Original Article

In Vitro Evaluation of Microleakage Around Orthodontic Brackets Using Laser Etching and Acid Etching Methods

Mohammad Hossein Toodehzaeim[1], Sogra Yassaei[2], Maryam Karandish[3]✉, Sedigeh Farzaneh[4]

[1]Assistant Proffesor, Department of Orthodontics, Faculty of Dentistry, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
[2]Associate professor, Department of Orthodontics, Faculty of Dentistry, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
[3]Assistant Proffesor, Department of Orthodontics, Faculty of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran
[4]Dentist

Abstract

Objective: path of microleakage between the enamel and adhesive potentially allows microbial ingress that may consequently cause enamel decalcification. The aim of this study was to compare microleakage of brackets bonded either by laser or acid etching techniques.

Material and Methods: The specimens were 33 extracted premolars that were divided into three groups as the acid etching group (group 1), laser etching with Er:YAG at 100 mJ and 15 Hz for 15s (group 2), and laser etching with Er:YAG at 140 mJ and 15 Hz for 15s (group 3). After photo polymerization, the teeth were subjected to 500 thermal cycles. Then the specimens were sealed with nail varnish, stained with 2% methylen blue for 24hs, sectioned, and examined under a stereomicroscope. They were scored for marginal microleakage that occurred between the adhesive-enamel and bracket-adhesive interfaces from the occlusal and gingival margins. Data were analyzed with the Kruskal- Wallis test.

Results: For the adhesive-enamel and bracket-adhesive surfaces, significant differences were not observed between the three groups.

Conclusion: According to this study, the Er:YAG laser with 1.5 and 2.1 watt settings may be used as an adjunctive for preparing the surface for orthodontic bracket bonding.

Key Words: Enamel; Etching, Dental; Er-YAG Lasers; Orthodontic Brackets

✉ Corresponding author:
M. Karandish, Department of Orthodontics, Faculty of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran

karandishm@sums.ac.ir

Received: 11 January 2014
Accepted: 16 March 2014

Journal of Dentistry, Tehran University of Medical Sciences, Tehran, Iran (2014; Vol. 11, No. 3)

INTRODUCTION

Acid etching was the first standard method to prepare the enamel surface for composite filling mechanical retention introduced by Buonocore in 1955 [1].

The investigators have been working to reach the best bond strength with the lowest cost and energy [2]. Laser beam can be used in many aspects of dentistry. Although Apple et al postulated that subablative Er laser application causes fine enamel cracks reducing its positive effect of prevention on enamel caries [3], others supported the laser beam effect on dental structure [4-6]. After irradiation of enamel surface with CO2 and Er:YAG laser beams, Kwon et al. described the improved crystallinity after Er:YAG ablation [5]. Cecchini et al. observed reduction in enamel solubility without severe enamel alterations [6].

In a study conducted by Chen and Huang, melted surfaces and crater-like holes 1-20 μm in diameter were observed in the CO2 and Nd:YAG laser irradiation [4].

In comparison of 10 Hz Er:YAG lasers [(100mJ, 12.7J/Cm2), (100mJ, 7.5 J/Cm2) and (150mJ, 11J/Cm2)], Rodriguez-Vilchis and coworkers discerned different crack sizes, changes in morphological and chemical patterns and roughness of the interior of the cracks [7]. Due to recent studies altering the laser energy parameters can cause different effects on dental tissues [2,6].

Challenging results have been published on the bond strength of laser etching. Attrill et al. [8] introduced laser etching as an adjunctive method for enamel preparation. They showed that however resin restoration retention of laser etching was higher than the negative control group, the mean shear bond strength was lower than the conventional acid etching.

In a study conducted by Lee et al., the bond strength of brackets etched with acid and Er:YAG laser were compared [2]. They concluded that Er:YAG etching was an effective adjunctive method for enamel preparation for it takes much less time.

Some other investigations were guided on the evaluation of the amount of microleakage around bonding materials. In an experimental study, Davari et al. compared the microleakage under ceramic and metal brackets with LED and PAC units. They showed less microleakage with LED unit and lower microleakage at the gingival margin under ceramic brackets in comparison with metals [9]. In another study, the authors did not find an increase in the microleakage with high intensity curing lights in comparison with the LED units [10]. Ramoglu et al. demonstrated higher microleakage for resin modified glass ionomers in comparison with conventional adhesives [11].

