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# EFFECT OF Er YAG LASER AND SELF ETCHING ON MECHANICAL PROPERTIES OF TWO OF TYPES PIT AND FISSURE SEALANTS: AN IN VITRO STUDY

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## ABSTRACT

**Background:** Pit-and-fissure sealants are recommended to prevent caries in newly erupted permanent molars. Occlusal surfaces are prone to caries due to deep pits and fissures that trap plaque, with over two-thirds of caries in children occurring in these areas.

**Aim:** Compare the effect of Er: YAG laser Fotona and self-etching Adper™ 3M ESPE of two types of fissure sealants [3M Clinpro™ (Hydrophobic) and Ultraseal XT hydro (Hydrophilic)] on microleakage.

**Material and Method:** A total of 40 extracted premolars were randomly split into two groups of 20, with each group receiving a different type of fissure sealant: Group I: Clinpro™ 3M ESPE (hydrophobic) and Group II: Ultraseal XT hydro (hydrophilic). Each main group was then split into two smaller subgroups (N=10) according to the enamel pretreatment method: Sub-groups IA and IIA received self-etching adhesive Adper™ 3M ESPE, while Sub-groups IB and IIB underwent Er:YAG laser Fotona treatment. The samples were kept in distilled water until testing, premolars were prepared and subjected to thermocycling and dye penetration analysis. Cross-sections were examined under a stereomicroscope was quantified using Image J software. Outcomes were assessed by two blinded examiners to ensure reliability.

**Results:** The result of the study showed significant differences in microleakage, IA had the highest percentage of no leakage (40.0%), while IB and IIB had 0%, with severe leakage most common in IIB (60.0%) ($p = 0.037$ and $p = 0.029$).

**Conclusion:** Self-etching was the best pretreatment method for both hydrophobic and hydrophilic fissure sealants in terms of decreased the microleakage.

**KEYWORDS:** Laser etching, microleakage, pit and fissure sealant, self-etching.

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## INTRODUCTION

Dentistry has focused significantly on preventing and reducing tooth decay over the last ten years. This involves various methods like diet changes, fluoride treatments (topical and systemic), sugar alternatives, pit-and-fissure sealants, and caries vaccines.[1]

Pit and fissure sealants are highly recommended and widely recognized as effective methods for preventing cavities, particularly in newly erupted permanent molars.[2] Occlusal surfaces feature pits and fissures that are particularly vulnerable to caries, as they tend to accumulate bacteria and plaque more easily, making removal from these areas challenging.[3] Over two-thirds of childhood cavities are reported to form on chewing surfaces.[4,5]

Dental pit and fissure sealant is a material applied to the chewing surfaces in the pits and fissures of teeth. Its purpose is to block decay-causing bacteria and their food from entering the natural grooves and depressions.[6] This preventative measure was first introduced by Cueto and Buonocore in 1967 to protect occlusal pits and fissures from dental caries.[7]

How well pit and fissure sealants work depend heavily on how long they stay on the tooth. Roughening the enamel surface is one of the best ways to improve retention, as it helps the sealant stick better.[8] Acid-etching is a well-established and widely accepted technique for preparing enamel surfaces, aimed at enhancing the secure bonding of various restorative dental materials. This method is regarded as the conventional standard in dentistry, primarily due to its proven effectiveness in creating micromechanical retention for bonding agents. By effectively roughening the enamel surface, acid-etching improves the adhesion of materials, ensuring a durable and reliable restoration.[9]

Resin-based pit and fissure sealants, which contain hydrophobic materials like bis-GMA, need a completely dry environment to bond properly. Achieving this isolation is very challenging, especially with teeth that are still erupting. While hydrophilic bonding agents can help by reducing the need for a perfectly dry field, using them significantly increases procedure time and cost, making the process more complex and technique-sensitive.[10] This has led to the suggestion of alternative methods for preparing fissures for sealant retention, moving beyond traditional acid etching. These alternatives include enameloplasty, using an air-polishing system, and laser treatment..[11]

For the past three decades, laser applications in dentistry have been a significant area of research, and their popularity has recently grown. When lasers irradiate hard dental tissue, they alter its composition: the calcium/phosphorus ratio changes, the carbonate/phosphate ratio decreases, and more stable, acid-resistant compounds form. This process makes the tooth less vulnerable to acid attacks and cavities. Furthermore, lasers can also sterilize fissures by acting on dental plaque. Consequently, using lasers has been proposed as a pretreatment to roughen enamel before applying pit and fissure sealants.[12]

In modern adhesive dentistry self-etching adhesives have been introduced to simplify the bonding process by elimination of washing step and reducing procedure time of conventional acid etch. This advantage renders them a good alternative to the conventional acid etching system, especially in pediatric dentistry.[13] Thus, it is essential to evaluate the outcome of applying hydrophilic and hydrophobic pit and fissure sealant after enamel treatment by laser or self-etching adhesive.

