Original Article

In vitro evaluation of shear bond strength and microleakage of different pit and fissure sealants

Prashant Babaji, Shivali Vaid[1], S. Deep[2], Samvit Mishra[3], Madhulika Srivastava[4], Thomas Manjooran[5]

Department of Pedodontics and Preventive Dentistry, Sharavthi Dental College, Karnataka, [1]Department of Oral Pathology and Microbiology, MPCD and Research Centre, Gwalior, [2]Department of Pedodontics, Triveni Dental College, Chhattisgarh, [3]Department of Orthodontics, Bhabha College of Dental Sciences, Bhopal, Madhya Pradesh, [4]Department of Pedodontics, BBDCODS, Lucknow, Uttar Pradesh, [5]Department of Pedodontics, PSM Dental College, Kerala, India

Corresponding author (email: <babajipedo@gmail.com>)
Dr. Prashant Babaji, Department of Pedodontics and Preventive Dentistry, Sharavthi Dental College, Shimoga, Karnataka, India.

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Abstract

Aim and Objectives: Fissure caries is most common in children due to deep pit and fissures. Pit and fissure areas on the occlusal surface of the teeth make them susceptible to dental caries, which need to be prevented or restored. Fissures sealant reduces the risk of occlusal caries. The present study was done to evaluate microleakage and shear bond strength of various fissure sealants. **Materials and Methods:** Thirty-six extracted molars were randomly allocated equally (n = 12) into three groups with three different sealants to evaluate shear bond strength and microleakage at sealant space. The shear bond strengths was evaluated with one-way analysis of variance and microleakage by Kruskal–Wallis nonparametric test using the Statistical Package for the Social Sciences version 18.0 (Chicago: SPSS Inc, 2009). **Results:** Tetric flow (16.8 MPa) recorded the highest shear bond strength and the difference was statistically significant with enamel loc (12.8 MPa). There was no statistically significant difference in relation to microleakage ($P > 0.05$) in the tested groups. **Conclusions:** Tetric flow recorded the highest shear bond strength and the difference was statistically significant with enamel loc. However, there was no statistically significant difference among the groups regarding microleakage.

Key words: *Composite, fissure, flowable, microleakage, pit, sealant, shear bond strength*

INTRODUCTION

Occlusal surface accounts for 12.5% of the total tooth areas of teeth.[1] Fissure caries is most common in children due to deep pit and fissures.[2] Pit and fissures are classified as self-cleansable (V and U type) and nonself cleansable (I and k type). Pit and fissures are deep grooves and are sites for stagnation of food debris and microorganisms. These areas are difficult to clean, which results into fissure caries. Unfavorable morphology makes these fissures difficult for salivary access and minimizes fluoride deposition for preventive effect.[1-3] Fissure caries accounts for 50% of all the carious lesions.[1] Pit and fissures areas on the occlusal surface of the teeth make them susceptible to dental caries which need to be prevented or restored.

Filling of fissure areas reduces the risk of occlusal caries.[4-7] Simonsen advocated preventive resin

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restoration to fill the vulnerable fissures with composite sealant after opening with small tapered fissure bur.[1] Various types of fit and fissure sealants have been suggested such as glass ionomer cement, resin based (filled or unfilled), flowable composite, and fluoride releasing.[2,4,8,9] Filler content in the sealant increases its viscosity and decreases wear resistance. However, Barnes *et al*. stated that viscosity and flowability of fissure sealants does not affect its sealing quality.[8] Several studies have shown that fluoride released from glass ionomer sealant reduces caries.[7] Joshi *et al*. from their study concluded that fissure sealant reduces occlusal caries and observed less microleakage with composite material than with glass ionomer cement and compomer.[4]

Ideal requirements of fissure sealants should be biocompatible, better sealing ability, and resistance and retention to wear and abrasion. Sealing ability and shear bond strength differs among different fissure sealants used.[10] Lesser the microleakage better will be the sealing ability. Improved shear strength increases the longevity of sealant. The present study was conducted to assess the shear bond strength and microleakage of three different pit and fissure sealants.