Borsatto et al. [12] evaluated the Silane-enamel microleakage on deciduous teeth. The teeth were prepared with Er:YAG laser, laser plus acid, and merely acid. The pits and fissures were sealed with resin sealants. They found the highest microleakage in the merely laser etched group. Class V composite restoration on third molars showed significantly less microleakage on occlusal walls of the acid etched group. This study rejected laser etching as a valuable method for preparing restorative cavities [13]. Hamamci et al. [14] compared three methods of total etch, acid etch and laser etching with two powers. Acid etch had the lowest microleakage of all groups. They later suggested that laser etching might serve as an alternative to acid etching although the least microleakage was reported in the acid etched group [15]. Hess et al. showed that sand blast and low power Er;Cr:YSGG were not capable of enamel etching for bonding molar tubes [16]. In addition, they proposed that 1.5 and 2 W lasers might be an alternative to acid etching. This study was designed to assess the microleakage around metal orthodontic brackets with acid etching compared with laser etching.

MATERIALS AND METHODS

The simple sampling procedure was used. With α=0.05 and β=0.2, eleven samples were estimated for each group.

Thirty three premolar teeth were extracted for orthodontic treatment. The teeth were collected from a private clinic in Yazd, Iran. The crowns were caries free and had no restorations or fracture lines. They were not contaminated with any chemical substance such as H_2O_2 or bleach. All the teeth were debrided from soft tissues on the surface with a dental scaler.

The samples were classified accidentally into three groups:
Group 1: etching with orthophosphoric acid
Group 2: etching with Er:YAG laser – energy: 100mJ, frequency: 15Hz for 15 seconds
Group 3: etching with Er:YAG laser – energy: 140mJ, frequency: 15Hz for 15 seconds
For the first group, the enamel surface was polished for 10 seconds and rinsed with water. Then the surface was desiccated for 20 seconds. The teeth were etched for 30 seconds with orthophosphoric acid (Ormco etching solution, Italy), rinsed for 30 seconds and desiccated. In this stage, the white chalky appearance of the enamel was observed.
For the second group, polishing and debridement was done as explained before and the enamel surface was etched for 15 seconds with Er:YAG laser (kavo laser key III, Germany)-100mJ, 15Hz.
The laser beam was radiated with a 2060 handpiece on a defocus mode from 20mm perpendicular to the enamel surface as manufacturer's constructions. The enamel surface was etched with a sweeping movement in a cover column and row pattern.
The third group was debrided as the two previous groups and etched with Er-YAG laser-140mJ, 15Hz for 15seconds.
For all the samples, the surface was desiccated and the primer (Grengloo/sds-Ormco, Italy) was applied immediately. With a low intensity air stream an adequate primer thickness was achieved. The primer was cured with LED (lite 695c/DEWT AMERICA – Taiwan) for 5 seconds. The Grengloo (Ormco) adhesive was applied to bond the stainless steel twin premolar brackets (22 SS MBT, American orthodontics, USA). A bracket gauge was used for delicate bracket placement. After bracket placement, each tooth was stabilized in a piece of rubber to prevent bracket displacement. The adhesive was cured for 10 seconds from occlusal and 10 seconds from gingival edges with a 45° angle from the bracket base.
The LED (lite 695c) head was at about 2-3mms from the tooth.
At the end, thermo cycling between 55°C ±2 for 30 seconds with a transition time of 30 seconds was performed with the thermocycle (Vafaee Fac., Iran) for 500 cycles.
Before color penetration, the teeth apices were sealed with sticky wax. Then the teeth were sealed with nail varnish maintaining 1mm safety zone from the bracket base. The samples were soaked in 2% methylene blue solution for 24hs at room temperature.
After rinsing with water and cleaning the surface colors with a tooth brush, the teeth were desiccated and stabilized in orthodontic self-cure acrylic resin (Orthiresin/Densply limited, England).
Two buccolingual sections on the mesial and distal wings of the bracket were done with a diamond bur of cutting instrument (Vafee co, Iran) with adequate water. The penetration of color in all samples at the gingival and occlusal margins of adhesive-bracket and enamel-adhesive was evaluated with x_{16} magnification of stereomicroscope (Olympus SZX7; Olympus optical, Tokyo, Japan).
The amount of microleakage was measured with a digital gauge (Shoka Golf, Japan).
The measurements were repeated 2 days later by the same practitioner. One of the limitations of our study and of course all other in vitro studies is the preparation of absolutely undamaged teeth and their disinfection.
One operator and examiner were involved and they were blind to the method of etching during the study.
After the microscopic evaluation of color penetrance and scoring the data, the results were analyzed with Kruskal-Wallis in SPSS 16 software.

RESULTS

As it is shown in tables 1-3, bracket-adhesive microleakage was lower than enamel-adhesive microleakage in all three groups.

