Original Article

Effect of Erbium Laser on Microtensile Bond Strength of Fissure Sealant in Primary Teeth: An *in vitro* Study

Jehan AlHumaid, Adel Sulaiman Alagl, Sumit Bedi

Department of Preventive Dental Sciences, College of Dentistry, Imam AbdulRahman Bin Faisal University, Dammam, Saudi Arabia

Abstract

Background: Laser etching has several advantages as compared with conventional acid etching. However, results of earlier studies on conditioning surfaces with erbium, chromium:yttrium–scandium–gallium–garnet (Er, Cr:YSGG) before application of the fissure sealant have been inconclusive.

Aim: The study aimed to evaluate the microtensile strength of resin-based fissure sealant bonded to primary enamel conditioned by Er, Cr:YSGG laser with varying power outputs.

Materials and Methods: Fifty sound primary first molars were randomized into the following five groups based on pretreatment choice: Group 1: 3.5 W laser etching + acid etching; Group 2: 2.5 W laser etching + acid etching; Group 3: 3.5 W laser etching with no acid; Group 4: 2.5 W laser etching with no acid and Group 5: acid etching with no laser. Acid etch was performed with 35% orthophosphoric acid for 30 s. Laser etching was performed with Er, Cr:YSGG (2780 nm) laser using G6 tips and 600 µm diameter, 2.5 W or 3.5 W power outputs, pulse duration of 140 µs and a repetition rate of 20 Hz. Sealant was applied on the buccal surface followed by an incremental buildup with composite resin. Microtensile bond strength was assessed and compared among the five groups using one- and two-way ANOVA.

Results: There was no statistical difference in the mean bond strength between groups except in Group 4 (9.66 MPa) (Group 1: 15.57 MPa; Group 2: 14.18 MPa; Group 3: 14.78 MPa; Group 5: 14.63 MPa).

Conclusion: Pretreatment with 3.5 W Er, Cr:YSGG laser alone results in microtensile bond strengths similar to that produced by acid etching, indicating that enamel etching using 3.5 W Er, Cr:YSGG laser would result in the long-term success of pit and fissure sealants in primary teeth.

Keywords: Erbium, chromium: yttrium–scandium–gallium–garnet, laser, microtensile bond strength, phosphoric acid etch, pit and fissure sealant, primary enamel

Address for correspondence: Dr. Sumit Bedi, Department of Preventive Dental Sciences, Division of Pediatric Dentistry, College of Dentistry, University of Dammam, P. O. Box 1982, Dammam 31441, Kingdom of Saudi Arabia.
E-mail: sbrajinder@iau.edu.sa

INTRODUCTION

There has been a shift from "extension for prevention" to "minimally invasive dentistry" in the recent past. Scientific developments in the field of adhesive dentistry have enabled dentists to replace carious tooth structure with minimal invasiveness and to control caries. This has resulted in the decline of caries prevalence over the past decades and has changed the caries patterns.[1-3]

Access this article online

Quick Response Code:

Website:
www.sjmms.net

DOI:
10.4103/sjmms.sjmms_102_17

For reprints contact: reprints@medknow.com

How to cite this article: AlHumaid J, Alagl AS, Bedi S. Effect of erbium laser on microtensile bond strength of fissure sealant in primary teeth: An *in vitro* study. Saudi J Med Med Sci 2018;6:27-31.

Despite the developments, pits and fissures of the occlusal surface are susceptible to caries because their characteristic morphology is such that they tend to retain food and bacteria and are inaccessible to mechanical oral hygiene.[4,5] In fact, pits and fissure surface constitute 56% to 70% of all carious lesions in children aged 5–17 years.[6,7] Nevertheless, pit and fissure sealants are effective in preventing caries. Retention of these sealants, one of the factors that determine its effectiveness, depends on the adhesion of sealant to enamel and surface pretreatment before sealant placement.[5,7]

Conventional pretreatment of the enamel surface includes the use of various concentrations of phosphoric acid to create microporosity, which helps in the formation of the micromechanical bond at the enamel–sealant interface.[2,8,9] However, a disadvantage of acid etching is that the enamel can become more susceptible to caries because of demineralization.[5,6,10] In addition, any remaining debris at the base of the fissures and prismless enamel can affect the adhesion of the filling material at the enamel–sealant interface.[3,4] Other disadvantages with acid etching include its technique sensitivity and difficulty in achieving isolation.[6-11] These disadvantages have resulted in research for alternatives when preparing enamel surfaces to receive adhesives.

