Scholars Journal of Dental Sciences

OPEN ACCESS

Abbreviated Key Title: Sch J Dent Sci
ISSN 2394-4951 (Print) | ISSN 2394-496X (Online)
Journal homepage: https://saspublishers.com

Comparison of Shear Bond Strength of Orthodontic Brackets Bonded to Enamel Prepared by Er: Yag Laser and Conventional Acid Etching Technique-An in-Vitro Study

Dr. Harish Kumar N, BDS, MDS[1*]; Dr. Badri Narayanan, BDS, MDS[2]; Dr. Vinaya S. Pai, BDS, MDS[3]; Dr. Siri Krishna, BDS, MDS[4]; Dr. Manjunath Hegde, BDS, MDS[5]

[1]Assistant Professor, Department of Orthodontics AND Dentofacial Orthopedics, Bangalore Institute of Dental Science and Hospital, Bangalore-560027, India
[2]Orthodontics, Bangalore Institute of Dental Sciences and, Hospital, Bangalore-560027, India
[3]Professor, Bangalore Institute of Dental Sciences and Hospital, Bangalore-560027, India
[4]Professor, Bangalore Institute of Dental Sciences and Hospital, Bangalore-560027, India
[5]Professor and Head, Bangalore Institute of Dental Sciences and Hospital, Bangalore-560027, India

DOI: https://doi.org/10.36347/sjds.2024.v11i06.001 | **Received:** 02.07.2024 | **Accepted:** 07.08.2024 | **Published:** 09.08.2024

***Corresponding author**: Dr. Harish Kumar N, BDS, MDS
Assistant Professor, Department of Orthodontics AND Dentofacial Orthopedics, Bangalore Institute of Dental Science and Hospital, Bangalore-560027, India

Abstract **Original Research Article**

***Background*:** Brackets are one of the important components in orthodontic treatment which helps in transferring forces to the teeth to appreciate teeth movement. So, it is very important to have a better bond strength between brackets and teeth which can be achieved by different materials and techniques. Initially, etching (surface preparation) was done on the surface of the teeth by acid (37% phosphoric acid) to bond brackets directly to the teeth. Later with the introduction of lasers, surface preparation was done using Er: YAG laser which was considered as an alternative and better technique when compared with the conventional acid technique. ***Objective*:** To compare the differences in shear bond strength of orthodontic brackets bonded to enamel prepared by Er: Yag laser and conventional acid etching technique. ***Results*:** The shear bond strength of the acid group showed the least bond strength. ARI Index shows that group 3 laser etched group had major bond failure at favorable site with most number of score value between score1 to 3. ARI Index of group A & B showed most number of score value between score4 to 5 with major bond failure at unfavorable site. ***Conclusion*:** ANOVA and Chi-square test revealed statistically significant difference between 3 different groups on assessing the SBS and ARI Index. Group C (laser etched group at W. 1mJ & 10Hz) showed better bond strength at a clinically acceptable level and also had major bond failure at favorable site which produces least damage to the enamel surface. Group B laser etched group even though had higher bond strength of 15.95 MPa, their value highly deviates from the clinically required level of 8Mpa.

Keywords: Er: YAG laser; Shear bond strength; Orthodontic brackets.

INTRODUCTION

Orthodontic treatment involves the use of both removable and fixed appliances. It is widely documented that fixed appliances are more efficient at correcting malocclusions than removable appliances and therefore fixed appliances are more commonly used in contemporary orthodontic practice [1].

In fixed orthodontic treatment brackets are important to transfer forces to the tooth surface. Initially, brackets were welded to the bands followed by cementation [2].

The separation process, was accomplished initially by placing brass wires and later elastomeric. Many orthodontists found this as a disadvantage due to gingival trauma and decalcification on using bands for welding brackets. Therefore, the obvious solution to these problems for the clinician was to attach the brackets directly to the enamel surface of the teeth thus eliminating the need for banding [3].

The evolution of orthodontic materials started from the past five decades till the present, which has a unique progress curve characterized by periods of

intense activity with many developments [4].

