Research Article

Comparative evaluation of shear bond strength of conventional & hydrophilic pit and fissure sealants on permanent molars - An *in vitro* study

P. Jayashri[1]*, Joseph John[2], I. Meignana Arumugham[1], R. Pradeep Kumar[1], D. Srisakthi[1]

ABSTRACT

Introduction: Sealants are considered to be more effective in preventing and arresting pit and fissure caries of primary and permanent molars. Laboratory *in vitro* tests play a key role in providing the necessary information regarding the efficacy of new products in a short period of time. Therefore, the aim of the present study to compare and evaluate the shear bond strength of conventional and hydrophilic fissure sealants applied to the enamel on the buccal surface of permanent molars. **Materials and Methods:** Twenty extracted third molars were included in the study. The teeth were randomly divided into two groups. Group I: Conventional sealant (Clinpro3M ESPE) and Group II: Hydrophilic sealant (Ultraseal XT Hydro). Buccal surfaces of each tooth were pretreated with the acid etchant, and respective sealants were placed perpendicular to the polished surfaces using an elastomeric mold. All the samples were embedded in resin block, and shear bond strength was evaluated using universal Instron machine. Independent *t*-test used to compare the difference in the mean shear bond between the groups and the level of statistical significance was set at a value of $P < 0.05$. **Results:** The mean shear bond strength of Group I sealant was found to be 13.71 ± 0.94 MPa and for Group II, it was 20.39 ± 0.98 MPa. Group II presented a significantly higher shear bond strength than that of Group II ($P = 0.001$). **Conclusion:** Ultraseal XT Hydro (Group II) had maximum shear bond strength than that of Clinpro sealant (Group I).

KEY WORDS: Pit and fissure sealants, Shear bond strength, Universal Instron machine

INTRODUCTION

Dental world constitutes newer technologies and preventive approaches in the field of dental caries which have transformed the emphasis from treatment of disease to prevention of disease. One of the commonly and widely used preventive approaches for dental caries is pit and fissure sealant application, which has shifted the treatment philosophy from "Drill and Fill" to that of "Seal and Heal."[1] Evidence suggests that 56–70% of the carries in children of 5–17 years of age occurs in pit and fissures.[2,3]

Buonocore in 1955 described acid etch bonding to enamel as new technology and it was employed in the form of resin sealants for the first time in the prevention of pit and fissure caries.[4] Simonsen illustrated pit and fissure sealant as a material that is introduced into the occlusal pits and fissures of caries-prone teeth, thus forming a micromechanically-bonded, protective layer cutting access of caries-producing microorganisms from their source of nutrients.[5]

Access this article online	
Website: jprsolutions.info	ISSN: 0975-7619

Based on a systematic review, a 2016 guideline panel convened by the American Dental Association Council on Scientific Affairs and the American Academy of Pediatric Dentistry recommended the following evidence-based clinical proposal for the use of pit and fissure sealants on the occlusal surfaces of primary and permanent molars in children and adolescents.[6] The clinical proposal which describes that sealants are efficient in preventing, arresting and progression of pit and fissure occlusal caries lesions of primary and permanent molars in children and adolescents compared to the non-use of sealants or use of topical fluoride.[6]

[1]Department of Public Health Dentistry, Saveetha Dental College, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu, India, [2]Department of Public Health Dentistry, Asan Memorial Dental College and Hospital, Chengalpattu, Chinna Irumbedu, Tamil Nadu, India

***Corresponding author:** Dr. P. Jayashri, Department of Public Health Dentistry, Saveetha Dental College, Saveetha Institute of Medical and Technical sciences, Saveetha University, 162, Poonamallee High Road, Velappanchavadi, Chennai - 600 077, Tamil Nadu, India. Phone: +91-7904181675. E-mail: shrijaya2009@gmail.com

Received on: 30-01-2017; Revised on: 27-02-2018; Accepted on: 28-04-2018

On this basis, over the past few years, a wide spectrum of resin-based sealants has been introduced in the dental merchandise. To improve the property of resin-based sealants, manufacturers have added filler particles, fluoride, and fluorescence to the material. One such newer brand of sealant is UltraSeal XT hydro sealant which is 53% highly filled resin with thixotropic (ideal viscosity), and advanced adhesive technology allows it to flow into pit and fissures and bond effectively without a drying agent to the tooth.[7] Sealants also can be either clear or colored. Colored sealants have an advantage as their presence or absence on the tooth surface can be easily seen. One such colored sealant that changes its color during polymerization is Clinpro 3M ESPE.[8]

One of the prerequisites for a sealant to be effective as suggested by Brauer is that it should have good and prolonged adhesion to enamel.[9] The retention rate of a sealant is directly related to the micromechanical bonding between the sealant and tooth enamel. Shear bond strength measures the ability of sealant to bond to tooth structure. Higher shear bond strength is equated with enhanced performance.[10] This necessitates the rationale for the study. Therefore, the effectiveness of resin-based sealants depends on sealant retention which could be directly attributed to the shear bond strength of the material.

