Comparative Evaluation of Tensile Bond Strength of Two Pit and Fissure Sealants using Two Different Preparation Techniques – Endosonics and Fissurotomy Bur

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Abstract

Aim: The aim of the study was to compare and evaluate tensile bond strengths of fluoride containing resin-based sealant (Fissurit Fx) with that of Aegis with Amorphous Calcium Phosphate (ACP) sealant as well as compare effect of preparation techniques with fissurotomy tapering bur or endosonic tip. **Materials and Methods:** Maxillary first premolar teeth were extracted for orthodontic purposes and samples were embedded in blocks of self-curing acrylic resin. Preparations of fissures were done using fissurotomy bur STF and endosonic tips. SS wires of 21 gauges were embedded into sealant and cured. Samples were thermocycled for a dwell time between 5°C and 55°C to correlate with maximum temperature range measured *in vivo*. The selected teeth were distributed into 4 groups of 15 teeth each. Group 1 (Aegis with ACP with fissurotomy bur), Group 2 (Aegis with ACP with endosonic tips), Group 3 (Fissurit fx with endosonic tips), and Group 4 (Fissurit Fx with fissurotomy bur). The specimens were put to test under 5555 instron machine. The statistical analysis was done using the one-way ANOVA test. **Results:** Tensile bond strength was significantly greater for Aegis ACP sealant as compared to fissurit FX sealant. Tensile bond strength of Aegis ACP sealant using endosonic tips was significantly greater than Aegis ACP sealant using fissurotomy bur. **Conclusion:** Smart material Aegis with ACP pit and fissure sealant proves to be a better alternative to Fissurit Fx sealant in terms of retention and remineralization of enamel.

Keywords: Amorphous calcium phosphate, Fissurotomy bur, Pit and fissure sealants, Tensile bond strength.

Introduction

Dental caries is a multifactorial disease caused by alteration in the composition of the bacterial biofilm, leading to an imbalance between the demineralization and remineralization processes and manifested by the formation of carious lesions in primary and permanent dentitions.[1] Ripa (1973)[2] observed that though the occlusal surfaces represented only 12.5% of total surfaces of permanent dentition; they accounted for almost 50% of dental caries in school children. Pit and fissure caries accounts for about 90% of the caries of permanent posterior teeth and 44% of caries in the primary teeth in children and adolescents.[3] The term Pit and fissure sealants is used to describe a material that is introduced into 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. Buonocores[4] classic study of 1955 marked the start of a major revolution in clinical practice of dentistry. The first clinical benefit from Buonocores work was the introduction of the 1st pit and fissure sealant, Nuva seal (LD Caulk, Milford, Del). It was a resin-based sealant introduced in 1971 utilizing high concentration of phosphoric acid.

Sealant retention depends on procedure used for fissure preparation.[5] Mechanical preparation has been suggested to provide better access to the deeper fissure areas, thus enabling removal of debris, deeper sealant penetration and improved retention.[6] There is widespread disagreement amongst the professionals between invasively opening the fissure before sealant application, and noninvasive sealant application. One of the invasive techniques is enameloplasty or reshaping of enamel, carried out with help of suitable rotary cutting instruments.[7]

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Recently, erupted teeth have a porous enamel lining and the fissures are rich in cellular and organic debris. This porous zone of enamel bordering the fissures offers a three dimensional honeycombed structure into which fissure sealants could be locked. Any procedure can be carried out at the earliest possible time after eruption to make effective preventive use of fissure sealants.[8] One of the commonly used materials is light cured Bis GMA-based composite resin, combined with methyl methacrylate as a diluent.[9] A major disadvantage of these materials is their shrinkage at polymerization causing gap formation, that enables bacterial penetration and leads to failure of restoration.[10]

Amorphous Calcium Phosphate (ACP) is a non crystalline form of calcium phosphate, which has shown to remineralize tooth structure and aid in prevention of tooth decay. ACP has 2 properties, preventive and restorative, that justify its use in dental cements and adhesives and sealants. During a carious attack, the hydroxyapatite is removed from tooth surface resulting in cavities. The carious attack is result of exposure to low pH conditions either from bacteria, other biological organisms releasing acid, food or other acidic beverages. ACP at neutral pH remains ACP. When low pH values occur during a carious attack, ACP converts to hydroxyapatite and precipitates thus replacing the hydroxyapatite lost to acid.[11] The present study aims at comparing the tensile bond strength of fluoride containing resin-based sealant (Fissurit Fx) with that of an ACP containing sealant (Aegis) using two different preparation techniques, that is, using fissurotomy tapering bur and endosonics.

