Original Article

Comparative Evaluation of Penetration Ability of Three Pit and Fissure Sealants and Their Relationship with Fissure Patterns

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KEY WORDS
Pit and fissure sealants;
Dental caries;
Glass ionomer cements;
Resins;

ABSTRACT

Statement of the Problem: Pit and fissure sealant placement is considered as an effective modality for prevention of caries on occlusal surfaces. Penetration, retention and lateral wall adaptation are the key factors in success of pit and fissure sealant restorations.

Purpose: The purpose of this paper was to compare penetration ability and lateral wall adaptation of three commercially available pit and fissure sealants.

Materials and Method: The present *in-vitro* study was done on 45 extracted sound human molars to evaluate the fissure pattern and assess the penetration ability of three commercially available sealants [Delton® FS Sealant (Dentsply DeTrey GmbH, Konstanz, Germany), Clinpro™ Sealant (3M™ ESPE™, Minnesota, USA) and GC Fuji VII Glass Ionomer Cement (GC Asia Dental Pte Ltd, Singapore)] on molars divided into 3 equal groups of 15 each, with further sectioning of each sample into 2 parts giving 30 samples per group. Following thermocycling and embedding of teeth in clear auto-polymerizing acrylic resin, sections were evaluated for fissure morphology, sealant penetration, unfilled space, lateral wall adaptation, and for presence of voids.

Results: Penetrability of all the sealants studied was found to be significantly more in U-type fissure pattern (93.89%) followed by V-type (78.62%), IK-type (74.34%) and then in I-type (65.91). The depth of penetration of the GC Fuji VII Glass Ionomer sealant (85.82%) was found to be superior followed by unfilled resin sealant (Clinpro™ Sealant- 78.26%) and then by filled resin sealant (Delton® FS Sealant- 74.89%).

Conclusion: U- type fissure pattern was more common than other fissure patterns and showed significantly higher penetrability of different type of sealants evaluated in the present study. GIC based sealant, due to significantly higher penetration depth than unfilled and filled sealants used in the present study, can be preferred over filled or unfilled resin sealants.

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Introduction

Caries involving occlusal surfaces of molars comprises 52.7% to 66.3% of all carious lesions while occlusal surface of molars makes only 13% of total surfaces. [1] Molars may have more risk for caries due to the complex shape of their occlusal fissure morphology, which is considered an ideal site for the retention of bacteria and food remnants, and is inaccessible to mechanical cleaning/debridement. The occlusal fissure pattern has been classified based on fissure morphology: V, U, I

(Y1), IK (Y2) and inverted Y types (Nagano, 1961). [2]

Early attempts to protect pits and fissures from caries attack by prophylactic odontotomy (Hyatt, 1921) and fissure eradication were tried, but with little success. [3] Similar results were met with chemical agents like ammonical silver nitrate, [4] zinc chloride & potassium ferrocyanide. [5] Placement of pit and fissure sealants is considered an effective modality for prevention of caries onset on occlusal surfaces of posterior teeth. Cost- effectiveness and decreased caries risk up to nine times are some of the potential advantages of placing pit and fissure sealants, which justify their use in prevention against dental caries. [6] Resin based materials are the materials of choice today because of their high retention rates and superior wear resistance; however, these materials are clinically limited because of their inherent hydrophobic nature and inability to be used in moist environment. [7] In contrast, glass ionomer pit and fissure sealant has the advantage of very high fluoride release along with antibacterial property, free flowing consistency, and improved adherence to enamel. [8-9]

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. [10] Apart from the penetration depth of the sealant, extension of the sealant material over the enamel of cuspal inclines is another factor considered in successful bonding of the pit and fissure sealant to the tooth. [11] The penetration of sealant into pit and fissure depends on its geometric configuration, the presence of material deposits within it, the physical and chemical properties of the enamel, and good clinical technique. Hence, the purpose of this study was to compare penetration ability and lateral wall adaptation of three commercially available pit and fissure sealants.