Newer brands of pit and fissure sealants continue to be developed, despite the lack of scientifically based information addressing the bonding performance of these materials. Laboratory *in vitro* tests play a key role in providing the necessary information regarding the efficacy of new products in a short period of time. In the present study, Ultraseal XT hydro is compared with conventional Clinpro 3M ESPE sealant. Several *in vitro* studies have been conducted to evaluate the shear bond strength of Clinpro 3M ESPE sealant with different sealant material,[11,12] but no studies have compared the effect of this two pit and fissure sealant. Hence, the present *in vitro* study was designed to compare and evaluate the shear bond strength of conventional and hydrophilic fissure sealants applied to the enamel on the buccal surface of permanent molars.

MATERIALS AND METHODS

An experimental randomized *in vitro* study was carried out on a sample of 20 third molar teeth extracted for orthodontic or surgical reasons. The sample size was calculated based on a study using a *prioi* Pushpalatha *et al.*[11] by G*Power 3.1.2 software. The minimum sample size of each group was calculated, following these input conditions: Power of 0.85 and $P \leq 0.05$ and sample size arrived were 10 teeth per group with a total sample size of 20. Teeth with intact occlusal surface were included, and those teeth with a developmental defect and with caries were excluded from the study.

Before the start of the study, ethical clearance was obtained from the Institutional Ethics Committee, Saveetha University (STP/SDMDS13PHD43). All the molars were randomly allocated to two groups of 10 molars each using computer-generated randomization with 5 block of two letters (A and B). The teeth were cleaned by soaking them in 5% sodium hypochlorite. The remaining periodontal tissue and calculus were removed. All the teeth were then microscopically examined for caries and other possible cracks or defects. The specimens that were not fulfilling the inclusion criteria were rejected while those fulfilling were stored in 10% formalin solution until further use.

The buccal surfaces of each tooth were cleaned with prophy paste and then polished with silicon carbide paper to obtain a flat enamel surface. For all the specimens, 37% phosphoric acid etchant was applied to the enamel for 20 s, rinsed and dried with air spray for 20 s. A Teflon mold of 3 mm in diameter and 3 mm in height was placed over each tooth perpendicular to the polished surfaces. The test materials [Table 1] were placed in the mold in an incremental fashion to form a button and cured according to manufacturer's instructions. Once the materials were light-cured, the specimens were stored in distilled water at 37°C for 24 h to avoid dehydration.

Then, the specimens were embedded in acrylic resin block with the treated surface exposed. These mounted specimens were color-coded according to the groups assigned before evaluating the shear bond strength [Figure 1]. Universal Instron testing machine [Figure 2] was used wherein the treated surface of the samples was held parallel to the shearing rod at a crosshead speed of 1 mm/min. This procedure was repeated for all the samples.

Table 1: Tested materials

Material	Group I clinpro	Group II ultraseal XT hydro
Principal Ingredient	Triethylene glycol dimethacrylate, BISGMA, tetrabutylammonium tetrafluoroborate, dichloride methylsilane, silica, dye	Triethylene glycol dimethacrylate, diurethane dimethacrylate (DUDMA), aluminum oxide, methacrylic acid, titanium dioxide, sodium monofluorophosphate
Manufacturer	3M ESPE	Ultradent

The readings were obtained in kilograms and recorded. These readings were then converted into Newtons by multiplying the reading by 9.81 (1 kg = 9.81 N). The shear bond strength of the pit and fissure sealants in N/mm^2 (MPa) was calculated using the formula:

Bond strength (MPa) = load/area.

Where area of the bonding surface in mm^2 was obtained with the following formula:

Area = $2\pi r^2$

Where r is equal to the radius of the sealant button in mm and π is a constant with value equal to 3.14.

Shear bond strength of all the specimens was calculated and recorded. Then, the compiled data were subjected to statistical analysis.

Data were entered into Microsoft Excel spreadsheet and analyzed using SPSS software (IBM SPSS Statistics, Version 20.0, Armonk, NY: IBM Corp). Descriptive statistics were used for data summarization and presentation. Shapiro–Wilks test employed to test the normality of the data set. Independent t-test was used to compare the difference in the mean shear bond between the groups. The level of statistical significance was set at a value of $P < 0.05$.

