***ISSN:* 1812–1217**

The Bond Strength of the Bonded Bracket to Enamel Surface Treated with Acid and Microetcher

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ABSTRACT

Aims: To evaluate shear and tensile bond strengths of the bonded brackets to the enamel surfaces treated with acid and microetcher. **Materials and methods:** The sample include 30 intact extracted upper left first premolars, the teeth were collected from orthodontics clinic and private clinics. The sample was grouped into three groups (10 teeth for each group), which were: acid etched, microetched at 5mm distance, and microetched at 10mm distance.. Stainless steel brackets (Roth System) were bonded to the buccal enamel surfaces utilizing light cure composite (transbond^{TM} XT) according to the manufacturer instructions. All the groups were thermocycled, the temperature range is 5 $\pm$ 3 ºC to 50 $\pm$ 3 ºC with a 30 seconds dwell time in each bath. The shear and tensile bond strengths of the bonded bracket were measured by using the shear and tensile Universal testing machine. The results were analyzed statistically; that include: Descriptive, ANOVA and Duncan's testes at $p \leq 0.05$ significant level. **Results**: It was reveled that the shear and tensile bond strength values of the bonded brackets to enamel treated with the acid were greater significantly than that treated with microetcher. **Conclusions**: The acid agent is considered the most practical conditioner to the enamel to achieve strong shear and tensile bond strengths.

Key words: Shear, tensile, acid etch, microetcher.

Obaidi HA, Hanna MH. The Bond Strength of the Bonded Bracket to Enamel Surface Treated with Acid and Microetcher. *Al–Rafidain Dent J*. 2009; 9(1): 71-76.
Received: 12/12/2007 ***Sent to Referees***: 12/12/2007 ***Accepted for Publication:*** 21/2/2008

INTRODUCTION

Achieving a low bond failure rate should be a high priority objective, for replacing loose brackets is inefficient, time–consuming and costly. Consequently, a continuous search is on for higher bond strengths, better adhesives, simpler procedures and materials that will bond in the presence of saliva. However, most bond failures result from inconsistencies in the bonding technique and not because of the bonding resins, inadequate bond strengths, or quality of the brackets being used [1]. Orthodontic brackets are routinely bonded to enamel using the acid–etch technique. Gardner and Hobson [2] found that the most optimal and sensible routine for acid etching is applying 37% phosphoric acid for 30 seconds.

Recently alternative approaches to bonding, including the use of different enamel preparations including microetching [3,4]. Microetching (Sandblasting/Air Abrasion) is air abrasive technology uses a high speed stream of aluminum oxide particles propelled by air pressure [5]. Air abrasion techniques relay on the transfer of kinetic energy from a stream of powder particles on the surface of tooth structures or a restoration to produce a fractured surface layer, resulting in roughness for bonding [6,7]. When these particles hit the tooth surface they abrade it without heat, vibration or noise [8].

The aims of the study are to evaluate and to compare the shear and tensile bond strengths for the bonded brackets to acid etched and microetched enamel surfaces.

MATERIALS AND METHODS

The sample included 40 extracted upper first premolars for orthodontic treatments, the teeth were collected from the orthodontics clinic of dental collage and from privet clinics in the center of Mosul

City. After extraction, the teeth were debrided of soft tissue remnants and stored initially in 70% ethyl alcohol; then the samples were kept in sterilized normal saline at room temperature to prevent dehydration [(3)]. The teeth which are used for tensile and sheer bond strength measurements prepared by doing sectioning in the cemento–enamel junction to separate crown from root [(9)].

The teeth prepared for shear bond strength measurements were mounted on a glass slide placed on the surveyor table that is previously adjusted in parallel plane with the base. The tooth was then fixed on the glass slide in an upright position using soft wax at the root apex. The analyzing rod of the surveyor (QD, England) was used to orient the teeth so that the force could be applied parallel to the buccal surface of the tooth. After that each tooth was embedded in self curing acrylic resin using a metal ring which was placed around the tooth so after complete setting of the acrylic, each tooth was rechecked for the proper orientation with the help of the analyzing rod. The teeth prepared for tensile bond strength measurements were mounted as follows: The metal ring was filled by cold cure acrylic resin about 2/3 of its height. After complete curing the sectioned tooth was placed and oriented in the surveyor, so that the force could be applied perpendicular to buccal surface, then complete pouring the ring with acrylic resin.

