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Assessment of Shear Bond Strength and Marginal Sealing Ability of Pit and Fissure Sealants: An *in vitro Study*

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ABSTRACT

Aim: The aim of the present study was to compare the shear bond strength and marginal sealing ability of self-adhering flowable composite and conventional fissure sealant.

Materials and methods: The samples consisted of 30 healthy premolar teeth which were extracted due to orthodontic reasons and randomly divided into two groups of 15, i.e., group I (Fissurit F) and group II (Dyad Flow). Shear bond strength and marginal sealing ability of both the groups were evaluated in Statistical Package for the Social Sciences (SPSS) version 16.

Results: The mean shear bond strength of Dyad Flow (group II) was found to be 1.4 ± 0.87 MPa and in Fissurit F (group I), it was 1.3 ± 1.4 MPa. Differences between the groups were statistically significant. In group II, 53.3% of specimens demonstrated score 0; 33.3% showed score 1; and 13.3% showed score 2. In group I, scores 0 and 1 showed 33.3% of dye penetration respectively. Scores 2 and 3 demonstrated 26.6 and 6.6% of dye penetration respectively. But there was no significant difference between both the sealant groups.

Conclusion: The present study concluded that self-adhering flowable composite was found to have better shear bond strength and marginal sealing ability than conventional fissure sealant.

Clinical significance: Self-adhering flowable composite can be effectively used in pediatric patients in whom isolation is difficult and exclusion of bonding agent leads to decrease in time consumption.

Keywords: Marginal sealing ability, Pit and fissures, Sealants, Shear bond strength.

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INTRODUCTION

Oral health is an important part of overall health in children as well as adults. Dental caries are more prevalent in children and it could be because of eating patterns and lack of hygiene maintenance. Occlusal surface is more susceptible to caries because of its morphology. The occlusal surface occupies 12.5% of the total areas of teeth. Pit and fissures are deep grooves and are sites for stagnation of food debris and microorganisms. Fissure caries are common in children due to deep pit and fissures. Pit and fissures are classified as self-cleansable (V and U types) and nonself-cleansable (I and k types). These areas are difficult to clean, which results in fissure caries. Unfavorable morphology makes these fissures difficult for salivary access and minimizes fluoride deposition for preventive effect. Fissure caries accounts for 50% of all the carious lesions. Pit and fissure areas on the occlusal surface of the teeth make them susceptible to dental caries, which need to be prevented or restored.[1,2] As truly said, prevention is better than cure, and we pedodontists play an important role in prevention.

Fluorides and other caries preventive approaches (e.g., mechanical plaque control) seem to be less effective for preventing carious lesions in pit and fissure surfaces compared with smooth surfaces.[3]

Pit and fissure sealant is a material that is introduced into the occlusal pits and fissures of caries-susceptible teeth, thus forming a micromechanically bonded, protective layer cutting access of caries-producing bacteria from their source of nutrients.[4] Plentiful clinical studies have documented the efficacy of pit and fissure sealants in caries prevention.[5] Sealants are an underused therapy; only 30% of children 6 to 8 years old have at least one dental sealant.[6]

Today, there are multiple commercially available sealant materials, including resin-based sealants, such as urethane dimethacrylate or bisphenol A-glycidyl methacrylate monomers that are polymerized by means of either a chemical activation-initiation or a light activation system. Glass ionomer cements are another type of sealant material that have been widely recognized and used for their fluoride-release properties.[7]

An important property of pit and fissure sealant is the marginal sealing ability. Defects in marginal sealing will lead to marginal leakage, allowing the passage of bacteria and fluids at the interface of the tooth and the sealant, thus resulting in occurrence of dental caries underneath the sealant.[8] Thus, the success of pit and fissure sealants largely depends upon the long-term retention and tight micromechanical adhesion to enamel surfaces.

