OPEN ACCESS

Saudi Journal of Oral and Dental Research
Abbreviated Key Title: Saudi J Oral Dent Res
ISSN 2518-1300 (Print) |ISSN 2518-1297 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article

Laser v/s Conventional - Comparison of Shear Bond Strength of Orthodontic Brackets Bonded Using Various Etching Techniques

Dr. Vipul Kumar Srivastava[1], Dr. Shally Mahajan[2*], Dr. Shweta Chaudhary Mehta[3], Dr. Isha Singh[4], Dr. Anshdeep Singh[5], Dr. Tarun Saxena[6]

[1]Private Practitioner, 32 Pearls Multispeciality Dental Clinic, Lucknow, Uttar Pradesh, India
[2]Professor, Dept of Dentistry, Dr RMLIMS, Lucknow, Uttar Pradesh, India
[3]Private Practitioner, 32 Pearls Dental Clinic, Lucknow India
[4]Senior lecturer, Department of Conservative dentistry and endodontics, Seema Dental College and hospital, Rishikesh, UK
[5]Reader, Department of Conservative Dentistry and Endodontics, Seema Dental College and hospital, Rishikesh, UK
[6]Senior lecturer, Department of Conservative dentistry and endodontics, Seema Dental College and Hospital, Rishikesh, UK

DOI: 10.36348/sjodr.2021.v06i09.002 | **Received:** 19.07.2021 | **Accepted:** 26.08.2021 | **Published:** 15.09.2021

***Corresponding author:** Dr. Shally Mahajan

Abstract

Background/Objectives: The following study was performed to test and compare the shear bond strength and of the orthodontics brackets bonded to extracted human premolar teeth using various etching procedures and also to determine the brackets / adhesive failure mode. ***Materials/Methods:*** The teeth were acid-etched using 37% orthophosphoric acid, laser-etched with Er: YAG (Fotona Lares, wavelength, 2 940 nm) and both acid etching followed by laser etching. Orthodontic brackets were bonded to all the teeth using Transbond XT paste (3M Unitek). ***Results:*** Shear bond strength of all teeth of each group was determined by using Universal testing machine. Data obtained were compared by Kruskal Wallis analysis of variance (ANOVA) and chi-square (χ^2) test was used to compare the adhesive remnant index (ARI) scores for all the three groups. ***Conclusions:*** The study found laser-etched procedure more effective than acid-etched procedure and both acid and laser-etched procedures in the management of orthodontics.

Keywords: Orthodontic brackets, Acid etching, Laser therapy, Er: YAG laser, Bond strength.

INTRODUCTION

Direct bonding of orthodontic brackets to the etched enamel surface of the tooth has always been an area of interest to many clinicians and academicians. There have been many studies conducted worldwide regarding the various procedures of enamel surface treatments and the different etching times required for proper bonding [1-3].

Buonocore in 1955 described phosphoric acid as a simple means for increasing the adhesion of acrylic filling materials to enamel surfaces.[4] He demonstrated that the adhesion of attachments to the tooth surface was enhanced, when the tooth was etched with 85% phosphoric acid for 30 seconds. He suggested that this could be due to the conditioning of tooth surface, facilitating mechanical adhesion of attachments, by penetration of the adhesive into the pores, subsequent to the etching, which allowed intimate contact of the adhesive.

The advent of bonding orthodontic brackets using epoxy resin by Newman G.V. in 1964 has revolutionized clinical orthodontics [5].

Since that time, several other types of etching techniques have been used amongst which Er: YAG laser has been shown to be an effective tool in cavity preparation, etching and removal of caries from enamel and dentin but their comparative efficacy was not well documented [6-8].

The purpose of the present study was to test and compare the shear bond strength and of the orthodontics brackets bonded using three etching procedures: conventional acid etching, etching with Er: YAG laser and both acid and laser etching and also to determine the brackets / adhesive failure mode.