Materials and Methods

This study was carried out in the Department of Pediatric and Preventive Dentistry, Jaipur dental college in collaboration with BOSCH Company, Sitapura Industrial Area, Jaipur. Maxillary first premolar teeth were extracted in the department of Pediatric dentistry, Jaipur dental college, Jaipur for orthodontic correction purpose after taking informed consent from the parents of children. The selected teeth were thoroughly washed in running water to remove blood and saliva. They were then stored in normal saline until subjected to experimental procedures.

The study was done in stepwise manner by completing 15 samples each time. The selected teeth were then embedded in blocks of self-curing acrylic resin (DPI-RR). Standardization up to 0.5 mm of fissurotomy bur and endosonic tip was done. Markings were made on fissurotomy bur using sharp explorer tip and a plastic stopper was place on the endosonic tip. Preparations of fissures were done with fissurotomy bur STF (0.6 mm width, 1.5 mm length) and endosonic tips. SS wires of 21 gages were embedded into the sealant and curing was done with LED. Storage of teeth was done in normal saline for 24 h. On the day of the study, the teeth were properly cleaned and taken thereafter for testing. The differences in thermal expansion between the sealant and the tooth structure, coupled with polymerization shrinkage leads to marginal gap formation, which is still a serious problem when pit and fissure sealants are used. Thermocycling effect, which induces a thermal stress in *in vitro* samples, stimulates the oral environment that may be present during the service period of a sealant. In the present study, samples were thermocycled for a dwell time between 5°C and 55°C, so as to maintain a difference of 49°C, which approximates the maximum temperature range measured in vivo, as demonstrated by Barghi and Simmons *et al*. (1976).[12]

Technique of fissure preparation and sealant placement used in the study:

The selected teeth were distributed into four groups of 15 teeth each.

Group 1 (Pink color)

The fissures in these specimens were prepared using fissurotomy bur (Micro STF). Then, the specimen in this group were subjected to rinsing, drying, etchant application (30 s) followed by application of Fissurit Fx. To prevent voids and air entrapment, the sealant was gently teased through the fissure with 0.5 mm tip of periodontal probe. A 21 gauge SS wire was placed into the sealant and polymerized using a light cure unit for 20 s.

Group 2 (White color)

The fissures in these specimens were prepared using endodontic tips (Confident). Then, the specimen in this group were subjected to rinsing, drying, etchant application (30 s) followed by application of Fissurit Fx. A 21 gauge SS wire was placed into the sealant and polymerized using a light cure unit for 20 s.

Group 3 (Light pink color)

The fissures in these specimens were prepared using fissurotomy bur (Micro STF). Then, the specimen in this group were subjected to rinsing, drying, etchant application (30 s) followed by application of Aegis with ACP pit and fissure sealant. A 21 gauge SS wire was placed into the sealant and polymerized using a light cure unit for 20 s.

Group 4 (Brown color)

The fissures in these specimens were prepared using endodontic tips. Then, the specimen in this group were subjected to rinsing, drying, etchant application (30 s) followed by application of Aegis with ACP. A 21 gauge SS wire was placed into the sealant and polymerized using a light cure unit for 20 s.

Tensile bond strength testing was done using instron testing machine. The specimen was put to test under the 5555 instron machine. Instron machine has a fully digital testing system with high precision control and accuracy, includes automated control of test methods. The statistical analysis was done using the one-way ANOVA test.

Results

Group II Aegis ACP sealant using endosonic tips showed highest (126.49 ± 22.92) tensile bond strength followed by

Group I Aegis ACP using fissurotomy burs (107.17 ± 36.56) and Group III Fissurit Fx using fissurotomy burs (96.19 ± 15.94). Minimum tensile strength was found with Group IV Fissurit Fx using endosonic tips (95.19 ± 15.94) (Table 1).

Table 2 shows that average critical difference was calculated by one-way ANOVA test and it was set to be 17.32. Group II (Aegis ACP using endosonic tips) showed a critical difference of 19.32 when comparing with Group I (Aegis ACP using fissurotomy bur). Group I showed a critical difference of 10.98 when compared with Group IV (Fissurit Fx using fissurotomy bur). Group IV showed critical difference of 1.00 when compared with Group III. Comparing these differences with critical difference it can be concluded that Group II Aegis ACP using Endosonic tips differs significantly from Group II Aegis ACP using fissurotomy bur, Group IV Fissurit Fx using fissurotomy bur and Group III Fissurit Fx using endosonic tips.

Discussion

In the present study, 60 premolar teeth were selected as samples. Non carious premolars were chosen in accordance with criteria of (Vijayraghvan, Stephen moss 1995).[13] As they have adequate occlusal fissure morphology and are the most common teeth indicated for extraction for reasons other than caries and thus have their occlusal fissure characteristics preserved.

