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PENETRATION ABILITY AND MICROLEAKAGE ASSESSMENT OF TWO DIFFERENT MATERIALS USED AS FISSURE SEALANTS

ОЦЕНУВАЊЕ НА СПОСОБНОСТА ЗА ПЕНЕТРАЦИЈА И МИКРОПРОПУСТЛИВОСТА НА ДВА РАЗЛИЧНИ МАТЕРИЈАЛИ УПОТРЕБЕНИ КАКО ЗАЛЕВАЧИ

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Abstract

Pit and fissure sealant placement is considered to be an effective modality for prevention of caries on occlusal surfaces. Penetration, retention and marginal adaptation are the key factors in success of pit and fissure sealant restorations. The failure of marginal adaptation leads to marginal leakage, which means passage of bacteria, fluids, molecules or ions between the enamel and the sealant, creating a possibility for development of dental caries below the sealant. **Aim:** The aim of this study is to assess and compare microleakage and penetration ability of a resin based sealant and a glass-ionomer cement sealant. **Materials and Methods:** In order to achieve this objective, an in vitro study will be conducted containing 30 premolars and molars extracted for orthodontic purposes, without any structural anomalies, divided in two groups of 15 samples in each group. Group-I: Fissures sealed with a resin based sealant (Helioseal-F, Ivoclar Vivadent AG, Liechtenstein). Group-II: Fissures sealed with a glass-ionomer cement sealant (Fuji Triage, GC Corporation Tokyo, Japan). **Results**: The first group contains samples, sealed with resin based Helioseal-F. 10 (66, 67%) samples demonstrate level-0 microleakage, 2 (13, 33%) samples demonstrate level-1 microleakage and 3 (20, 00%) samples demonstrate level-3 microleakage; 7 (46,67%) samples demonstrate level-0 penetration ability and 8 (53,33%) samples demonstrate level-1 penetration ability. The second group contains samples sealed with glass-ionomer based Fuji Triage. 3 (20%) samples demonstrate level-0 microleakage, 1 (6,67%) sample demonstrate level-1 microleakage, 3 (20%) samples demonstrate level-2 microleakage, 8 (53,33%) samples demonstrate level-3 microleakage; 10 (66,67%) samples demonstrate level-0 penetration ability and 5 (33,33%) samples demonstrate level-1 penetration ability. **Conclusion:** By observing the penetration ability and the marginal leakage score of a resin based sealant and a glass-ionomer sealant we can conclude that both materials could be recommended as a primary sealant material in the action plan strategies for prevention of dental caries. **Key words:** Prevention, microleakage, penetration ability, pit and fissure sealant.

Апстракт

Залевањето на јамичките и фисурите се смета како ефективен модалитет во превенцијата на денталниот кариес во оклузалните површини. Способноста за пенетрација, ретенција и маргинална адаптација се клучни фактори во успехот на залевачите. Неуспехот на маргиналната адаптација води кон маргинална пропустливост, што значи премин на бактерии, течности, молекули или јони меѓу глеѓта и залевачот, овозможувајќи развој на дентален кариес под залевачот. **Цел:** Цел на нашата студија е оценувањето и споредбата на микропропустливоста и способноста за пенетрација на смолестиот(композитниот) и гласјономерниот залевач. **Материјал и Метод:** За реализација на поставената цел, се спроведе in vitro истражување во кое беа употребени 30 екстрахирани премолари и трети молари,без структурни аномалии, поделени на две групи по 15 заби. Првата група ја сочинуваа заби кои беа залеани со композитен залевач (Helioseal-F, Ivoclar Vivadent AG, Liechtenstein), втората група ја сочинуваа заби кои беа залеани со гласјономерен залевач (Fuji Triage, GC Corporation Tokyo, Japan). **Резултати:** Првата група ја сочинуваат заби кои беа залеани со Helioseal-F. Кај 10 (66,67%) заби нема пенетрација на боја (скор 0), кај 2 (13,33%) заби утврдена е пенетрација на боја до половината на должината на залевачот (скор 1), додека кај 3 (20,00%) заби е утврдена пенетрација на боја во базата на фисурата (скор 3); Кај 7 (46,67%) заби утврдивме комплетна пенетрација на залевачот (скор 0) и кај 8 (53,33%) заби е утврдена некомплетна пенетрација на залевачот (скор 1). Втората група на заби ја сочинуваат заби кои беа залеани со Fuji Triage . Кај 3 (20%) заби нема пенетрација на боја (скор 0), кај 1 (6,67%) заб утврдена е пенетрација на боја до половина на должина на залевачот (скор 1), кај 3 (20%) заби утврдена е пенетрација на боја поголема од половината на должина на залевачот (скор 2), и кај 8 (53.33%) заби утврдивме пенетрација на боја во базата на фисурата (скор 3); Кај 10 (66,67%) заби утврдивме комплетна пенетрација на залевачот (скор 0) и кај 5 (33,33%) заби е утврдена некомплетна пенетрација на залевачот (скор 1). **Заклучок:** Обсервирајќи го резултатот од способноста за пенетрација и маргиналната пропустливост на композитниот и гласјономерниот залевач, двете материјали може да бидат препорачани како примарен материјал во стратегиите за превенција на денталниот кариес. **Клучни зборови:** Превенција, микропропустливост, способност за пенетрација, фисурен залевач.