Rapid strides in material science over the years have produced progressively advanced materials making the direct bonding procedure more precise, comfortable, time- effective [5] and also acceptable among patients [5].

Acid etching changes the enamel surface from a lower energy hydrophobic to a higher energy hydrophilic surface, showing increase surface tension and wettability [6].

Bonding of brackets between composite to porcelain interface was possible by using chemical etchants like silane couple agent and 10% hydroflouric acid [7].

Laser an acronym for "Light Amplification by Stimulated Emission of Radiation" had started its evolution in 1960, where the first functioning laser was built by an American Physicist Maiman at the Hughes Research Laboratories by using a synthetic ruby crystal made of aluminium oxide and chromium oxide [8].

With the recent introduction of Erbium-doped yttrium aluminium garnet (Er:YAG) laser in dentistry for the ablation of hard tissues, including enamel and dentin, laser enamel preparation has been proposed as an alternative to phosphoric acid etching. This was approved in 1997 by the U.S. Food and Drug Administration (FDA). Laser was initially used for ablation of dental hard tissue with an early report suggesting an increase in acid resistance on the enamel adjacent to the ablated area [9].

Shear bond strength (SBS) is the main factor, which is concerned with the evolution of bonding materials, were the bond strength of orthodontic brackets should be able to withstand masticatory forces and forces applied during orthodontic treatment. Reynolds stated that mean shear bond value should be between 5.9-7.8MPa to withstand orthodontic force and to prevent brackets from frequent debonding [6].

Hence the purpose of this study was to compare the shear bond strength of orthodontic brackets bonded to the enamel of tooth surface etched by Er:YAG (Erbium doped yttrium aluminium garnet laser) laser with conventional acid etching.

The null hypothesis states that there was no significant difference between shear bond strength of brackets bonded to enamel prepared using Er:YAG laser and conventional acid etching.

Aim

The purpose of this study was to compare the effectiveness of shear bond strength of brackets bonded to enamel with its surface preparation using Er: YAG laser with two different power outputs in comparison to the conventional acid etch technique.

MATERIALS AND METHOD

Study Design

Samples collected were mounted in the PVC pipes filled with self-cure acrylic resin, where, the crown surface was above the level of acrylic resin so that it can be held in the clamp of the universal testing machine

The enamel surface of each tooth was first polished using pumice. The teeth were then washed with distilled water and air-dried.

Materials

a) Acid etchant - 37% Phosphoric acid (3M Unitek)
b) Erbium, chromium: yttrium, scandium, gallium, garnet Laser (Fontana, light walker, Slovenia)
c) Light emitting diode (Elipar Deep cure –L, 3M Unitek) (Fig 2)
d) Bonding agent (Transbond XT, 3M)
e) Adhesive (3M Unitek)
f) MBT 0.022" Premolar Brackets (3M, Gemini series)
g) Universal Testing machine (50kN/2.5Kn, Make: FIE, Model: UNITEK 9450)

- This in-vitro study was designed to evaluate the difference in shear bond strength of orthodontic brackets bonded to enamel prepared by Er:YAG laser and conventional acid etching technique.
- 60 extracted human premolar teeth that fulfill the inclusion criteria were selected for the study from patients who underwent extraction for orthodontic treatment in the Department of Orthodontics and Dentofacial Orthopedics at Bangalore Institute of Dental Sciences & Post-Graduate Research Centre, Bangalore.

Sample selection:

Inclusion criteria:

- Extracted premolar teeth (as part of patient's orthodontic treatment protocol)
- Extracted teeth free of dental caries, attrition, abrasion, abfraction and fluorosis

Exclusion criteria:

- Teeth affected by dental caries, attrition, abrasion, abfraction and fluorosis
- Tooth having restoration.
- The mounted samples were divided into three groups, 20 each based on the type of etching technique and its parameters:

GROUP A (Purple colour) (n=20) = Conventional acid etching (37% phosphoric acid)
GROUP B (Green colour) (n=20) = Er:YAG Laser irradiation at 1W, 100mJ & 10Hz power output
GROUP C (Yellow colour) (n=20) = Er:YAG Laser irradiation at 1.5W, 150mJ & 10Hz power output

The PVC pipes were wraped with three different colour papers with labels (GA, GB and GC) to differentiate among the three groups; the samples in each group were numbered from S1 to S20.