In pedodontics, maintaining isolation is a tricky task to perform during the process of sealant therapy due to lack of cooperation of the children. Thus, insufficient isolation increases the risk of microleakage, decreased shear bond strength, and subsequent treatment failure. Therefore, use of pit and fissure sealant which requires an easier application and fewer working steps is needed.[9] Keeping this in mind, the present study is aimed to compare the shear bond strength and marginal sealing ability of self-adhering flowable composite and conventional fissure sealant.

MATERIALS AND METHODS

The main objective of this study was to assess the shear bond strength and marginal sealing ability of self-adhering flowable composite and conventional fissure sealant.

The samples consisted of 30 healthy premolar teeth, which were extracted due to orthodontic reasons and randomly divided into two groups of 15. After extraction, teeth were selected based upon following criteria.

Inclusion Criteria

- Teeth with intact occlusal surface.

Exclusion Criteria

- Teeth with developmental defects.
- Teeth with dental caries.

After collection, teeth were made free of all the soft tissue, debris, and calculus with the help of scaler. The cleaned teeth were then stored in distilled water.

Study groups: 15 teeth in each group

Group I: Fissurit F (conventional fissure sealant).

Group II: Dyad Flow (self-adhering flowable composite).

Placement of Sealant

Group I

The occlusal surface of all the teeth was etched using 37% phosphoric acid for 15 seconds, and then the etched surface was rinsed and air-dried for 5 seconds. The bonding agent was applied on the occlusal fissures of previously etched surface for 15 seconds using a microbrush. The occlusal surface of teeth was air-dried for 5 seconds to evaporate the solvent and light cured for 20 seconds using light curing unit. Fissurit F sealant was then applied on the fissure and cured for 20 seconds according to the manufacturer's instructions.

Group II

Dyad Flow was placed directly (bonding agent was not necessary in this group, as it was incorporated) on the grooves using a microbrush for 20 seconds. Light curing was performed using ultraviolet light.

Assessment of Shear Bond Strength

After sealant application, shear load was applied using a universal testing machine (Triax Digital 50, Controls, 132 Milan, Italy) in a way parallel to the bonded interface at a speed of 0.5 mm/min until breakdown occurred. The load at failure was recorded in Newtons. The diameter of the debonded composite cylinder was measured with a digital caliper (Orteam srl, Milan, Italy). Bond strength was then calculated in megapascals.

Assessment of Marginal Sealing Ability

For assessment of marginal sealing ability, teeth were immersed in 1% methylene blue dye for 24 hours at 37°C. After they were removed from the dye solution, the teeth were cleaned and the samples were sectioned longitudinally from the middle of the cavity into two parts.

The sections were then examined under the optical microscope with a magnification of 40× to check for the presence and degree of microleakage.

The linear penetration of the dye from the external margin of the cement was scored according to the criteria given by Popoff et al,[10] which is as follows (Fig. 1):

- Score 0: No microleakage
- Score 1: Dye penetration up to one-third of axial wall

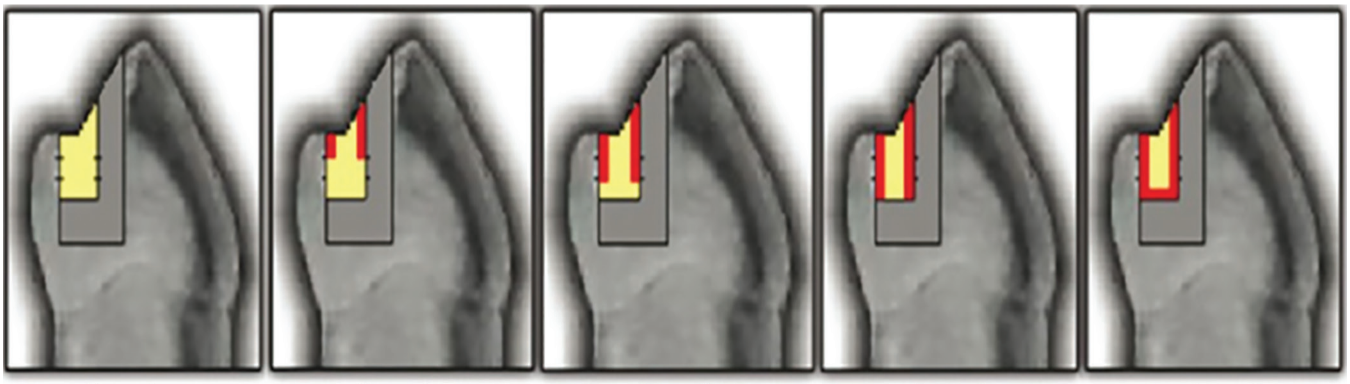


Fig. 1: Scoring criteria for microleakage (marginal sealing ability)

