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Assessment of Microleakage among Various Pit and Fissure Sealants: A Comparative Approach

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Abstract

Background: Pit and fissures are considered to be highly vulnerable sites for the adhesion of cariogenic microorganisms and consequently result in caries formation. Microleakage remains the primary concern associated with sealant failure. A sealant is considered an effective preventive measure against dental caries only when it is securely bonded to the tooth and effectively shields the pits and fissures from the oral bacterial environment.

Aim: To compare the microleakage of two different pit and fissure sealants placed on permanent molars.

Materials and methods: A total of 32 extracted molars were randomly divided into two groups of 16, group I samples were restored with Yuseal and group II with Fissure Seal. Further these samples were subjected to thermocycling, immersed in 2% methylene blue dye, sectioned and evaluated under stereomicroscope to assess the amount of dye penetration. A non-parametric test (Mann–Whitney *U*) was performed to compare the mean microleakage score difference between the groups.

Results: Both the groups showed some degree of dye penetration, with Group I demonstrating lower microleakage scores compared to Group II. However, the difference was not statistically significant.

Conclusion: The findings of the study recommend that both Yuseal and Fissure Seal are suitable for use as pit and fissure Sealants in permanent molars.

Keywords: Dental caries, Fissure Seal, Microleakage, Pit and fissure sealant, Yuseal.

Introduction

Minimally invasive dentistry has recently emerged as a more conservative approach to caries management, focusing on the use of preventive materials. Dental caries can be prevented or slowed down by pit and fissure sealants by acting as a barrier between oral flora, food debris, and acid-producing microbes that get harbor in the grooves of the teeth.[1] According to the International Pediatric Dentistry Guidelines, sealing primary and permanent molars in children and adolescents is recommended to prevent development of caries.[2] Liu et al.[3] reported 44% reduction in caries risk in rural children with sealed fissures, compared to 35% reduction in urban children. Similarly, Splieth et al.[4] highlighted the significant benefits of fissure sealants in preventing dental caries on the occlusal surfaces of both primary and permanent dentitions.

An effective sealing material should exhibit properties such as biocompatibility, retention and wear resistance. Additionally, the bond between the sealant and enamel is crucial, as microleakage at this interface can undermine the treatment.5 Microleakage refers to the infiltration of oral fluids into the space between the tooth and restorative material, leading to bacterial invasion, loss of sealant material and the development of secondary caries.[7] It is a primary concern in direct restorative procedures and a major cause of restoration failure.[8]

In vitro studies are vital for evaluating new products and guiding their use. Although data on the microleakage of Yuseal and Fissure Seal pit and fissure sealants is limited, this in vitro study aims to compare the microleakage performance of these two pit and fissure sealants.

Materials and Methods

This *In Vitro* study was performed in the department of Pediatric and Preventive dentistry, in collaboration with the Oral and Maxillofacial Pathology. Institutional ethical clearance was obtained prior to the commencement of the study.

Methodology

The study sample comprised thirty-two human permanent molar teeth extracted for orthodontic or surgical reasons. Teeth with intact occlusal surfaces were included, while those with developmental defects, cracks, caries or existing restorations were excluded. Initially, the teeth were cleaned with periodontal curettes to remove any residual soft tissue and debris, then disinfected with hydrogen peroxide. The cleaned teeth were subsequently stored in distilled water until further use.

The crown portions of the selected teeth were embedded in self-cure acrylic resin. The thirty-two molar teeth were then randomly divided into two groups of sixteen teeth each. Group I received treatment with Yuseal (Anabond-Stedman), while Group II was treated with Fissure Seal (Waldent). Both materials were applied to the prepared occlusal surfaces of the teeth following the manufacturer's instructions.

Enameloplasty was performed on all samples in both groups by widening the pits and fissures to 0.5 mm using a 1/4 round tungsten carbide bur (SS White Carbide Bur FG2) in a low-speed handpiece with continuous water spray. It was essential to ensure that all tooth surfaces were dry before the application of the sealant.

For Group I samples, acid etching was carried out on the occlusal surfaces using 37% orthophosphoric acid (D-tech XT Etch) for 30 seconds. After etching, the surfaces were rinsed with water for 30 seconds and thoroughly air-dried. A bonding agent (Nano Bond, WALDENT) was then applied to the fissures with a micro brush and cured for 20 seconds. The sealant was introduced slowly and carefully into the pits and fissures using a stirring motion to avoid air bubbles. Finally, curing was performed for 20 seconds with a light-curing unit held approximately 2 mm from the surface. Upon curing, the sealant hardened and turned opaque white.