Introduction

Occlusal surface accounts for 12.5% of the total tooth area of teeth.1 From a primary prevention perspective, anatomic grooves or pits and fissures on occlusal surfaces of permanent molars trap food debris and promote the presence of bacterial biofilm, thereby increasing the risk of carious lesions development. Effectively penetrating and sealing these surfaces with a dental material, for example, pit-and-fissure sealants, can prevent lesions and are part of a comprehensive caries management approach.2 A Fissure sealant application is one of the most reliable and effective method for preventing occlusal caries. The advantage of the sealant application is significant caries risk reduction compared to non-sealed controls as well as lower cost compared to restoration placement.3 Retention rates vary according to the proper isolation of the working field, viscosity of the sealant material, preparation of enamel surfaces, and the use of an adhesive system.4

Many methods have been defined for applying fissure sealant and many materials used as a sealant have been developed. However, there is no clear consensus regarding which application technique is superior or which type of a sealant material is the most durable under oral conditions.5 Glass ionomer, resin, recently giomer-based fissure sealants, and flowable composites are the main material groups that can be used as fissure sealants. In vivo or in vitro performance of most of these materials has been investigated intensively, however, there is no material suggested as an ideal pit and a fissure sealant.6 Generally, resin-based materials are recommended having the advantage of better retention and glass-ionomer-based materials are recommended due to the advantages of fluoride release and lower moisture sensitivity.7

The preventive effect of the pit and fissure sealing is mainly based on the ability of sealant materials to flow through pits and fissures and completely fill them without any gaps or air entrapments. As long as the sealant material remains bonded to the enamel, the effective protection will continue. Microleakage is the most affecting factor on adhesion failure between the sealant and the tooth structure and can be determined by many in vitro techniques . With the advantages of reliability, simplicity, and ease of application, the dye penetration test is a well-established and commonly used method for the determination of in vitro microleakage .8

Retention and good adaption of the sealants with the occlusal surface of the enamel is essential for their success. Therefore the aim of the study is to evaluate microleakage and penetration depth of different materials used as fissure sealants.

This study will assess and compare marginal leakage and penetration ability of a resin based sealant as well as a glass-ionomer based sealant.

Materials and methods

In order to achieve this objective, we have conducted an in vitro study in which we used 30 extracted premolars and molars devoid of any caries, structural anomalies, without restorations and with orthodontic indication for extraction, distributed equally in two groups (15 in each). After the extraction the samples were held in a saline solution.

Distribution in two groups:

- Group-I: Fissures sealed with composite based fissure sealant (Helioseal-F, Ivoclar Vivadent AG, Liechtenstein).
- Group-II: Fissures sealed with glass-ionomer cement sealant (Fuji Triage, GC Corporation Tokyo, Japan)

For conducting microleakage and penetration ability assessment, the samples were cleaned with periodontal curettes and pumice prophylaxis, undergone for washing, application of 3% peroxide toilet and were dried with an oil free air syringe.

1. According to the manufacturer instructions, the samples from the first group were etched with a 37% phosphoric acid gel in duration of 30 seconds, rinsed with water, dried with an oil free air syringe and sealed with a resin based sealant Helioseal-F. The sealant was photopolymerized for 20 seconds with a halogen lamp Bonart art-L2 with a wavelength around 400 nm.
2. As the manufacturer instruction suggests, the samples of the second group were treated with dentin conditioner in a period of 20 seconds. The occlusal enamel was dried smoothly, in order to gain a wet occlusal surface. With a plastic dental spatula we mix the powder and the liquid in a proportion of 1.8/1 and apply it directly on a dental occlusal surface.

