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Shear Bond Strength of Four Types of Pit and Fissure Sealants (In Vitro Study)

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ABSTRACT

Aims of the study: This in vitro study aimed to evaluate the shear bond strength of four different types of pit and fissure sealants that bond to the enamel of teeth and cured by light emitting diode (LED).

Materials and methods: 40 upper first premolars which were randomly divided into 4 main groups of 10 teeth in each, based on the pit and fissure sealant applied (Conseal F, Fisseal, Charmseal and Smart seal). Each tooth was polished, etched, rinsed then dried with air stream to obtain a uniformly white, dull, chalk-like appearance. The etched surface was covered with a piece of adhesive tape (3-mm-diameter circular hole). Then an O plastic ring was placed over the demarcated enamel site then the sealant was inserted into the O-plastic ring, and cured for 40seconds with light emitted diode (LED). After curing, the specimen was removed from the clamping device, and the -O-plastic ring was separated, leaving a sealant cylinder (3mm × 3mm) adhering to the enamel surface. The samples were stored in artificial saliva until the time for the shear test. The shear bond strength was measured with (Unconfined Shear Testing Machine).The values of bond strengths obtained with megapascal (MPa).

Results: The result showed significant difference when ($p \leq 0.05$) and the Conseal F had the greater shear bond strengths followed by Fissealand Charmseal. While the Smart seal had the lowest shear strengths.

Conclusions: Sufficient shear bond strength was produced for all pit and fissure sealants,

Keywords: pit and fissure sealant, shear bond strength, LED light curing machine

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INTRODUCTION

Pits and fissures (PF) are developmental defects found on the occlusal surface of posterior teeth and on buccal and palatal surfaces of molars. They are most vulnerable to caries, including partially erupted permanent first and second molars and premolars.[1] This is due to that PF with high steep walls and narrow bases are favour the retention of food debris and microorganisms and caries may result from fermentation of this food and the formation of acid, Also they are often so deep that it is difficult for the bristles of a tooth brush to clean the plaque deposits in the area. Sealants are indicated as a method to reduce the incidence of occlusal dental caries.[2] The preventive benefits of such treatment rely directly upon the sealant‘s ability to thoroughly fill pits, fissures, and/or anatomical defects, as well as to remain completely intact and bonded to enamel surfaces without marginal Microleakage at the resin-tooth interface.[3] The caries preventive success of sealants is due to the establishment of a tight seal, which prevents micro leakage of nutrients to the micro flora in the deeper parts of the pits and fissures.[4] The retention rate of a pit and fissure sealant is directly related to the micromechanical bond between the sealant and enamel. Shear bond strength measures the ability of sealant to bond to tooth structure. Higher shear bond strength equated with enhanced performance. [5]

The aims of this study is to evaluate the shear bond strength of four different types of pit and fissure sealants that bond to the enamel of teeth and cured by light emitting diode (LED).

MATERIALS AND METHODS

Materials: Four light curing pit and fissure sealants resin based used in this study which are: Smart Seal loc F (Advanced fissure sealant with fluoride and moisture tolerant Hydrophilic, Detax company, GERMANY), Fisseal Extra (highly filled, white with fluoride, Promedica Company, GERMANY),CHARM SEAL (Dentkist Company, KOREA) and CONSEAL-F (SDI company, AUSTIRALIA). (Table 1).

Methods: A 40 sound human premolars teeth were newly extracted for orthodontic reason. Teeth were hand scaled and cleaned with water/pumice slurry and rotating bristle brushes to remove deposits of calculus, plaque, or debris.[6-8] Teeth were examined under a ×20 magnifier to discard those with structural defects and were stored in distilled water atroom temperature (25^{o}C)for a maximum of one month.[9] To prevent bacterial growth, the water was changed weekly. Prior to use, the teeth were washed thoroughly in running water then they were cleaned with an ultrasonic machine (woodpecker, china) and polishing with a slow-speed hand piece and rubber cup/ prophylaxis pumice "Fluoride-free pumice" for 10seconds and soaked in new clean distilled water.[9,10] Then the teeth embedded inside cupper rings (21,91mm outside diameter, 15,73mm inside diameter and 19,75 mm length), then rings were filled by dental cold cure acrylic resin, (Respal, ITALY) until the roots were covered 3 mm below the cement enamel junction. When the cold cure acrylic resin set for all specimens, they were arranged into study groups.[10,11]