Lasers have been studied as surface pretreatment agents, but with limited application in primary teeth.[12-16] Laser etching has the advantage of being painless with no vibration or heat produced and requires no isolation of teeth, thereby making it more attractive and comfortable for young children. It has been reported that laser treatment of enamel results in fractured, irregular surface texture and alters the calcium–phosphorus ratio, resulting in the development of more stable complexes. This decreases the vulnerability of enamel to acids and dental caries.[15,16] These advantages of treating the enamel with laser seem to be particularly beneficial for the adhesion at the enamel–sealant interface in primary teeth as the enamel consists of an acid-resistant prismless layer.[6,7,11] To date, studies that have addressed the effects of erbium, chromium: yttrium–scandium–gallium–garnet (Er, Cr:YSGG) laser have focused on microleakage and mechanical properties of composite bonded to primary and permanent enamel and dentin surfaces.[7,12-15] Although some studies have reported the conditioning of surfaces with Er, Cr:YSGG before application of the fissure sealant, the results were inconclusive.[11,16] Therefore, the aim of this *in vitro* study was to assess and compare the effect of two different power outputs of Er, Cr:YSGG laser on the microtensile strength of a resin-based pit and fissure sealant bonded to enamel in primary teeth.

MATERIALS AND METHODS

Sample size was calculated (http://powerandsamplesize.com/Calculators/Compare-2-Means/2-Sample-Equality) using the following assumptions: alpha error = 5%; study power = 80%; lowest microtensile strength (in acid etch group) = 8; highest tensile strength (in acid etch complemented by laser group) = 13 and standard deviation = 3.6.[16] The minimum required sample size was estimated to be 9. An additional 10% was added to account for any laboratory processing errors, thus making the sample size per group to be 10, with the total number of required specimens being 50.

Accordingly, 50 caries-free primary first molars extracted because of exfoliative mobility and/or orthodontic reasons were collected. An informed consent was taken from the patient's parent/guardian before the extraction procedure. The extracted teeth were disinfected in 0.5% chloramine-T solution for 1 week and subsequently stored for 1 month in sterile saline at 4°C. Using the Random Allocation Software (http://mahmoodsaghaei.tripod.com/Softwares/randalloc.html), teeth were randomly divided into five groups, with each group consisting of 10 molars. Each group was treated as follows:

- Group 1: Laser etching using 3.5 W Er, Cr:YSGG + 35% orthophosphoric acid etching
- Group 2: Laser etching using 2.5 W Er, Cr:YSGG + 35% orthophosphoric acid etching
- Group 3: Laser etching using 3.5 W Er, Cr:YSGG with no acid
- Group 4: Laser etching using 2.5 W Er, Cr:YSGG with no acid
- Group 5: Acid etching using 35% orthophosphoric acid with no laser.

The allocation of each specimen into a treatment group was concealed by giving each specimen a number and placing these numbers on the back of a sealed envelope. After generating a randomization sequence, an assistant wrote the group to which each specimen belonged on a square of paper and folded it inside the envelope carrying the number of the specimen and then sealed the envelope. At the time of applying the treatment, the specimen with its envelope was retrieved and the envelope was opened to identify and apply the treatment.

Er, Cr:YSGG (2780 nm) laser (Waterlase MD, Biolase Technology Inc., CA, USA) [Figure 1] was used with G6 tips and 600 μm diameter (2780 nm) at 140 μs pulse with a repetition rate of 20 Hz for power outputs of 2.5 W and 3.5 W. Spray adjustment was done at the level of 70%

air and 60% water (2.5 W) as well as 80% air and 70% water (3.5 W) to avoid overheating the enamel. The laser beam was aligned in noncontact mode at 1-mm distance perpendicular to the occlusal surfaces for 15 s. Later, the molars were rinsed and air dried gently for 10 s each. For acid etching, the occlusal surfaces of molars were etched according to manufacturer's instructions with 35% orthophosphoric acid gel (Scotchbond™ Etchant, 3M ESPE, St. Paul, USA) for 30 s and then rinsed and air dried for 15 s each.

Later, 1-mm thick resin-based fissure sealant (ClinPro™, 3M Dental Products, St. Paul, USA) was applied using a 2 × 1 mm plastic mold. The sealant was light-cured for 20 s (Mectron, Starlight Pro GAC, Italy). A 5-mm high buildup was incrementally added using composite resin (Filtek Z350, 3M ESPE, St. Paul, USA). Each increment was light-cured for 20 s.