MATERIAL AND METHODS

A total of 45 freshly extracted human premolars extracted for orthodontic purpose were selected for the study. The selection criteria included teeth with intact buccal enamel, caries free, no cracks due to extraction forceps and teeth not subjected to any pretreatment chemical agents such as alcohol, formalin or hydrogen peroxide. These teeth were thoroughly cleaned of any soft tissue debris, blood and were stored immediately in 'Thymol' at room temperature until testing.

Sample preparation for testing shear bond strength

The selected teeth were mounted in cold cure acrylic resins poured into rectangular moulds made according to the zig size of the Instron machine. The teeth were embedded in the acrylic vertically in such a way that the long axis of the teeth was parallel to the central axis of rectangular moulds and only the occlusal surface was visible. After mounting the samples were stored in distilled water for 12 hours at room temperature.

The mounted samples were randomly divided into three groups with each group having equal number of teeth: Group a, Group B and Group C. Samples in each group were numbered from 1 to 15 for proper identification.

Before etching, the buccal surfaces of all the teeth were polished using fluoride free pumice paste with prophylactic rubber cup, for 10 seconds and then thoroughly rinsed with a stream of water for 10 seconds, dried with oil free compressed air source.

The dried enamel surfaces of the samples were treated as follows:

- Group A were treated with acid-etching using 37% orthophosphoric acid for 15 seconds.
- Group B were laser etched with Er: YAG laser (Fotona Lares, wavelength, 2 940 nm; 150 mJ/pulse, 10 pulses per second, 10 seconds) (Figure 1).
- Group C samples were subjected to acid etch followed by laser treatment with Er: YAG.

Bonding of the brackets

To standardize the technique single operator did the bonding. A single coat of light cure adhesive primer (Transbond XT- 3M Unitek Monrovia, Calif) was applied with the help of brush and cured for 10 seconds.

Then light cure adhesive paste (Transbond XT- 3M Unitek Monrovia, Calif) (Figure 2) was placed on the pre-molar PEA metal bracket base [Class I Orthodontics – Freedom Mim Roth, (Bracket base area: 10.5mm^2)] (Figure 2) which was earlier coated with a single layer of adhesive primer and the brackets were placed on the prepared teeth, at pre-determined area.

Brackets were adjusted to their final positions and pressed closely against the teeth surfaces. Excess adhesive flash surrounding the periphery of the brackets was carefully removed with an explorer.

The adhesive was cured for light curing was performed for a total of 40 seconds by irradiating the mesial, distal, occlusal, and gingival aspects of the tooth for 10 seconds each. These teeth then were stored in the distilled water at room temperature for 24 hours. Figure 3 shows the specimens used in the study after etching, after bonding and after debonding.

Testing Apparatus

Shear bond strength of all the samples were determined using a universal testing machine. A Universal Testing Machine (Instron 3382) at CIPET (Lucknow) with a chisel edge mounted on the crosshead of a testing machine with a load cell carrying 0-3000 Kilograms was attached to the machine. A crosshead speed of 1 mm / minute was used to debond the brackets.

The acrylic block holding the tooth for shear bond test was positioned so that the force was applied to the bonded bracket, parallel to the buccal surface of tooth (Figure 4).

The shear strength was tested for each sample and the point of breakage for each sample were recorded in Kilograms and converted into Megapascals (Mpa).

$$\text{Shear bond strength in Megapascals} = \frac{\text{Debonding force in kilograms} \times 9.81}{\text{Bracket base area } (10.5\ \text{mm}^2)}$$

Residual adhesive

The surface of remained resin on enamel was observed and the amount of remained adhesive was evaluated according ARI developed by Artun and Bergland.

ARI SCORES

0: No Adhesive on Tooth

1: Less Than Half of the Enamel Bonding Site Was Covered With Adhesive

2: More Than Half of the Enamel Bonding Site Was Covered With Adhesive

3: The Enamel Bonding Site Was Covered Entirely With Adhesive

Data obtained was subjected to statistical analysis to know the significance of difference within groups tested, after debonding. Descriptive statistics, including the mean, standard deviation, and minimum and maximum values, were calculated for each group.