In present study, teeth were rinsed with air water spray and dried, followed by etchant application, sealant application and polymerization with a LED for 20 s which is also in accordance with Selecman (2007).[14] Before the sealant application in our study a 21 gauge wire was inserted into the prepared fissure and the sealant was applied and photo cured. Castro (2004)[15] also adopted similar technique for performing tensile bond strength test.

Table 1: Mean tensile strength of the four groups

Group	n	Mean±SD
Aegis ACP using fissurotomy bur (Group I)	15	107.17±36.56
Aegis ACP using endosonic tips (Group II)	15	126.49±22.92
Fissurit Fx using endosonic tips (Group III)	15	95.19±15.94
Fissurit Fx using fissurotomy burs (Group IV)	15	96.19±10.47

ACP: Amorphous calcium phosphate

Table 2: Critical difference between the four groups

Groups	Mean±SD	Difference
Aegis ACP using endosonic tips (Group II)	126.49±22.92	
Aegis ACP using fissurotomy burs (Group I)	107.17±36.56	19.32
Fissurit Fx using fissurotomy bur (Group IV)	96.19±10.47	10.98
Fissurit Fx using endosonic tips (Group III)	95.19±15.94	1.00

Critical difference: 17.32. ACP: Amorphous calcium phosphate

Sealant material were placed in four groups and polymerized by conventional LED for minimum of 40 s (as per manufacturer instructions). The differences in thermal expansion between the sealant and the tooth structure, coupled with polymerization shrinkage leads to marginal gap formation, which is still a serious problem when pit and fissure sealants are used. Thermocycling effect, which induces a thermal stress in *in vitro* samples, simulates the oral environment that may be present during the service period of a sealant. In the present study, samples were thermocycled between 5°C and 55°C, so as to maintain a difference of 49°C, which approximates the maximum temperature range measured *in vivo*, as demonstrated by Simmons *et al*. (1976).[12]

The prepared samples were stored after sealant placement in saline for 24 h. Sealant tensile bond strength to enamel was tested using an Instron 1125 material testing machine (Instron Corp, Canton, MA) at crosshead speed of 2 mm/min. The parameters directly tested here included the method of fissure preparation[16] researched the Invasive technique of pit and fissure sealant placement, which consisted of a clinical procedure in which a preventive opening with minimal removal of dentinal tissue was prepared to establish the presence of caries on the occlusal surface. Godoy and Gwinett (1994)[17] described the enameloplasty sealant technique in which a specially designed bur is used for fissure preparation. SEM examination showed an increase in surface area in samples treated by this technique; in present study, fissurotomy micro STF bur is used that enlarges entrances to fissures by a maximum of 0.6–1.1 mm.

Many studies have confirmed higher sealant retention rates following mechanical preparation. According to Tadokaro,[18] the sealant easily penetrates the enlarged fissures and adheres to walls resulting in better retention. Another explanation for better retention was given by Feldens *et al*.,[6] who mentioned that mechanical preparation widened and deepened the fissure by eliminating organic material and plaque and a very thin layer of enamel, resulting in a thicker layer of sealant. Thus, resin penetration into enamel is the key to successful bonding and long term retention. Previous studies have demonstrated various measures to increase resin penetration, Godoy and Gwinett (1997)[17] found that even if acid etching gels or solutions are scraped into fissures with an explorer tip, the gels, solutions or sealant did not penetrate beyond fissural constriction. They also found that pumice prophylaxis did not completely and consistently remove material deposits from pits and fissures. The residual material that occluded pits and fissures did remain. Moreover, sometimes pumice particles may get lodged into the fissures and are not removed after rinsing and this would further prevent acid and sealant penetration into fissures. Thus, pumice prophylaxis could not provide successful cleaning of pits and fissures, which was necessary for good retention of sealant.

In an attempt to enhance sealant penetration and retention, air polishing was also suggested by (Symmons, 2003).[19] The technique improved fissure cleanliness and sealant adaptation, but did not permit the sealant to reach the base of pits and fissures: perhaps due to air entrapment. Another more radical technique proposed to enhance sealant penetration was mechanically enlarging the pits and fissures with a bur, always maintaining the preparation in enamel (Burrow, 2003).[20] demonstrated superior sealant retention with this technique. He explained his results by stating that when the fissure was opened up before sealing, it allowed a resin plug to be formed rather than a thin layer and such resin plug adhered better to the etched enamel surface. Another reason for the better adaptation and retention of sealants placed on enlarged pits and fissures was given, stating that the bur treatment removed the outermost prismless layer of enamel. This layer was described as "coral like" enamel by Godoy and Gwinett (1991)[17] when acid etched enamel was evaluated under scanning electron microscope. The difference in retention rates was considered to be due to difference in topography between prismless enamel and prismatic enamel.