Samples were stored in sterile saline at 37°C and later fixed on a phenolic ring. Sticks of 1 × 1 mm were obtained by sectioning the samples parallel to the adhesive interface by ground-section sutures (Accustom-50, Struers, Rødovre, Denmark) for strength testing using Microtensile Tester (Bisco, Schaumburg, USA).[17] For each group, 20 slices were prepared and they were exposed to a tension load with a cross-head speed at 1 mm/min until the sample failure ensued. The load at failure (F [N]) and the cross-sectional area (A [mm^2]) at the fracture were recorded to calculate the bond strength (P [MPa]) as follows: P (MPa) = F (N)/A (mm^2).

The mean microtensile strength between the study groups was compared using one- and two-way ANOVA, followed by Bonferroni *post hoc* test. Data were analyzed using SPSS version 20.0 (SPSS Inc., Chicago, IL, USA). $P < 0.05$ was considered statistically significant.

Figure 1: Erbium, chromium:yttrium–scandium–gallium–garnet laser (Waterlase iPlus, Biolase Tech Inc., CA, USA)

This study (IRB 2015-02-103) was approved by the Institutional Review Board of Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia, on March 25, 2015.

RESULTS

The mean (standard deviation [SD]) bond strength in Group 1 (3.5 W laser + acid etching) was 15.57 MPa (3.71), and in Group 2 (2.5 W laser + acid etching), it was 14.18 MPa (2.83). The mean (SD) bond strength in Group 3 (3.5 W laser etching alone) and Group 4 (2.5 W laser etching alone) was 14.78 MPa (1.71) and 9.66 MPa (2.20), respectively, while in Group 5 (acid etching alone), it was 14.63 MPa (3.73). Group 4 had significantly lower mean than the other four groups ($P < 0.0001$); there was no statistical difference between the other four groups [Figure 2].

DISCUSSION

This study showed that the microtensile bond strength produced between the enamel and sealant is similar with acid etching and/or Er, Cr:YSGG laser pretreatment. However, if Er, Cr:YSGG laser is to be used alone, a power of 3.5 W is needed because lower power (2.5 W) produces inferior microtensile bond strength.

Previous studies evaluated the effectiveness of using laser in cavity preparations and primary enamel conditioning with varying degrees of success. In line with our results, Drummond *et al.*[17] and Shahabi *et al.*[18] found that acid etching significantly increases the bond strengths compared with laser treatment. However, in contrast, studies have also demonstrated that laser treatment produces bond

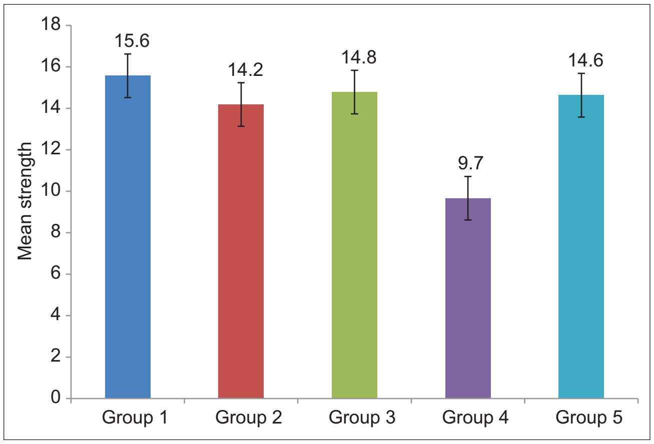

Figure 2: Mean (standard deviation) microtensile bond strengths (MPa) in the study groups

strengths that were comparable[19] or higher[20,21] than those produced by acid etching. This variation in results can be attributed to different types of lasers used (i.e., CO_2, neodymium-doped yttrium aluminum garnet [Nd:YAG] and erbium-doped yttrium aluminum garnet [Er:YAG] lasers) or differences in power outputs or settings between these studies. Specifically, with respect to Er:YAG laser use, Wanderley *et al*.[22] found Er:YAG laser to have a favorable effect on increasing the shear bond strength of dental composite to primary enamel, whereas other studies assessing pit and fissure sealants reported lower bond strengths in primary teeth.[16-19] The results of our study corroborate with that of Wanderley *et al*.[22] and, because similar Er:YAG power outputs were used in both studies, signify the impact of power output in successfully etching the enamel in primary teeth. Further, Borsatto *et al*.,[20] in their study using primary molars, concluded that conditioning the enamel with both acid etching and Er:YAG laser results in an increased tensile strength of the sealants. In another study, Borsatto *et al*.[21] demonstrated the advantage of carrying out acid etching before Er:YAG laser treatment as it results in lower microleakage of fissure sealants.

