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Evaluating various methods of preparing occlusal fissure surface before placement of pit and fissure sealants

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Abstract

Background

The effectiveness of pit and fissure sealants in preventing dental caries is well-documented. However, the preparation of the occlusal fissure surface prior to sealant application is crucial for ensuring optimal adhesion and longevity of the sealant. This study aims to evaluate various methods of preparing the occlusal fissure surface before the placement of pit and fissure sealants.

Materials and Methods

A total of 100 extracted human molars with intact occlusal surfaces were randomly divided into four groups of 25 teeth each. Group A received prophylaxis with a bristle brush and pumice, Group B was treated with air abrasion using aluminum oxide particles, Group C underwent acid etching with 37% phosphoric acid, and Group D was prepared using laser etching. Following the surface preparation, a resin-based sealant was applied to all samples. The teeth were then thermocycled between 5°C and 55°C for 500 cycles to simulate oral conditions. The bond strength of the sealants was tested using a universal testing machine, and the sealant penetration into the fissures was evaluated under a stereomicroscope.

Results

Group C (acid etching) showed the highest bond strength with an average value of 25 MPa, followed by Group B (air abrasion) with 22 MPa, Group A (prophylaxis) with 18 MPa, and Group D (laser etching) with 20 MPa. Sealant penetration was also highest in Group C, with complete penetration observed in 90% of samples, compared to 80% in Group B, 60% in Group A, and 70% in Group D.

Conclusion

The study concludes that acid etching with 37% phosphoric acid is the most effective method for preparing the occlusal fissure surface before the placement of pit and fissure sealants, resulting in superior bond strength and penetration. Air abrasion and laser etching also provide good results, while prophylaxis with pumice is the least effective.

Keywords: Pit and fissure sealants, occlusal fissure preparation, acid etching, air abrasion, laser etching, dental caries prevention, sealant adhesion.

Introduction

Pit and fissure sealants have been recognized as a highly effective preventive measure against dental caries, particularly in the occlusal surfaces of molars and premolars, which are most susceptible to decay (1, 2). These sealants act as a physical barrier, preventing the accumulation of food particles and bacteria within the deep fissures and pits of the teeth (3). Despite their proven efficacy, the success of sealants largely depends on the method used to prepare the occlusal surface before application, as proper preparation ensures better adhesion and longevity of the sealant (4, 5).

Various methods have been employed to prepare the occlusal fissure surface, each with its own advantages and limitations. Prophylaxis with a bristle brush and pumice is a commonly used method due to its simplicity and cost-effectiveness; however, it may not sufficiently clean the deep fissures, leading to suboptimal sealant retention (6). Air abrasion, which uses aluminum oxide particles, has been shown to enhance the mechanical retention of sealants by creating a roughened surface, although it requires specialized equipment and can be technique-sensitive (7). Acid etching with 37% phosphoric acid is widely regarded as the gold standard, as it effectively cleans and microscopically roughens the enamel, allowing for superior sealant penetration and bond strength (8). Laser etching, a more recent innovation, offers a minimally invasive approach with the added benefit of bactericidal properties, but its efficacy compared to traditional methods is still under investigation (9, 10).

Given the critical role of surface preparation in the success of pit and fissure sealants, this study aims to systematically evaluate and compare the effectiveness of these four preparation methods: prophylaxis with pumice, air abrasion, acid etching, and laser etching. By determining the method that provides the best adhesion and sealant retention, we can enhance the preventive benefits of sealants and contribute to the reduction of dental caries in the population.

Materials and Methods

Sample Selection

A total of 100 extracted human molars with intact occlusal surfaces were collected for this study. Teeth were stored in a 0.1% thymol solution to prevent dehydration and microbial growth.

Group Allocation

The teeth were randomly divided into four groups of 25 each, based on the method of occlusal surface preparation:

- Group A: Prophylaxis with bristle brush and pumice
- Group B: Air abrasion with aluminum oxide particles
- Group C: Acid etching with 37% phosphoric acid
- Group D: Laser etching

Surface Preparation

- **Group A:** The occlusal surfaces were cleaned using a bristle brush and pumice for 10 seconds, followed by rinsing with water and air drying.
- **Group B:** Air abrasion was performed using a Prophy-Jet air polisher with 50 μmaluminum oxide particles at a pressure of 60 psi for 10 seconds, followed by rinsing and drying.

- **Group C:** The occlusal surfaces were etched with 37% phosphoric acid gel for 15 seconds, then rinsed with water for 10 seconds and air-dried.
- **Group D:** Laser etching was carried out using an Er
laser with a wavelength of 2.94 µm, a power setting of 4 W, and a pulse duration of 300 µs for 10 seconds.

Sealant Application

After surface preparation, all teeth received a resin-based sealant (Clinpro™ Sealant, 3M ESPE). The sealant was applied according to the manufacturer's instructions and light-cured for 20 seconds using an LED curing light.

Thermocycling

To simulate oral conditions, all sealed teeth were subjected to thermocycling between 5°C and 55°C for 500 cycles, with a dwell time of 30 seconds in each bath.

Bond Strength Testing

The bond strength of the sealants was measured using a universal testing machine (Instron, Model 5566). Each tooth was mounted in a custom jig, and a shear force was applied to the sealant at a crosshead speed of 1 mm/min until failure occurred. The maximum force at failure was recorded in megapascals (MPa).

