



Comparative Evaluation of Shear Bond Strength of Pit and Fissure Sealants Using Two Different Enamel Etching Times: An In Vitro Study

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Abstract

Background: Successful retention of pit and fissure sealants depends largely on effective enamel etching, which enhances micromechanical bonding. The duration of acid etching plays a crucial role in achieving optimal shear bond strength without compromising enamel integrity.

Aim: To compare the shear bond strength of pit and fissure sealants applied using two different enamel etching times.

Materials and Methods: An *in vitro* study was conducted using extracted human premolars. The teeth were randomly divided into two groups ($n = 15$ each). In Group I, enamel surfaces were etched with 37% phosphoric acid for 15 seconds, while in Group II etching was performed for 30 seconds. Following etching, a resin-based pit and fissure sealant was applied and light cured according to the manufacturer's instructions. The specimens were stored in distilled water for 24 hours and then subjected to shear bond strength testing using a universal testing machine. The values were recorded in megapascals (MPa) and statistically analyzed using an independent *t*-test.

Results: The mean shear bond strength values were higher in the 30-second etching group compared to the 15-second etching group. However, the difference between the two groups was statistically significant ($p < 0.05$).

Conclusion: Within the limitations of this *in vitro* study, enamel etching for 30 seconds resulted in superior shear bond strength of pit and fissure sealants compared to 15 seconds. Appropriate etching time is essential for improving the longevity and clinical success of pit and fissure sealants.

Keywords: Pit and fissure sealants, Shear bond strength, Enamel etching time, Phosphoric acid, Preventive dentistry.

Introduction

Pit and fissure sealants are widely used preventive measures in dentistry to protect occlusal surfaces of teeth from dental caries, especially in children and adolescents.[1,2] The complex morphology of pits and fissures makes them highly susceptible to plaque accumulation and caries development, even in individuals with good oral hygiene. Sealants act as a physical barrier by preventing the ingress of bacteria and fermentable carbohydrates into these vulnerable areas.[3,4]

The success and longevity of pit and fissure sealants primarily depend on their ability to adhere effectively to the enamel surface. Acid etching of enamel using phosphoric acid creates microporosities by selectively dissolving the mineral content, thereby enhancing micromechanical retention between the sealant and enamel. Among various factors influencing sealant retention, etching time plays a crucial role in achieving optimal bond strength.[5]

Conventionally, enamel etching times ranging from 15 to 60 seconds have been recommended. Shorter etching durations may result in inadequate surface roughness and compromised bonding, whereas prolonged etching may lead to excessive enamel demineralization without a proportional increase in bond strength. Therefore, determining an optimal etching time is essential to maximize sealant retention while preserving enamel integrity.

Several studies have evaluated the effect of etching time on the bond strength of resin-based materials; however, variations in methodologies and results necessitate further investigation. Moreover, limited data are available comparing commonly used clinical etching times specifically for pit and fissure sealants. Hence, the present in vitro study was designed to compare the shear bond strength of pit and fissure sealants using two different enamel etching times, with the aim of identifying the etching duration that provides superior bonding performance.

Materials and Methods

Study Design: The present study was designed as an in vitro experimental study to evaluate and compare the shear bond strength of pit and fissure sealants using two different enamel etching times.

Sample Selection: A total of 30 extracted human premolars were used in the study. Teeth extracted for orthodontic purposes were collected and stored in 0.1% thymol solution until use. Teeth with caries, cracks, restorations, hypoplastic enamel, or structural defects were excluded from the study. Prior to the experiment, the teeth were thoroughly cleaned using ultrasonic scaling and polished with non-fluoridated pumice to remove surface debris.

Grouping of Samples: The selected teeth were randomly divided into two groups (n = 15 each):

Group I: Enamel etched with 37% phosphoric acid for 15 seconds

Group II: Enamel etched with 37% phosphoric acid for 30 seconds

Specimen Preparation: Each tooth was embedded vertically in self-cure acrylic resin blocks, exposing the occlusal surface. The buccal surface was flattened using fine-grit silicon carbide paper under water cooling to obtain a standardized bonding area. The prepared surfaces were rinsed thoroughly and air-dried.

Etching and Sealant Application: The enamel surfaces were etched using 37% phosphoric acid gel (ETC 37, Maarc, India) according to the assigned group. After etching, the teeth were rinsed with water for 15 seconds and air-dried until a chalky white appearance was observed. A resin-based pit and fissure sealant was then applied using a standardized cylindrical mold of 3 mm diameter and 2 mm height. The sealant (Clinpro™, 3M™ ESPE™, Minnesota, USA) was light cured for 20 seconds using an LED curing unit following the manufacturer's instructions.