Er, Cr:YSGG laser has been used in previous studies to etch enamel in permanent teeth before application of the sealant, but few studies have assessed the resulting microtensile bond strength to primary enamel.[22,23] The enamel of primary teeth consists of acid-resistant prismless surface layer, which increases the enamels resistance to orthophosphoric acid and laser.[11,12] Accordingly, higher power outputs were selected in our study, in line with a similar study conducted by Cehreli *et al*.[11] Previous studies assessed bond strengths in permanent teeth and found that Er, Cr:YSGG laser decreased bond strengths.[13,23,24] The results of our study on conditioning primary enamel with Er, Cr:YSGG laser corroborate the results of those studies. Basaran *et al*.[13] studied bond strength of orthodontic brackets and reported that enamel conditioning by conventional acid etch is comparable with etching using 1 W and 2 W Er, Cr:YSGG laser. Olivi and Genovese[25] concluded that to condition primary enamel with Er, Cr:YSGG laser before acid etching, an energy level of 65–75 mJ, power output of 0.65–3.7 W and a repetition rate of 10–50 Hz are recommended. The following parameters, as recommended by the manufacturer, were used in our study for enamel conditioning: power outputs 2.5 W and 3.5 W, pulse duration 140 μs and repetition rate 20 Hz and 75 mJ/pulse. However, variation in these parameters has been shown to result in various etching patterns, and thus may have affected the bond strengths in those studies.[23,26-28]

In our study, the group conditioned with 2.5 W Er, Cr:YSGG laser alone had microtensile bond strength values significantly lower than those of other groups; the microtensile bond strengths between the other groups were not statistically different. These results are in agreement with that of other studies.[13,16,25] It has been reported that Er, Cr:YSGG laser causes microexplosions on the enamel surface, which may further lead to irregularities at macro- and microscopic levels. Laser energy targets the hydroxyl groups of water molecules in dental hard tissues and results in evaporation of these components, which may further eliminate the inorganic materials through explosion.[11] In another study, the bond strength was reported to decrease significantly with the use of Er, Cr:YSGG laser treatment compared with acid etching, and the authors concluded that this may be because of chemical alterations in the enamel structure caused by the laser treatment, thus increasing the resistance against acid demineralization.[5] Nevertheless, the results of the present study suggest that putative advantages of laser etching outweigh the extensive fissuring caused by the lasers, as it consequently leads to an increased bond strength of sealants. Larger samples by means of scanning electron microscope should be examined in future enamel bond strength studies.

CONCLUSION

Within the limitations of this *in vitro* study, it has been shown that pretreatment with 3.5 W Er, Cr:YSGG laser results in microtensile bond strengths similar to that produced by acid etching, whereas pretreatment with 2.5 W laser produces low microtensile bond strength. Therefore, given its advantages, enamel etching using 3.5 W Er, Cr:YSGG laser would significantly enhance the long-term success of pit and fissure sealants in primary teeth. Future studies using erbium laser with varying parameters would help further validate these results.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Buonocore MG. Pit and fissure sealing. Dent Clin North Am 1975;19:367-83.
2. Gwinnett AJ. Human prismless enamel and its influence on sealant penetration. Arch Oral Biol 1973;18:441-4.
3. Celiberti P, Lussi A. Use of a self-etching adhesive on previously etched intact enamel and its effect on sealant microleakage and tag formation. J Dent 2005;33:163-71.

