Comparative study of resin sealant and resin modified glass ionomer as pit and fissure sealant

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Article Info

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Abstract

The purpose of the present study was to compare the marginal integrity of resin modified glass ionomer cement with that of resin sealant, *in vitro*. Forty artificial pit and fissure cavities were prepared in occlusal surface of extracted premolar teeth by using ¼ round carbide bur. Cavities were condensed with artificial organic debris followed by cleaning with prophylaxis pumice brush and paste and then separated into two treatment groups. In Group A, 15 fissure cavities were sealed by resin sealant and in Group B, 15 fissure cavities were sealed by resin modified glass ionomer sealant. These specimens were subjected to thermo-cycling followed by dye penetration test. The remaining 5 cavities from each group were analyzed for debris score by the SEM. The results of the microleakage test showed that the efficacy of preventing microleakage of samples sealed by resin modified glass ionomer sealant was higher than the samples sealed by resin sealant. However, no significant differences were found. It can be concluded that use of resin modified glass ionomer sealant is a good alternative for sealing pits and fissures.

Introduction

Pits and fissures that are not self-cleansing are extremely susceptible to dental caries, because they accumulate organic debris, providing suitable sites for the development of dental caries.[1-4] Following the cleaning of pits and fissures, the use of a sealant material would provide a physical barrier between the surface of the tooth and oral environment, therefore, reducing the risk of dental caries. However, the long-term results of sealant retention are still controversial. It has been reported that approximately 50% of the applied sealant volume was lost after 1 month, followed by 75% at the end of 2 years.[5] Possible reasons for this early loss include the presence of organic debris, wear or fracture of sealant materials or unetched areas after routine cleaning.[6,7] Furthermore, microleakage of fissure sealants due to polymerizetion shrinkage,[8] insufficient material penetration,[9] saliva contamination,[10] and sealant viscosity,[11] may also adversely affect the success of fissure sealing. Therefore, the marginal sealing ability of sealing materials is extremely important for successful treatment. Lack of sealing allows the occurrence of marginal leakage, i.e. passage of bacteria, the presence of organic debris, fluids, molecules and ions through the tooth-material interface, which can prompt caries lesion progression underneath the restoration.[8] However, the success of sealant retention depends on the ability of the material to promote an appropriate sealing of pits, fissures or eventual enamel defects, and remain completely intact and bonded to enamel surface.[12]

Glass ionomer sealant was introduced in 1974.[13] Since then, studies on these sealants have been conducted by several investigators.[14-16] Glass ionomer sealant presents a chemical bond to dental tissue and has anti-cariogenic effect by fluoride release. It has been suggested that the glass ionomer sealants, through their fluoride release, can prevent the development of caries even after the visible loss of sealant material. However, the deficiencies of glass ionomer sealant are lack of toughness, early water sensitivity, low abrasion resistance and different retention rates.[4] Glass ionomer sealant has poorer retention rate than resin based sealant material, and the effect of caries reduction is equivocal.[17] Therefore, glass ionomer sealant is mainly used when it is not possible to use a resin material, for example, due to poor patient compliance.[17] Nevertheless, it has been considered that the glass ionomer sealants, through their fuoride release, can prevent the development of caries even after the visible loss of sealant material.

On the other hand, resin sealants comprise a Bis-GMA resin, which is applied to the occlusal surface of the tooth using acid-etch technology.

They work by physically obliterating the pit and fissure system which harbors cariogenic organisms and thereby inhibit the initiation of caries. The composites are lightly or not filled in order to keep the viscosity low, thus allowing for a deep penetration of the material into pits and fissures, where a resin impregnated layer of enamel is formed, producing the sealing effect *in vitro* studies.[11, 18] Unfilled resin based sealants showed successful marginal sealing ability and microtensile bond strength to the enamel structure.[19] Also, it was demonstrated that resin based sealants exhibited promising retention rates over glass ionomers because of their better stability under occlusal forces due to their main component, Bis-GMA.[20] First developed in the 1960s, they are an established technology and widely used in clinical practice. Disadvantages of resin sealant include polymerizetion shrinkage, marginal microleakage, loss of adhesion and secondary caries.