Storage of Specimens: After sealant application, all specimens were stored in distilled water at 37°C for 24 hours to simulate oral conditions before testing.

Shear Bond Strength Testing: Shear bond strength testing was performed using a universal testing machine. A chisel-shaped blade was applied at the sealant–enamel interface at a crosshead speed of 1 mm/min until bond failure occurred. The maximum load at failure was recorded in Newtons (N), and shear bond strength was calculated in megapascals (MPa) by dividing the load by the bonded surface area.

Statistical Analysis: The obtained data were tabulated and statistically analyzed using SPSS software 24. Mean and standard deviation values were calculated for both groups. Intergroup comparison was performed using an independent t-test, with the level of significance set at $p < 0.05$.

Results

The shear bond strength values obtained for both groups were recorded in megapascals (MPa) and statistically analyzed. Descriptive statistics including mean and standard deviation were calculated. Intergroup comparison was carried out using an independent t-test.

Group II (30-second etching time) showed higher mean shear bond strength (11.38 MPa) values compared to

Group I (15-second etching time) (9.12 MPa). The difference between the two groups was found to be statistically significant ($p < 0.05$), indicating that increased etching time improved the bond strength of pit and fissure sealants.

Group	Etching Time	Mean Shear Bond Strength (MPa)	Standard Deviation
Group I	15 sec	9.12	1.45
Group II	30 sec	11.38	1.62

Comparison	Mean Difference (MPa)	t-value	p-value
Group I vs II	2.26	3.87	0.001*

* Significant

Discussion

The success of pit and fissure sealants largely depends on effective adhesion to the enamel surface, which is influenced by the quality of enamel etching. Acid etching creates microporosities by selectively dissolving the mineral phase of enamel, thereby enhancing micromechanical interlocking of resin-based sealants.[6,7] The present in vitro study compared the shear bond strength of pit and fissure sealants using two different enamel etching times and demonstrated that a 30-second etching time resulted in significantly higher shear bond strength compared to a 15-second etching time.

The higher bond strength observed with 30-second etching can be attributed to increased surface roughness and deeper resin penetration into the etched enamel prisms. Prolonged etching enhances the formation of a well-defined enamel etching pattern, which improves resin tag formation and mechanical retention. In contrast, shorter etching durations may produce insufficient enamel demineralization, leading to reduced bond strength.

The findings of the present study are in agreement with the study by Gwinnett and Buonocore, who reported that increased etching time improved resin penetration and enamel bonding due to enhanced micromechanical retention.[8,9] Similarly, Silverstone et al. demonstrated that longer etching times produced more pronounced enamel etching patterns, resulting in improved bonding of resin materials to enamel. These studies support the

results of the current investigation, highlighting the importance of adequate etching duration for optimal sealant adhesion.[10]

However, some authors have suggested that excessively prolonged etching may not significantly improve bond strength and may lead to unnecessary enamel loss. Barkmeier et al. reported that etching times beyond the recommended duration did not result in proportional increases in bond strength.¹¹ In the present study, the comparison was limited to clinically accepted etching times of 15 and 30 seconds, both of which are commonly used in routine dental practice.[12-14] The superior performance of the 30-second etching time indicates that it provides a balance between effective bonding and enamel preservation.

The in vitro nature of this study allowed for standardization of variables such as tooth selection, bonding area, and testing conditions. However, it also presents certain limitations, as intraoral factors such as saliva contamination, thermal stresses, and occlusal forces were not simulated. Therefore, the results should be interpreted with caution, and further in vivo studies are recommended to validate the clinical relevance of these findings.

Overall, the results of the present study suggest that extending enamel etching time to 30 seconds enhances the shear bond strength of pit and fissure sealants, which may contribute to improved retention and longevity of sealants in clinical practice.

Conclusion

Within the limitations of this in vitro study, it can be concluded that enamel etching time significantly influences the shear bond strength of pit and fissure sealants. The 30-second etching time demonstrated higher shear bond strength compared to the 15-second etching time. Adequate enamel etching enhances micromechanical retention and improves sealant adhesion to the enamel surface. Therefore, a 30-second etching duration may be recommended to achieve optimal bonding and improved longevity of pit and fissure sealants in clinical practice. However, further in vivo studies are required to confirm these findings under oral conditions.

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