Acid etching of the enamel surface (Acid etching gel 32%, Bisco dental products, Itasca, USA) was achieved after polishing for 10 seconds with rubber cup and oil/fluoride free pumice, followed by rinsing with distilled water for 10 seconds and drying with oil–free compressed air for 10 seconds. Then the tooth's surface was etched for 30 seconds using 37% phosphoric acid supplied by the manufacturer. The tooth was finally rinsed with distilled water for 30 seconds and dried with oil–free compressed air for 30 seconds (according to manufacturer, Bisco dental products, Itasca, USA).

Microetching the enamel surface was performed by using a fixed microetcher (Micro etcher II, Danville engineering, USA) and sample positions had been done by two special holders, five and tine millimeters distance was fixed between the buccal surface and the tip of the microetcher utilizing electronic digital vernia (Metr-ISO-Gew, China). Enamel surfaces were micro–etched in the center area, where the bracket was to be bonded, using 50–µm aluminum oxide particles (Tru. etch, orthotechnology, Netherlands) for four seconds. The tooth was finally rinsed with distilled water for 30 seconds and dried with oil–free compressed air for 30 seconds [(4,10,11)].

Bonding Procedure was achieved by the application of mixed primers A and B to the prepared surfaces and air flush for 5–6 seconds with air syringe, a thin layer of the bonding resin (Transbond™ XT, 3M uniteck, USA) was applied to the prepared surface, and then light cured (Densply, Taiwan) for 20 seconds as close as possible enaml surface, then the Orthodontic composite resin was applied to the bracket (Stainless brackets Roth System, Ultra–minitrim, Dentaurum, Germany) base; then by using bracket clamp the bracket was gently placed in the prepared surface (according to manufacturer instruction). The sample was placed on the surveyor table which already positioned in a parallel plane with the floor. The bracket was then loaded for 20 seconds using a 200 gm load on the top of the surveying arm [(12,13)], then we removed any excess composite and then light curing each side of the bracket with 15 seconds. After 24 hours of storage in distal water at room temperature, the samples were subjected to the thermocycling procedure, which was done to simulate oral environment under laboratory conditions for 200 times [(14)]. The temperature range is 5 $\pm$ 3 ºC to 50 $\pm$ 3 ºC with a 30 seconds dwell time in each bath [(15)].

Shear and tensile bond strength measurement were done with a universal shear and tensile testing machine .with cross (ZWEGLE, F140, Germany) head speed of 0.5 mm/minute [(16)]. The force at bond failure was recorded in kilograms, and the force in mega pascal (MPa) was calculated by converting the bond force into Newton, and then dividing this by the bracket base bonding area in square meters.

The data were analyzed statistically

using the descriptive analysis (mean, stander deviation, minimum and maximum values) and analyses of variances (Anova and Duncan's Multiple Range at $p \leq 0.05$ significant level).

RESULTS

Descriptive statistics that include mean, standard deviation, minimum and maximum value of the shear and tensile bond strengths for the three enamel surface treatment methods are listed in Table (1) . The findings of the present study showed that acid etched enamel group gave rise to the highest mean for the shear and tensile bond strengths, while microetching enamel group at 10 mm distance gave rise to the lowest one.

Table (1): Descriptive statistics of the bond strengths for bonded bracket to the acid and microetched enamels.

Variable	Group	No.	Mean	± SD	Min	Max
Shear	Acid Etch	10	13.06	1.96	10.22	16.00
	Microetched 5 mm	10	6.53	1.40	4.55	9.00
	Microetched 10 mm	10	4.35	0.92	2.88	5.66
Tensile	Acid Etch	10	11.65	1.90	8.91	15.00
	Microetched 5 mm	10	4.35	0.98	2.88	5.74
	Microetched 10 mm	10	2.84	0.79	1.99	4.56

Mean in mega pascal (MPa).

