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Research Article

Evalaution Of Shear Bond Strength Of Orthodontic Brackets Bonded To Enamel Surface With Laser Conditioning. - An In Vitro Study

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ARTICLE INFO | **ABSTRACT**

AIM : The Aim of the study is an In-vitro evaluation of the shear bond strength of composite resin bonded to enamel which is pretreated using acid etchant and Laser etching .

MATERIALS AND METHODS: 32 extracted human teeth were divided in two groups of 16 each (Groups A and B). In Group A, prepared surface of enamel was etched using 37% phosphoric acid (Scotchbond, 3M). In Group B, enamel was surface treated by laser Er: Cr: YSGG (Waterlase MD, I plus Biolase Technology Inc., San Clemente, CA, USA) operating at a wavelength of 2,780 nm and having a pulse duration of 60ms in H mode with at 2W/30 Hz .Bonding agent (Scotchbond Multipurpose, 3M) was applied over the test areas on 16 samples of Groups A and B each, and light cured. Composite resin (Transbond XT ,3M) . The samples were tested for shear bond strength.

RESULTS:Mean shear bond strength for acid-etched enamel was (11.93 ± 1.06MPa) significantly higher ($P < 0.01$) than for laser-etched enamel(9.56 ± 1.25 MPa) ARI revealed both laser etched and acid etched revealed a score 2 more than half the adhesive on tooth surface .

CONCLUSIONS: For enamel surface, mean shear bond strength of bonded composite obtained after laser etching were lower than those obtained after acid etching.ARI scores had negligible differences betweens the acid etched and laser etched.

Keywords: Enamel etching, laser etching, shear bond strength, phosphoric acid etching, erbium, chromium:yttrium, scandium, gallium, garnet laser

INTRODUCTION

Orthodontics is a dynamic profession where advancements in materials, techniques, and innovation are constantly sought after.Orthodontic treatment is hingeing on a force system to be applied to the teeth via brackets bonded to enamel. To achieve a better bond strength, enamel must be acidetched with 37% orthophosphoric acid.[1] Although the acid-etching technique is helpful in orthodontics, the bonding process needs to be enhanced to minimize enamel loss while maintaining clinically relevant bond strengths. Alternative tooth surface preparation techniques, like laser irradiation, have recently been developed.[2] Since orthodontic patients are more likely to acquire caries or white spot lesions, laser etching has been suggested as a means of preventing caries. This might be very significant.[3] Laser etching eliminates procedural errors, saves time, and is accurate. Therefore, laser irradiation could be a useful method for conditioning the enamel in preparation for orthodontic bonding.[4]

Different kinds of hard tissue and soft tissue lasers have been utilized in dentistry. The erbium laser family is the most beneficial of them since it has a wavelength that matches the primary absorption peak of hydroxyapatite and water. Er:YAG and Er, Cr:YSGG lasers therefore have good interaction with the surface of enamel and dentin as well as all biological tissues. Laser etching of Er, Cr:YSGG creates microcracks suitable for resin penetration. According to Berk N et al. [5], etching with an Er, Cr:YSGG laser is painless and doesn't cause vibration or heat. Once enamel is exposed to laser, the enamel undergoes physical changes like melting and recrystallization, forming numerous pores and small bubbles.[6,7]

Enamel surfaces can be altered by varying the laser's pulse duration. The length and amplitude of laser pulses can be actively controlled electrically with variable square pulse technology. You can change the pulse duration from 50 to 100, 300, 600, or 1000 µs. The ablation process is more successful and the thermal effect is not noticeable on the tissue surface because of the high energy in shorter pulses and decreased energy loss with heat.[8]

The purpose of this study is to compare the,shear bond strength (SBS), after the enamel surface has been etched using Er:YSGG and 37%phosphoric acid followed by bonding and also compare scores for the adhesive remnant index (ARI)

MATERIALS AND METHODS

32 human premolar teeth extracted for orthodontic treatment were collected, cleaned, and stored in distilled water at room temperature for a short period of time, which had intact enamel and no caries, cracks, restorations, or infections. Teeth were randomly divided into two groups of 16 and root portion were embedded Acrylic blocks with the buccal surface parallel to the load direction under SBS testing. Before bonding, teeth were pumiced and rinsed.