In Group II, etching was performed with 37% orthophosphoric acid for 10-15 seconds, not exceeding 30 seconds. Following etching, the teeth were thoroughly rinsed with water and air-dried using a three-way syringe for 15 seconds until a white frosty appearance of the enamel was achieved. A bonding agent was then applied and polymerized. The sealant was placed on the prepared tooth surface and cured with a light-curing unit for 20 seconds. All restored teeth were subsequently stored in normal saline until further use to prevent dehydration.

To simulate the oral environment, the test specimens underwent thermocycling, with cycles between 5°C and 55°C, each with a dwell time of 30 seconds, for a total of 500 cycles. After thermocycling, the specimens were coated with two layers of nail varnish, leaving a 1 mm margin around the restoration edges exposed. The specimens were then immersed in 2% methylene blue dye for 24 hours to allow the dye to diffuse into any potential gaps between the tooth and restoration interface. Following immersion, the samples were rinsed with distilled water to remove any excess dye.

The samples were sectioned at the cervical margin to separate the root portion using a diamond disc mounted on a straight handpiece. The crown portion was then longitudinally sectioned in a buccolingual direction into two halves through the middle of the sealant using a safe-sided diamond disc mounted on a straight micromotor handpiece with a continuous flow of water. Sections with dislodged sealant material were discarded.

The sectioned specimens were examined under a stereomicroscope at 10x magnification to assess dye penetration, and photomicrographs were taken. The degree of microleakage was evaluated based on the extent of dye penetration between the sealant and the tooth interface, following the criteria established by Ovrebo and Raadal.[9] The scoring method used was as follows: Score 0 – no dye penetration; Score 1 – dye penetration restricted to the outer half of the sealant; Score 2 – dye penetration reaching the inner half of the sealant; Score 3 – dye penetration into the underlying fissure. (Figure 1)

The entire procedure, from sample preparation to interpretation of the results, was carried by a single operator. However, to avoid bias, a second investigator who is unaware of the prior results re-evaluated the samples randomly. As the inter examiner variability is not statistically significant, ($P<0.05$) the values given by the first investigator were only considered.

Statistical analysis was performed using SPSS version 20 software (IBM SPSS, Armonk, NY, USA). Inter group comparison of microleakage scores were done using Mann-Whitney test. The p-value is considered significant when it is less than 0.05.

Results

The distribution of teeth among different groups according to microleakage scores were represented in Graph I and Table I which signifies that Group I, treated with Yuseal, 56.25% of samples showed no dye penetration, while 43.75% had dye penetration restricted to the outer half of the sealant. On contrary, group II treated with Fissure Seal had 25% of samples with no dye penetration and 75% with dye penetration restricted to the outer half of the sealant. Intergroup comparison revealed that group I treated with Yuseal had lower microleakage scores compared to Group II; however, the differences between the groups were not statistically significant (Table II)

Discussion

A pit and fissure sealant plays a crucial role in preventive oral health strategies by reducing occlusal caries. An ideal sealant material should possess properties such as biocompatibility, strong retention and resistance to abrasion and wear. The bonding of the sealant to enamel is particularly important, as microleakage at the tooth-material interface can cause treatment failure. Ganesh and Shobha[10] reinforced this by demonstrating that the sealant's marginal adaptation to enamel is key to its effectiveness and longevity, as it helps minimize microleakage and ensure a good seal.

In this study, the microleakage performance of Yuseal and Fissure Seal sealants was assessed and compared. Both materials are relatively new, and no prior studies have evaluated their effectiveness. According to the manufacturers, Yuseal (Anabond Stedman) offers fluoride release for up to 96 hours, 100% enamel wall adaptation, 0% toxicity, and minimal microleakage. A notable feature of Yuseal is its color change from pink to opaque upon application. The polymer used in Yuseal consists of Bis-GMA and TEGDMA.[11] Fissure Seal (Waldent) is also a light-curing, fluoride-releasing sealant, designed with inorganic filler to enhance fluoride release. Its optimal flow properties allow for deeper penetration, improving mechanical retention and seal strength. It contains silanated barium glass powder (inorganic filler), urethane dimethacrylate, triethylene glycol dimethacrylate, amorphous fumed silica, curing agents and stabilizer.[12]