Resin modified glass ionomer has been introduced to reduce the above-mentioned disadvantages of GI and resin sealants. It is composed of a dimethyl monomer, hydroxyethylmethacrylae (HEMA), is grafted in the polyacrylic acid.[21] Resin modified GIs (RMGICs) have a better wear resistance, higher moisture resistance, higher fracture toughness and a longer working time. The resin ratio of RMGICs ranges from 4.5 to 6%.[22] It is claimed that this is a persuasive material with ideal flowability and a concomitantly high filler content of 70 w/w%.[23] Furthermore, it has other outstanding qualities, such as optimal wetting properties, high transverse strength and excellent abrasion resistance. The fluoride release is also optimum.[24]

The purpose of this present study was to compare the marginal sealing ability of resin modified glass ionomer sealants with that of resin sealant by preparing artificial pit and fissure cavity and artificial organic debris, *in vitro*.

Materials and Methods

This experimental *in vitro* study was performed during the period between June, 2012 to May, 2013.

Sample preparation

Sample preparation of this study is originally based on previous study.[25] A total of 40 extracted non carious human premolar teeth were used. These teeth were extracted for orthodontic reason. Following extraction, these teeth were stored in 0.9% NaCl solution. All teeth were carefully cleaned to eliminate tarter, calculus, stain and remained tissue with the help of ultrasound scalar.

Preparation of fissure grooves

Artificial fissure grooves (width 1 mm) confined to a depth of 1 mm in enamel was then prepared on the occlusal surface of each tooth. These grooves were made over the intact fissure groove using a ¼ round carbide bur (Mani Inc., Japan) with a high-speed hand piece, based on a previous study model.[25]

Preparation of organic debris and condensation

Artificial organic debris was prepared according to a previous study.[25] It contained 20% of liquitex (Liquitex Co., USA), 30% of starch gruel (Fueki-ko, Fueki Co., Japan), 30% of poster color (Sakura Co., Japan), and finally 20% of solid food fragments for rats (MR-stock, Nihon-Nosan Co., Japan) originally used for animal feed. All ingredients were mixed together to simulate a clinical debris condition. All fissures were then filled with the organic debris by using a small spoon excavator (#EXC-7, Nordent Manufacturing Inc., USA). They were then stored in a moist chamber until use.

Cleaning of fissure

Fissures were cleaned with a dry, pointed bristle brush (Merssage brush CA, YDM Co., Japan) and prophylaxis tooth paste (Propylaxis paste, CCS, Clean Chemical Sweden A.B., Sweden) using a low-speed hand piece (550 cycles per min), and rinsed with water. Fissure cavities were then dried with oil free compressed air.

Restoration

Five cavities from each group were analyzed for debris score remaining by the SEM. Then the remaining 15 cavities from each category were sealed by one of the sealants used for this study. In group A, fissure cavities were filled by resin sealant. Treated cavities were acid-etched with 37% phosphoric acid for 15 sec rinsing with water. Dry and then filled with a low viscosity sealant material (Dia Dent, Diaseal, Europe) using a disposable applicator nozzle supplied by the manufacturer, and the tip of an explorer was used to ensure that all pits and fissures were properly sealed. The sealant material was left for 20 sec prior to polymerization to allow for the proper capillary action of resin infiltration. Finally, the sealant material was light-cured.

In Group B, fissure cavities were filled by resin modified glass ionomer sealant (Hy-Bond Resiglass, Japan). The enamel was conditioned by etching with 37% phosphoric acid and then washed and dried carefully to obtain a chalky-white enamel surface with a micro brush for 15 sec then rinsed the teeth with water for 10 sec and wiped off excess water with gauze. Use of no-rinse, self-etching bonding agents instead of acid-etching prior to sealant application is not recommended. No-rinse, self-etching bonding agents may provide less retention than the acid-etching technique. Apply the minimum amount of sealant required to adequately cover the pit and fissure network. Remove any air bubbles or voids before curing. Clinical evidence on the use of bonding agent following acid-etching to enhance sealant retention is inconclusive and no recommendation on its use can be made at this time. Position the light-curing tip as close as possible to the surface being sealed and cured.

Analysis of debris score

The degree of debris score in 5 cavities of each group was analyzed according to a modified debris scale criteria,[25] by using stereomicroscope as follows: 0: Only few small debris particles remaining at cavity, 1: Light coverage of debris <25% cavity (minimum), 2: Moderate coverage of debris of the cavity>25% but <50% cavity (moderate), 3: Heavy coverage of debris of the cavity >50% but <75% cavity (maximum), 4: Complete or nearly complete cavity covered by the debris (full coverage).