Figure 1: Color coded tooth samples of Group I and II mounted on acrylic blocks

Figure 2: Universal Instron testing machine

RESULTS

Ten samples from each group were tested for shear bond strength. The measurements were obtained in kilogram-force which was converted to Newton by multiplying with a constant value of 9.81, and finally, the bond strength values [Table 2] of Group I and II were determined by the load(N)/area ($2\pi r^2$ = 2 × 3.14× 3= 14.13). Table 3 presents the values of Group I sealant which ranges from 12.54 to 15.35 and for Group II sealant ranges from 18.55 to 22.22. The mean force applied to break the sealant button from the tooth surface was found to be higher for Group II sealant (20.39 ± 0.98) than Group I sealant (13.71 ± 0.94). Table 4 shows the mean difference between the groups which were found to be −6.68 and "t" value of −15.44. Independent t-test showed P = 0.001 revealed a statistically highly significant difference in mean bond strength between the groups which, in turn, signify Group II sealant found to be superior to the Group I sealant. Figure 3 presents the data on the frequency distribution of shear bond strength values using a split histogram. Of 10 samples examined, the majority of the

Table 2: Bond strength (MPa) measurements of Group I and II samples

Tooth samples	Bond strength (MPa)=N/mm^2	
	Group I	Group II
1	12.54	22.22
2	13.32	19.52
3	14.33	20.89
4	13.17	20.20
5	14.36	18.55
6	15.35	20.76
7	13.31	20.98
8	13.30	20.57
9	12.60	19.72
10	14.82	20.58
Mean	13.71	20.39

Table 3: Mean force applied to break the sealant button from the buccal tooth surface of Group I and II

Descriptive statistics	Group I	Group II
Number of samples	10	10
Mean force applied	13.71	20.39
SD	0.94	0.98
Median	13.32	20.58
Minimum	12.54	18.55
Maximum	15.35	22.22

SD: Standard deviation

samples (6 samples) showed bond strength values ranging between 12 and 13.5 MPa with respect to Group I sealant. In Group II sealant, it was found to be ranging between 20 and 21.5 MPa.

DISCUSSION

Due to the complex morphology of occlusal pit and fissures, these surfaces are highly caries susceptible.[13] This is especially true for erupting teeth that are in the maturation process[12] and anatomic characteristics cause difficulty in access for cleansing procedures and further incomplete enamel maturation adds to caries susceptibility.[11] Therefore, the rationale for the use of pit and fissure sealant is due to the high susceptibility of these surfaces to dental caries.

The first clinical study on sealant retention was by Cueto and Buonocore in 1967. They found an 86.3% reduction in carries 1 year after application of sealant. The efficiency of sealants in preventing caries has been associated with the duration and degree of sealant retention.[14]

The retention of resin sealants is a micromechanical process established by the infiltration and further polymerization of the sealant into the microporosity network created by the acid etchant on the enamel surface. Due to the high enamel reactivity induced by acid etching, even minute exposures to saliva, as brief as 1 second, are reported to be enough to create a pellicle that partially occludes the micropores leading to an ultra-structural alteration of etched enamel and precluding the formation of the resin tags responsible for mechanical adhesion.[15] On the basis of salivary contamination, newer resin-based hydrophilic sealant such as Ultraseal XT hydro with its characteristic thixotropic property, chases moisture deep into pit and fissures on a microscopic level and its advanced adhesive technology allows it to flow into pit and fissures, and bond effectively without a drying agent to the tooth.[7] Therefore, the retention rate of a pit and fissure sealant is directly related to the micromechanical bond between the sealant and enamel[9] which can be evaluated by measuring the shear bond strength of sealants which provide a guide for clinical use of these materials.

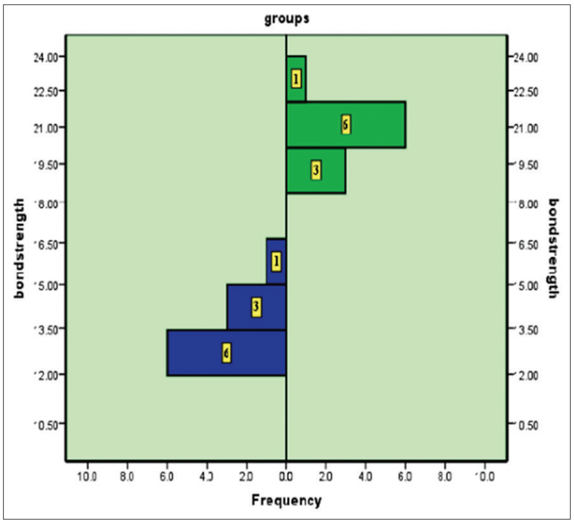

Figure 3: Frequency distribution of shear bond strength values of Group I and Group II sealants using the split histogram