Sealants can be applied using either non-invasive or invasive techniques. The invasive approach, known as mechanical preparation or enameloplasty, involves using a rotary instrument to widen the fissures. This method enhances the ability to diagnose underlying decalcification, removes debris, improves sealant retention by enabling deeper penetration and increases the surface area available for bonding.[1]

For optimal sealant retention, it's essential to maximize the bonding surface area and ensure the enamel is clean, dry, and free from salivary contamination during sealant application. The use of a bur to enlarge occlusal fissures has been recommended to increase the enamel surface area and enhance sealant retention. When enameloplasty is performed, the sealant penetrates more effectively, leading to excellent adaptation between the sealant and enamel. Adequate resin penetration into the enamel is crucial for achieving successful sealant bonding.[13] Shapira et al.[14] after a 6-year clinical evaluation of pit and fissure sealants, found that teeth prepared mechanically showed a significantly higher retention rate. Shiota et al.[15] and Ripa et al.[16] reported that the base of occlusal grooves or fissures in molars usually have prismless enamel layer that should be removed to improve retention of sealants. Hansen[17] reported that the marginal gap dimension at the restoration/tooth interface is not dependent on the cavity depth, but mostly on the cavity diameter at the occlusal surface.

Enameloplasty seems to remove the potential problems associated with placing sealing material on the peripheral enamel. It can be speculated that the benefits of enameloplasty on microleakage may be due to its effect on prismless enamel.[17] In a study conducted by Ripa et al.[16] a layer of apparently "prismless" enamel was found on all the deciduous teeth and 70% of the permanent teeth. Kodaka et al.[18] recently evaluated the structural and distribution patterns of surface "prismless" enamel in human permanent teeth. They reported that the band-like "prismless" enamel was about 20 - 30μm in thickness and 100 - 300μm in length and was observed in fissure and cervical enamel. Gwinnett's[19] observed that the presence of a prismless enamel layer may reduce the mechanical retention of sealants. This effect could be attributed to variations in surface topography between prismless and prismatic enamel. In areas of prismless enamel, no resin tags indicating sealant penetration were visible, whereas these tags were evident in regions where the prismless enamel had been removed. The resin projections associated with prismless enamel were significantly shorter in length compared to those observed in prismatic enamel when examined under scanning electron microscopy.[11,14,15] Considering these factors, enameloplasty could be considered for fissure preparation prior to sealant placement in the current study. Hatibovic-Kofman et al[20] stated that bur preparation coupled with acid etching to be significantly better at reducing microleakage than pumice and etch. Geiger et al[21] demonstrated that the deeper the level of sealant penetration, the lower the probability of microleakage.

Feigal[22] demonstrated that applying a bonding agent between the sealant and enamel interface significantly reduces microleakage. Incorporating a bonding agent into the traditional sealant technique has shown promising results in enhancing both retention and reducing microleakage. In the present study, Waldent Nano Bond Universal Adhesive, a light-curable, 5th generation bonding agent, was used for this purpose.

Researchers have shown that no material can completely seal pits and fissures to prevent gap formation and subsequent microleakage. The most probable cause of gap formation is the difference in thermal expansion between the sealing material and tooth structure. The thermal expansion coefficients of sealing materials are 2–4 times greater than those of enamel. For example, resin materials have expansion coefficients ranging from 25–60 ppm/°C, while enamel and dentin have lower values of 11.4 ppm/°C and 8 ppm/°C, respectively. Daily temperature changes in the oral environment can cause gaps to form, leading to bacterial penetration at the sealant-enamel interface.[8] To evaluate microleakage in in vitro studies, thermocycling is a common method to simulate the oral environment and the long-term stresses restorations face. In this study, the teeth samples were subjected to 500 thermal cycles between 5°C and 55°C, with a dwell time of 30 seconds, following the protocols of studies by Penugonda et al.[23] and Sytner et al.[24] which are considered clinically relevant.

In dentistry, methods such as dye penetration, radioisotope method, acetate peel technique, confocal laser scanning and micro computed tomography (Micro-CT) have been used to evaluate the microleakage.[25] In the present study, dye penetration method has been used to assess the amount of microleakage, as it is inexpensive, non-toxic and detects even small amounts of leakage. In this study, Methylene blue was used as the dye for 24 h, as it is readily detectable under visible light, soluble in water and was able to diffuse freely. Similar method was followed in the studies conducted by Joshi k et al[26] and Panse et al.[27]

Intergroup comparison of microleakage between group I and group II revealed that group I, treated with Yuseal, had the least microleakage, with a mean rank of 14.00, compared to group II, treated with Fissure Seal, which had a mean rank of 19.00. Although no statistically significant difference was observed between the groups ($p = 0.077$), it is suggested that Yuseal exhibited lower microleakage scores. This may be attributed to its chroma technology, prolonged fluoride release, superior flow, quicker and easier adaptation.