This study was carry out to Compare the effect of Er: YAG laser fotona and self-etching adper™ 3M ESPE of two types of fissure sealants [3M ClinproTM (Hydrophobic) and Ultraseal XT hydro (Hydrophilic)] on microleakage.

## MATERIALS AND METHODS

This study was conducted after obtaining ethical approval from ethical committee of Faculty of Dentistry Mansoura University with reference number **(M01011023 PP)** in November 2023.

Sample size calculations were based on the difference in mean microleakage scores between different adhesive materials retrieved from previous research (Youssef et al., 2023).[14] Using G power program version 3.1.9.4 to calculate sample size based on effect size of 1.66, using 2-tailed test, α error =0.05 and power = 90.0%, the total calculated sample size will be 9 in each subgroup at least.

Forty sounds extracted premolars for orthodontic purposes were selected to be used in this study according inclusion criteria that was sound premolars free from any decay with deep pits and fissures and also free from cracks and developmental defects. Any premolars previously restored or with extensive loss of crown structure due to caries or trauma was excluded from study.

All teeth were first cleaned according to guidelines of the center of disease control and prevention.[12] This entailed using a brush and soap detergent enzyme, followed by rinsing in potable water for one minute, to remove any visible tissue. Then all teeth were stored in a container filled with 0.1% thymol solution until used in this study.

The selected teeth were randomly and equally divided into 2 main groups (N=20) according to type of fissure sealant applied, Group I: Clinpro 3M ESPE (Hydrophobic) group and Group II: Ultraseal XT hydro (Hydrophilic) group. Then, each main group was divided equally into 2 sub-groups (N= 10) according to type of enamel surface pretreatment, Sub-group IA & IIA: Self-Etching Adhesive Adper™ 3M ESPE and Sub-group IB & IIB: Er: YAG Laser Fotona.

**In sub-group IA, IIA: (Self-Etching Adhesive)** Single drop of self-etching adhesive adper™ 3M ESPE was dispensed into a dispensed dish. A single adhesive layer was applied for 15 seconds of active application using a bond brush. On the tooth surface the bond layer was dried gently using air flow spray and cured for 20 seconds according to the manufacturer's instructions.[15]

**In sub-group IB, IIB (Laser Application)** 2.94- µm Er: YAG laser fotona was used to perform laser irradiation. The device was set to the following parameters 1.6 W of power output, 400 mJ of pulse energy, 4-Hz repetition rate. Pulse width 50µs with 40% air and 40%water. The delivery of laser beam was in a non-contact and pulsated mode of super short pulse and perpendicular to the specimen surface through tipless hand piece at a constant working distance of approximately 12 mm and with spot size of 0.9mm for 15 seconds.

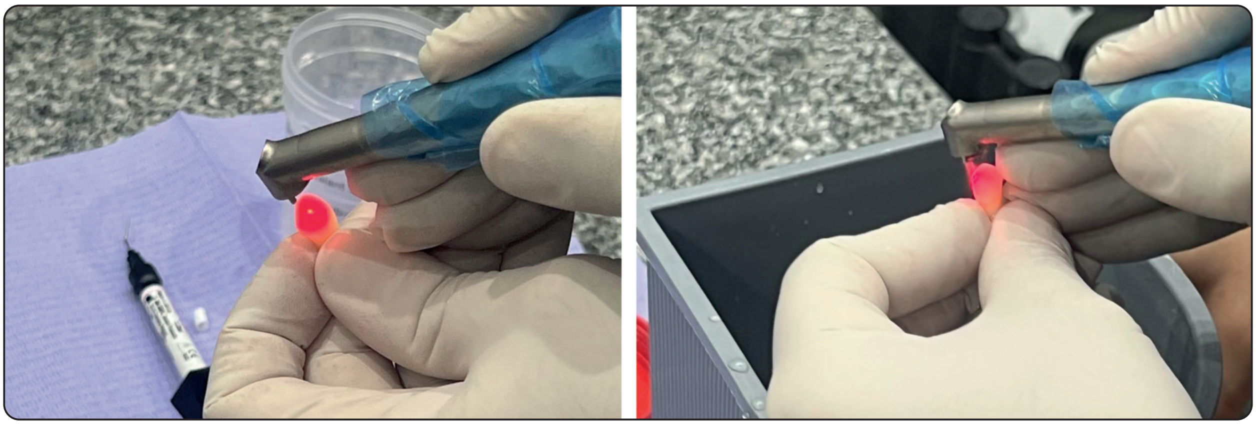

Fig. (1) During specimen preparation using Er:YAG laser.