Table 1. Comparison of Bracket-Adhesive Microleakage on Occlusal and Gingival Surfaces in the Three Groups

Group	Numbers	Occlusal			Gingival			Total		
		Mean	Med.	SD	Mean	Med.	SD	Mean	Med.	SD
1	28	0	0	0	0.071	0	0.262	0.714	0	0.262
2	25	0.16	0	0.624	0.24	0	0.723	0.28	0	0.737
3	30	0.067	0	0.254	0.268	0	0.583	0.339	0	0.66
P-Value*		0.336			0.346			0.223		

* P-value <0.05 is significant

Table 2. Comparison of Enamel -Adhesive Microleakage on Occlusal and Gingival Surfaces in the Three Groups

Group	Numbers	Occlusal			Gingival			Total		
		Mean	Med.	SD	Mean	Med.	SD	Mean	Med.	SD
1	28	0.357	0	0.731	0.714	1	0.854	0.967	1	0.881
2	25	0.72	0	1.1	1.2	1	1.154	1.4	1	1.19
3	30	0.433	0	0.679	1.03	1	0.850	1.23	1	0.898
P-Value*		0.432			0.182			0.353		

* P-value <0.05 is significant

Table 3. Total Microleakage in All Samples

	Total Bracket-Adhesive Microleakage in All Samples	Total Enamel-Adhesive Microleakage in All Samples
Mean	0.229	1.193
Med.	0	1
SD	0.591	0.993

The adhesive-bracket and the enamel-adhesive microleakage on occlusal and gingival surfaces and altogether does not show a significant difference between the three groups (P-value<0.05).

DISCUSSION

Laser etching has absorbed a lot of attention in the recent years. Most of the studies have evaluated the shear bond strength of brackets.

One of the most frequent methods used in microleakage studies are colors that are easier and more accessible [13]. Here we applied this method and tried methylene blue. Although alkaline fushin is the most applicable color, it can disturb the results due to its attachment to the carious dentin [13]. In different studies, the density of the substances varied between 0.5% and 10% and the drown time were 4-72hs. We adopted methylene blue 2% for 24hs.

The microleakage studies were performed in vitro as well as in vivo, but most of them were in vitro similar to our study. Recently, Er:YAG laser has been examined by researchers and it is used for enamel preparation [17].

In our study, the lowest enamel-adhesive microleakage was in the acid etch group (mean: 0.964, med: 1, SD: 0.881) and the maximum microleakage was in Er:YAG laser (100mJ, 15Hz) with the mean of 1.4, median of 1 and SD=1.19. These differences were not statistically significant between the three groups (P>0.05).

In all the groups the greater microleakage was at the gingival margin confirming the study conducted by some other studies. They related the greater microleakage to the curvature of enamel surface at the gingival margin and consequently to the greater adhesive thickness accumulating there [11, 17]. However, bracket-adhesive microleakage can be a failure in the bracket bond strength; the enamel-adhesive microleakage is much more dangerous due to its tendency to create a white spot.

Moshonov et al. showed color penetrance in none of their samples showing the effectiveness of Er:YAG laser on enamel etching similar to our study [18]. The results of a study performed by Karlovic et al. [19] also introduced laser etching as an adequate method for better marginal seal. They showed less microleakage in the cavity prepared by laser than ultrasonic.

A power set of 1.8 w (90 mJ, 20 Hz) was used in Er:YAG laser etching in a study carried out by Hamamci et al. [14]. In this study, microleakage was significantly high in all groups. There was a significant difference between laser and acid etch groups. The difference between the results performed by our study and the study conducted by Hamamci et al. may be due to adhesive bonding. Despite the same source of radiation used in both studies (LED), the limitation of tooth surface to radiation was different. A 4×4 cm acrylic window that was used in the study carried out by Hamamci et al. for laser irradiation, could reduce the accuracy of the needed area for etching. So the bracket could be bonded out of the prepared area. On the other hand, this limitation was not considered in the acid etch group. Here we preferred to apply acid phosphoric gel on the buccal surface of the teeth except 1mm from the surroundings (occlusal, gingival, mesial and distal). For laser etching we repeated the same prescription to equalize our groups. After all, the additional laser radiation was much lower than the amount needed for cavity preparation with higher power; so this amount can be ignored.

In the study performed by Borsatto et al. [12], there was a significant difference of the enamel-silane microleakage between laser and acid etch groups. Er:YAG laser prepared grooves had higher microleakage. The energy level of laser beam was near our set (120mJ), so the lower frequency (4Hz) could be the reason of this difference between the study conducted by Borsatto et al. and our study. The importance of the best adjustment sets has been shown in recent studies including the study performed by Berk et al. [20].

By the SEM evaluations they found that the best power set for enamel etching is 1-1.5w. We adopted 1.5w and 2.1w and no meaningful difference was depicted. It may be concluded that both sets are acceptable.