Group A: The enamel surfaces were etched with 37% orthophosphoric acid for 30 seconds, followed by thorough washing and drying.
Group B: Laser irradiation was done with an output power of 1W, energy of 100mJ and frequency of 10 Hz.
Group C: Laser irradiation was done with an output power of 1.5W, energy of 150mJ and frequency of 10Hz.

- After etching a single coat of light cure adhesive primer (Transbond XT, 3M Unitek) was applied on the tooth surface using an applicator tip (Fig 14) and then cured using Light Emitting Diode light curing unit (3M UNITEK) with a wavelength of 430-480nm.
- After the brackets were debonded, adhesive remnant index (ARI) was used to assess the amount of adhesive resin retained on the enamel surface of each tooth to find the site of bond failure.
- The remnant adhesive on the enamel surface of the tooth was evaluated using a stereomicroscope at a magnification of 10× scored from 1 to 5.

Table 1: Adhesive Remnant Index score of 1 to 5

SCORE	Remnant Adhesive on Enamel Surface
SCORE 1	100% Composite remaining on enamel tooth surface
SCORE 2	More than 90% of the composite remaining on the enamel tooth surface
SCORE 3	More than 10% and less than 90% of the composite remaining on the enamel surface
SCORE 4	Less than 10% of the composite remaining on the enamel surface
SCORE 5	No composite remaining on the enamel surface

RESULTS

Sample size estimation

The sample size was estimated using the G-Power software v. 3.1.9. [(Franz Faul, Universität Kiel, Germany)]. The effect size to be measured (d) at 42%, power of the study at 80% and the alpha error at 5%, the sample size needed was obtained at 60 which was divided into three categories with 20 samples in each.

Therefore, the total sample size was 60, which was divided into three groups:

- Group A : 20
- Group B : 20
- Group C : 20

This in-vitro study was designed to evaluate the difference in shear bond strength of orthodontic brackets bonded to enamel prepared by Er:YAG laser and conventional acid etching technique.

60 extracted human premolar teeth that fulfill the inclusion criteria were selected for the study from patients who underwent extraction for orthodontic treatment in the Department of Orthodontics and Dentofacial Orthopedics at Bangalore Institute of Dental Sciences & Post-Graduate Research Centre, Bangalore.

Table 2 and Graph 1 depicts the difference in shear bond strength (in Mpa) among the three different groups using one-way ANOVA test.

The shear bond strength of orthodontic brackets bonded to enamel prepared (etched) by Er:YAG laser

with an output power of 1W, energy of 100mJ and 10Hz (Group B) had the highest shear bond strength.

The surface prepared by Er:YAG laser with an output power of 1.5W, energy of 150mJ and 10Hz (Group C) had higher shear bond strength than the control group etched with 37% phosphoric aid (Group A).

High statistically significant difference was observed in the shear bond strength between three different groups.

Table 3 depicts the multiple pairwise comparisons of mean difference in Shear Bond Strength among the groups using Tukey's Post hoc Test.

Graph 2 depicts the difference in shear bond strength (Mpa) among the three different groups which is arranged in descending order

High statistical significance was observed.

i. Group B showed the highest mean shear bond strength when compared with Group A (P<0.001) and Group C (P=0.002).
ii. Group C showed a higher mean shear bond strength than Group A (P<0.001).