Fig. (2) Specimen after surface preparation using Er:YAG laser.

First, each occlusal surface of each premolar received its surface pretreatment according to its group and its type of fissure sealant according to its subgroup. Then, the apex of each premolar was sealed with sticky wax and each tooth was covered by a double layer of nail polish applied 1mm away of tooth sealant conjunction.[16] All the teeth were kept in distilled water at 37°C for 24 hours before thermocycling process.[8] Then, all teeth were subjected to thermocycling for 500 cycles in two water baths held between 5-55°C with 30 seconds in each bath (dwell time) and a transfer time of 10 seconds.[17] After thermocycling, all teeth were immersed in 2% methylene blue dye solution for 24 hours at room temperature. After that, the teeth were rinsed under running water to remove any excess of the solution.

All the teeth were buccolingually bisected at the middle of the occlusal surface into two halves using a low-speed diamond saw (Top Dent, Edenta Golden, Swiss) to obtain two sections from each tooth for microleakage.[18] Each cross section was observed under Stereomicroscope with 40X magnification, and the image was taken by digital camera, and then transferred to the computer system for analysis.[14] Measurement of dye penetration and sealant penetration within the fissure in relation to the depth of the whole fissure was carried out using Image J, 1.41a, (NIH, USA) image analysis software.

For outcome assessment, Microleakage[19] of sealant materials were graded according to the following scoring systems. In microleakage Score 0: No penetration, Score 1: Dye penetration extending up to one-third of the sealant-tooth interface, Score 2: Dye penetration extending from one-third to two-thirds of the length of the sealant tooth interface and Score 3: Dye penetration more than two-thirds of the length of the sealant tooth interface.

Microleakage of pit and fissure sealant were scored by the two examiners who were blinded to type of enamel treatment and type of fissure sealant. In case of disagreement, the worst score was documented. Both outcomes were assessed by two examiners twice with a 2-weeks interval to assess intra-examiner reliability while inter-examiner reliability was measured by comparing the scores of both assessors at the first assessment.[20]

## Statistical analysis

Data analysis was conducted using SPSS program for Windows (version 26). First, the Kolmogorov-Smirnov test was used to check if the data was normally distributed.

Qualitative data were presented using counts and percentages. To test the association between categorical variables, the Monte Carlo test was applied when the expected count in any cell was less than five. Continuous variables were presented as mean ± SD (standard deviation) for normally distributed data and the two groups were compared by independent t-test. The threshold of significance is fixed at 5% level (p-value). The results were considered significant when the $p \leq 0.05$. The smaller the p-value obtained, the more significant are the results.

## RESULTS

This study was carried to evaluate and compare the effect of either Er: YAG laser fotona or self-etching adhesive adper™ 3M ESPE enamel surface pretreatment on Microleakage of two different types of fissure sealants [Clinpro (Hydrophobic) and Ultraseal XT hydro (Hydrophilic)].

### Microleakage among the studied groups

The distribution of microleakage scores among different studied subgroups are presented in **Table (1)** and **Figure (3)**. Microleakage values were recorded in different subgroups, and statistical analysis using the Monte Carlo test showed significant differences between IA vs. IB (p=0.037) and IIA vs IIB (p=0.029) subgroups. The highest percentage of no microleakage (score 0) was found in subgroup IA (40.0%) and subgroup IIA (30.0%), as compared to 0% in subgroups IB and IIB. Subgroups IB and IIB had a higher percentage of severe microleakage (score 3), with the highest incidence in subgroup IIB (60.0%). **Table (1)** demonstrated that subgroups treated with self-etching adhesives (IA and IIA) exhibited significantly lower microleakage compared to subgroups treated with Er:YAG laser (IB and IIB). There was no statistically significant difference between IA and IIA or IB and IIB subgroups.