The purpose of breaking a bonded assembly is to try to establish a number or value showing how strong the bond was. In the shear bond test, the bond is broken by force working parallel to the surface. The ISO document specified a shear test apparatus consisting of a solid block for fixation of the specimen and a connecting shearing blade with a sharp edge. Bond strength is more predictive of materials retentive potential, hence about its durability and utility.[16] Sealant employed in the present study included filled (Ultraseal XT hydro) and unfilled (Clinpro 3M ESPE) sealant. The buccal surfaces of all teeth were considered as this surface allowed the shearing force to be exactly perpendicular to the bonded specimen.[17]

The mean shear bond strength of Group I (Clinpro) was found to be 13.71 ± 0.94 MPa. Similar results were reported by Dhillon and Pathak[12] and Rirattanapong *et al.*[18] with a bond strength of 13.43 ± 0.90 and 12.42 ± 2.95, respectively, which was comparable to the present study.

The mean shear bond strength of Group II (Ultraseal XT hydro) in the present study was found to be 20.39 ± 0.98, which was comparatively higher than Group I (Clinpro) sealant. In the present study, there was highly statistically significant difference was observed between the two groups using independent *t*-test. This was in accordance with the studies conducted by Singh *et al.*[19] which compared the shear bond strength of filled and unfilled resin-based pit and fissure sealants. They reported that Clinpro yielded lower bond

Table 4: Mean difference in shear bond strength of Group I and Group II sealant

Groups	Mean±SD	Degree of freedom	Mean difference	"*t*" value	"*P*" value
Group I	13.71±0.94	9	−6.68	−15.44	0.001*
Group II	20.39±0.98	9			

Independent *t*-test (P<0.05). SD: Standard deviation strength than delton. This outcome can be described due to the presence of fillers in Delton, since these particles increase the resistance of the material to abrasion[20] and also increase the mechanical resistance of the material.

On the contrary, a study conducted by Pushpalatha *et al.*[11] found that bond strength of the unfilled resin sealant (Clinpro) was superior and showed a statistically significant difference to that of the filled resin sealant (Helioseal F). They observed that resin sealants possess both low viscosity and excellent wetting properties as found in unfilled.[21] For a liquid to flow over a solid, the surface tension of the solid must be greater than the surface tension of the liquid. Less viscous sealants present better flow and thus get penetrated more deeply into the fissures. For this reason, a filled sealant would be less prone to completely fill a fissure than an unfilled material. The difference in chemical composition of the monomeric matrix causes a difference in flow properties of the final polymers in filled sealants. There was no significant difference between the bond strength of the two resin-based sealants (Clinpro and Eco-S) in a study done by Dhillon and Pathak,[12] Park *et al*.,[22] and Marcushamer *et al*.[23]

The main difference between the tested sealants in the present study relies on presence or absence of fillers, since both materials are resin based and contains fluoride in their composition. The main reason for the higher shear bond strength of Ultraseal XT Hydro is mainly due to its advanced adhesive technology, and the filled sealants, unlike unfilled sealants, have inorganic fillers in their composition that makes them of higher viscosity. This impairs the ability of these sealants to flow into pits and fissures close to the bottom because of which shorter resin tags are formed.[20]

Therefore, the null hypothesis regarding no difference in shear bond strength of two different pit and fissure sealants applied to the enamel on the buccal surface of permanent third molars is rejected which reveals that shear bond strength of Ultraseal XT Hydro was found to be superior to Clinpro sealant.

CONCLUSION

Within the limits of this *in vitro* study and according to the methodology and the results drawn, the following statements were concluded that Ultraseal XT Hydro (Group II) had maximum shear bond strength value of 20.39 MPa than Clinpro sealant (Group I) which was 13.71 MPa.

Based on the findings of the present study, it can be concluded that bond strength is considered to be predictive of the material retentive ability, hence higher the bond strength, stronger the resistance to curing stress and oral function loading.