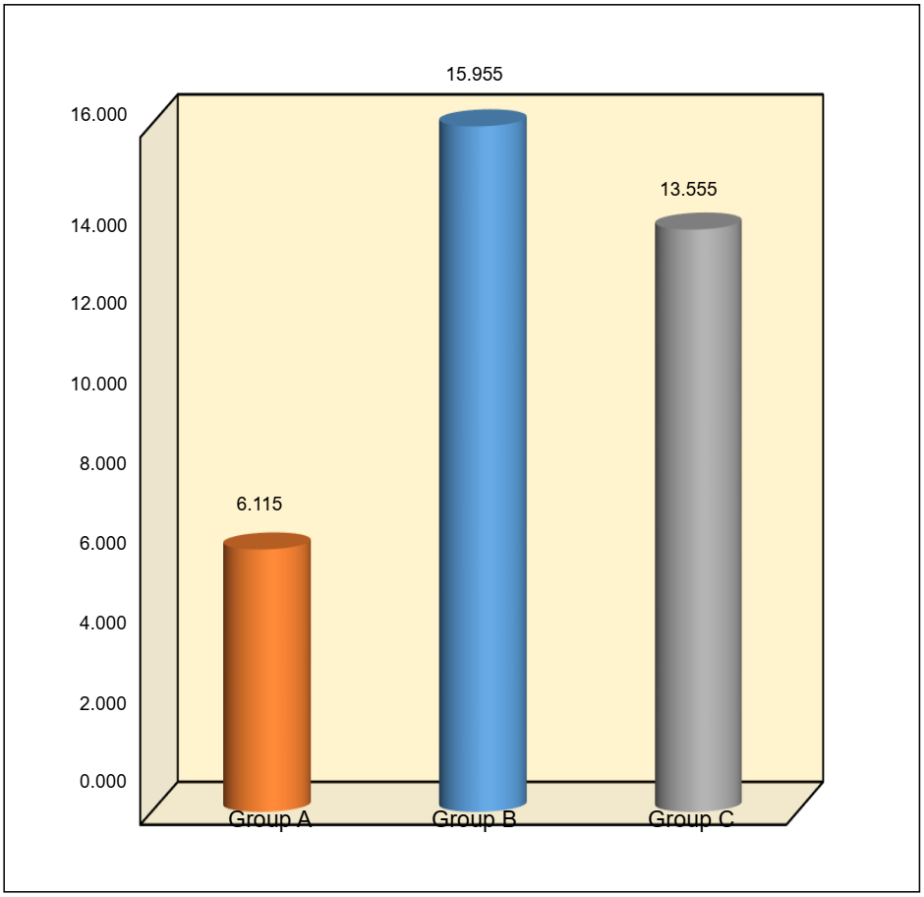
Table 2: Comparison of mean Shear Bond Strength (in Mpa) between different groups using One-way ANOVA Test

Groups	N	Mean	Standard Deviation	Min	Max	P-value
Group-A: Acid Etching 37% Phosphoric acid	20	6.115	1.677	3.60	8.60	<0.001*
Group-B: Er: YAG Etching 1W, 100mJ, 10Hz	20	15.955	2.385	10.80	21.40	<0.001*
Group-C; Er: YAG Etching 1.5W, 150mJ, 10Hz	20	13.555	3.002	6.00	18.00	<0.001*

