Effect of sandblasting surface treatment of the mesh area on bonding strength of the brackets (SEM study)

Wael M Refai[*1] and Mohamed A El Ruwaini[2]

[1]Department of Orthodontics, Faculty of Dentistry, Minia University, Minia, Egypt
[2]Department of Orthodontics, Faculty of Dentistry, MSA University, Cairo, Egypt
W_refai_67@hotmail.com

Abstract: In this study, the effect of surface treatment (sandblasting) of the mesh area of the bracket was assessed. Integra brackets were used. The study comprised two groups (30 each). Brackets were conventionally bonded in the first group. In the second one, they were bonded after sandblasting the mesh area of the brackets. Instron machine was used to detect the maximum shear bond strength of the bracket. Moreover, representative SEM micrographs were taken and interpreted at different magnifications. The results revealed an increase in the force of displacement in the second group. SEM also showed increased roughness of the mesh area after bracket displacement in the second group. This was attributed to the increase in the mechanical interlock between composite and the mesh area.
[Wael M Refai and Mohamed A El Ruwaini **Effect of sandblasting surface treatment of the mesh area on bonding strength of the brackets (SEM study)]** Journal of American Science 2011; 7(12):792-798]. (ISSN: 1545-1003). http://www.americanscience.org.

Key words: Brackets, mesh area, surface treatment, sandblasting

1. Introduction:

The foundation for adhesive restoratives was laid down in 1955, when Buonocore proposed that acid could be used to alter the surface of enamel to render it more receptive to bonding systems. This discovery had a great impact on Orthodontics and bonding substituted banding accordingly.

The mesh area of the bracket had drawn extensive attention. Many designs were invented so as to increase the mechanical bond between composite and bracket. Studies proved that Bracket base design significantly affects mean shear bond strength [(24)].

The first metal brackets were milled from cold drawn stainless steel and had crude perforated bases into which adhesive could flow (**Sheykholeslam and Brandt, 1977**) [(25)]. The original metal pads contained only one row of perforations along the outer margins and the relatively larger inner smooth surface was incapable of contributing to retention. This base design was later changed to foil-mesh bracket bases, which produced greater bond strength (**Reynolds and von Fraunhofer, 1977**) [(21)]

In an attempt to optimize the adhesive bond between composite and bracket, surface treatment of the mesh area was one of the various modalities to realize this goal. Treatments range from none, to spraying metal alloy onto the base, to the most common treatment of microetching and sandblasting.

These attempts were so mandatory since **McColl *et al*** (1998) indicated that shear bond strength is independent of surface area of the mesh. They also advocated that there was no need to increase base surface area beyond 6.82 mm^2 [(16)]. Moreover, **Bishara *et al*** (2004), indicated that single- and double-mesh bracket bases have comparable shear bond strength and bracket failure modes. [(4)]

There was a debate about bond strength and sandblasting. Studies proved that it is improved others proved that sandblasting has a little or no effect on bond strength. **Sunna and Rock** (2008) [(27)] conducted a study over 60 patients. The bond strength of 1112 brackets was monitored over one year. Sandblasting did not significantly improve the retention of mesh based orthodontic brackets in this study.

Conversely, chairside sandblasting proved to significantly increase the 1-hour, after bonding, mean shear bond strengths. [(23)] **McColl *et al*,** (1998) [(16)]also evaluated the effects of sandblasting bracket base mesh surfaces, reducing base surface area, and etching enamel with various acid types. They found that sandblasting and microetching of foil-mesh bases increased the shear bond strength.

In addition, sandblasting proved to be more effective in removing composite without a significant change in bond strength compared with ultrasonic cleaning and silane treatment [(20)]. The study conducted by **Seema *et al*** (2003) demonstrated that bracket base design significantly influences sandblasting and that brackets with a 60-gauge foil-mesh or an integral undercut machined base achieve higher bond strengths. This study further showed that sandblasted brackets can be reliably reused [(23)] .

The objective of this study was to find a rapid office method of treating brackets to produce clinically acceptable bond strengths with minimal changes in the physical properties of the brackets.

