

Shear and Tensile Strengths of The Bonded Bracket to The Ceramic Surface

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الخلاصة

الأهداف: تهدف الدراسة إلى تقييم قوة القص والشد على ربط الحاصرات التقيمية على أسطح الخزف المعالجة بواسطة حامض الهيدروفلوريك وحماز التخريش الدقيق. **المواد والطرق:** ضمت العينة 30 نموذج من الضواحك الأولى العلوية اليمنى تم جمعها من عيادات تقويم الأسنان والعيادات الخاصة، قسمت العينة إلى ثلاث مجموعات (10 أسنان لكل مجموعة) الأولى عوملت حامضياً والثانية عوملت بالتخريش الدقيق على بعد 5ملم والثالثة عوملت بالتخريش الدقيق على بعد 10ملم. تم ربط حاصرات تقيمية غير قابلة للصدأ على أسطح الخزف باستخدام الراتنج الضوئي، ثم تعريض المجموعات لحمام مائي. تم قياس قوة القص والشد باستخدام حمّاز قياس القص والشد ثم حللت البيانات إحصائياً باستخدام الإحصاء الوصفي وأنوفا ودنكن بقيمة بي 0.05 بعد هاماً. **النتائج:** بينت الدراسة إن قوة القص والشد للحاصرة التقيمية على أسطح الخزف المعالجة بالتخريش الدقيق على بعد 5ملم أكبر معنوياً مقارنة بالتخريش الحامضي والتخريش الدقيق على بعد 10ملم. **الخلاصة:** أسطح الخزف المعالجة بواسطة التخريش الدقيق مفضلة بقوة في ربط الحاصرات التقيمية.

ABSTRACT

Aims: To assess the shear and tensile strengths of the bonded bracket to the treated porcelain surface with hydrofluoric acid, and microetcher. **Materials and Methods:** The sample included 30 specimens of porcelain blocks (6 mm in diameter and 2mm thickness). The sample was grouped into three groups, 10 specimens for each group. The groups were: acid etched, microetched at 5mm distance, and microetched at 10mm distance. Stainless steel brackets (Roth System) were bonded to the treated porcelain surfaces using light cure Orthodontic composite resin. All the groups were thermocycled. 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 multiple analysis range testes at $p \leq 0.05$ significant level. **Results:** It was revealed that the shear and tensile bond strength values of the bonded brackets to porcelain surface treated with microetcher at 5mm distance was greater significantly than that treated with acid etch, and microetched at 10mm distance. **Conclusions:** The porcelain surface treated with microetcher is strongly recommended for bonding orthodontic brackets.

Key words: Porcelain, Bond strength, Hydrofluoric acid, Microetcher.

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INTRODUCTION

The increased number of adults seeking orthodontic treatment making clinicians often bond orthodontic brackets to teeth that have different types of restorations, including porcelain. One of the materials that particularly has presented problems to orthodontist is porcelain surface^(1,2). The difficulty that clinicians face in situation is that the porcelain surface essentially is inert; i.e., it does not bond (adhere) readily to other materials. Therefore, a number of approaches have been attempted to alter the surface characteris-

tics of porcelain to provide sufficient bond strength to allow for the placement of orthodontic brackets^(3,4).

When bonding orthodontic brackets to porcelain surfaces, it is necessary to change the inert characteristics of the surface to achieve clinically acceptable bond strength. This alteration is accomplished by either increasing the roughness of the porcelain surface by either mechanical or chemical etching⁽¹⁾. Recent advances in materials and techniques indicate that effective bonding of orthodontic attachments to non-enamel surfaces now may be poss-

ible particularly by the use of the microetcher which uses 50 μm or 90 μm aluminum oxide particles at different pressure has been advantageous for bonding to different artificial tooth surfaces⁽⁵⁻⁷⁾.

The aim of the study is to evaluate the shear and tensile bond strengths of the bonded bracket to the porcelain surface treated chemically (using 9.5% hydrofluoric acid) and mechanically (using microetcher).