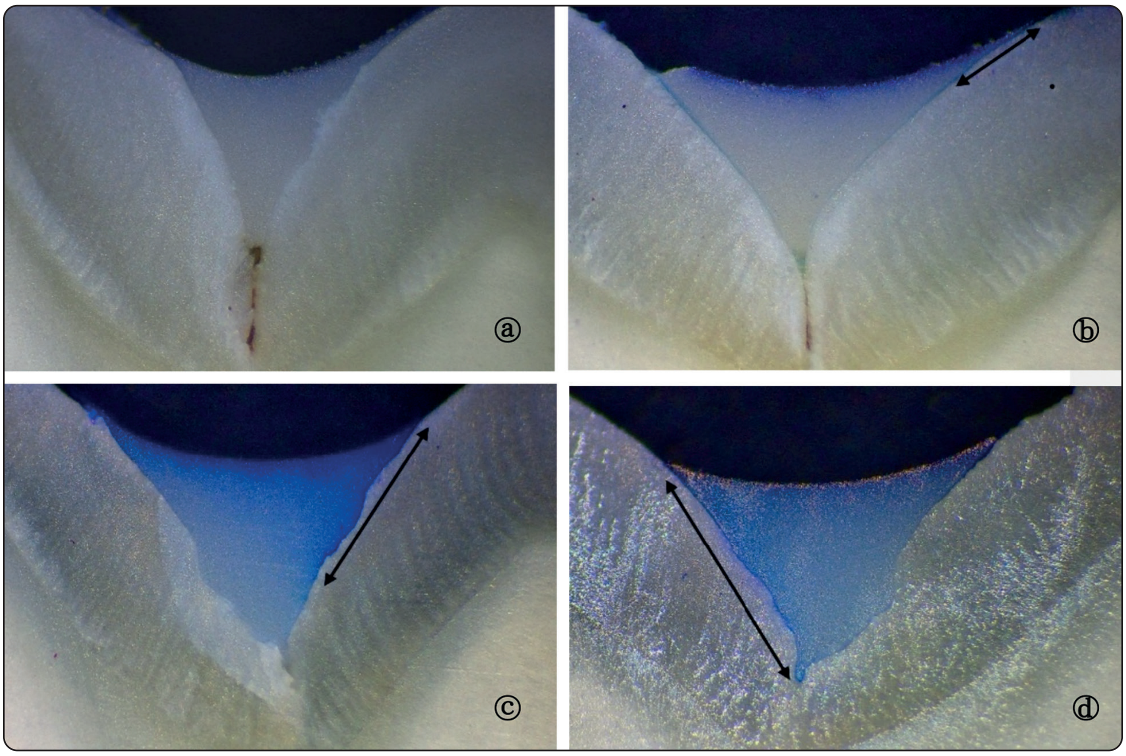


Fig. (3) Scoring system for microleakage, (a) Score 0 microleakage, (b) Score 1 microleakage, (c) Score 2 microleakage, (d) Score 3 microleakage.

TABLE (1) Number and percentage of micro leakage among different subgroups studied.

| Micro leakage | Group I | | Group II | | Test of significance | | | |
|---|---|---|---|---|---|---|---|---|
| | IA | IB | IIA | IIB | P1 | P2 | P3 | P4 |
| 0 | 4 (40.0%) | 0 (0.0%) | 3 (30.0%) | 0 (0%) | 0.813 | 0.556 | 0.037* | 0.029* |
| 1 | 4 (40.0%) | 2 (20.0%) | 3 (30.0%) | 0 (0.0%) | | | | |
| 2 | 1 (10.0%) | 4 (40.0%) | 2 (20.0%) | 4 (40.0%) | | | | |
| 3 | 1 (10.0%) | 4 (40.0%) | 2 (20.0%) | 6 (60.0%) | | | | |

***Data were expressed as no (%), Monte carlo test was used, p1: IA vs. IIA, p2: IB vs. IIB, p3: IA vs. IB, p4: IIA vs. IIB***

## DISCUSSION

Pit and fissure sealants are widely recognized as a primary preventive measure against occlusal caries, particularly in newly erupted permanent molars of children and adolescents. Their effectiveness relies heavily on two main factors: the nature of the sealant material, whether hydrophobic or hydrophilic, and the technique used to prepare the enamel surface prior to application. Proper enamel pretreatment enhances adhesion, minimizes microleakage, and promotes deeper penetration into occlusal fissures, thereby increasing the sealant's long-term efficacy.[21]

This study was conducted to compare the performance of two enamel surface pretreatment methods, self-etching adhesive adper™ 3M ESPE and Er:YAG laser fotona, on two different types of fissure sealants: 3M™ Clinpro™ (hydrophobic) and Ultraseal XT hydro (hydrophilic). The key evaluated parameters were microleakage which are fundamental in determining sealant retention, marginal integrity, and caries prevention.