Microleakage test

The remaining 15 teeth in each group were subjected to a microleakage test according to a previous study.[25] All tooth surfaces except for the areas of the filled cavities and 1 mm outside the margins of the cavities were double coated with a nail varnish. The samples were thermo-cycled for 400 cycles between 5°C (±2) and 55°C (±2) with a 1-min dwell time at each temperature and immersed for 4 hours in a rodamine buffered dye solution. They were transversely bisected with a diamond saw disc (Isomet, Buehler, USA). The degrees of microleakage were scored in a blinded manner using dye penetration, based on a modified previously reported 4 grade-scale criteria, under a microscope by a technician who was not informed of the true nature and purpose of this experiment. Thus, judgment of the degrees of microleakage was kept blind. Where scores were different at both sides, the higher degree of leakage score was used for the evaluation. The criteria were as follows: 0: No dye penetration, 1: Dye penetration restricted to the outer half of the sealant, 2: Dye penetration to the inner half of the sealant, 3: Dye penetration into the underlying fissure.[25]

SEM observation of the enamel–sealant interface

To verify any gap present between the enamel and sealant, cut sections were then polished to the high glass with waterproof carbide paper from 400 to 2000 grit, immersed in 40% phosphoric acid gel for 15 min, and then were observed by SEM.

Data collection and statistical analysis

Statistical analysis of the *in vitro* study result was done by computer software device as Statistical Package for Social Science (SPSS ver. 20). The results were presented in tables. For significant of difference, ANOVA and independent t-test were performed. A value of $p>0.05$ was considered as significant.

Table I

Degree of remaining debris and microleakage

Group	Scores				Mean ± SD	p value
	0	1	2	3		
Debris score (n = 5)						
A	3	2	0	0	0.4 ± 0.5	0.1ns
B	3	2	0	0	0.4 ± 0.5	
Microleakage (n = 15)						
A	10	1	1	3	0.8 ± 1.3	0.1 ns
B	12	1	1	1	0.4 ± 0.9	

Data were expressed as Mean ± SD. Statistical analysis were done by One-way ANOVA and independent sample t-test, n=number of samples, ns=not significant ($p>0.05$)

Results

Table I shows that the results of the degree of remaining debris. In Group A, among the 3 of 5 samples, no debris remaining (score 0) was recognized after prophylaxis cleaning followed by acid-etching. However, the remaining 2 samples were lightly covered by debris (score 1). The mean (± SD) debris removal of the samples was 0.4 ± 0.5. On the other hand, in Group B, 3 of 5 samples, showed no natural debris remaining (score 0) and the remaining 2 samples were lightly covered by natural debris (score 1). The mean (± SD) debris removal of the samples was 0.4 ± 0.5. All the values were almost similar and the differences among the groups were statistically not significant ($p>0.05$). In microscopic observation, when enamel surface was subjected to SEM observation, it was found that after removal of organic debris by using brush with prophylactic pumice paste, a debris-like particle was found on the treated surface (before acid-etching) and enamel structure was not visible (Figure 1A). Following acid-etching, the removal of debris-like particle exposed the enamel prisms (Figure 1B).

The results of the microleakage test showed that in Group A (resin sealant), 10 samples revealed no microleakage (score 0). The mean (± SD) debris removal of the samples was 0.8 ± 1.3. However, in Group B (resin modified glass ionomer cement), 12 samples revealed no microleakage (score 0). The mean (± SD) debris removal of the samples was 0.4 ± 0.9. In stereoscopic observation, sealant restoration also showed good adaptation of the sealant with the tooth tissue (Figure 2A). There was no gap found between sealant and enamel (Figure 2B). However, 3 resin sealant and 1 resin modified glass ionomer revealed some degree of microleakage. Microscopic observation of enamel-sealant interface