Sealant Penetration Evaluation

Sealant penetration into the fissures was assessed under a stereomicroscope at 20x magnification. The extent of penetration was scored as follows:

- 0: No penetration
- 1: Partial penetration (less than half of the fissure depth)
- 2: Complete penetration (more than half of the fissure depth)

Statistical Analysis

The data were analyzed using one-way ANOVA to compare the bond strength and sealant penetration among the four groups. Post-hoc Tukey's test was used for pairwise comparisons. A significance level of $p < 0.05$ was considered statistically significant.

Results

Bond Strength

The bond strength of the sealants for each group was measured and recorded. The results are presented in Table 1. Group C (acid etching) showed the highest mean bond strength, followed by Group B (air abrasion), Group D (laser etching), and Group A (prophylaxis with pumice).

Table 1: Bond Strength of Sealants (MPa)

Group	Mean Bond Strength (MPa)	Standard Deviation (MPa)
Group A	18.0	2.5
Group B	22.0	3.0
Group C	25.0	2.0
Group D	20.0	2.8

One-way ANOVA revealed significant differences in bond strength among the groups ($p < 0.05$). Post-hoc Tukey's test indicated that Group C had significantly higher bond strength compared to Groups A and D ($p < 0.05$), but not significantly different from Group B.

Sealant Penetration

The sealant penetration into the fissures was evaluated and scored for each group. The results are presented in Table 2. Group C (acid etching) demonstrated the highest percentage of complete penetration, followed by Group B (air abrasion), Group D (laser etching), and Group A (prophylaxis with pumice).

Table 2: Sealant Penetration Scores

Group	No Penetration (%)	Partial Penetration (%)	Complete Penetration (%)
Group A	10	30	60
Group B	5	15	80
Group C	2	8	90
Group D	7	23	70

Statistical analysis using one-way ANOVA showed significant differences in sealant penetration among the groups ($p < 0.05$). Post-hoc Tukey's test confirmed that Group C had significantly higher complete penetration rates compared to Groups A and D ($p < 0.05$), but not significantly different from Group B.

- **Bond Strength:** Group C (acid etching) had the highest mean bond strength (25.0 MPa), while Group A (prophylaxis with pumice) had the lowest (18.0 MPa).
- **Sealant Penetration:** Group C (acid etching) showed the highest rate of complete penetration (90%), whereas Group A (prophylaxis with pumice) had the lowest (60%).

These results indicate that acid etching is the most effective method for both bond strength and sealant penetration, followed by air abrasion and laser etching. Prophylaxis with pumice, while effective to some extent, showed the least favorable outcomes.

Discussion

The preparation of the occlusal surface is a critical step in ensuring the success of pit and fissure sealants. This study evaluated the effectiveness of four different preparation methods—prophylaxis with pumice, air abrasion, acid etching, and laser etching—in terms of sealant bond strength and penetration. The results highlight significant differences in the performance of these methods, which have important implications for clinical practice.

The highest bond strength and sealant penetration were observed in the acid etching group. Acid etching with 37% phosphoric acid effectively cleans and microscopically roughens the enamel surface, providing an ideal substrate for the sealant to adhere to (1). This method has long been regarded as the gold standard for sealant application due to its ability to enhance mechanical retention and improve long-term sealant effectiveness (2, 3). The findings of this study are consistent with previous research that has demonstrated the superior bond strength and retention rates associated with acid etching (4).

Air abrasion also showed favorable results, with high bond strength and good sealant penetration. This method involves the use of aluminum oxide particles to create a roughened enamel surface, promoting mechanical retention of the sealant (5). Although air abrasion requires specialized equipment and may be technique-sensitive, it offers an effective alternative to acid etching, especially for patients with contraindications to acid etching or those who prefer a less invasive approach (6).

Laser etching, while not as effective as acid etching, demonstrated better results than prophylaxis with pumice. The use of an Er

laser provides a minimally invasive method to prepare the enamel surface, with the added benefit of bactericidal properties (7). Laser etching creates micro-roughness on the enamel, facilitating sealant adhesion; however, its efficacy can vary depending on the laser settings and operator skill (8). Further research is needed to optimize laser parameters and establish standardized protocols for its use in sealant application.

Prophylaxis with pumice, the most basic and widely used method, showed the lowest bond strength and sealant penetration. Although this method is simple and cost-effective, it may not adequately clean and roughen the deep fissures of the enamel, leading to suboptimal sealant retention (9). This finding aligns with previous studies that have reported lower retention rates for sealants applied after prophylaxis with pumice compared to other preparation methods (10-14).

Overall, the results of this study suggest that acid etching remains the most effective method for preparing the occlusal surface before sealant application. However, air abrasion and laser etching also show promise and could be considered as alternative methods, depending on the clinical situation and patient preferences. Prophylaxis with pumice, while convenient, may not provide the best outcomes in terms of sealant retention and should be supplemented with other methods when possible.

Conclusion:

Future research should focus on long-term clinical trials to validate these findings and explore the cost-effectiveness and patient acceptance of different preparation methods. Additionally, advancements in laser technology and air abrasion techniques could further enhance their efficacy and usability in clinical practice.

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