Materials and Method

The present in-vitro study was conducted on 45 extracted third molars, which had been extracted due to orthodontic or periodontal reasons. Third molars with macroscopic fractures, hypoplasia, restorations, attrition, or carious occlusal surface were excluded from the study. Forty-five third molars were divided into three groups of 15 each to study the fissure morphology and penetration ability of three commercially available sealants. The sealants studied in the present investigation were:

1. Group A: Filled fluoride releasing (Delton® FS sealant, (Dentsply DeTrey GmbH, Konstanz, Germany) sealant was used which is white, light cure resin sealant supplied in syringe with disposable tip
2. Group B: Unfilled fluoride releasing (Clinpro™, 3M™ ESPE™, Minnesota, USA) sealant was used which is pink, light cure resin sealant supplied in syringe with disposable tip
3. Group C: Fuji VII Glass ionomer (GC Asia Dental Pte Ltd, Singapore) sealant was used which is pink and dual cure sealant supplied in bottle-liquid system

The extracted molars were cleaned of debris, soft tissues and calculus and were then stored in distilled water until further use. The occlusal surface of the extracted teeth was cleaned with oil-free aqueous pumice slurry using a prophylactic nylon brush in a slow-speed, contra-angle handpiece. The pits and fissures were then rinsed with an air-water spray and air-dried. The teeth were mounted in clay so that the crown was exposed. Sharp explorer was then run through the pits and fissures to remove any remaining debris/slurry followed by air-drying with a three-way syringe.

In Group I and II (Delton® FS Sealant and Clinpro™ Sealant), acid etching was done using 37% phosphoric acid gel (3M™ Scotchbond™ Universal Etchant gel, Minnesota, USA) which was carefully applied to the occlusal surface covering all the pits and fissures for 60 seconds with a brush tipped applicator. Then, thorough rinsing was done with air-water spray for 10 seconds to remove all etchant completely. Air-drying was then done for 5 seconds with a three-way syringe and observed for the frosty appearance of the enamel.

Then, Delton® FS Sealant and Clinpro™ Sealant were carefully dispensed in the appropriate amount onto the etched occlusal surface from mesial (in maxillary molars) or distal pit (in mandibular molars) and guided to flow to the other pits and fissures with the help of a brush tipped applicator. The sealant was allowed to flow for 10 seconds, and then it was polymerised using a light cure unit for 20-40 seconds, and checked with an explorer for complete polymerization and adaptability.

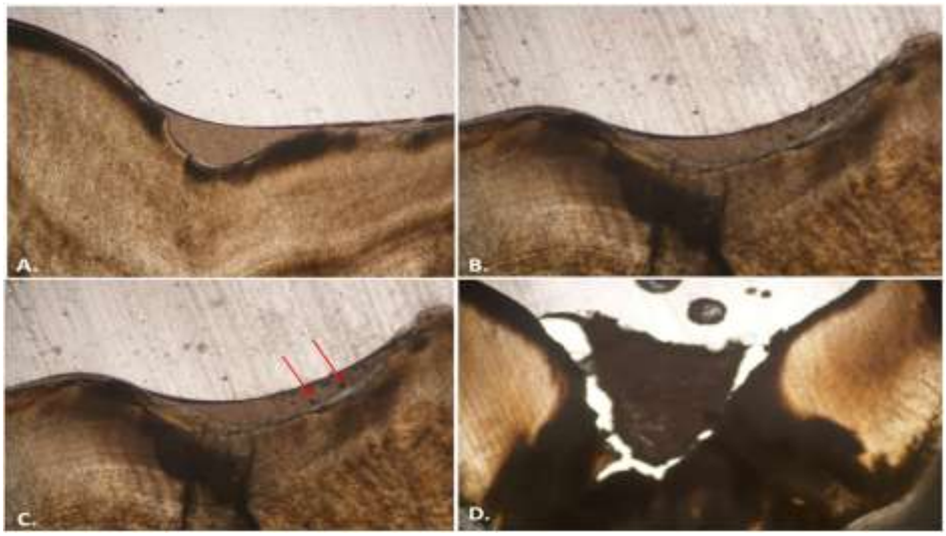

Figure 1: Ground sections of fissures (4X magnification) a. Well-adapted sealant (resin-based) b. Partially adapted (resin based) c. Presence of void in sealant d. Sealant not adapted (Glass ionomer sealant)

The resin sealant Clinpro™, which was initially pink on application turned light yellow after polymerization.