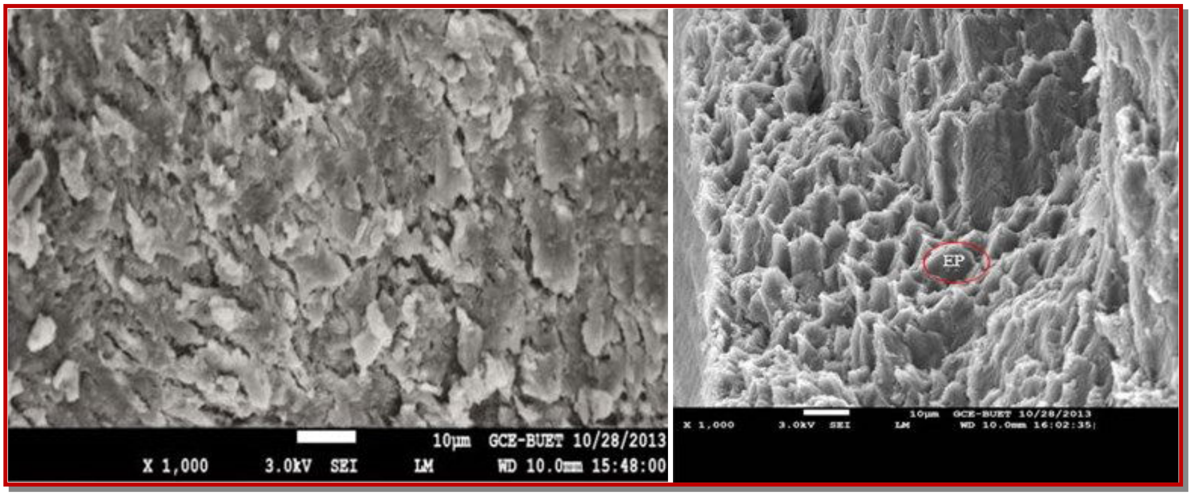

Figure 1: Enamel surface before acid-etching (x 1,000) (left), Enamel surface after acid-etching (X 1,000), EP: Enamel prism (right)

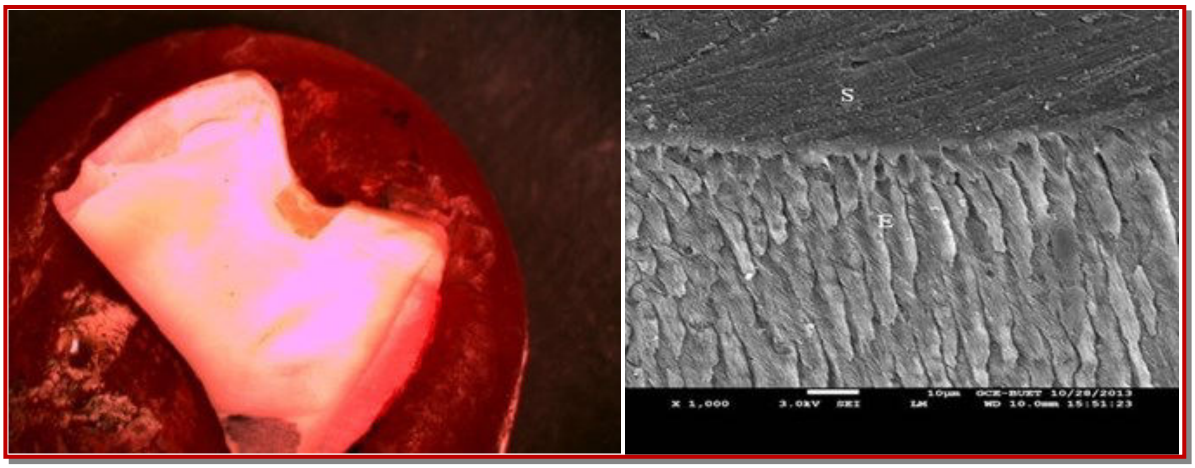

Figure 2: Stereoscopic photograph of good adaptation of sealant (left), No gap between sealant and enamel by the SEM (x 1,000), S: Sealant, E: Enamel (right)

also revealed that gaps were observed at the enamel -sealant interfaces in both stereoscopy (Figure 3A) and SEM (Figure 3B).

