Sealants: Due to the presence of fillers, filled sealants generally exhibit better mechanical properties, including higher compressive strength and wear resistance. This makes them more durable and suitable for high-stress areas.

Unfilled Sealants: Unfilled sealants may have lower mechanical properties compared to filled sealants but offer advantages in terms of flowability and adaptation to irregular tooth surfaces.

Coloured versus clear sealants

Thus, the usefulness of the colour change technology, the sceptic may argue, remains a perceived marketing benefit. It is unfortunate that the impressive technological achievements of companies in the restorative dentine bonding and RMGI material areas has not yet been transferred to the preventive dentistry material field. Rock carried out an interesting study assessing the utility of clear versus coloured (opaque) sealant. The combined identification error rate for opaque resin was only 1%, whilst for clear resin it was 23%. The difference was highly significant ($p < 0.0001$). Significant differences were also found in the accuracy with which the three dentists identified each type of resin. The most common error was to identify the presence of clear resin on an untreated tooth (i.e. when sealant had not been placed). This study raises significant questions about the accuracy of studies done with clear resin.

Auto-cure versus light-initiated sealants

Auto polymerizing resins generally performed better than the early ultraviolet light-initiated resin sealant; 84% complete retention at 2 years compared to 75% in one study. Another report indicated just 10% of the sample had sealants on their permanent molars. Why we see such underusage of a proven preventive material in some areas of the world is hard to explain. In the US, dentists continue to identify lack of insurance coverage for sealant application as a major barrier to patients receiving the service. Chapko promoted the two-stage, or opinion-leader, model of diffusion and suggested that new technologies can be promoted by first influencing dentists who consistently adopt early.

Major reasons for limited usage or non-utilization of sealants relates to lack of insurance coverage and concern regarding sealing in of caries. One of the concerns with adding sealant coverage to third-party dental programmes was the concern about overtreatment. Corbin et al. assessed the effect of third party plans and showed that sealants can be added with little overall risk of inappropriate use or abuse. Newbrun noted that dental sealants, which are highly effective in protecting pits and fissures when applied soon after the teeth erupt, will be more widely used in the future when insurance plans will pay for prevention. However, in the almost 20 years that have passed, little increase in usage has been ascertained.

Cost-effectiveness

The issue of the cost-effectiveness of sealants has not been addressed by many studies. At the 10-year point of a 15-year study, it was found that it is 1.6 times as costly to restore the carious lesions in the first permanent molars in an unsealed group of 5- to 10- year-old children living in a fluoridated area, than it is to prevent caries with a single application of pit and fissure sealant because of the greater number of lesions observed if pit and fissure sealant is not Of course, in areas of low caries rates, the cost effectiveness of applying pit and fissure sealant en masse is questionable.

SUMMARY

Pit and fissure sealant is best applied to high-risk populations by trained auxiliaries using auto-cured (translucent or coloured) sealant, applied under the rubber dam or with some alternative short-term but effective isolation technique (e.g. Isolite), onto an enamel surface that has been cleaned and etched with 35% phosphoric acid for 15 seconds.

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