Shear bond strength data were summarized as Mean ± SE and compared by non-parametric Kruskal-Wallis (H) analysis of variance (ANOVA) by ranks as data were not normal and heterogeneous in nature. ARI scores were compared by chi-square (χ^2) test. A two-sided (α=2) $p<0.05$ was considered statistically significant. Analysis was performed on STATISTICA (window version 6.0) software.

RESULTS

Shear bond strength

The shear bond strength of three groups (Group A: acid-etched, Group B: laser-etched and Group C: acid-etched and laser-etched) are summarized in Table 1 and also shown graphically in Figure 5.

Table 1 and Fig. 5 both showed that the mean shear bond strength of Group B was comparatively higher than both Group A and Group C.

Comparing the mean shear bond strength of three groups, ANOVA revealed significantly ($p<0.01$) different shear bond strength among the groups (H: 2, 45=9.66, p=0.008). Further, pair wise multiple comparisons (Table 2) showed that the mean shear bond strength of Group B was significantly ($p<0.01$) different and 60.3% higher as compared to Group A (Mean ± SE: 6.48 ± 1.31 vs. 16.33 ± 2.68, Z=3.02; p=0.008). However, the mean shear bond strength did not differed ($p>0.05$) between Group B and Group C though it was 29.7% higher in Group B as compared to Group C (16.33 ± 2.68 vs. 11.48 ± 1.47, Z=0.86; p=1.000). Further, the mean shear bond strength also not differed ($p>0.05$) between Group A and Group C though it was 37.8% higher in group C as compared to Group A (6.48 ± 1.31 vs. 11.48 ± 1.47, Z=2.15; p=0.094).

ARI score

The ARI scores of three groups are summarized in Table 3 and also shown graphically in Fig. 6. Table 3 and Fig. 6 both showed that the frequency (%) of ARI score "0" was highest in Group A (33.3%), followed by Group B (13.3%) and Group C the least (6.7%). In contrast, ARI score "1" was highest in Group C (60.0%), followed by Group A (33.3%) and Group B the least (20.0%). Further, ARI score "2" was higher and similar in both in Group B (26.7%) and Group C (26.7%) as compared to Group A (13.3%). However, ARI score "3" was highest in Group B (40.0%) followed by Group A (20.0%) and Group C the least (6.7%). Comparing the ARI scores among the groups, χ^2 test revealed similar ($p>0.05$) proportions of ARI scores among the groups (χ^2=11.14, p=0.084) i.e. not differed statistically.