REFERENCES

1. Singh S, Adlakha V, Babaji P, Chandna P, Thomas AM, Chopra S. A comparative evaluation of the effect of bonding agent on the tensile bond strength of two pit and fissure sealants using invasive and non-invasive techniques: An *in–vitro* study. J Clin Diagn Res 2013;7:2343-7.
2. Kaste LM, Selwitz RH, Oldakowski RJ, Brunelle JA, Winn DM, Brown LJ, *et al.* Coronal caries in the primary and permanent dentition of children and adolescents 1-17 years of age: United states, 1988-1991. J Dent Res 1996;75 Spec No:631-41.
3. Meneghim MC, Saliba NA, Pereira AC. Importance of the first permanent molars in the determination of DMFT Index. J Brasi Odontop Odontol Bebê 1999;2:37-41.
4. Buonocore MG. A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. J Dent Res 1955;34:849-53.
5. Simonsen RJ. Pit and Fissure Sealants. In: Clinical Applications of the Acid Etch Technique. 1st ed. Chicago, IL: Quintessence Publishing Co, Inc.; 1978. p. 19-42.
6. Wright JT, Crall JJ, Fontana M, Gillette EJ, Nový BB, Dhar V, *et al.* Evidence-based clinical practice guideline for the use of pit-and-fissure sealants: A report of the american dental association and the american academy of pediatric dentistry. J Am Dent Assoc 2016;147:672-82000000000000.
7. Ultradent Products, Inc. Product Guide for Ultraseal XT Hydro; 2013.
8. Strassler HE, Grebosky M, Porter J, Arroyo J. Success with pit and fissure sealants. Dent Today 2005;24:124, 126-30, 132-3.
9. Muthu MS, Kumar NS. Pit and Fissure Sealants and Preventive Resin Restoration. Pediatric Dentistry Principles and Practice. 1st ed. Noida: Elsevier Publishers; 2009. p. 213-6.
10. Lindemuth JS, Hagge MS. Effect of universal testing machine crosshead speed on the shear bond strength and bonding failure mode of composite resin to enamel and dentin. Mil Med 2000;165:742-6.
11. Pushpalatha HM, Ravichandra KS, Srikanth K, Divya G, Done V, Krishna KB, *et al.* Comparative evaluation of shear bond strength of different pit and fissure sealants in primary and permanent teeth - An *in-vitro* study. J Int Oral Health 2014;6:84-9.
12. Dhillon JK, Pathak A. Comparative evaluation of shear bond strength of three pit and fissure sealants using conventional etch or self-etching primer. J Indian Soc Pedod Prev Dent 2012;30:288-92.
13. Borsatto MC, Giuntini Jde L, Contente MM, Gomes-Silva JM, Torres CP, Galo R, *et al.* Self-etch bonding agent beneath sealant: Bond strength for laser-irradiated enamel. Eur J Dent 2013;7:289-95.
14. Arrow P, Riordan PJ. Retention and caries preventive effects of a GIC and a resin-based fissure sealant. Community Dent Oral Epidemiol 1995;23:282-5.
15. Hormati AA, Fuller JL, Denehy GE. Effects of contamination and mechanical disturbance on the quality of acid-etched enamel. J Am Dent Assoc 1980;100:34-8.
16. Oilo G. Bond strength testing – what does it mean? Int Dent J 1993;43:492-8.
17. Prabhakar AR, Sahana S, Mahantesh T, Vishwas TD. Effects of different concentrations of bleaching agent on the micro hardness and shear bond strength of restorative materials – An *in vitro* study. J Dent Oral Hyg 2010;2:7-14.
18. Rirattanapong P, Vongsavan K, Surarit R. Shear bond strength of some sealants under saliva contamination. Southeast Asian J Trop Med Public Health 2011;42:463-7.
19. Singh N, Agrawal G, Subhash A, Suneela S, Barabde AS, Kumar GA, *et al.* A comparative evaluation of shear bond strength of different pits and fissure sealants: An *in vitro* study. J Contemp Dent Pract 2013;14:917-23.

20. Barroso JM, Torres CP, Lessa FC, Pécora JD, Palma-Dibb RG, Borsatto MC, *et al.* Shear bond strength of pit-and-fissure sealants to saliva-contaminated and noncontaminated enamel. J Dent Child (Chic) 2005;72:95-9.
21. Irinoda Y, Matsumura Y, Kito H, Nakano T, Toyama T, Nakagaki H, *et al.* Effect of sealant viscosity on the penetration of resin into etched human enamel. Oper Dent 2000;25:274-82.
22. Park K, Georgescu M, Scherer W, Schulman A. Comparison of shear strength, fracture patterns, and microleakage among unfilled, filled, and fluoride-releasing sealants. Pediatr Dent 1993;15:418-21.
23. Marcushamer M, Neuman E, García-Godoy F. Fluoridated and nonfluoridated unfilled sealants show similar shear strength. Pediatr Dent 1997;19:289-90.

Source of support: Nil; Conflict of interest: None Declared