4. Burrow MF, Makinson OF. Pits and fissures: Remnant organic debris after acid-etching. ASDC J Dent Child 1990;57:348-51.
5. Chimello-Sousa DT, de Souza AE, Chinelatti MA, Pécora JD, Palma-Dibb RG, Milori Corona SA, *et al*. Influence of Er:YAG laser irradiation distance on the bond strength of a restorative system to enamel. J Dent 2006;34:245-51.
6. Moshonov J, Stabholz A, Zyskind D, Sharlin E, Peretz B. Acid-etched and erbium:Yttrium aluminium garnet laser-treated enamel for fissure sealants: A comparison of microleakage. Int J Paediatr Dent 2005;15:205-9.
7. Uşümez S, Orhan M, Uşümez A. Laser etching of enamel for direct bonding with an Er, Cr:YSGG hydrokinetic laser system. Am J Orthod Dentofacial Orthop 2002;122:649-56.
8. Pires PT, Ferreira JC, Oliveira SA, Azevedo AF, Dias WR, Melo PR, *et al*. Shear bond strength and SEM morphology evaluation of different dental adhesives to enamel prepared with Er:YAG laser. Contemp Clin Dent 2013;4:20-6.
9. Keller U, Hibst R, Geurtsen W, Schilke R, Heidemann D, Klaiber B, *et al*. Erbium:YAG laser application in caries therapy. Evaluation of patient perception and acceptance. J Dent 1998;26:649-56.
10. Fowler BO, Kuroda S. Changes in heated and in laser-irradiated human tooth enamel and their probable effects on solubility. Calcif Tissue Int 1986;38:197-208.
11. Cehreli SB, Gungor HC, Karabulut E. Er, Cr:YSGG laser pretreatment of primary teeth for bonded fissure sealant application: A quantitative microleakage study. J Adhes Dent 2006;8:381-6.
12. Lee BS, Lin PY, Chen MH, Hsieh TT, Lin CP, Lai JY, *et al*. Tensile bond strength of Er, Cr:YSGG laser-irradiated human dentin and analysis of dentin-resin interface. Dent Mater 2007;23:570-8.
13. Basaran G, Ozer T, Berk N, Hamamci O. Etching enamel for orthodontics with an erbium, chromium:yttrium-scandium-gallium-garnet laser system. Angle Orthod 2007;77:117-23.
14. Ergücü Z, Celik EU, Unlü N, Türkün M, Ozer F. Effect of Er, Cr:YSGG laser on the microtensile bond strength of two different adhesives to the sound and caries-affected dentin. Oper Dent 2009;34:460-6.
15. Cardoso MV, De Munck J, Coutinho E, Ermis RB, Van Landuyt K, de Carvalho RC, *et al*. Influence of Er, Cr:YSGG laser treatment on microtensile bond strength of adhesives to enamel. Oper Dent 2008;33:448-55.
16. Sungurtekin E, Oztaş N. The effect of erbium, chromium: yttrium-scandium-gallium-garnet laser etching on marginal integrity of a resin-based fissure sealant in primary teeth. Lasers Med Sci 2010;25:841-7.
17. Drummond JL, Wigdor HA, Walsh JT Jr., Fadavi S, Punwani I. Sealant bond strengths of CO(2) laser-etched versus acid-etched bovine enamel. Lasers Surg Med 2000;27:111-8.
18. Shahabi S, Bagheri HG, Ramazani K. Tensile bond strength of sealants following Er:YAG laser etching compared to acid etching in permanent teeth. Lasers Med Sci 2012;27:371-5.
19. Walsh LJ, Abood D, Brockhurst PJ. Bonding of resin composite to carbon dioxide laser-modified human enamel. Dent Mater 1994;10:162-6.
20. Borsatto MC, Corona SA, Ramos RP, Liporaci JL, Pécora JD, Palma-Dibb RG, *et al*. Microleakage at sealant/enamel interface of primary teeth: Effect of Er:YAG laser ablation of pits and fissures. J Dent Child (Chic) 2004;71:143-7.
21. Borsatto MC, Corona SA, de Araújo FP, de Souza-Gabriel AE, Pécora JD, Palma-Dibb RG, *et al*. Effect of Er:YAG laser on tensile bond strength of sealants in primary teeth. J Dent Child (Chic) 2007;74:104-8.
22. Wanderley RL, Monghini EM, Pecora JD, Palma-Dibb RG, Borsatto MC. Shear bond strength to enamel of primary teeth irradiated with varying Er:YAG laser energies and SEM examination of the surface morphology: An *in vitro* study. Photomed Laser Surg 2005;23:260-7.
23. Firat E, Gurgan S, Gutknecht N. Microtensile bond strength of an etch-and-rinse adhesive to enamel and dentin after Er:YAG laser pretreatment with different pulse durations. Lasers Med Sci 2012;27:15-21.
24. Sasaki LH, Lobo PD, Moriyama Y, Watanabe IS, Villaverde AB, Tanaka CS, *et al*. Tensile bond strength and SEM analysis of enamel etched with Er:YAG laser and phosphoric acid: A comparative study *in vitro*. Braz Dent J 2008;19:57-61.
25. Olivi G, Genovese MD. Laser restorative dentistry in children and adolescents. Eur Arch Paediatr Dent 2011;12:68-78.
26. Berk N, Başaran G, Ozer T. Comparison of sandblasting, laser irradiation, and conventional acid etching for orthodontic bonding of molar tubes. Eur J Orthod 2008;30:183-9.
27. Wen X, Zhang L, Liu R, Deng M, Wang Y, Liu L, *et al*. Effects of pulsed Nd:YAG laser on tensile bond strength and caries resistance of human enamel. Oper Dent 2014;39:273-82.
28. Ramires-Romito AC, Reis A, Loguercio AD, Hipólito VD, de Goes MF, Singer JM, *et al*. Microtensile bond strength of sealant and adhesive systems applied to occlusal primary enamel. Am J Dent 2007;20:114-20.