MATERIALS AND METHODS

Shear bond strength tests

Thirty-six sound premolar teeth extracted for orthodontic purpose were selected for the study. Sample size was calculated with ±0.5 of standard deviation with minimum expected difference of 0.74 and 0.05 of significance criterion at 90% statistical power. Roots were cut off 2 mm below the cementoenamel junction with diamond saw at low speed under water-coolant. The crowns were embedded in acrylic resin blocks with exposed sound buccal or lingual surfaces. Enamel surface was cleaned on each tooth with a nonfluoride, oil-free paste (Nupro Prophylaxis Paste, Dentsply Detrey, Kostanz, Germany), using a low-speed hand piece with brush under water coolant.

Thirty-six teeth were randomly categorized in to three equal groups with 12 samples per group based on the sealant type used for shear bond strength testing. Table 1 lists different flowable resin sealants used along with manufacturer details and composition.

Group 1 – Etchant Gel + Tetric Flow

Group 2 – Etchant Gel + Helioseal F

Group 3 – Etchant gel + Enamel Loc

In all the three group specimens, enamel surface was etched with 37.5% phosphoric acid for 60 s followed by washing and drying. Tetric flow, Helioseal F, and Enamel loc sealants were applied in respective groups in a 2-mm thick layer over the conditioned enamel substrate and cured using ultraviolet light. The bonded specimens were then left undisturbed at 37°C for 24 h in 100% humidity before shear bond strength testing. Shear load was applied using a universal testing machine (Triax Digital 50, Controls, 132 Milan, Italy) in a direction parallel to the bonded interface at a crosshead speed of 0.5 mm/min until failure occurred. The load at failure was recorded in Newtons (N). The diameter of the debonded composite cylinder was measured with a digital caliper (Orteam srl, Milan, Italy). Bond strength was then calculated in Mega Pascals (MPa). Failure rate were assessed by a single trained investigator under an optical microscope (Nikon type 102, Tokyo, Japan) at 40× magnification, and classified as cohesive within the substrate (enamel or sealing material), adhesive (between sealing material and enamel), or mixed (if adhesive and cohesive fractures occurred simultaneously).

Table 1: Pit and fissure sealants used and manufacturer details

Pit and fissure sealant	Manufacturer	composition
Tetric flow	Vivadent, Schaan, Liechtenstein	Flowable composite
Heliosel F	Ivoclar Vivadent AG, Liechtenstein, Germany	Bis-GMA, dimetacrylates fluorosilicate glass, silica, titanium dioxide, initiatizers and stabilizers
Enamel loc	Premier Dental Products Company, REV	UDMA, TEGDMA, Methacrylated phosphoric acid esters, 4-methacryloxy ethyltrimellitic acid, photo initiators, fumed silica, TiO_2

UDMA=Urethane dimethacrylate, TEGDMA=Triethylene glycol dimethacrylate

Microleakage evaluation

Thirty-six extracted human third molars free of caries, cracks, and restorations were included for the study and pumice prophylaxis was done. Acid etching of the occlusal surface with 37% phosphoric acid was done for 60 s. Then, test sealants were applied to the pit and fissures and light cured for 20 s. Flowable resin sealants (Helioseal F, Tetric flow, and Enamel Loc) were applied into the fissures with a tip syringe and air entrapment was avoided using dental probe manipulation before starting polymerization. Teeth were stored for 24 h at 100% humidity and 37°C.

Dye penetration was performed by sealing the root apex with epoxy resin, and teeth were coated with two layers of nail polish with 2 mm of window around the exposed sealant margin. Then specimens were immersed in 2% buffered methylene blue dye for 24 h. One blinded examiner evaluated the depth of dye penetration in each section. Later, nail varnish and wax were dried and resin blocks were prepared.

These resin blocks were longitudinally sectioned in a buccolingual direction with diamond saw under water-coolant to create three sections per tooth. The specimens were mounted on aluminum stubs, sputter-coated with gold (Bal-Tec SCD 005Sputter Coater; Balzers, Liechtenstein, Germany) and then examined with scanning electron microscope (SEM) (JEOL JSM-6460LV, JEOL Industries; Tokyo, Japan) at magnification of 30×. Dye penetration was assessed using ranked scale as 0 = absence of dye penetration; 1 = dye penetration up to to the outer half of the sealant (good); 2 = dye penetration extending to the inner half of the sealant (fair); 3 = dye penetration extending to the underlying fissure (poor).