The root apices were sealed with red wax. All the samples were then covered with two layers of nail varnish, except for the 1-mm window around the sealant margins, and then immersed in 2% methylene blue solution for 24 h.

After the dye exposure, the teeth were thoroughly cleaned under running tap water for 5 minutes so that the superficial dye could be removed. On the other hand, the nail varnish was removed with a scalpel. Longitudinal sections were prepared with a diamond disk, in bucco-lin-

gual direction. Approximately 1.5 mm thick sections were made to assess the level of penetration depth and the degree of dye penetration in the occlusal cavity walls separately under a binocular microscope at 40X magnification, and the same were photographed with a digital camera. We determinate the penetration ability at 2 levels as Navin H.K9 stated and marginal dye penetration in 4 levels as did the authors: Overbo R.C and Raddal M.10

PENETRATION ABILITY

0 – Penetration of the sealant into the underlying fissure

1 – Incomplete penetration of the sealant

MARGINAL LEAKAGE

0 - No dye penetration

1 - Dye penetration up to one half the sealant's length

2 - Dye penetration greater than one half, not including the underlying fissure

3 - Dye penetration into the underlying fissure

Microleakage and penetration ability data for each group was compared using the Kruskal-Wallis test (H). Significant differences were evaluated using the Mann–Whitney U test (Z), t- test - independent samples (t) and the difference between the two proportions (p).

Results

1. Penetration ability score

First group contains samples, sealed with resin based material: Helioseal F; 7 (46,67%) samples demonstrate level-0 penetration ability and 8 (53,33%) samples demonstrate level-1 penetration ability. Second group contains samples, sealed with glass-ionomer based material: Fuji Triage; 10 (66,67%) samples demonstrate level-0 penetration ability and 5 (33,33%) samples demonstrate level-1 penetration ability (Table 1).

p>0,05 (p=0,40) indicates that there is no statistically significant difference between the penetration of the sealant into the underlying fissure and the incomplete penetration **of the first group** samples (Helioseal-F, Ivoclar Vivadent AG, Liechtenstein), although incomplete penetration is more presented compared to the complete one.

p>0,05(p=0,12) indicates that there is no statistically significant difference between the penetration of the sealant into the underlying fissure and the incomplete penetration of **the second group samples** (Fuji Triage, GC Corporation Tokyo, Japan), although complete penetration is more presented compared to the incomplete one.

2. Marginal leakage score

The First group contains samples, sealed with resin based Helioseal-F. 10 (66, 67%) samples demonstrate

Table 1: Penetration ability of resin based and glass-ionomer sealant

	n	Penetration ability score Rate (%)	
		0	1
Group 1 Resin based sealant (Helioseal-F, Ivoclar Vivadent AG, Liechtenstein)	15	7	8
		46.67%	53.33%
Group2 Glass-ionomer cement sealant (Fuji Triage, GC Corporation Tokyo, Japan)	15	10	5
		66.67%	33.33%

Table 2: Microleakage of resin based and glass-ionomer sealant

	n	Microleakage score Rate (%)			
		0	1	2	3
Group 1 Resin based sealant (Helioseal-F, Ivoclar Vivadent AG, Liechtenstein)	15	10	2	0	3
		66.67%	13.33%	0.00%	20.00%
Group2 Glass-ionomer cement sealant (Fuji Triage, GC Corporation Tokyo, Japan)	15	3	1	3	8
		20%	6.67%	20%	53.33%

Table 3: Correlation between the penetration ability and the marginal leakage of resin based sealant

	Marginal leakage	Penetration ability		Total
		0	1	
n	0	5	5	10
%		33,33%	33,33%	66,67%
n	1	0	2	2
%		0,00%	13,33%	13,33%
n	3	2	1	3
%		13,33%	6,67%	20,00%
n	Total	7	8	15
%		46,67%	53,33%	

Table 4: Correlation between the penetration ability and the marginal leakage of glass-ionomer sealant

	Marginal leakage	Penetration ability		Total
		0	1	
n	0	3	0	3
%		20,00%	0,00%	20,00%
n	1	0	1	1
%		0,00%	6,67%	6,67%
n	2	2	1	3
%		13,33%	6,67%	20,00%
n	3	5	3	8
%		33,33%	20,00%	53,33%
n	Total	10	5	15
%		66,67%	33,33%	

level-0 microleakage, 2 (13, 33%) samples demonstrate level-1 microleakage and 3 (20, 00%) samples demonstrate level-3 microleakage. Second group contains samples, sealed with glass-ionomer based Fuji Triage. 3 (20%) samples demonstrate level-0 microleakage, 1 (6,67%) demonstrates level-1 microleakage, 3 (20%) samples demonstrate level-2 microleakage, 8 (53,33%) samples demonstrate level-3 microleakage.