In Group III (GC Fuji VII Glass Ionomer Cement), occlusal surface was gently cleaned with GC conditioner for 20 seconds, and rinsed for 20 seconds. The surfaces were then dried by blotting with cotton pellet. The GC Fuji VII Glass Ionomer Cement was mixed as per the manufacturer's instruction and was applied to the occlusal surface using a plastic filling instrument. A disposable fine brush was used to spread it on pits and fissures and sealant was then allowed to flow for 10 seconds. After that, sealant was light cured for 20 seconds followed by application of petroleum jelly on the occlusal surfaces.

Subsequent to the pit and fissure sealants application, teeth were then demounted from clay and were subjected to thermocycling for 200 cycles in 5°C and 55°C with a dwell time of 60 seconds in each bath and a transfer time of 3 seconds. These specimens were completely embedded in clear autopolymerising acrylic resin and were sectioned longitudinally bucco-lingually from the central fossa, yielding two sections of 150µ per tooth using hard tissue microtome (Leica Biosystems, Germany). Sections were then viewed using a binocular light microscope at a minimum magnification of 4X for fissure morphology, sealant penetration, unfilled space, lateral wall adaptation and for any voids (Figure 1). The

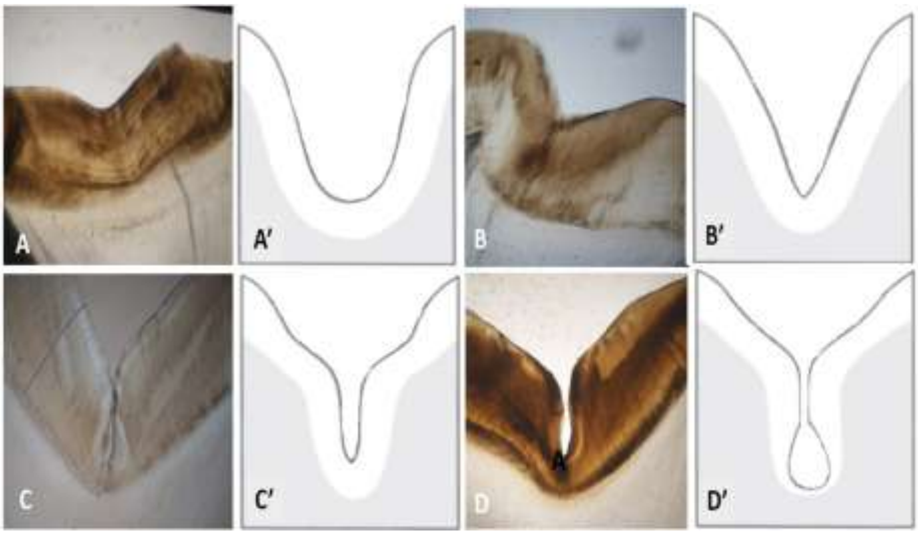

Figure 2: Different Fissure patterns (Longitudinal ground sections 4X magnification):
A-A'- U fissure pattern. B-B'- V fissure pattern C-C'- I fissure pattern D-D'- IK fissure pattern

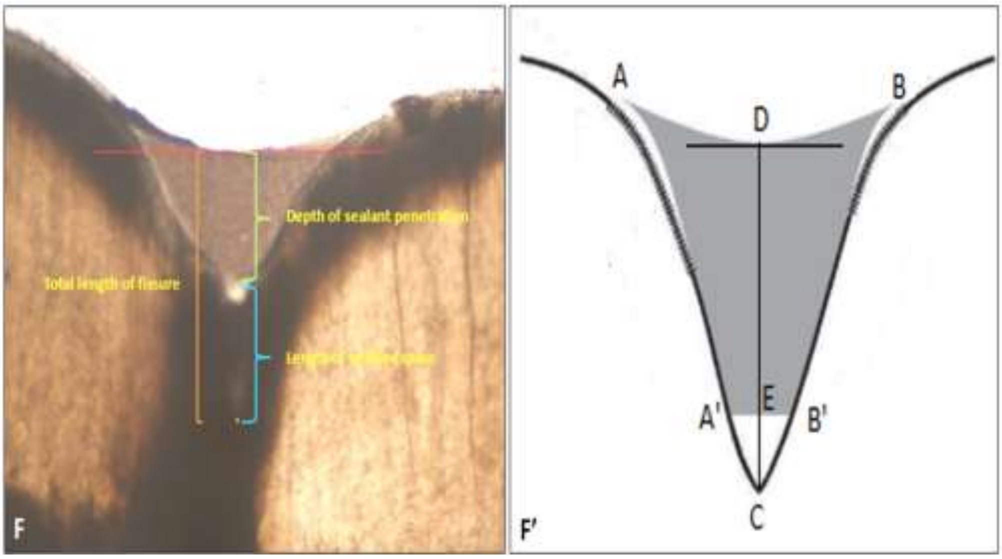

Figure 3: Calculations for depth of fissure sealants

parameters that were studied were:

1. Fissure morphology (classified as U, V, I and IK) [2] (Figure 2)
2. Sealant penetration depth (μ) calculated as length measured (μ) from the deepest point on concavity of the upper margin of the occlusal sealant (D) to the base of the sealant (E). (Figure 3)
3. Length of Unfilled space (μ) calculated as length measured (μ) from base of the sealant (E) to the base of the fissure (C). (Figure 3)
4. Total length of fissure (μ) calculated as length measured (μ) from deepest point on the upper margin of the sealant (D) to the base of the fissure (C). (Figure 3)
5. Penetrability (%) = $\frac{\text{Sealant Penetration Depth}}{\text{Total Length of Fissure}} \times 100$ (Figure 3)

All the linear measurements were made with the help of software (ImageJ, National Institutes of Health, Bethesda, USA) and calculated in microns (μ). Three measurements of each section were taken and the mean value of these three readings per section was adopted as the representative values. The values were then tabulated and subjected to statistical analysis.

Results

Results of the study are summarized in Table 1. U- type fissure pattern (N=30; 33.3%) was found to be more common followed by V-type and I-type (N=26; 28.9%) and least for IK-type (N=8; 8.9%). However, no statistical significant difference (*p*> .05) was found between the prevalence of four types of fissure patterns studied

Table 1: Summary of penetrability and lateral wall adaptation of three different sealants and their distribution according to fissure patterns

	Mean depth of penetration (%)					**Lateral wall adaptation**		
	U (N=30)	**V (N=26)**	**I (N=26)**	**IK (N=8)**	**Total (N=90)**	**Adapted**	**Partially Adapted**	**Not adapted**
Group A Filled fluoride releasing (Delton® FS sealant, Dentsply)	93.45±7.13 (N=12)	66.58±28.08 (N=8)	61.52±9.11 (N=8)	50.25±0.59 (N=2)	74.89±21.96 (N=30)	18(60%)	12(40%)	0(0%)
Group B Unfilled fluoride releasing (Clinpro™, 3M ESPE)	91.11±12.65 (N=10)	83.67±15.19 (N=6)	64.04±13.34 (N=10)	73.55±11.25 (N=4)	78.26±17.13 (N=30)	20(66.67%)	10(33.33%)	0(0%)
Group C Fuji VII Glass ionomer (GC) sealant	98.01±3.69 (N=8)	84.12±12.64 (N=12)	72.65±23.96 (N=8)	100.00±0.00 (N=2)	85.82±17.50 (N=30)	20(66.67%)	8(26.7%)	2(6.63%)
Total	93.89±8.92	78.62±20.10	65.91±16.43	74.34±20.21		58(64.4%)	30(33.33%)	2(2.27%)

on using ANOVA. The depth of penetration of the GC Fuji VII Glass Ionomer sealant (85.82%) was found to be superior followed by unfilled resin sealant (Clinpro™ Sealant- 78.26%) and then by filled resin sealant (Delton® FS Sealant- 74.89%). However, the result was statistically non-significant (*p*> .05) between the three groups of sealants on using ANOVA. The overall penetrability of all the pit and fissure sealants studied was found more in U-type fissure pattern (93.89%) followed by V-type (78.62%), IK-type (74.34%) and then in I-type (65.91). However, the result was statistically non-significant (*p*= 0.138) between the four types of fissures on using ANOVA. Overall 64.4% of the sections in all the three sealant groups showed good lateral wall adaptation except 2.2% of the sections in group III (GC Fuji VII Glass Ionomer Cement) where sealant did not adapt to both the lateral walls of the fissure. However, the result was statistically non-significant (*p*= 0.138) when the mean values of lateral wall adaptation was compared between different sealant groups.