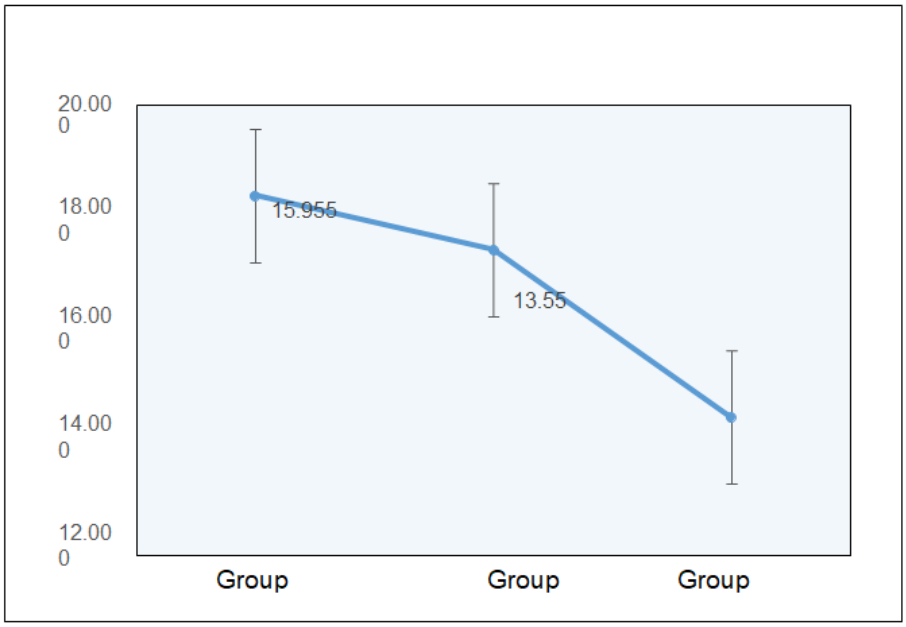
*- indicates statistically significant

Table 3: Multiple pairwise comparison of mean diff. in Shear Bond Strength b/w groups using Tukey's Post hoc Test

(I) Groups	(J) Groups	Mean Diff. (I-J)	95% CI for the Diff.		P-Value
			Lower	Upper	
Group A	Group B	-9.840	-11.678	-8.002	<0.001*
	Group C	-7.440	-9.278	-5.602	<0.001*
Group B	Group C	2.400	0.562	4.238	0.002*



Graph 1: Difference in shear bond strength (in Mpa) among the three different groups



Graph 2: Mean Shear Bond Strength (in Mpa) among different groups [Arranged in descending order]

DISCUSSION

Tooth movement can be clinically accomplished by means of removable and fixed appliances. Even though removable appliances are less visible when compared with fixed appliance, they cannot move teeth in all three planes of space as effectively as full-banded appliances [10]. Removable appliances are also not as efficient or consistent in producing optimum correction. Full-banded appliances even though they have more precision control, they require more chair side time for fabrication [10].

Bonding of brackets directly to the tooth surface was possible after the introduction of acid etch technique in 1955 [11] by Buonocore. Newman in 1964 started applying this technique in direct bonding of brackets to enamel surface using epoxy adhesives and polycarbonate brackets, which has been accepted worldwide after Zachrisson published his study on post-treatment evaluation of direct bonding over a full period of orthodontic treatment in a large sample of individuals [1, 12].

Olsen *et al*., [13] stated that better bond strength can be obtained when the time taken for acid-etching is between 10- 30 sec which is similar to the study done by Beech D. R & Jalaly T [14] where better bond strength was obtained even on etching for 5 and 15seconds.

This bond strength was similar to the bond strength obtained on etching for 1- minute.

Chung and Hwang [15] conducted a study to evaluate the effectiveness of using sandblasting on non-enamel surface (metal and porcelain) and concluded that sandblasting the metal and porcelain surface has provided a better bond strength.

Chung *et al.*, [16] suggested that direct sandblasting on tooth surface provides the bond strength at clinically acceptable level and is also a viable alternative to chemical etching techniques for natural tooth structure.

In 1960s, after Maiman introduced the ruby laser, several types of laser have been applied in dentistry, such as carbon dioxide (CO_2) laser, neodymium-doped: yttrium aluminum garnet (Nd:YAG) laser and diode lasers [17]. These lasers were suitable for soft-tissue treatment especially in periodontology while the later available mid- infrared lasers (erbium-doped yttrium aluminum garnet [Er:YAG] and erbium, chromium: yttrium, scandium, gallium, garnet [Er,Cr:YSGG]) allow ablation of both soft and hard-tissues with minimal thermal side-effects [18].

CONCLUSION

From the present study, it was concluded that:

- Brackets bonded to enamel surface prepared using laser showed higher bond strength than enamel surface prepared using acid
- Group C showed better bond strength at a clinically acceptable level and its ARI evaluation showed major bond failure at a favorable site and produced least damages to the enamel surface.
- ARI evaluation of Group A and B showed that major bond failure was seen at an unfavorable site which produced more damage to the enamel surface.
- From a orthodontist point of view, lasers are used only among higher economic status patients as it might not be affordable for all types of individuals, whereas 37% orthophosphoric acid is better to use among all types of patients and provide better bonding strength.