In Group A , the enamel surface were etched with 37% phosphoric acid gel for 20 seconds, rinsed with air/ water spray for 15 seconds, and dried to a chalky-white appearance.

In Group B, the enamel surface were conditioned with Er:Cr:YSGG (Waterlase MD, Iplus 2- Biolase Technology Inc., San Clemente, CA, USA) (FIGURE-1) operating at a wavelength of 2,780 nm with energy level set for 2w /30hz, and having a pulse duration of 60ms in H mode, for 20 seconds. as demonstrated in (FIGURE-2)

Dentarum steel brackets (equilibrium 2 MBT 022) with an average bracket base surface area of 10.55 mm2 were bonded to upper premolars using enlight primer and adhesive (ORMCO) according to the manufacturer's instructions. The adhesive was light cured 5 seconds on each proximal side,occlusal and gingival surface .

The SBS was tested using a universal testing machine operating at a speed of 1mm/minute. The specimens were stressed in an occlusogingival direction under the occlusal wings of the bracket and parallel to the long axis of the tooth.The values were obtained in Newton. After debonding, the bracket bases and the enamel surfaces were examined under 10× magnification using a stereomicroscope to determine the amount of residual adhesive remaining on each tooth.

The ARI, ranging from 0 to 3, was used to assess the amount of adhesive left on the tooth surfaces.
A score of 0 indicates no adhesive remained on the tooth surface.
1 indicates less than half of the adhesive remained on the tooth.
2 indicates more than half of the adhesive remained on the tooth.
3 indicates all adhesive remained on the tooth structure

FIGURE -1

FIGURE-2

Statistical analysis

Descriptive and Inferential statistics were analyzed by IBM SPSS version 20.0 (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp). Mean and SD were used to summarize quantitative data. Frequency and Percentage were used to summarize qualitative data. Data was summarized using appropriate bar charts. Throughout the study, a P value of <0.05 was considered as a statistically significant difference. Shear bond strength is evaluated using independent sample T test.

Results

Assessment of Shear Bond Strength

There were statistically significant differences while comparing acid-etched group with 2 W/30 Hz laser-etched group ($P < .001$). The values were higher in acid etched group (11.93 ± 1.06MPa) compared to laser-etched groups (9.56 ± 1.25 MPa). (As depicted in Table 1)

Assesment of ARI score

The ARI scores of the samples are listed in Table 2 . both laser etched and acid etched exhibited a score 2(More than half the adhesive remaining on the tooth surface) However, the results were statistically not significant (*P* > .05).(FIGURE-3)

FIGURE -3

DEMONSTATING ARI SCORE 2

Comparison of Shear bond strength

Group	Mean	Std. Deviation	Mean Difference	t	P value	95% Confidence Interval of the Difference	
Acid etched	11.9381	1.06326	2.37200	5.727	0.0001	1.52366	3.22034
Laser etched	9.5661	1.20092					

Table 1 -There is a significant difference in the values between the 2 groups. The values is higher in Acid etched group

Comparison of ARI

Variable	Score	Acid etched		Laser etched		P value
		N	%	N	%	
ARI	No adhesive remaining	1	6.7	1	6.7	0.940
	< half remaining	5	33.3	5	33.3	
	> Half remaining	8	48.7	9	54.3	
	All adhesive is remaining	2	13.3	1	6.7	

TABLE-2 -The difference in ARI score between acid etched and laser etched is statistically insugnificant