The shear bond strengths was evaluated with one-way analysis of variance (ANOVA) and microleakage by Kruskal–Wallis nonparametric test at 5% significance level using the statistical software Statistical Package for the Social Sciences version 18.0 (Chicago: SPSS Inc., 2009)

RESULTS

Table 1 indicates different flowable composite sealants used, manufacturer details, and composition. The one-way ANOVA revealed that the shear bond strengths of the tested materials differed significantly ($P = 0.015$). Tetric Flow 16.8 (MPa) recorded the highest shear bond strength and the difference was statistically significant with Enamel loc (12.8 MPa) [Table 2].

Table 2: Shear bond strength of pit and fissure sealants

Pit and fissure sealant	N	Mean (MPa)	SD	Significance
Tetric flow	12	16.8	2.7	A
Heliosel F	12	13.7	7	AB
Enamel loc	12	12.8	4.8	B

One-Way ANOVA and post hoc test (P<0.05). SD=Standard deviation

Majority of teeth sealed with Tetric flow and Helioseal F showed absence of dye penetration (score 0), they showed score 1 in three teeth and score 2 in each, but no teeth with score 3. Enamel loc scored less compared to other two. This indicates that Enamel loc has comparatively more microleakage. Statistically, there was no significant difference in relation to microleakage ($P > 0.05$) in the tested groups [Table 3].

Table 3: Comparison of microleakage scores distribution (0 to 3 score)

Pit and fissure sealant	N	Score			
		0	1	2	3
Tetric flow	12	8	3	1	0
Heliosel F	12	7	4	1	0
Enamel loc	12	5	4	2	1

Kruskal-Wallis non-parametric test was used to compare the groups for statistically significant differences at 5% significance level

DISCUSSION

Permanent first molar are most susceptible for occlusal caries because of variation in occlusal fissure morphology and long eruption phase.[2] Use of sealants reduces the chances of fissure caries.[5] Upon application of fissure sealants into the caries susceptible fissures, they reduce caries risk by sealing fissures from the oral environment.[11] Clinical success of fissure sealant depends on adequate isolation, morphology of pit and fissure, material characteristics, long term retention, and marginal integrity.[6,8,12] Isolation of the tooth is the most important step of sealant placement because sealing of pit and fissures always carry the risk of contamination which influences an effective seal.[13]

Etching of enamel surfaces increases retention of sealants by increasing the surface area. Etching of tooth surface produces rough areas so that resin tags can penetrate deep into the enamel to create an effective mechanical bond and improve sealant retention[2] The resin sealants create mechanical bond with underlying etched enamel rods by flowing into microporosities and forming resin tags. Formation of the resin tag indicates sealing ability.[8] Lack of sealing ability of fissure sealant results into microleakage and dental caries.[10] Microleakage is considered as the main reason for restoration failure. Sealant is considered successful if it protects pits and fissures from the oral environment by firmly adhering to the enamel surface.[5]

Traditional pit and fissure sealants are hydrophobic and cannot be applied where there is moisture to ensure success. These materials are based on bisphenol A glycol dimethacrylate (Bis-GMA) and other monomers that are primarily hydrophobic in nature and require a dry field. Several hydrophilic resin sealants were introduced into market with success. Ratnaditya *et al*. found better retension and sealability of hydrophilic resin sealant (Embrace™ Wet Bond) compared with hydrophobic resin sealant (Delton FS).[6]

Proper handling of sealant material is important for its long-term clinical success. The efficacy of pit and fissure sealants depends on their ability to achieve adequate bonding with the conditioned enamel. Resin-based fluoride-releasing sealants have been developed to provide caries preventive effect of fluoride to a material. Helioseal F used in our study is a fluoride-releasing flowable composite. Markovic *et al*. observed greater fluoride release compared with other glass ionomer materials.[5]