Table 1: Comparison of shear bond strength between groups

	Groups	*n*	*Mean (MPa)*	*Standard deviation*	*Standard error mean*	*t-value*	*p-value*
Shear bond strength	Group I (Fissurit F)	15	1.3	1.4	0.37	−2.5	0.01
	Group II (Dyad Flow)	15	1.4	0.87	0.22		

Table 2: Comparison of marginal sealing ability between groups

	Score	*Group I (Fissurit F)*	*Group II (Dyad Flow)*	*χ^2 value*	*p-value*
Marginal sealing ability	0	5 (33.3%)	8 (53.3%)	2.35	0.5
	1	5 (33.3%)	5 (33.3%)		
	2	4 (26.6%)	2 (13.3%)		
	3	1 (6.6%)	0		

- Score 2: Dye penetration up to two-thirds of axial wall
- Score 3: Dye penetration onto the entire axial wall
- Score 4: Dye penetration onto the pulpal wall

The tooth–sealant interface was photographed using a digital camera attached to the microscope. Sections were observed under the optic microscope to check for the presence and degree of microleakage.

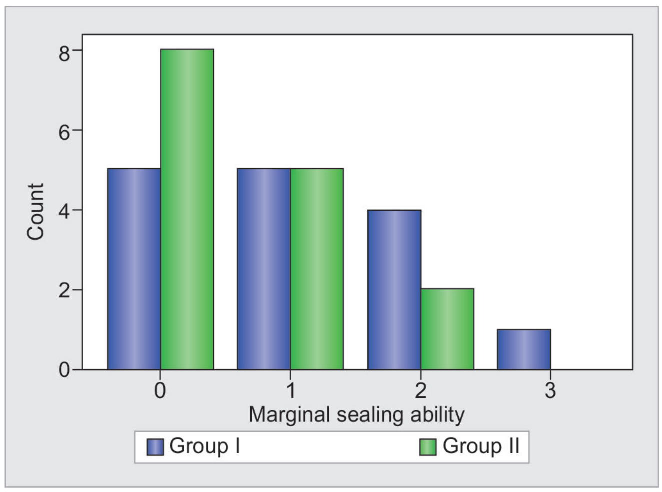
Statistical Analysis

Collected data were entered into Microsoft Excel and analyzed by independent sample t test and chi-square test in SPSS version 16; p-value < 0.05 is considered to be statistically significant.

RESULTS

As seen in Table 1, the mean shear bond strength of group II (flowable composite group), 1.4 ± 0.87 MPa, is more compared with that of group I (conventional pit and fissure sealant group), 1.3 ± 1.4. Difference between the two groups is found to be statistically significant.

In group II, 53.3% of specimens demonstrated score 0; 33.3% showed score 1; and 13.3% showed score 2. In group I, scores 0 and 1 showed 33.3% of dye penetration respectively. Scores 2 and 3 demonstrated 26.6 and 6.6% of dye penetration respectively (Table 2 and Graph 1).



Graph 1: Comparison of marginal sealing ability between groups

According to the chi-square test, there was no significant difference between both the sealant groups. It was less in the self-adhering group when compared with the conventional fissure sealant group.

DISCUSSION

The present *in vitro* study was done to assess shear bond strength and marginal sealing ability of Dyad Flow (flowable composite) and Fissurit F conventional pit and fissure sealants.