Fig-1: Laser Etching of Enamel with ErYAG laser

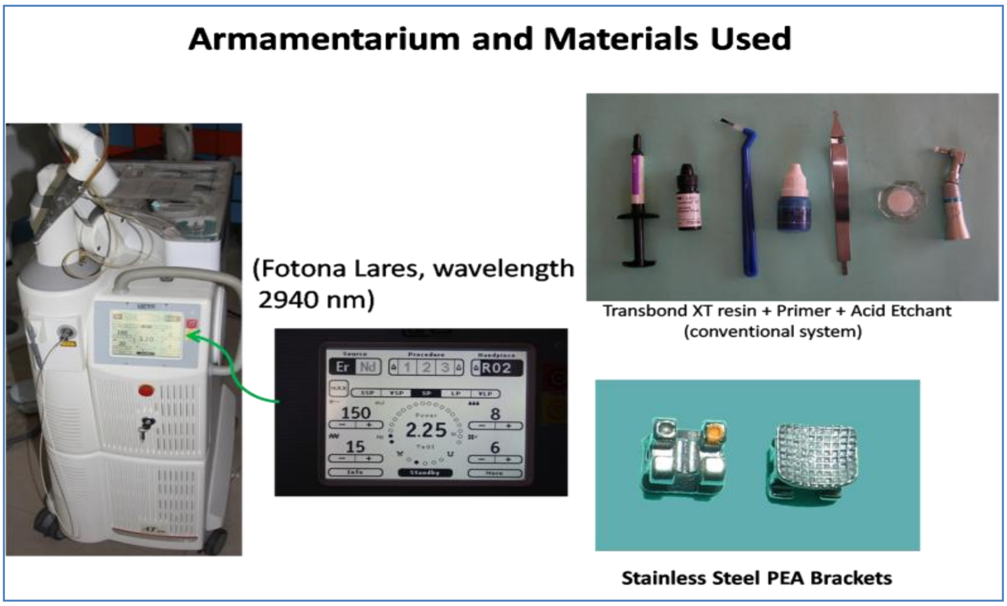

Fig-2: Armamentarium used for the study

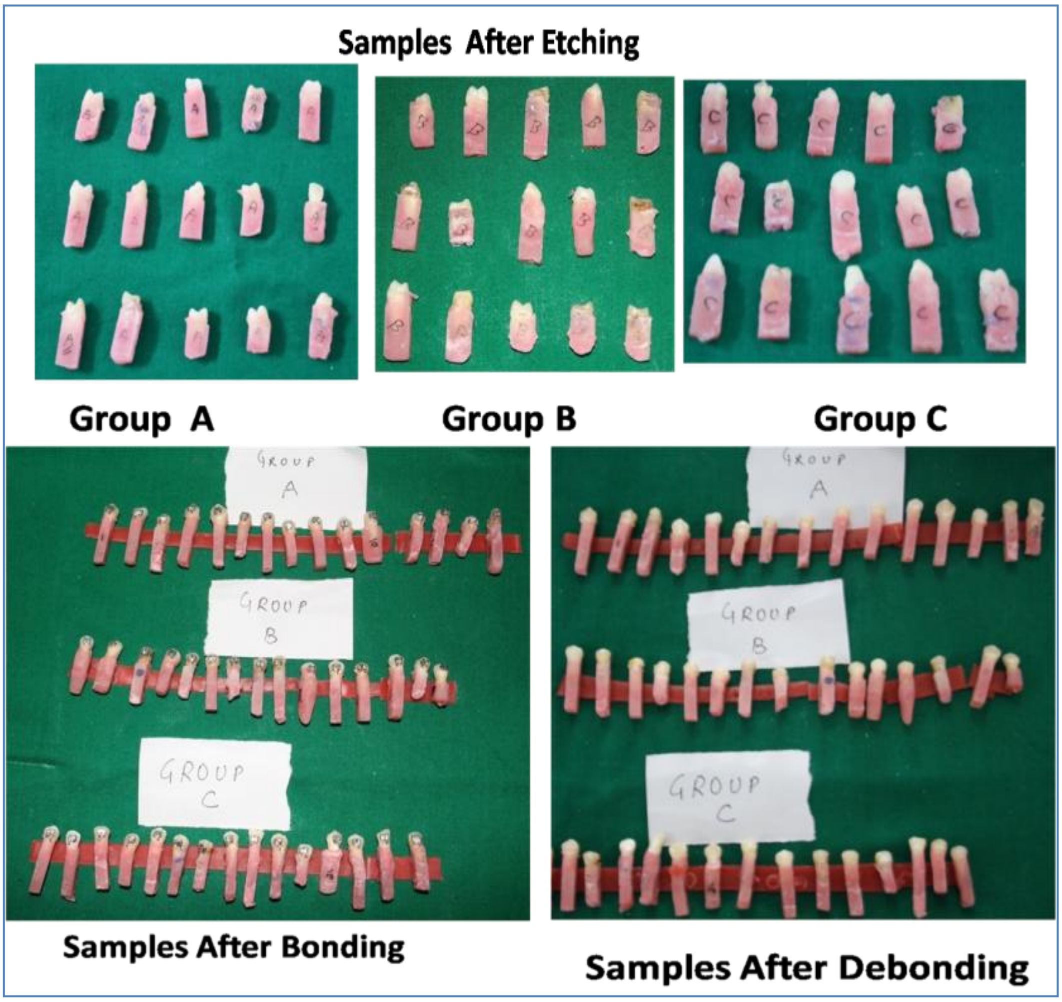

Fig-3: Samples for the study - After etching, Bonding and Debonding

Fig-4: Mounted Specimen for checking Shear Bond Strength

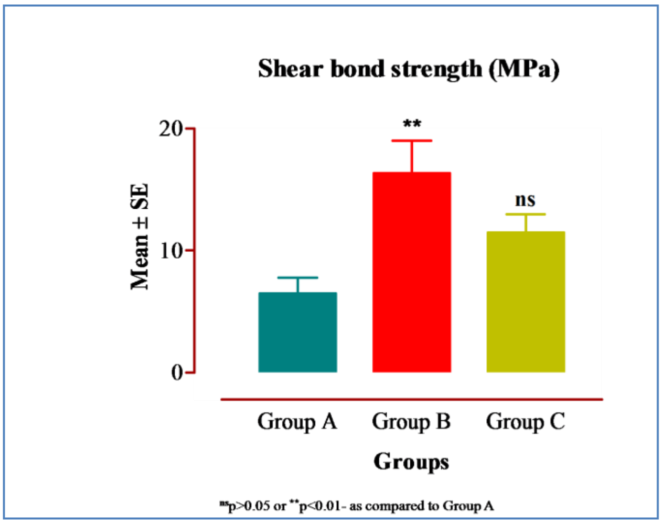

Fig-5: Comparative shear bond strength (MPa) of three groups

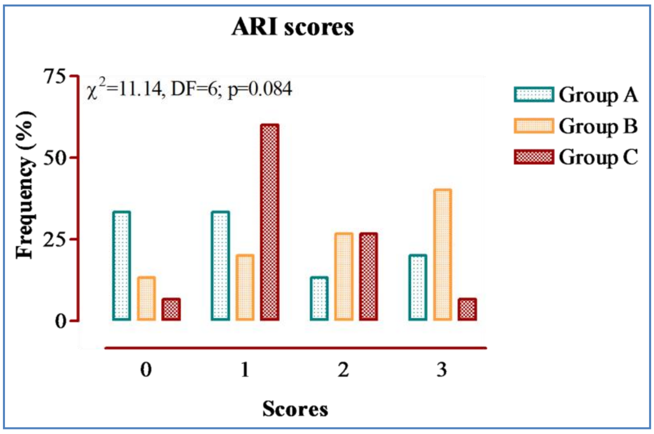

Fig-6: Distribution of ARI scores of three groups

Table-1: Shear bond strength (MPa) of three groups

Statistic	Group A	Group B	Group C	ANOVA H(2,n=45)	p value
N	15	15	15	9.66	0.008
Mean	6.48	16.33	11.48		
Median	6.15	16.93	9.88		
SD	5.09	10.40	5.71		
SE	1.31	2.68	1.47		
Min	0.79	2.81	4.09		
Max	18.64	32.94	22.41		

Table-2: Comparisons of mean shear bond strength among the groups

Comparisons	Z value	p value
Group A vs. Group B	3.02	0.008
Group A vs. Group C	2.15	0.094
Group B vs. Group C	0.86	1.000

Table-3: Distribution of ARI scores of three groups

ARI scores	Group A (n=15)	Group B (n=15)	Group C (n=15)	χ^2 value (DF=6)	p value
0	5 (33.3%)	2 (13.3%)	1 (6.7%)	11.14	0.084
1	5 (33.3%)	3 (20.0%)	9 (60.0%)		
2	2 (13.3%)	4 (26.7%)	4 (26.7%)		
3	3 (20.0%)	6 (40.0%)	1 (6.7%)		

ARI scores:
0: no adhesive on tooth
1: less than half of the enamel bonding site was covered with adhesive
2: more than half of the enamel bonding site was covered with adhesive
3: the enamel bonding site was covered entirely with adhesive

DISCUSSION

Maijer and Smith [9] in their study stated that for successful clinical bonding, shear bond strength of 6-8 MPa is essential for orthodontic treatment. For achieving successful bonding, the bonding agent must penetrate to the enamel surface; have easy clinical use, dimensional stability and enough bond strength.