The teeth were randomly divided into 4 main groups of 10 teeth each, based on the pit and fissure sealant applied. The buccal area of each tooth was used as a testing surface.[12]Each enamel surfaces were etched with a 37% semi-gel Phosphoric Acid (H3PO4), (CHARM SEAL), Dentkist company, KOREA for 15 seconds, rinsed thoroughly for 15 seconds, dried with a mild, oil-free air stream to obtain a uniformly white, dull, chalk-like appearance,(Figure 1).For standardization, the bonding sites were demarcated by attaching a piece of insulating tape "adhesive tape" with a 3-mm-diameter circular hole in the middle,[7]Then this insulating tape was attached to buccal surface,(Figure 2).So etched surface was covered with this adhesive tape.[9] This hole was made by rubber-dam punch.[5]The specimens were individually fixed in a metallic clamping device that secured the test enamel surface parallel to a flat base. O-plastic ring was placed over the demarcated enamel site and carefully attached with adhesive tape, providing a cylindrical cavity 3 mm in height and 3 mm in diameter that was coincident with the demarcated enamel bonding site.

The sealant was inserted into the O-plastic ring, increments according to the manufacturer's instructions attempting to avoid air bubbles entrapment, in two increments, with each one polymerized for 40 seconds(Figure 3), specimens cured with Light Cure Unit Machine LED Type (Woodpecker, China) wavelength 450-470nm and with light power (intensity) 1200 mW/Cm^2.[11] As the cavity was completely filled, the specimen was removed from the clamping device, and the -O-plastic ring was separated, leaving a sealant cylinder (3 mm × 3 mm) adhering to the enamel surface.[10](Figure 4).After storing the specimens for 24h in artificial saliva at 37˚c, [8] the specimens were air dried and were tested in shear mode by using a shear knife-edge blade in an Unconfined Shear Testing Machine (GERMANY) with a crosshead speed of 0.5mm/second.[9] Each specimen was placed in the Universal testing machine so that the treated surface was parallel to the shearing rod of the Unconfined Shear Testing Machine.[5]A shear load was applied to the base of each cylinder.[13] (Figure 5).

Load was applied at a cross-head until sealant separated from enamel surface and readings were recorded. This was repeated for all the specimens. The readings were obtained in kilograms and recorded. These readings were then converted into Newton by multiplying the reading by 9.81 (1 kg = 9.81 N), and bonding surface area in millimeter square (mm)^2. The shear bond strength of the pit and fissure sealant in Newton/mm^2=Megapascal (MPa) was calculated using the formula:

Shear bond strength (MPa) = load/area

Shear bond strength of all the specimens were calculated and recorded. Then the compiled data were subjected to statistical analysis. [5]

Statistical analysis Readings are analyzed statistically by Descriptive Analysis, which was used to find out the mean, standard deviation, range, minimum value and maximum value. Analysis of Variance (one-way ANOVA test) was used to determine the presence or absence of a significant difference among different groups at 0.05 level of significance and Duncan's multiple range test was used to determine the significant difference between the groups. Analysis was done by using software program SPSS-version 22".

RESULTS

The values of shear bond strength and the descriptive statistics for all sealants showed in (Table 2).The Conseal Fshows the best bond strength followed by Fisseal, Charmseal and Smart seal respectively. While in the analysis of variance of One way (ANOVA) test for groups, shows statistically significant difference ($p \leq 0.05$) between them as illustrated in (Table 3).The result of the Duncan's multiple range test in table (4) shows that group 4 (Smart seal) have the lowest mean values of shear bond strength with a significant difference ($p \leq 0.05$) while the remaining groups show no significant difference.

DISCUSSION

The means of shear bond strength of all fissure sealants used in this study consider acceptable and able to withstand masticatory forces, as it exceed the minimum shear bond strength (5.9-7.8) MPa which was suggested by Reynolds (14).