Discussion

In the present study, higher prevalence of U-type fissure pattern (33.3%) was observed followed by V-type (28.9%), I-type (28.9%) and least for IK- type (8.9%). These findings also correlate with the studies conducted by Duangthip *et al.* [12], Selectman *et al.* [13], and Marks *et al.* [14]

Two large groups of materials were used in the present study for sealing pits and fissures: resin based sealant (Delton® FS Sealant and Clinpro™ Sealant) and a glass ionomer cement (GC Fuji VII Glass Ionomer Cement). The resin-based sealants were further categorized as filled (Delton® FS Sealant) and unfilled (Clinpro™ Sealant) based on the presence or absence of the fillers respectively. Fillers are added to the pit and fissure sealants in order to increase their wear and abrasion resistance. Resin-based materials possess high retention rates and superior wear resistance but are clinically limited by the difficulties inherent in their use due to the technique sensitivity, as these materials are primarily hydrophobic in nature and require a dry field. [6] Whereas, glass ionomer pit and fissure sealant has the advantage of very high fluoride release along with antibacterial property, better handling property, free flowing consistency and improved adherence to enamel. [8-9] In addition, Antonson *et al.* found that glass ionomer sealant performed better under wet contamination conditions compared to resin-based sealant hence, material type could be given more consideration while treating pediatric patients. [15]

Properties of the pit and fissure sealants such as surface tension and viscosity are the most important factors that influence penetration of the sealants. [16] Addition of the filler particles alters the viscosity and lowers the sealant's ability to penetrate into fissures and microporosities of etched enamel. In the present study, depth of penetration was found to be superior for GC Fuji VII glass Ionomer Cement (85.82%) followed by Clinpro™ Sealant (78.26%) and Delton® FS Sealant (74.89%). The lower penetrability noticed in case of filled sealant (Delton® FS Sealant), when compared with the unfilled sealant (Clinpro™ Sealant), could be because of added filler particles. This increases the viscosity of the material and lead to reduced flow and incomplete depth of penetration of the sealant to the bottom of the occlusal fissures especially in case of deep and narrow fissures like I-type and IK- type. Clinically, lesser depth of penetration can also affect the retention of the sealant, which might be one of the factors in the reduction of retention rate. However, with the unfilled sealant (Clinpro™ Sealant) which is less viscous, there is greater potential for the sealant to flow, spread more rapidly over surface, and penetrate.

At times, the size of the filler particles may be larger than the porosities of the enamel. Therefore, faster penetration rates are found with larger holes, denser liquids and those with high surface tension, but slower rates are found with fluids that are more viscous. Thus, it is not only the addition of filler particles that alter the flow of the sealant but the size of the filler particles used can also influence the depth of penetration of the pit and fissure sealant. Moreover, it has been studied that the sealants containing fluoride tend to be thicker than those without fluoride [17] but it did not affect the result of our study as all the three sealants chosen were fluoride containing.

In addition, penetrability of a pit and fissure sealant varies depending on the occlusal fissure morphology (U, V, I, IK). In the present study, depth of penetration of the pit and fissure sealants was found to be significantly more in U-type fissure pattern (93.89%) followed by V-type (78.62%), IK-type (74.34%) and then in I-type (65.91%). The results of the present study correlated with the studies done by Gwinnett *et al.*, [18] Powell *et al.* [19], Symons *et al.* [11], Durmusoglu *et al.* [20], Petrovic *et al.* [21], Selectman *et al.* [13], Grewal N *et al.* [10], and Zhao L *et al.* [22]

The depth of penetration was greater in case of U-type and V-type fissure pattern as they are wide and shallow when compared to I-type and IK-type fissures. The I-shaped fissure is quite constricted and may resemble a bottleneck in that the fissures may have an extremely narrow slit appearance with a larger base as it extends towards the dentino-enamel junction. Complete penetration of sealant into complex fissure systems, especially deep and narrow fissures is difficult compared to wide and shallow fissures due to the phenomenon of closed end capillaries or isolated capillaries. These fissures may also have a number of different branches fail to be filled with sealants. Hence, this in vitro study also proves that occlusal morphology is a limiting factor for penetration of fissure sealants.