Hard-tissue lasers were introduced in dentistry nearly 20 years ago and a number of wavelengths have been tried and experimented upon for ablation of hard tissue, including enamel, dentin, cementum and bone [10, 11].

Er:YAG (erbium-doped yttrium aluminium garnet) lasers have been effective in the removal of dental tissues. It has been suggested that they are also useful for preparing dental surfaces for adhesion, but results to date have been controversial [12].

The bond strength of orthodontic brackets should be enough to not cause bonding failure and delay in treatment and it also should have adequate resistance against chewing forces and stresses from archwires [13]. On the other hand, easy debonding of the brackets without any damage to the teeth needs sufficient and safe bond strength [14].

In the present study, the shear bond strength of three groups (Group A: acid-etched, Group B: laser-etched and Group C: acid-etched and laser-etched) showed that the mean shear bond strength of Group B and Group C were comparatively higher than Group A.

These findings reduced the credibility of laser application for enamel preparation, considered as an unfavorable characteristic. The reason may be related to the irregular etching pattern of surfaces irradiated by laser. Sasaki *et al*. [15] found that preparation of enamel surfaces by Er: YAG laser cannot be done homogeneously. Surfaces irradiated by laser showed some areas which were similar to unlased enamel surfaces but surface preparation by acid etch technique showed more homogeneous patterns which was like honey comb pattern that is favorable structure for adhesion process.

Controversial results were obtained from different studies which evaluated the effect of laser irradiation compared to conventional methods due to different study designs and various Parameters used in these studies [16, 17].

In the present study there was a significant difference between laser group and conventional group. Both laser groups had higher bond strengths than the acid-etch group. In similarity, Uşümez *et al*. [18] reported higher distribution coefficient for shear bond strength of orthodontic brackets in laser prepared surfaces.

However, high variances of values in bond strength of irradiated enamel should be considered to find the appropriate parameters for applying Er: YAG laser as a favorable alternative for surface conditioning.

Laser delivery devices today have a number of parameters that can be modified by the clinician like pulse mode, power density and frequency to obtain the desired results.

Ozen *et al*. [19] conducted a study using different irradiation powers to prepare the tooth enamel for bonding using Er, Cr: YSGG laser. It was found that with a 1.50-W laser produced sufficient etching for orthodontic bonding, but irradiation with the 0.75-W laser did not.

Through this study we have concluded that lasers definitely can be used as an alternative to conventional procedures considering the fact that correct parameters of energy levels are choosen to obtain the desired resuts for bonding procedures. We concluded that the correct parameter of energy level has to be chosen to get the desired result for bonding procedures

CONCLUSION

The study found the mean SBS obtained with a laser-etched procedure is more effective than acid-etched procedure and both acid and laser-etched procedures in the management of orthodontic bonding.

The site of failure in brackets bonded with laser etching is dominantly at adhesive enamel interface and is not safe for enamel during debonding.

Lasers definitely can be used as an alternative to conventional procedures but the correct parameter of energy level has to be chosen to get the desired result for bonding procedures.

REFERENCES

1. Eslamian,L., Farahani, A.B., Mousavi, N., Ghasemi, A. (2011). The effects of various surface treatments on the shear bond strengths of stainless steel brackets to artificially-aged composite restorations. *Aust Orthod J, 27* (1),28-32