The difference between the bond strengths of fissure sealants used in this study may be related to the chemical compositions of the materials itself. (See Table 1)

As the pit and fissure sealants used in this study have different chemical composition as its manufacture consideration. These differences in composition will produce variation in the rate of movement of a liquid into a capillary space which is related to what is called the viscosity, as a liquid with low viscosity, high surface tension, and low contact angle have high flow ability (i.e., good wetting)will penetrate faster and deeper than one that which have high viscosity. This feature is important in adhesives, such as pit and fissure sealants, which lead it penetrate deeply into surface roughness and crevices quickly for good bonding.[15]

Harris and Garcia-Godoy[16] suggested that the control of the viscosity of the sealant is important to obtain optimum results and the viscosity determines the penetration of resin into the etched areas of enamel to provide adequate retention of the sealant. Furthermore, Karaman*et al*[17] were suggested that the retention rate, differ according viscosity of the sealant material, with a higher viscosity there might be problems in a complete obturation of the depth of a fissure system. From this we can explain that way the CONSEAL-F which have less filler (low viscosity) will penetrate faster and deeper (CHARM SEAL and Smart Sealandloc F)which arehigh filler content (high viscosity). This study agree with Chongvisal*et al*(6) who showed that the difference in bond strengths may be related to the chemical compositions of the materials itself.

Yildiz*et al*was said that the composition of PFS play a role in its retention rate asuccess. [18].Yılmaz*et al*[19]stated that an increase of the inorganic filler rate (increase viscosity) causespoor retention.

Fernandes*et al* said that when the three sealants (Helioseal F, Conseal F and Clinpro) have been tested. The filler loading (percentage by weight) in Clinpro and Conseal F are 6% and 7%, respectively. Lesser filler loading contributes to low viscosity values in these sealants. It also enables better penetrability into pits and fissures. While Helioseal F has a filler loading of 43% by weight, making it more viscous in comparison to Clinpro and Conseal F. The higher viscosity of Helioseal F did not seem to make the sealant more resistant to fracture in comparison to the low viscosity sealants, Clinpro and Conseal F.[20].

On the other hand this study disagree with Yılmaz*et al*[19]and Ansari and Hashemi [21] who showed that the rate and type of filler could not had an influence on the retention rates of the PFS, which showed similar retention rates.

Anyway the increase in bond strength will give rise to get better retention for sealants in clinical use.[6] Optimal physical properties of the sealant are important for a successful fissure sealing in the oral environment. Increased mechanical strength of a material placed over pit and fissures can support occlusal stresses during chewing, protecting the adhesive interface and increasing long-term retention. It has been shown that long-term retention of the sealant is a crucial requirement for effective caries prevention and for arresting caries progression.[22]

CONCLUSIONS

The pit and fissure sealant CONSEAL- F showed the best bonding seal to enamel followed by Fisseal Extrathen CHARM SEAL then Smart Seal locF.

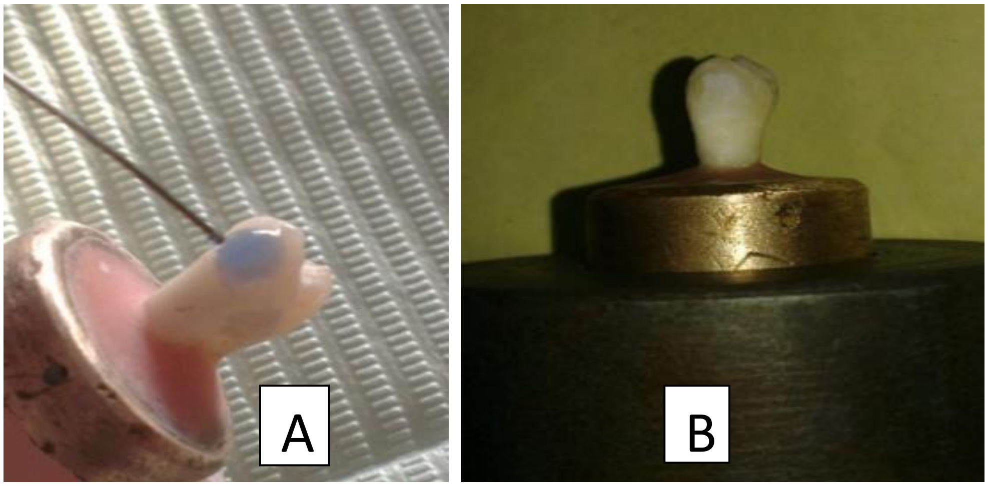

Figure 1: A. Etching with a 37% semi-gel phosphoric acid and B. white, dull, chalk-like appearance