The results in our study suggest that the overall depth of penetration of all the three pit and fissure sealants is more than 70% of entire fissure depth which can be correlated to the study done by Covey *et al.* [23] Further, 31.11% of the fissures showed the complete depth of penetration by the sealants. The complete penetrability of the sealants was more common in both U-type and V-type of fissure pattern due to their wide and shallow anatomy, which favored greater flow of the sealant when compared to I-type and IK-type that are deep and narrow. However, Symons states that fissure sealants show very good adaptability against vertical fissure walls, but lack the ability to penetrate entirely to the fissure bottom. [11] Study done by Bottenberg *et al.* and Duangthip and Lussi also suggest that it is difficult for etchant and consequently sealant to reach the bottom of the fissure especially in ampular or constrictive fissures. [12, 24]

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 are evidences 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. [25] 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.

Lateral wall adaptation of the resin sealants (Delton® FS Sealant and Clinpro™ Sealant) was found to be superior when compared to Glass Ionomer Cement (GC Fuji VII). The presence of minute voids were noticed as tiny black dots under the light microscopy in all the three pit and fissure sealants (Delton® FS Sealant, Clinpro™ Sealant and GC Fuji VII Glass Ionomer Cement). This might in turn affect the integrity and strength of the pit and fissure sealants. These voids could have been resulted because of the air entrapment within the pit and fissure sealant material.

Another contrasting feature noticed in the ground sections of molars with resin-based sealant (Delton® FS Sealant and Clinpro™ Sealant) and GC Fuji VII Glass Ionomer Cement was the presence of a smooth surface in the former and rough surface in the latter as finishing and polishing was not done in the present study. Therefore, the placement of pit and fissure sealants in the occlusal fissures is incomplete without finishing and polishing the surface of the sealant as well as removal of the occlusal interferences. Hence, glass ionomer sealant requires adequate finishing and polishing following its placement in the occlusal pits and fissures.

One of the practical difficulty encountered in the present in-vitro study while viewing the ground sections of molars under a light microscope at 4X was that the base of the occlusal fissure could not be clearly appreciated. However, other modalities like stereomicroscope and scanning electron microscope can be used to overcome such problem.

Thus, pit and fissure sealant placement can be considered as an effective treatment modality in preventive dentistry. Though all the three sealants have shown the depth of penetration of more than 70% but due to better results obtained with glass ionomer sealant (85.82%) versus Clinpro™ Sealant (78.26%) and Delton® FS Sealant (74.89%), former may be preferable over resin based sealants for sealing the occlusal pits and fissures in order to prevent dental caries.

Conclusion

1. Four fissure patterns were studied (U, V, I, IK) and U- type fissure pattern (33.3%) was found to be more prevalent followed by V-type (28.9%) and I-type (28.9%) and least prevalent for IK-type (8.9%).
2. Penetrability of all the pit and fissure sealants studied was found to be significantly more in U-type fissure pattern (93.89%) followed by V-type (78.62%), IK-type (74.34%) and then in I-type (65.91%).
3. The depth of penetration of the GC Fuji VII Glass Ionomer sealant (85.82%) was found to be superior followed by unfilled resin sealant (Clinpro™ Sealant- 78.26%) and then by filled resin sealant (Delton® FS Sealant- 74.89%).
4. Lateral wall adaptation of the resin sealants (Delton® FS Sealant and Clinpro™ Sealant) was found to be superior when compared to Glass Ionomer Cement (GC Fuji VII) and presence of voids were noticed in all the three pit and fissure sealants (Delton® FS Sealant, Clinpro™ Sealant and GC Fuji VII Glass Ionomer Cement).

Conflict of Interest

The authors disclose no potential conflicts of interest.

References

[1] Demirci M, Tuncer S, Yuceokur AA. Prevalence of caries on individual tooth surfaces and its distribution by age and gender in university clinic patients. Eur J Dent. 2010; 4: 270-279.

[2] Nagano T. Relation between the Form of Pit and Fissure and the Primary Lesion of Caries. Dent Abstr. 1961; 6: 4265.

[3] Hyatt TP. Prophylactic odontotomy: the cutting into the tooth for the prevention of disease. Dental Cosmos. 1923; 65: 234-241.

[4] Klein H, Knutson JW. Studies on Dental Caries. XIII. Effect of Ammoniacal Silver Nitrate on Caries in the First Permanent Molar. J Am Dent Assoc. 1942; 29:1420-1426.

[5] Ast DB, Bushel A, Chase HC. A clinical study of caries prophylaxis with zinc chloride and potassium ferrocyanide. J Am Dent Assoc. 1950; 41: 437-442.