The one-way ANOVA test revealed that the shear bond strengths of the tested materials differed significantly ($P = 0.015$). Tetric flow 16.8 (MPa) recorded the highest shear bond strength and the difference was statistically significant with Enamel loc (12.8 MPa). On the other hand, Helioseal F has fluoride-releasing effect and has shear bond strength of 13.7 MPa [Table 2]. Bond strength is considered to be predictive of the materials' retentive ability based on the consideration that, the higher the bond strength, the stronger the resistance to curing stress and oral function loading.[14]

The use of organic dyes as tracers is the most common method for microleakage assessment *in vitro* studies. In the present study, we used stored specimens in methylene blue for 4 h, according to the methodology used in the studies by Hatibovic *et al*., and microleakage was scored according to the level of leakage at the sealant–enamel interface.[15] The present study used methylene blue to investigate dye penetration because it is readily detectable under visible light, soluble in water, and it diffuses freely.[12] Microleakage analysis using dyes was shown to be indicative of the sealing ability.[15]

In the present study, adaptation ability was evaluated with SEM because of its magnification and depth of focus and because it provides visual observation of the adaptation of sealing material to enamel walls through the entire fissure system.[5]

Majority of the teeth sealed with Tetric flow and Helioseal F showed absence of dye penetration (score 0), they showed score 1, in three teeth and score 2 in each, but no teeth with score 3. Enamel loc scored less compared to other two. This indicates that Enamel loc has comparatively more microleakage. Statistically, there was no significant difference in relation to microleakage ($P > 0.05$) in the tested groups. On SEM analysis, both Tetric flow and Helioseal F demonstrated satisfactory sealing ability. With reference to the sealing ability, it was assessed that the lack of optimal marginal sealing allows passage of bacteria and their accumulation at the bottom of the pits and fissures.[15] Several studies observed that no sealing material or technique can completely prevent microleakage.[5]

Pardi *et al*. in their study observed similar marginal seal with flowable compomer and resin-modified glass ionomer sealant.[10] Several researchers have observed better marginal sealing with resin-based sealants than glass ionomer cement.[5,7] Markovic *et al*. observed acceptable sealing ability with resin-based (Helioseal F) and glass ionomer (Fuji Triage) material.[5] Baca *et al*. found no improvement in retention with the use of one bottle dentin bonding system along with conventional fissure sealants.[16]

Kobayashi *et al*. found improved retention with Helioseal clear over Helioseal F.[17] Mehrabkhani *et al*. observed reduction in microleakage using low viscosity resin and observed no role of bonding agent in the reduction of microleakage. Rahimian-Imam *et al*. concluded lesser marginal microleakage with self adhering flowable composites over the conventional one. Similarly, Kucukyilmaz and Savas found superior adhesion with flowable composites with adhesive system compared to the conventional one in a 24-month clinical trial.[18-20]

Similar to our results, Topaloglu *et al*. observed statistically significant less microleakage with Helioseal F compared to Enamel loc and Fuji VII groups.[9] Prabhakar *et al*. found the highest microleakage scores with Guardian seal and lowest with the Embrace wet bond.[11] Many studies found better sealing ability with resin sealant than glass ionomer sealant.[2-4,12] Kwon *et al*. found similar sealing ability among three different flowable fissure sealants.[8] Margvelashvili *et al*. found no difference in sealing ability among tested groups.[14]

In present study, we found higher shear bond strength with Tetric flow compared to Helioseal F and Enamel loc. The higher viscosity of Helioseal F did not improve fracture resistance. The possible reason for higher bond strength in Tetric flow is the higher sealing ability compared to Enamel Loc. Enamel loc has comparatively greater microleakage but there was no statistically significant difference among the groups, which indicates equally good sealing ability among all tested groups.

Several researchers have confirmed the effectiveness of the resin sealants.[5-7,10] Fluoride releasing sealant such as Helioseal F is effective in caries susceptible individuals.

Clinical performance of the fissure sealant differs compared with *in vitro* results due to change in oral conditions and patient performance; hence, long term clinical studies with larger sample is required to assess the longevity of flowable resin sealants.

CONCLUSION

Tetric flow recorded the highest shear bond strength and the difference was statistically significant with Enamel loc. Statistically, there was no significant difference in relation to microleakage in the tested groups.

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Conflicts of interest

There are no conflicts of interest.

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