Discussion

Conventionally for Orthodontic bonding, the enamel is etched using 37% phosphoric acid. This creates microporosities, which in turn create a bonding mechanism through mechanical retention, which is the penetration of the resin tags into the microporous substrate. Although this technique has proven efficiency ,it has certain drawbacks, including the potential for decalcification, which exposes the enamel layer to caries attacks, and the coloring brought on by resin tags [9].
With the introduction of lasers in dentistry, their effects on the surface treatment of enamel have been investigated, and laser ablation became an alternative to acid etching.10 Laser irradiation produces an amount of surface roughness comparable [11] or similar [12] to acid etching. Er:YAG laser conditioning is proved to be effective for hard-tissue ablation without any thermal side effects.[13,14]
Er, Cr:YSGG, which has a high absorption coefficient in water and enamel. It led researchers to explore its use in enamel conditioning.A systematic review done by Amin Golshah et al, evaluated the effects of different types of laser etching versus phosphoric acid etching on shear bond strength of metal brackets to human enamel showed The Er,Cr:YAG group, used 0.5W to 3W showed however, showed 0.6 MPa higher SBS than phosphoric acid etching group, but this increase was not statistically significant.[15]

In our study, we used Er:Cr:YSGG (Waterlase MD, Iplus 2- Biolase Technology Inc., San Clemente, CA, USA) (FIGURE-1) operating at a wavelength of 2,780 nm with energy level set for 2w /30hz, and having a pulse duration of 60ms in H mode, for 20 seconds was selected for etching enamel surface .

Erbium plus chromium–doped yttrium-scandium-gallium-garnet (Er,Cr:YSGG) 2780-nm instruments are free-running pulsed lasers with wavelengths that are most highly absorbed in water, followed by good absorption in hydroxyapatite and poor
absorption in hemoglobin. Thermal rise in the superficial tissue layers is minimal and even less with concurrent water spray during the laser procedure minimises any damage to the enamel[17]

Recently, Berk et al, observed by means of a SEM analysis that 1 W, 1.5 W, and 2W Er, Cr:YSGG laser irradiation produced etching patterns similar to those of acid etching.[5] The time for laser etching used in this study was 15 s which was similar to acid etching time .He also suggested that etching with Er, Cr:YSGG laser is painless and does not produce either heat or vibration. As laser etching eliminates water spraying and air drying, chairside time can also be saved significantly. From a clinical perspective, saving chair time improves adhesion because it significantly reduces the risk of salivary contamination. Also, easy handling of the laser apparatus makes it attractive for clinical use.

Baygin *et al*. found that 10 s of 2W laser etching might be an alternative to enamel acid etching[18] Martvnez-Insua found weaker adhesion forces in an Er:YAG laser-etched enamel surface than an acid etched enamel surface. This was related to sub-surface cracks observed in (SEM) images [19]. Firat et al found that the microtensile bond strength was significantly lower in the acid-etched group than the Er, Cr:YSGG and Nd:YAG laser-etched enamel group for both bonding agents used.[20]

The Shear bond strength obtained in our study was 9.56 ± 1.25 MPa for laser etching procedure, which is less than acid etching procedure, which is found to be 11.93 ± 1.06 MPa. This variation could be caused by the laser being exposed unevenly, not reaching the entire surface area, which would result in a reduced bond strength.Studies have shown that the SBS of Er:YAG laser-conditioned surfaces is variable.[21-25] Er:YAG pulse duration and pulse energy play a decisive role related to laser ablation ability and the surface conditioning for adhesion.[26]

The adhesive remnant index scoring was carried out as proposed by Artun and Begland. Score 2 is seen more frequently in the acid etching group and laser etching groups

Stronger does not always equate to better in biology, at least not when it comes to orthodontics, as components are held together by tens or even hundreds of weaker linkages. In certain therapeutic contexts, high bond strength is required, especially when bonding mandibular premolars, to avoid recurring deboning. However, in some circumstances, like attaching ceramic brackets, a relatively low bond strength is required to avoid issues with debonding after the treatment.

In laser etching, depending on the clinical requirement, we can adjust the power output and irradiation duration to manipulate the bond strength. This versatility of lasers where the output power and duration can be changed to suit the clinical situation can also be an advantage.

Conclusion

The laser etching method yielded bond strengths of 2W/30Hz were similar to those achieved with acid etching. Thus, it can be said that laser etching is a potential substitute for acid etching. Because of its many benefits, including its accuracy, ease of use, speed, and ability to develop enamel resistant to cavities, laser etching can even yield better results.

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