Z= -2,38 and p<0.05(p=0.02) indicate that there is statistically significant difference between the microleakage score of the samples from the first group (resin based sealed samples) and the samples from the second group (glass-ionomer cement sealed samples). Microleakage score of the second group samples is significantly higher.

3. Correlation between penetration ability and marginal leakage

a). The first group samples – a resin based sealant (Helioseal F)

t=-0,18 and p>0,05 (p=0,87) indicate that there is no statistically significant difference between the microleakage score and the penetration ability score referring to group 1 samples. Microleakage score is

independent from the level of sealant penetration depth, and penetration ability score does not influence the level of microleakage.

b). The second group samples -a glass-ionomer cement sealant (Fuji Triage)

t=1,03 and p>0,05 (p=0,34) indicate that there is no statistically significant difference between the microleakage score and the penetration ability score referring to group 2 samples. The Microleakage score is independent from the level of the sealant penetration depth, and the penetration ability score does not influence the level of microleakage.

Photos below describe the penetration ability level and the microleakage level of few teeth sections, made while conducting our study.

Photos 1, 2, 3 and 4 were made from teeth sections of group 1 samples which were sealed with Helioseal-F.

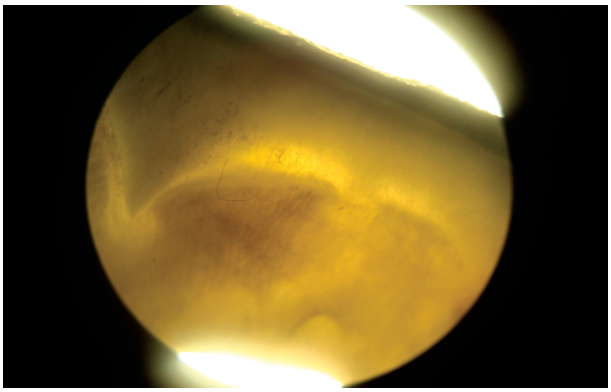

Photo 1. indicates: level 0 microleakage, level 0 penetration ability

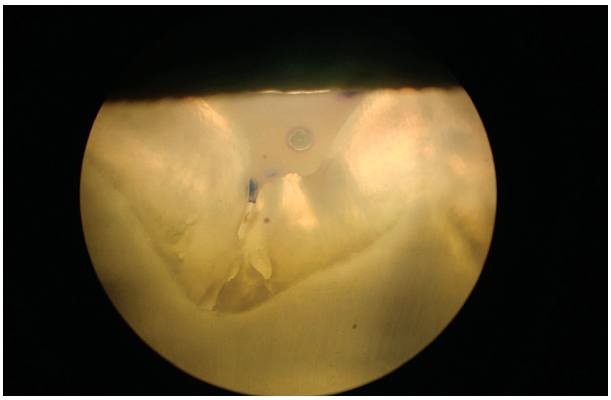

Photo 2. indicates: level 3 microleakage, level 1 penetration ability

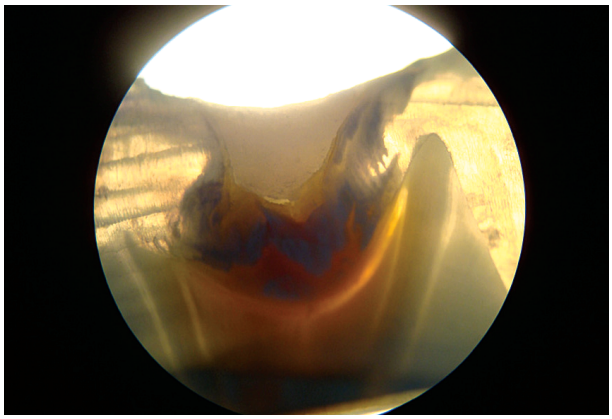

Photo 3. indicates: level 0 microleakage, level 1 penetration ability

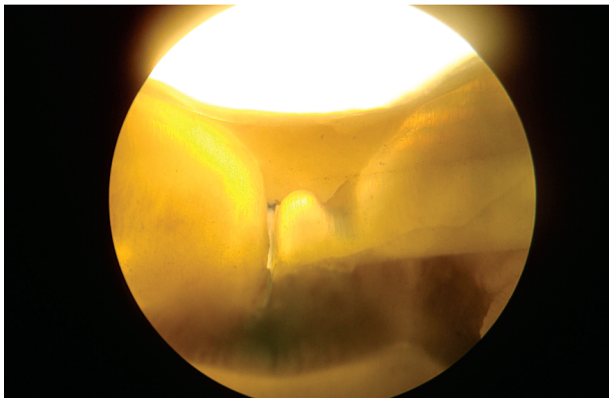

Photo 4. indicates: level 3 microleakage, level 1 penetration ability

Photos 5, 6, 7 and 8 were made from teeth sections of group 2 samples which were sealed with Fuji Triage