The fissurotomy Micro STF (SS White) burs used in the present study are specifically designed for recontouring the fissures and accessing decay with minimal enamel removal are fast cutting and conservative. Their use is however limited to pits, fissures and grooves and not indicated for treatment of larger decay. The fissurotomy Micro STF is especially indicated for enameloplasty procedure as its head length is 1.5 mm. The tapered shape of the bur allowed the cutting tip to encounter very few dentinal tubules at any given time and has been designed to minimize heat buildup and vibration. Since the cutting is restricted to enamel, need for LA is eliminated in most cases. Comparison to Fissurotomy burs to a regular 330 bur has demonstrated lessened invasiveness of the new design. Traditional cutting burs are found to remove far more enamel at any depth of cut and are designed to access caries which has progressed well beyond the DEJ. While the Fissurotomy Micro STF bur has been anatomically designed to enlarge the fissure and eliminate small caries without removing excessive healthy enamel or dentin. The design of the tip makes it enter into deepest fissures with limited cutting of enamel and dentine so that the depth of fissure is greater rather than the width.

In our study, we have also used Endosonic tip (P4). Our observation showed that Aegis ACP used along with endosonic tip showed higher tensile bond strength than the other three groups examined which is supported by the studies of Selecman[14] who found low penetrability of Aegis ACP sealant in fissures and least microleakage in fissures compared to other groups.

Three calcium phosphate-based remineralization systems have now been commercialized where the manufacturers claim the specific form of the calcium phosphate helps overcome the limited bioavailability of calcium and phosphate ions for remineralization process. One of the technologies is an unstabilized ACP (ACO or Enamelon).[11] This technology applies calcium ions and phosphate ions separately so that ACP forms intraorally. It rebuilds enamel, through a process called remineralization.

Shreshta 1999 and Grant 1999,[11] ACP Enamelon helps inhibition of caries in an animal model. Grant, 1999 also found similar results from his study. Schemehorn 1998 and Hicks - Flaitz 2000, ACP Enamelon helps inhibition of enamel demineralization *in vitro*. Sehemehorn 1999,[11] ACP Enamelon helps promotion of enamel subsurface lesion remineralization *in vitro*. The Enamelon technology is based on unstabilized ACP, where a calcium salt and a phosphate salt are delivered separately intraorally. The mixing of calcium ions with phosphate ions to produce an ion activity product for ACP which exceeds its solubility product results in immediate precipitation of ACP or in presence of fluoride ions, amorphous calcium fluoride phosphate. In the intra oral environment these phases (ACP and ACFP) are very unstable and rapidly transform to a more thermodynamically stable, insoluble crystalline phase. However, before the phases transform calcium and phosphate ions should be transiently bioavailable to inhibit demineralization of enamel and promote enamel subsurface lesion remineralization.

In one small clinical trial of technology in a group of high caries risk Papas,[21] head and neck radiation patients, no significant difference was found in coronal caries increment with the Enamelon plus fluoride dentifrice compared with that of standard fluoride dentifrices. However, a significant difference in root caries increment was observed with the Enamelon plus fluoride dentifrice producing a lower increment than standard fluoride dentifrices.

Several authors have expressed concern with unstabilized nature of the ACP that forms intraorally with this technology. The unstabilized ACP rapidly transforms to crystalline phases in the mouth and in doing so may act to promote dental calculus. Based on our results we can conclude that Aegis with ACP Pit and fissure sealant with Endosonic tip shows better tensile bond strength compared with other technique and sealant.

Conclusion

The results obtained from the present study help us to conclude that subjecting deep pits and fissures of the occlusal surfaces to the enameloplasty procedure before sealant placement, with help of fissurotomy bur (Micro STF) and endosonic tips led to changes in fissure micron morphology.

The results of present study showed that:

1. Tensile bond strength was significantly greater for Aegis ACP sealant as compared to fissurit FX sealant
2. Tensile bond strength of Aegis ACP sealant using endosonic tips was significantly greater than Aegis ACP sealant using fissurotomy bur.

Therefore, on the basis of these conclusions, smart material Aegis ACP pit and fissure sealant proves to be a better alternative to Fissurit Fx sealant in terms of retention and also shows better remineralization of enamel. Based on the results of our study, further studies on remineralization, penetration ability and SEM of Aegis ACP pit and fissure sealant should be undertaken.

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