As Bader et al. insist, many studies on microleakage use Er:YAG with high energy (more than 300mJ) that can damage the enamel surface [21]. Therefore, they show weak marginal seal or high microleakage. These micro indentations with high energy may not create an adequate surface for etching. By lowering the power energy set, Bader et al. [21] showed the same result for both laser and bur cavity preparations.

CONCLUSION

Although the mean of microleakage with 1.5w laser was the highest, no statistically significant difference was seen.

Laser etching of course with an adequate set can be an adjunctive method for enamel etching.

ACKNOWLEDGMENTS

Current study is based on a thesis submitted to the Faculty of Dentistry, Shahid Sadoughi University of Medical Sciences, in partial fulfillment of the requirements for the D.D.S. degree.

REFERENCES

1- BUONOCORE MG. A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. J Dent Res. 1955 Dec;34(6):849-53. No abstract available.

2- Lee BS, Hsieh TT, Lee YL, Lan WH, Hsu YJ, Wen PH, Lin CP. Bond strengths of orthodontic bracket after acid-etched, Er:YAG laser-irradiated and combined treatment on enamel surface. Angle Orthod. 2003 Oct;73(5):565-70.

3- Apel C, Meister J, Götz H, Duschner H, Gutknecht N. Structural changes in human dental enamel after subablative erbium laser irradiation and its potential use for caries prevention. Caries Res. 2005 Jan-Feb;39(1):65-70.

4- Chen CC, Huang ST. The effects of lasers and fluoride on the acid resistance of decalcified human enamel. Photomed Laser Surg. 2009 Jun;27(3):447-52.

5- Kwon YH, Lee JS, Choi YH, Lee JM, Song KB. Change of enamel after Er:YAG and CO2 laser irradiation and fluoride treatment. Photomed Laser Surg. 2005 Aug;23(4):389-94.

6- Cecchini RC, Zezell DM, de Oliveira E, de Freitas PM, Eduardo Cde P. Effect of Er:YAG laser on enamel acid resistance: morphological and atomic spectrometry analysis. Lasers Surg Med. 2005 Dec;37(5):366-72.

7- Rodríguez-Vilchis LE, Contreras-Bulnes R, Olea-Mejìa OF, Sánchez-Flores I, Centeno-Pedraza C. Morphological and structural changes on human dental enamel after Er:YAG laser irradiation: AFM, SEM, and EDS evaluation. Photomed Laser Surg. 2011 Jul;29(7):493-500.

8- Attrill DC, Farrar SR, King TA, Dickinson MR, Davies RM, Blinkhon AS. Er:YAG laser etching of dental enamel as alternative to acid etching. Lasers Med Sci. 2000 Dec;15:154-61.

9- Davari A, Yassaei S, Karandish M, Zarghami F. In vitro evaluation of microleakage under ceramic and metal brackets bonded with LED and plasma arc curing. J Contemp Dent Pract. 2012 Sep 1;13(5):644-9.

10- Ulker M, Uysal T, Ramoglu SI, Ertas H.Microleakage under orthodontic brackets using high-intensity curing lights. Angle Orthod. 2009 Jan;79(1):144-9.

11- Ramoglu SI, Uysal T, Ulker M, Ertas H. Microleakage under ceramic and metallic brackets bonded with resin-modified glass ionomer. Angle Orthod. 2009 Jan;79(1):138-43.

12- Borsatto MC, Corona SA, Ramos RP, Liporaci JL, Pécora JD, Palma-Dibb RG.

13- Microleakage at sealant/enamel interface of primary teeth: effect of Er:YAG laser ablation of pits and fissures. J Dent Child (Chic).

2004 May-Aug;71(2):143-7.

14- Ceballos L, Osorio R, Toledano M, Marshall GW. Microleakage of composite restorations after acid or Er-YAG laser cavity treatments. Dent Mater. 2001 Jul;17(4):340-6.

15- Hamamci N, Akkurt A, Başaran G. In vitro evaluation of microleakage under orthodontic brackets using two different laser etching, self etching and acid etching methods. Lasers Med Sci. 2010 Nov;25(6):811-6.

16- Hess E, Campbell PM, Honeyman AL, Buschang PH. Determinants of enamel decalcification during simulated orthodontic treatment. Angle Orthod. 2011 Sep;81(5):836-42.

17- 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 Dec;122(6):649-56.

18- 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 May;15(3):205-9.

19- Karlovic Z, Pezelj-Ribaric S, Miletic I, Jukic S, Grgurevic J, Anic I. Erbium:YAG laser versus ultrasonic in preparation of root-end cavities. J Endod. 2005 Nov;31(11):821-3.

20- 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 Apr;30(2):183-9.

21- Bader C, Krejci I. Indications and limitations of Er:YAG laser applications in dentistry. Am J Dent. 2006 Jun;19(3):178-86. Review.