MATERIALS AND METHODS

The sample included 30 porcelain specimens, 6 mm in diameter and 2mm thickness. The sample was grouped into three groups, 10 specimens for each group. The groups were: acid etched, microetched at 5mm distance, and microetched at 10mm distance. The porcelain sample was prepared as following: 30 cylindrical wax mold 6 mm in diameter and 2 mm in thickness were prepared and stone slurry was prepared and poured into container, the wax mold was then immersed into the stone in container. After complete setting of the stone, wax mold was eliminated. Porcelain powder (Dental porcelain "dentine body" major dentari prodotti, Italy), was mixed with distal water, applied with a brush on the space of the eliminated wax mold in the stone, vibrated manually and removed moisture with paper tissue. They were fired in porcelain furnace (programat x1, Ivoclar, Leichtenstein). After that a glazing was applied and re-enter the samples in the furnace again following the manufacturer instructions and as suggested by Al-Hamzi⁽⁸⁾.

The porcelain specimens that 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 specimen was then fixed on the glass slide in an upright position using soft wax at the base. The analyzing rod of the surveyor (QD, England) was used to orient the surface of the specimen so that the force could be applied parallel to the surface. After that each specimen was embedded in self curing acrylic resin using a metal ring which was placed around the specimens so after complete setting of the

acrylic, each specimen was rechecked for the proper orientation with the help of the analyzing rod. The specimen that 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 specimen was placed and oriented in the surveyor, so that the force could be applied perpendicular to surface, then complete pouring the ring with acrylic resin.

The glazed porcelain samples were etched with 9.5% hydrofluoric acid (Hydrofluoric acid gel 9.5% (Alphadent, USA). etch for 120 seconds. The samples then washed with water for 30 seconds and air dried with oil-free compressed air (according to manufacturer instructions).

Microetching the porcelain 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 ten millimeters distance was fixed between the surface and the tip of the microetcher utilizing electronic digital vernia (Metr-ISO-Gew, China). porcelain 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 porcelain sample was finally rinsed with distilled water for 30 seconds and dried with oil-free compressed air for 30 seconds.

The etched porcelain surface received a ceramic primer (saline coupling agent, All bond 2 universal bonding agents, Bisco dental products, Itasca, USA) for 90 seconds then air dried (according to manufacturer), bonding procedure was achieved by the application of mixed primers to the prepared surfaces and air flush for 5-6 seconds with air syringe, a thin layer of the bonding resin (TransbondTM XT, 3M uniteck, USA) was applied to the prepared surface, and then light cured (Densply, Taiwan) for 20 seconds as close as possible as to the surface, then the Orthodontic composite resin was applied to the bracket (Stainless brackets, Roth System, Ultraminitrim, 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 (QD, England) 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^(9,10), 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, All the samples were subjected to the thermocycling procedure, which was done to simulate oral environment under laboratory conditions for 200 times⁽¹¹⁾. The temperature range is 5 ± 3 °C to 50 ± 3 °C with a 30 seconds dwell time in each bath⁽¹²⁾.

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⁽³⁾. 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 millimeters.

The data were analyzed statistically using the descriptive analysis (mean, standard deviation, minimum and maximum values) and analyses of variances (ANOVA and Duncan's multiple analysis range test at $p \leq 0.05$ significant level).

RESULTS

Descriptive statistics that include mean, standard deviation, minimum and maximum value for the three surface treatment methods were listed in Table (1). The findings of the study showed that microetching porcelain group at 5 mm distance gave rise to the highest mean for the shear and tensile bond strengths, followed by microetching porcelain group at 10 mm then acid etched porcelain group.

Table (1): Descriptive statistics of shear and tensile bond strength for conditioned porcelain surfaces.

Variable	Group	No.	Mean	\pm SD	Min	Max
Shear	Acid Etch	10	11.02	1.43	8.34	13.56
	Microetched 5 mm	10	14.07	1.11	11.99	15.90
	Microetched 10 mm	10	11.37	1.17	9.88	13.00
Tensile	Acid Etch	10	10.94	1.36	8.91	13.70
	Microetched 5 mm	10	13.11	1.75	9.77	15.00
	Microetched 10 mm	10	11.06	1.17	8.98	12.81

Mean in mega pascal.