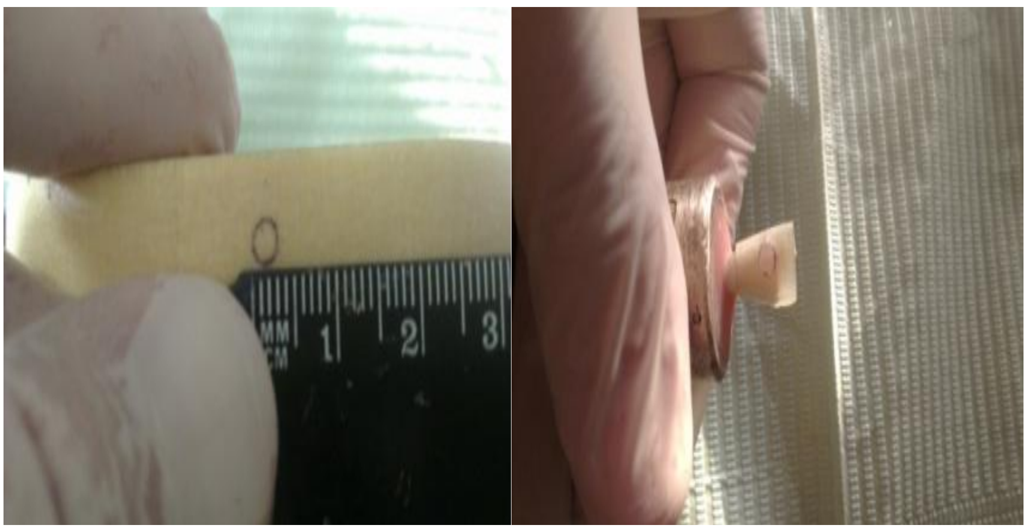

Figure 2: Insulating tape "adhesive tape" with a 3-mm diameter circular hole attached to buccal surface

Figure 3: The sealant was inserted into the O-plastic ring

Figure (4): Cylinder of sealant adhering to the enamel surface

Figure (5): Knife-edge blade in a Universal Testing Machine was applied to the Base of cylinder

Table (1): Materials compositions and its batch numbers

Brand name	**Shade**	**Batch**	**Composition**
CONSEAL- F, SDI company , AUSTIRALIA	White	3153	urethane dimethacrylate base. 7% filled with a submicron filler size of 0.04 microns to withstand surface wear.
Fisseal Extra, Promedica company, GERMANY.	White	2476	BIS-GMA, Dirurethanedimethacrylate, BHT, benzotriazolderivate and sodium fluoride highly filled High filler content (55% w/w),with fluoride.

CHARM SEAL, Dentkistcompany , KOREA	White	1432	BIS-GMA:2,2-bis[p-(2-hydroxy-3-methacryloly propoxyl) phenyl] propane derivatives, TEGDMA:triethylene-glycol-dimethacrylate UDMA: urethane dimethacrylate, Titanium dioxide,Silicon dioxide
Smart Seal &loc F, Detax company, GERMANY	Natural opaque	02581	Composite based, sealant & moisture tolerant –Hydrophilic, with fluoride, for permanent protection. Filler content 50%, Bis(methacryloxyethyl) hydrogen phosphate, TrimethylolpropaneTrimethacrylate.2-Propenoic acid, 2-Methyl-, 2-Hydroxyethyl ester, Phosphate, 2-dimethylaminoethyl methacrylate

Table (2): Descriptive analysis of shear bond strength in megapascal

Material	N	Minimum	Maximum	Mean	Median	Range	Std. Deviation
Conseal F	10	12.65	15.39	13.97	13.94	2.74	0.92
Fisseal	10	9.41	16.25	12.55	11.55	6.84	2.74
Charmseal	10	9.75	15.39	12.48	12.66	5.64	1.79
Smart seal	10	6.84	11.12	9.53	9.75	4.28	1.41

Table (3): Difference among sealant groups by using ANOVA (one way)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	104.719	3	34.906	10.307	.000
Within Groups	121.919	36	3.387		
Total	226.638	39			

Table (4): The Duncan's Analysis for Determining the Significant Difference among the Groups

Groups	N	Standard Deviation	Subset for alpha = 0.05	
			1	2
Conseal F	10	2.10		13.9720
Fisseal	10	2.73		12.5520
Charmseal	10	2.10		12.4840
Smart seal	10	1.12	9.5270	

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