Understanding these parameters and how they vary based on pretreatment method and sealant type provides essential guidance for selecting optimal preventive strategies in pediatric dentistry. Each of these parameters plays a pivotal role in the long-term effectiveness of caries prevention in occlusal surfaces.[10]

A thymol 0.1% solution was used as a storage medium in this study due to its documented neutrality on microleakage evaluation. Literature supports that thymol does not adversely affect the integrity of enamel or dentin margins when teeth are stored for up to six months. This selection ensured that storage conditions did not influence the degree of marginal leakage, thereby maintaining consistency and validity in the evaluation of sealing ability.[22]

Premolars were selected as the sample teeth in this study due to their anatomical similarity to molars in terms of occlusal fissure morphology, while offering easier accessibility and handling during laboratory procedures. Additionally, premolars are often extracted for orthodontic reasons, making them more readily available and ethically acceptable for in vitro studies without compromising clinical integrity.[14]

In this study, microleakage scores were significantly lower in groups treated with self-etching adhesive adper™ 3M ESPE (IA and IIA) compared to those treated with Er:YAG laser fotona (IB and IIB), with a particularly high incidence of severe microleakage (score 3) in the laser-only group IIB (60%).

The superior sealing ability of self-etching adhesives can be attributed to their ability to create a uniform demineralized enamel layer that allows for deep resin tag formation and enhanced hybridization, thereby improving marginal integrity [23,24] . In contrast, laser pretreatment, although capable of creating surface roughness, may result in irregular etching patterns and the formation of enamel cracks or a melted layer that hinders sealant adaptation, thus increasing microleakage risk.[25]

These findings are consistent with those reported by **Salah et al.**[26], who found that self-etching yielded lower microleakage values compared to laser treatment. Similarly, **El-Khadrawy et al.**[25] concluded that acid-etching alone resulted in significantly lower microleakage than Er:YAG laser, either alone or in combination.

Furthermore, **Butail et al.**[27] reported that laser-etched surfaces exhibited greater microleakage compared to those prepared with self etching, suggesting that laser may not provide sufficient surface energy or porosity to enable intimate sealant adaptation, especially when used without adjunctive acid treatment.

However, conflicting evidence has been presented in the literature. **Schwimmer et al.**[28] and

**Uçar et al.**[29] observed comparable microleakage values between laser-treated and acid-etched groups when the laser parameters were carefully optimized. This discrepancy again underscores the sensitivity of laser effectiveness to operator technique and equipment calibration.

Interestingly, although both hydrophilic and hydrophobic sealants showed lower microleakage when used with self-etch adhesive, there was no statistically significant difference between them. This suggests that the method of enamel pretreatment plays a more dominant role in preventing microleakage than the moisture tolerance or flow characteristics of the sealant itself. This is in agreement with **Youssef et al.**[14], who demonstrated that self-etch adhesive provided significantly better marginal sealing, regardless of the sealant's hydrophilicity.

Overall, the current results highlight that self-etching adhesives are more effective than laser in maintaining a tight seal and preventing fluid ingress at the sealant-enamel interface. This advantage is particularly valuable in pediatric patients, where isolation is often challenging, and any improvement in marginal integrity contributes significantly to long-term caries prevention.

The inferior performance of laser-treated groups in the current study may be due to the formation of a melted enamel layer or microcracks that interfere with resin flow, as well as increased surface irregularities that hinder sealant adaptation.[30] Additionally, variability in the laser's energy output and cooling system could affect the surface morphology and subsequently influence the sealant's ability to reach the fissure base.

The type of resin used in fissure sealants plays a crucial role in determining the overall performance of dental restorations, particularly regarding retention, durability, and resistance to microleakage. In this study, both hydrophobic and hydrophilic sealants performed better when applied with self-etch adhesives; however, the hydrophobic Clinpro™ sealant demonstrated slightly superior performance across all tested variables. This finding is likely attributable to the higher filler content and the optimized resin matrix of Clinpro™, which enhance mechanical stability and wear resistance over time.[31,32]

In the current study, while both sealant types showed improved performance when used with self-etch adhesives adper™ 3M ESPE, the slightly superior outcomes observed with the hydrophobic Clinpro™ sealant can be attributed to its optimized resin formulation and increased filler content, which reinforces the mechanical properties of the material.[31]

In pediatric dentistry, where achieving reliable moisture control during restorative procedures is challenging, the clinical value of self-etch adhesive protocols is underscored by their ability to form a robust hybrid layer even under suboptimal conditions. This property reduces microleakage and enhances sealant penetration, providing effective solutions for ensuring optimal performance in challenging clinical environments.[23,24] Although Er:YAG laser technology offers potential advantages such as disinfection and improved patient comfort, its effectiveness in the current study did not match that of self-etch systems.

## CONCLUSION

The findings of this study lead to several key conclusions regarding both hydrophobic and hydrophilic fissure sealants. First, self-etching emerged as the most effective pretreatment method, significantly enhancing bond strength. Additionally, in terms of microleakage prevention, self- etching outperformed the Er:YAG laser treatment.

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