REFRENCES

1. Hu, H., Li, C., Li, F., Chen, J., Sun, J., Zou, S., ... & Ye, Q. (2013). Enamel etching for bonding fixed orthodontic braces. *Cochrane Database of Systematic Reviews*, (11), 1-51.
2. 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. *Journal of dentistry (Tehran, Iran)*, *9*(1), 264-268.
3. Gange, P. (2015). The evolution of bonding in orthodontics. *American Journal of Orthodontics and Dentofacial Orthopedics*, *147*(4), S56-S63.
4. Rajagopal, R., Padmanabhan, S., & Gnanamani, J. (2004). A comparison of shear bond strength and debonding characteristics of conventional, moisture-insensitive, and self-etching primers in vitro. *The Angle Orthodontist*, *74*(2), 264-268..
5. Jamenis, S. C., Kalia, A., & Sharif, K. (2011). Comparative Evaluation of Shear Bond Strength of Orthodontic Brackets using Laser Etching and Two Conventional Etching Techniques: An in vitro Study. *Journal of Indian Orthodontic Society*, *45*(3), 134-139.
6. Reynolds, I. R. (1975). A review of direct orthodontic bonding. *British journal of orthodontics*, *2*(3), 171-178.
7. Andrade, C. G. D. S., Carneiro, D. P. A., Nabarrette, M., Correr, A. B., & Valdrighi, H. C. (2019). Influence of hydrofluoric acid etching time and concentration on shear bond strength of metal brackets to ceramic surfaces. *Revista de Odontologia da UNESP*, *48*, e20190102.
8. Özer, T., Başaran, G., & Berk, N. (2008). Laser etching of enamel for orthodontic bonding. *American journal of orthodontics and dentofacial orthopedics*, *134*(2), 193-197.
9. Rodríguez-Vilchis, L. E., Contreras-Bulnes, R., Sánchez-Flores, I., & Samano, E. C. (2010). Acid resistance and structural changes of human dental enamel treated with Er: YAG laser. *Photomedicine and Laser Surgery*, *28*(2), 207-211.
10. Newman, G. V. (1969). Adhesion and orthodontic plastic attachments. *American journal of orthodontics*, *56*(6), 573-588.
11. Buonocore, M. G. (1955). A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. *Journal of dental research*, *34*(6), 849-853.
12. Chow, L. C., & Brown, W. E. (1973). Phosphoric acid conditioning of teeth for pit and fissure sealants. *Journal of dental research*, *52*(5), 1158-1158.
13. Bishara, S. E., Ortho, D., & Truiove, T. S. (1990). Comparisons of different debonding techniques for ceramic brackets: an in vitro study: Part I. Background and methods. *American Journal of Orthodontics and Dentofacial Orthopedics*, *98*(2), 145-153.
14. Zachrisson, B. U. (1977). A posttreatment evaluation of direct bonding in orthodontics. *American journal of orthodontics*, *71*(2), 173-189.
15. Sakaki, T., Fukushima, T., Kawai, S., & Matsumoto, M. (1994). Effect of physical properties of direct bonding adhesives on bonding to etched enamel. *The Journal of prosthetic dentistry*, *71*(6), 552-559.
16. Chung, K., Hsu, B., Berry, T., & Hsieh, T. (2001). Effect of sandblasting on the bond strength of the bondable molar tube bracket. *Journal of oral rehabilitation*, *28*(5), 418-424.
17. Abu Alhaija, E. S., & Al-Wahadni, A. M. (2004). Evaluation of shear bond strength with different enamel pre-treatments. *The European Journal of Orthodontics*, *26*(2), 179-184.
18. Basaran, G., Özer, T., Berk, N., & Hamamcı, O. (2007). Etching enamel for orthodontics with an erbium, chromium: yttrium-scandium-gallium-garnet laser system. *The Angle Orthodontist*, *77*(1), 117-124.