The analysis of variance (ANOVA) for the three methods of shear and tensile strength showed significant difference among them as illustrated in Tables (2 and 3). The result of Duncan's multiple analysis range test (Tables 4 and 5) showed that

microetching porcelain group at 5 mm distance group was significantly higher than other groups ($p \leq 0.05$), and there is no significant difference between microetching porcelain group at 10 mm and acid etched porcelain group ($p \leq 0.05$).

Table (2): Analysis of ANOVA test for porcelain shear bond strength.

Source	df	SS	MS	F-value	p-value
Factor	2	55.74	27.87		
Error	27	41.74	1.55	18.03	0.000
Total	29	97.49			VHS

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

Table (3): Analysis of ANOVA test for porcelain tensile bond strength.

Source	df	SS	MS	F-value	p-value
Factor	2	29.78	14.89		
Error	27	56.50	2.09	7.12	0.003
Total	29	86.28			HS

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

Table (4): Analysis of Duncan's test for porcelain shear bond strength.

Group	No.	Mean	+ SD	Duncan's grouping*
Acid Etch	10	11.016	1.429	A
Microetched 5 mm	10	14.070	1.108	B
Microetched 10 mm	10	11.374	1.170	A

Mean (In mega pascal), Different letters mean statistically significant ($p \leq 0.05$).

Table (5): Analysis of Duncan's test for porcelain tensile bond strength.

Group	No.	Mean	+ SD	Duncan's grouping*
Acid Etch	10	10.939	1.356	A
Microetched 5 mm	10	13.110	1.750	B
Microetched 10 mm	10	11.059	1.173	A

Mean(In mega pascal), Different letters mean statistically significant ($p \leq 0.05$).

DISCUSSION

The brackets bonded to acid etched porcelain group have shear bond strength that is significantly lower from that where brackets bonded to microetched at 5mm distance. This result is in agreement with the authors⁽¹²⁻¹⁴⁾. This could be due to more surface roughness and thus more surface area for micromechanical bonding^(15,16), in addition to the chemical interaction due to the formation of siloxane bonds between porcelain surface and composite resin^(17,18). Moreover, better siloxane bonds formation can be achieved in the presence of the glassy phase in the porcelain⁽⁶⁾. Whereas the hydrofluoric acid dissolve the glassy phase⁽¹³⁾. There are little siloxane bond formation as compared with microetcher groups which may affects the bond strength. The results of microetched group at 10mm distance was statistically not significant from that of acid etched group. This result is in agreement with Oscan *et al.*,⁽¹⁹⁾ However, these findings were disagree with researchers^(20,21), who found that hydrofluoric acid results in higher shear bond strength than microetched one.

When comparing the two microetched groups, the group of at 5mm has signifi-

cantly higher shear bond strength (SBS) than at 10mm distance. This is due to that, as the distance between the surface and the microetcher nozzle decrease, more surface roughness would be generated and thus more micromechanical bonding characteristics and this is in agreement with Gray *et al.*,⁽²²⁾ Both of the acid etched and microetched groups result in shear bond strength that are much higher than the range of the clinically accepted orthodontic force which is between 6-8 MPa⁽²³⁾.

The comparison of tensile bond strength (TBS); the brackets bonded to microetched porcelain at 5mm distance have tensile bond strength that is significantly higher than brackets bonded to acid etched group. This result is in agreement with Cochrane *et al.*,⁽²⁴⁾ Whereas the results of microetched at 10mm distance group was statistically not significant from that of acid etched group. This result is in agreement with Kocaderelli *et al.*,⁽⁴⁾ However, these findings were disagree with Harari *et al.*,⁽²⁵⁾ who found that hydrofluoric acid result in higher tensile bond strength than microetched one. Possible explanation for that microetching group (at 5mm distance) results in higher bond strength is through the increase in surface

roughness than microetched porcelain at 10mm group⁽¹²⁾.

CONCLUSIONS

Microetching of the porcelain surface at 5 millimeters is practically give rise greater significant shear and tensile bond strength than acid etching and microetching at 10 millimeters.

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