The occurrence of dental caries, particularly along the pits and fissures of primary and permanent teeth, has been a key cause for concern. The National Health and Nutrition Examination Survey in America 2011 to 2012 data showed that, in the United States, nearly one-fourth of children and over one-half of adolescents experienced dental caries in their permanent teeth.[11]

The defensive strategies that have been practiced over the years to combat this involved methods, such as blocking off the susceptible fissures with zinc phosphate cement, mechanical fissure eradication, prophylactic odontotomy and chemical treatment with silver nitrate. Ingenuity in this effort against fissure caries continues, with new materials and technologies being tested each year. When Buonocore[12] described acid etch bonding to enamel as a recent technology, it was engaged in the form of resin sealants for the first time in the prevention of pit and fissure caries.[13,14]

The first clinical study on sealant retention was by Cueto and Buonocore.[12] They found 86.3% reduction in caries 1 year after the application of sealant. The effectiveness of sealants in caries prevention has been associated with the duration and degree of sealant retention.[15] The caries preventive property of sealant is based on the establishment of a seal which prevents leakage of nutrients to the microflora in the deeper parts of the fissure. The preventive effects of a sealant are there only as long as they remain completely intact and bonded in place.[2] It is nothing but the marginal sealing property of the sealant, i.e., lack of microleakage. Microleakage is defined as the passage of bacteria, fluids, molecules, and ions between the teeth and the sealing material.[16]

Flowable composites are resin composites that have fewer filler loading or a greater proportion of diluent monomers in the composite formulation. They are supposed to offer higher flow, enhanced adaptation to the internal cavity wall, easier insertion, and greater elasticity. Fissurit F is one of them that has conventionally been used as a pit and fissure sealant.[17] Fissurit F is clinically proven to be effective pit and fissure sealant in preventing dental caries.

Dyad Flow is a self-adhering flowable composite manufactured by Kerr, USA, which combines the resin technology of composites and adhesives into one by incorporating the bonding agent, i.e., acidic adhesive monomer into the flowable composite itself. It is claimed to rely on the chemical and micromechanical interaction between material and tooth structure or other substances.[18]

In this study, the mean shear bond strength of Dyad Flow (group II) was found to be 1.4 ± 0.87 MPa and in Fissurit F (group I), it was 1.3 ± 1.4 MPa. The difference was statistically significant.

Results were in accordance with the *in vitro* study by Babaji et al,[19] i.e., self-adhesive flowable composite (16.8 MPa) recorded the highest shear bond strength and the difference was statistically significant with conventional fissure sealant (12.8 MPa).

In the present study, the Dyad sealant group (group II) showed 53.3% of score 0, i.e., no dye penetration or adequate marginal sealing ability which was less in group I (Fissurit F group), i.e., 33.3%.

This was in accordance with studies by Harsha and Dhruv[20] in which Fissurit F sealant group showed 45% of score 0, whereas Dyad Flow composite showed 85% of the score. Even the study by Lele and Bhide[21] showed better marginal sealing ability in the Dyad group than in Fissurit F group. Other studies by Vichi et al[22] on the properties of self-adhering flowable composites also found that self-etch and self-adhering composites had lower microleakage than conventional flowable composites.

In contrast, the study by Biria et al[23] found that self-etch and self-adhesive sealants had greater microleakage in enamel margin than conventional sealants. They found out that self-adhesive sealants form weak resin microtags and a satisfactory hybrid layer in the enamel, which result in microleakage in the long run.

The better marginal sealing ability in group II than in group I might be due to one of the probable reasons explaining lower microleakage of self-etch and self-adhesive cements this being a higher hygroscopic expansion of these materials and their fairly low polymerization shrinkage (Dyad and Fissurit F).

Some of the limitations of this study were the fact that our study was an *in vitro* evaluation, and moisture control was easy to achieve than in clinical situation. So, clinical studies with a larger sample should be done to know the clinical problems and effectiveness.

CONCLUSION

The present study concluded that self-adhering flowable composite was found to have better shear bond strength and marginal sealing ability than conventional fissure sealant. Use of self-adhering flowable composite will also be beneficial in pediatric patients and in adult patients where control of saliva and isolation is difficult.

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