The analysis of variance (ANOVA) for the three methods showed that there is significant difference ($p \leq 0.001$) among them as illustrated in Tables (2 and 3).

Table (2): ANOVA Test for enamel shear bond strength.

Source	df	SS	MS	F–value	*p*–value
Factor	2	410.55	205.28	92.45	0.000 VHS
Error	27	59.95	2.22		
Total	29	470.51			

SS: Sum of squares; MS: Mean square; df: Degree of freedom.

Table (3): ANOVA Test for enamel tensile strength.

Source	df	SS	MS	F–value	*p*–value
Factor	2	444.15	222.08	128.64	0.000 VHS
Error	27	46.61	1.73		
Total	29	490.76			

SS: Sum of squares; MS: Mean square; df: Degree of freedom.

The result of Duncan's Multiple Range Test (Tables 4 and 5) showed that acid etching groups were significantly higher than other groups ($p \leq 0.001$).

Table (4): Duncan's Multiple Range Test for enamel shear bond strength.

Group	No.	Mean	± SD	Duncan's Grouping*
Acid Etched	10	13.06	1.96	C
Microetched 5 mm	10	6.53	1.40	B
Microetched 10 mm	10	4.35	0.92	A

*Means, in mega pascal (MPa), with different letters were statistically very highly significant ($p \leq 0.001$).

Table (5): Duncan's Multiple Range Test for enamel shear bond strength.

Group	No.	Mean*	± SD	Duncan's Grouping*
Acid Etched	10	11.65	1.90	C
Microetched 5 mm	10	4.35	0.98	B
Microetched 10 mm	10	2.84	0.79	A

*Means with different letters were statistically very highly significant ($p \leq 0.001$).

DISCUSSION

The shear bond strength of brackets adhered to acid etched revealed a significant higher shear bond strength than brackets adhered to microetched groups. This result is in agreement with Authors (4,17,18). Also this result is in agreement with Borsatto *et al.*, (19) who conducted their studies using composite without brackets. The Duncan's Multiple Range Test comparison of the mean demonstrates a significant difference at $p \leq 0.001$ level between the microetched enamel groups and the acid etched enamel groups with the latter exhibiting more shear bond strength. This could be explained as that acid etching provides micromechanical attachment by a variety of means, ranging from preferential dissolution of the prism cores resulting in a honeycomb appearance to peripheries resulting in a cobblestone appearance (20). This preferential dissolution of the prism can occur to a depth of 5–25 µ with the diameter of the defect ranging from 5–6 µ (21), whereas microetching produce a roughness of the enamel up to 5µ in depth, with ranging in width from 1 to 20µ (22), and result in irreversible loss of enamel (17) and irregular grooving with less regularly defined pattern than that demonstrated with acid etching (23). The mean shear debonding force for brackets bonded to microetched enamel with a distance of 5 mm group was still in the clinically acceptable orthodontic range for bond strength which is between 6–8 MPa (21).

The tensile bond strength of brackets adhered to acid etched group showed a significant higher tensile bond than brackets adhered to microetched groups. This result is in agreement with the Researchers (4,24). Also this result is in agreement with the Authors (7,25), (these studies used composite without brackets). The mean tensile debonding force for brackets bonded to microetched enamel group was less than half that recorded for brackets bonded to acid etched enamel group. These differences in the tensile bond strength may be due to that air–abrasion results in indiscreet removal of both organic and inorganic components of the enamel matrix which result in a relatively less effective surface roughness and provides lesser retention to the adhesive material (26), while Enamel etching with phosphoric acid created an etch pattern characterized by a deep and uniform demineralization area. These demineralized areas were infiltrated by the resin, producing well–formed resin tags penetrating into demineralized surface (27,28). So we could describe acid etching as a form of microetching, whereas sandblasting can be regarded as a form of macroetching (29). In the study, the mean tensile debonding force of bracket adhered to a microetched enamel groups is below the clinical acceptable orthodontic bond strength which disagree with Chung *et al.*, (3).

CONCLUSIONS

The conclusion derived from the study is that shear and tensile bond strengths of the bonded bracket to the acid treated enamel are more practical than that treated with microetcher.

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