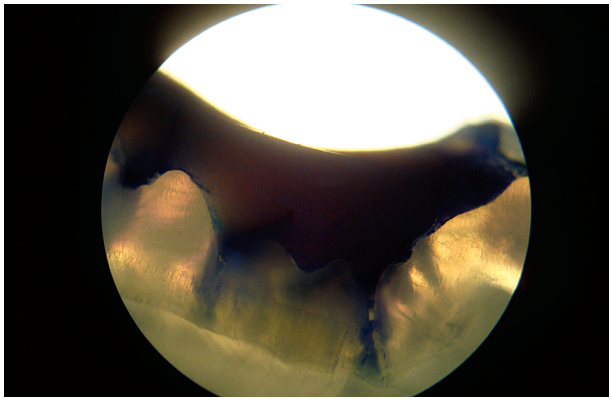

Photo 5. indicates: level 3 microleakage, level 1 penetration ability

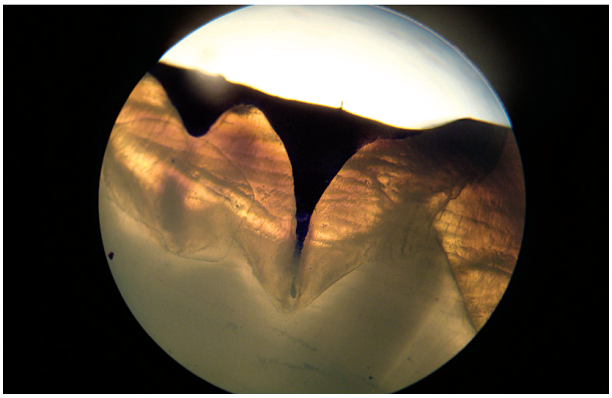

Photo 6. indicates: level 3 microleakage, level 1 penetration ability

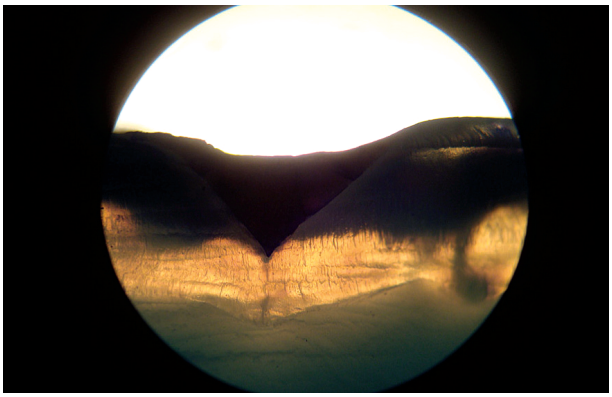

Photo 7. indicates: level 0 microleakage, level 0 penetration ability

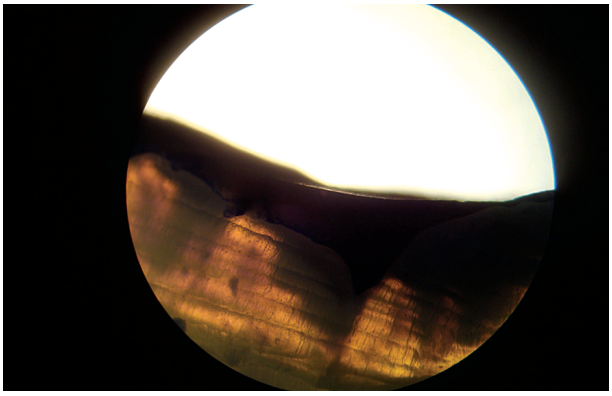

Photo 8. indicates: level 3 microleakage, level 0 penetration ability

Conclusion

Pit-and-fissure sealants have been used for nearly 5 decades to prevent and control carious lesions on primary and permanent teeth. Sealants are still underused despite their documented efficacy and the availability of clinical practice guidelines.11,12 International dentistry and paediatric dentistry guidelines recommend sealing the primary and permanent molars in children and adolescents to prevent the onset of cavities and minimize the progression of noncavitated occlusal carious lesions.13,14 Sealant efficiency depends on the ability of achieving strong bond with enamel of occlusal surface. This bond is greatly responsible for the level of microleakage in the interface enamel-sealant. The main reasons for sealant loss are addressed to microleakage, sealant depth penetration and placement technical skill.

Penetration depth is an important parameter that may increase the longevity of the sealant15 and affect the retention and adaptation of the sealant.16 Penetration of the sealant into the complete depths of pits and fissures, its lateral wall adaptation and subsequent retention are the key factors in the longevity of these restorations.17 The advantage of in vitro over in vivo studies is, that there is a possibility to determine the absolute depth of pits and fissures and the level of microleakage.

Results in our study considering penetration ability suggest that both tested materials: resin based and glass-ionomer sealants could penetrate total length of the fissure. Even in situations when penetration does not occur completely, the results are satisfying. Cowey et al recorded penetration of 70% for both resin based and glass-ionomer sealants.18 Petrovic et al concluded penetration of 80% for resin based and glass-ionomer sealants of entire fissure depth.19

No sealant remains perfectly adapted to the dental structure over time, and all will suffer some degree of microleakage. This is because the coefficient of thermal expansion of sealants is 2–4 times greater than that of enamel. Therefore, the constant temperature changes in the oral cavity give rise to the formation of gaps that facilitate the penetration of bacteria at the interface between the sealant and the enamel.20