[6] Droz D, Schiele MJ, Panighi MM. Penetration and microleakage of dental sealants in artificial fissures. J Dent Child (Chic). 2004; 71: 41-44.

[7] Hoffman I. A moisture tolerant, resin-based pit and fissure sealant. Dental Tribune. 2009; 4: 17A-18A.

[8] Khoroushi M, Keshani F. A review of glass-ionomers: From conventional glass-ionomer to bioactive glass-ionomer. Dent Res J (Isfahan). 2013; 10: 411-420.

[9] Hafshejani TM, Zamanian A, Venugopal JR, Rezvani Z, Sefat F, Saeb MR, et al. Antibacterial glass-ionomer cement restorative materials: A critical review on the current status of extended release formulations. J Control Release. 2017; 262: 317-328.

[10] Grewal N, Chopra R. The effect of fissure morphology and eruption time on penetration and adaptation of pit and fissure sealants: An SEM study. J Indian Soc Pedod Prev Dent. 2008; 26: 59-63.

[11] Symons AL, Chu CY, Meyers IA. The effect of fissure morphology and pretreatment of the enamel surface on penetration and adhesion of fissure sealants. J Oral Rehabil. 1996; 23: 791-798.

[12] Duangthip D, Lussi A. Effects of fissure cleaning methods, drying agents, and fissure morphology on microleakage and penetration ability of sealants in vitro. Pediatr Dent. 2003; 25: 527-533.

[13] Selecman JB, Owens BM, Johnson WW. Effect of preparation technique, fissure morphology, and material characteristics on the in vitro margin permeability and penetrability of pit and fissure sealants. Pediatr Dent. 2007; 29: 308-314.

[14] Marks D, Owens BM, Johnson WW. Effect of adhesive agent and fissure morphology on the in vitro microleakage and penetrability of pit and fissure sealants. Quintessence Int. 2009; 40: 763-772.

[15] Antonson SA, Antonson DE, Brener S, Crutchfield J, Larumbe J, Michaud C, et al. Twenty-four month clinical evaluation of fissure sealants on partially eruptedpermanent first molars: glass ionomer versus resin-based sealant. J Am Dent Assoc. 2012; 143: 115-122.

[16] Burrow MF, Burrow JF, Makinson OF. Pits and fissures: etch resistance in prismless enamel walls. Aust Dent J. 2001; 46: 258-262.

[17] Barnes DM, Kihn P, von Fraunhofer JA, Elsabach A. Flow characteristics and sealing ability of fissure sealants.

Oper Dent. 2000; 25: 306-310.

[18] Gwinnett AJ, Ripa LW. Penetration of pit and fissure sealants into conditioned human enamel in vivo. Arch Oral Biol. 1973; 18: 435-439.

[19] Powell KR, Craig GG. An in vitro investigation of the penetrating efficacy of BIS-GMA resin pit and fissure-coatings. J Dent Res. 1978; 57: 691-695.

[20] Durmuglu Ö, Ta Tekin DA, Özyöney G, Bozkurt FÖ, Yaniko Lu FC. Light microscopy and SEM evaluation of three different fissure sealants. OHDMBSC. 2005; 4: 26-32.

[21] Markovic D, Petrovic B, Peric T, Miletic I, Andjelkovic S. The Impact of Fissure Depth and Enamel Conditioning Protocols on Glass-ionomer and Resin-based Fissure Sealant Penetration. J Adhes Dent. 2011; 13: 171-178.

[22] Zhao L, Shi Q. Microleakage and penetration ability of different sealants. Int J Ped Dent. 2009; 19: 71-75.

[23] Covey DA, Johnson WW, Hopper LR. Penetration of various pit and fissure sealants into occlusal grooves. Available at: https://www.researchgate.net/publication/47393422_The_impact_of_occlusal_morphology_on_fissure_sealant_penetration

[24] Bottenberg P, Gräber HG, Lampert F. Penetration of etching agents and its influence on sealer penetration into fissures in vitro. Dent Mater. 1996; 12: 96-102.

[25] Oong EM, Griffin SO, Kohn WG, Gooch BF, Caufield PW. The effect of dental sealants on bacteria levels in caries lesions: a review of the evidence. J Am Dent Assoc. 2008; 139: 271-278.