Venker et al[28] demonstrated that sealants with color-changing properties facilitated better placement, reducing operator-dependent variability and improving overall clinical success. Subramaniam et al.[29] found that fluoride-releasing sealants exhibited lower microleakage due to the fluoride's role in strengthening enamel and preventing marginal degradation. Yuseal's superior flow properties and Bis-GMA-TEGDMA polymer matrix allow deeper penetration into the fissures, which improved mechanical retention and reduced the microleakage. Feigal et al.[30] highlighted that sealants with better flow characteristics resulted in deeper fissure penetration, improved retention and lowering the incidence of microleakage.

Resin-based sealants that share the Bis-GMA-TEGDMA composition support the claim of reduced microleakage.

Resin-based sealants, especially those with enhanced flow properties and fluoride release, have consistently shown superior sealing ability compared to non-resin-based sealants.

In the present study, both Yuseal and Fissure Seal are resin-based sealants that possessed superior sealing properties. This was further supported by Prabahar et al.3[1] who found greater gaps exists between the tooth and the sealant interface in glass ionomer cement than resin-based sealants. Despite being more viscous than resin-based sealants, glass ionomers have difficulty being seated properly in fissures, leading to more microleakage. Alirezaei et al.[32] found that dental caries development was lower with glass ionomer cement (GIC) sealants compared to resin-based sealants, but the resin-based sealants demonstrated superior retention.

As the results of the present study, showed no statistical significant difference in microleakage scores between group I and II it can be inferred that both Yuseal and Fissure seal can be successfully used as Pit and Fissure Sealants.

This in vitro study provided insights that encouraged more research into Yuseal and Fissure Seal. Additional limitations include the lack of long-term clinical follow-up, the absence of simulation of the oral environment's dynamic factors such as saliva and chewing forces and the inability to fully replicate patient variability in terms of enamel structure, application techniques and oral hygiene habits. Further studies are needed to provide deeper insights into the performance of these sealants under a range of clinical conditions.

Conclusion

Yuseal's unique chroma technology and prolonged fluoride release contribute to better adaptation and protection against caries. Fissure Seal's enhanced flow characteristics and fluoride-releasing capability also play a significant role in achieving excellent sealant performance. Therefore, both materials (Yuseal and Fissure seal) are viable choices for clinical application as pit and fissure sealants, offering reliable protection against occlusal caries and demonstrating their potential for long-term effectiveness in preventive dental care.

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Table 1: Descriptive study characteristics

Groups	No stain n (%)	Outer surface n (%)	P-value
Group I – Yuseal (n=16)	9 (56.25%)	7 (43.75%)	0.74
Group II - Fissure Seal (n=16)	4 (25%)	12 (75%)	

Chi-square test with p < 0.05 is statistically significant

Table 2: Intergroup comparison of microleakage between group I and group II

Groups	Mean rank	t^ value	p value
Group I – Yuseal	14.00	-1.771	0.077
Group II - Fissure Seal	19.00		

* Mann–Whitney u-test* with p < 0.05 is statistically significant

Graph 1: Distribution of teeth among different groups according to microleakage score

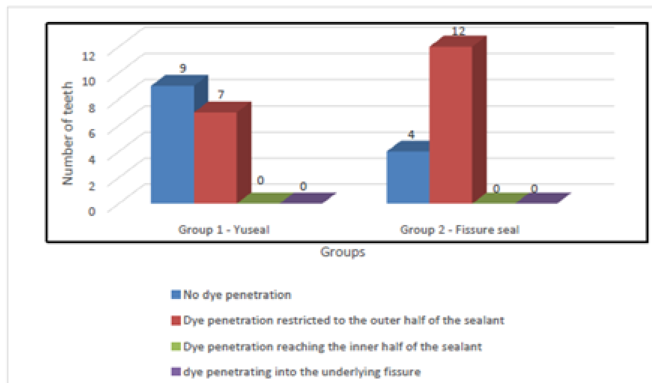

Figure 1: Diagram illustrating the dye penetration scoring system