2. Vilchis, S. R.J., Yamamoto, S., Kitai, N., Yamamoto, K. Shear bond strength of orthodontic brackets bonded with different self-etching adhesives. (2009) *Am J Orthod Dentofacial Orthop, 136* (3), 425-30.
3. Holtan, J.R., Nystrom, G.P., Phelps, R.A., Anderson, T.B., Becker, W.S. (1995) Influence of different etchants and etching times on shear bond strength. *Oper Dent. May-Jun, 20*(3); 94-9.
4. Buonocore, M.G. (1955). A simple method of increasing the adhesion of acrylic filling material to enamel surfaces. *J Dent Res.*, *34*, 849-853.
5. Newman, G.V. (1964). Bonding plastic orthodontic attachments to the tooth enamel. *J New Jersey Dent Soc*., 35, 346-358.
6. Basaran,G., Özer, T., Berk, N., and Hamamcı, O. (2007) Etching Enamel for Orthodontics with an Erbium, Chromium:Yttrium-Scandium-Gallium-Garnet Laser System . *Angle Orthod.*, *77,* 1; 117-124
7. Attrill, D.C, Farrar, S.R., King, T.A., Dickinson, M.R., Davies, R.M., Blinkhorn, A.S. (2000). Er: YAG Laser Etching of Dental Enamel as an Alternative to Acid Etching. *Lasers Med Sci, 15*, 154–16.
8. Liu, J., Liu, Y., Stephen, H.C.Y. (2006). Optimal Er: YAG laser energy for preventing enamel demineralization. *Journal of Dentistry, 34*, 62–66.
9. Maijer, R., Smith, D.C. (1979) A new surface treatment for bonding. *J Biomed Mater Res Nov, 13*(6); 975-85.
10. Featherstone, J.D.B., Fried, D. (2001) Fundamental Interactions of Lasers with Dental Hard Tissues. *Med. Laser Appl.*, *16*; 181–194.
11. Featherstone, J.D.B., Nelson, D.G.A. (1987). Laser Effects on Dental Hard Tissues Adv. *Dent. Res.*, *1*(1), 21–26.
12. Insua, M. A., Dominguez, D.S.L., Rivera, F.G., Penín, S.U.A. (2000). Differences in bonding to acid-etched or Er:YAG-laser-treated enamel and dentin surfaces. *J Prosthet Dent. Sep, 84*(3), 280-8.
13. Arnold, R.W., Combe, E.C., Warford, J.H. Jr. (2002). Bonding of stainless steel brackets to enamel with a new self-etching primer. *Am J Orthod Dentofacial Orthop Sep, 122*(3), 274-6.
14. Rajagopal, R., Padmanabhan, S., Gnanamani, J. (2004) A Comparision of shear bond strength and debonding charactristics of conventional, moisture-insensitive and self-etching primer. *The Angle Orthod Apr*, *74*(2), 264-8.
15. Sasaki, L.H., Lobo, P.D., Moriyama, Y., Watanabe, I.S., Villaverde, A.B., Tanaka, C.S. (2008). Tensile bond strength and SEM analysis of enamel etched with Er: YAG laser and phosphoric acid: a comparative study in vitro. *Braz Dent J, 19*(1), 57-61.
16. Hosseini, M.H., Namvar, F., Chalipa, J., Saber, K., Chiniforush, N., Sarmadi, S., & Mirhashemi. A.H. (2012) Comparison of Shear Bond Strength of Orthodontic Brackets Bonded to Enamel Prepared By Er: YAG Laser and Conventional Acid-Etching J Dent (Tehran). *Winter, 9*(1), 20–26.
17. Raji S. H., Birang , R., Majdzade, F., Ghorbanipour, R. (2012) Evaluation of shear bond strength of orthodontic brackets bonded with Er-YAG laser etching. Dent Res J (Isfahan) *May-Jun, 9*(3), 288–293.
18. Uşümez, S., Orhan, M., Uşümez, A. (2002). Laser etching of enamel for direct bonding with an Er, Cr: YSGG hydrokinetic laser system. *Is J Orthod Dentofacial Orthop Dec*, *122*(6), 649-56.
19. Ozer, T., Başaran, G., Berk, N. (2000). Laser etching of enamel for orthodontic bonding. *J Prosthet Dent. Sep, 84*(3), 280-8.