Discussion

Regarding the analysis of debris removal, the present study showed that organic debris cleaned with pointed bristle brush with prophylaxis paste frequently left residual materials and was unable to clean the enamel walls of the fissures completely. A previous study indicated that in the clinic, proper cleaning of pits and fissures to long-term retention of the sealants is essential for the reduction of caries.[4] Because the anatomical structure of fissures plays an important role in sealant penetration and retention,[26] artificial fissure grooves confined to a depth of 1 mm in enamel were prepared for debris condensation instead of using natural pit and fissure cavities. This study model was originally based on a previous study,[25] and is useful for comparing different methods for debris removal in pit and fissure areas. In the present study, debris removal by pointed bristle brush with prophylaxis pumice paste was examined by stereoscopic and SEM. After removal of organic debris by using a brush with prophylactic pumice paste, a debris-like particle was found on the treated surface (before acid etching) and enamel structure were not visible. Following acid-etching, removal of debris-like particle was observed and enamel prisms were exposed. These features were almost similar to the structure of previous studies that have been described as flaky or irregular surface.[25, 27] Furthermore, the results found in the present study were in agreement with some of the previous studies that some fissures were not cleaned by bristle brush.[6, 7, 25]

The results of the microleakge between resin cement and resin modified glass ionomer cement in the present study showed that in both groups, no significant difference was found between the resin sealant and resin modified glass ionomer sealant ($p>0.05$). Previous studies have indicated that excellent retention and longevity of sealants depend on the degree of remaining debris, the penetrability of the

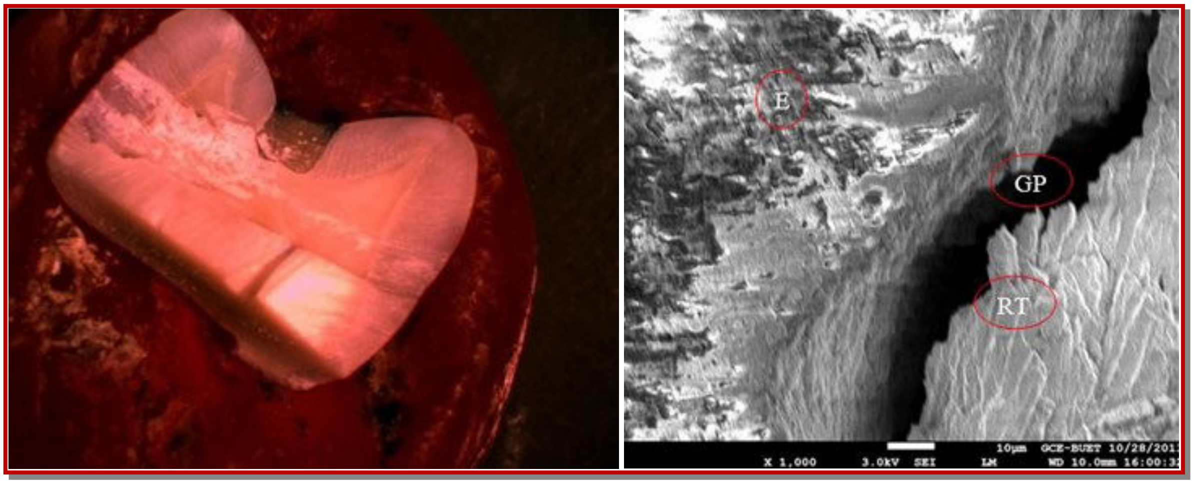

Figure 3: Stereoscopic photo of loss of adaptation (left), Gap between sealant and enamel, broken RT (x 1,000), E: Enamel, GP: Gap, RT: Resin tag (right)

sealant material into acid-etched enamel or marginal sealing, and wear or abrasion resistance.[6,7] The results of microleakage test in the present had similarities and dissimilarities with those of previous studies. Yamada et al.[25] reported that resin sealant is better than that of the resin modified glass ionomer sealant. However, Morales-Chávez et al.[28] reported that there is no difference between resin modified glass ionomer sealant and resin sealant. The differences may be due to the use of the natural fissures of the previous studies. In the present study, artificial fissure groove and organic debris were used. Comparing to the natural groove, we consider that this technique is able to search more precisely the microleakage degree than that of natural fissure. Other reasons may be due to the differences in viscosity of sealant materials. Because, in the present study, 3 of resin sealant and 1 of resin modified glass ionomer revealed some degree of microleakage. Microscopic observation of enamel-sealant interface also revealed that gaps were observed at the enamel-sealant interfaces in both stereoscopy and SEM. Gaps can be produced due to loss of adaptation of sealant to enamel, less penetration of the sealant, and insufficient curing of sealant. There may also be residual debris or entrapped air when placing the sealant as observed by stereoscopy, and resin tags were not recognized by SEM.

Conclusion

The use of resin modified glass ionomer sealant is a good alternative for sealing pits and fissures.

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