Our study results considering microleakage demonstrated greater microleakage in samples sealed with a glass ionomer cement sealant when compared with a resin based sealant, similar results observed Ganesh and Shobha21, Gunjal, Nagesh and Raju22, Rirattanapong, Vongsavan, and Surarit.23 In contrast, Markovic et al24 using a fluorine-releasing resin sealant and a glass ionomer modified with acidic monomers and Pardi et al25 using a self-curing unfilled LCRBS , a fluid composite, a fluid compomer and a RMGIS, detected no significant differences in microleakage between the different materials.

No material is able to penetrate down to the bottom of deep and narrow fissures; it is understandable that some clinicians suspect that there are microorganisms in unfilled space or that the sealant is often placed over an incipient caries lesion. However, there is evidence that bacteria cannot remain vital and that caries lesion stops if the sealant is placed over an incipient lesion. Sealing material eliminates nourishment sources for S. Mutans and converts an active lesion into the passive caries lesion.26 Hence, authors feel that clinically maximum depth of penetration and good adaptation is more important than the complete penetration of the sealant to the base of the fissure.

The association between the risk of caries and complete loss of retention of pit and fissure sealants is significant with LCRBS, but not with glass ionomer sealants, probably due to their ability to release fluorine.27 Frencken and Wolke28 showed that, although detachment of the ionomer was observed clinically, the sealing material was retained at the bottom of the pits and fissures microscopically, with the sealing material exerting its preventive effect at the bottom of the cavity.

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 is no data that support the use of a glass-ionomer sealant in preference to a resin sealant, mainly due to the poorer retention of the glass-ionomer materials. In fact, the recent report of the ADA Council of Scientific Affairs reported that 'Resin-based sealants are the first choice of material for dental sealants' and that 'Glass-ionomer cement may be used as an interim preventive agent where there are indications for placement of a resin-based sealant but (where) concerns about moisture control may compromise such placement.29

Our findings, concerning penetration ability and microleakage of the glass-ionomer sealant and the resin based sealant, suggest using these sealants as an effective treatment modality in preventive dentistry. Sealants from this study have shown high level of penetration ability, although a glass-ionomer sealant showed better results. Regarding the microleakage level, a glass-ionomer sealant demonstrated a higher level of microleakage compared with a resin based sealant. Considering fluoride release ability factor of the glass-ionomer sealant, the preventive ability continues, although showing higher level of microleakage.

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