2. Material and Methods:

The study was conducted over one type of brackets (Integra, RMO). Sixty extracted caries free human premolars were used. Each tooth was cleaned from soft tissue and blood using a hand scaling instrument (Ash instruments Dentsply, UK). Teeth were immersed in Thyomol and stored in refrigerator for less than 15 days. Visual and magnifying lens inspections were performed to exclude teeth with any developmental abnormalities or cracks.

The criteria for tooth selection included the following: an intact buccal enamel that was not subjected to any pretreatment chemical agents, such as hydrogen peroxide; no cracks as a result of the pressure of the extraction forceps; and no caries. The teeth were cleansed and then polished with pumice and rubber prophylactic cups for 10 seconds [3] .

Samples preparation and grouping:

Premolars were divided into two groups (30 each). Each of them was embedded in plaster mould. (Fig 1) In the first group, brackets were used in the conventional way following manufacture instruction: etching, washing, drying and finally applying bonding agent and composite. They were bonded to the buccal surface of extracted premolars. Bonding was carried out by using composite (Monolock composite, RMO). Excess bonding resin was removed using small scaler.

In the second group, the mesh area of the brackets was sandblasted before being bonded. The same previously mentioned composite type was used following the same procedures.

Sandblasting procedure:

Sandblasting was carried out with a portable sandblasting unit (Danville Engineering, Danville, Calif) using 50 um aluminum oxide abrasive powder at 3 mm from the bracket base. To ensure a constant distance of 3 mm, 2 pieces of stainless steel orthodontic wire were measured and taped to the tip of the sandblasting handpiece[24]. The conditioned surface was then dried for 30 seconds with the air dryer.

Shear bond strength testing:

Instron machine (Fig 2) was used to debond the bracket from the buccal surface of the tooth. The speed of the machine was 0.5 mm/min. An occlusal-gingival load was applied to the bracket, which produced a shear force at the bracket-tooth interface, with a flattened-end steel rod attached to the crosshead of a Universal Test Machine. A computer, which was electronically connected with the test machine, recorded the results of each test in megapascals.

After failure, the speciemenrs were visually inspected to detect type of failure (adhesive between tooth enamel and composite interface, cohesive within composite or adhesive between composite and mesh. Specimen with adhesive failure between enamel and composite interface or cohesive within composite was rejected. Only those with adhesive failure between mesh and composite were recorded.

Measurement of the bracket base:

For accuracy of the measurements obtained, the base of the bracket had to be calculated. Accordingly, a measuroscope (Nikon M22 -U) was used to determine the approximate dimensions of the bracket base. (Fig 3) The force producing failure was recorded and converted into force per unit area (MPa) by dividing the measured force values by the mean surface area of the bracket base.

Statistical analysis:

The results of the bond strength were recorded and tabulated. Data management and analysis were performed using statistical analysis system to measure the bond strength. A two-way analysis of variance (ANOVA) was performed.

Scanning electron microscopy:

Additionally, representative SEM micrographs were taken and interpreted at different magnifications. The scanning electron microscope (Fig 4) used in this study is made in Japan model SEM JEOL 5410 with magnification up to 200 k . It was chosen for assessing mesh area of the brackets of the two groups: untreated and sandblasted.

Fig 1: Premolrs embedded in plaster mould

Fig 2: Instron machine

Fig 3:Measuroscope

Fig 4: Scanning electron microscope

3. Results

Concerning the results of the push out test, maximum load, deflection, work, stiffness as well as shear bond strength were detected (Table I, Fig 5).

The maximum load increased significantly, almost double, with treated brackets. This was also detected when comparing the deflection in the two groups. The treated brackets groups also exhibited significant increase in both stiffness and shear bond strength than the untreated group.

Table I: Parameters detected from the push out test

		Surface treatment	No treatment
Maximum load	Mean	117.56	66.94
	St. Dev	15.50	8.04
Deflection (mm)	Mean	3.46	1.66
	St. Dev	0.30	0.15
Work (J)	Mean	0.185	0.03
	St. Dev	0.01	0.001
Stiffness (N/mm)	Mean	47.54	70.09
	St. Dev	4.081	4.68
Shear bond (MPA)	Mean	9.53	5.69
	St. Dev	0.47	0.52

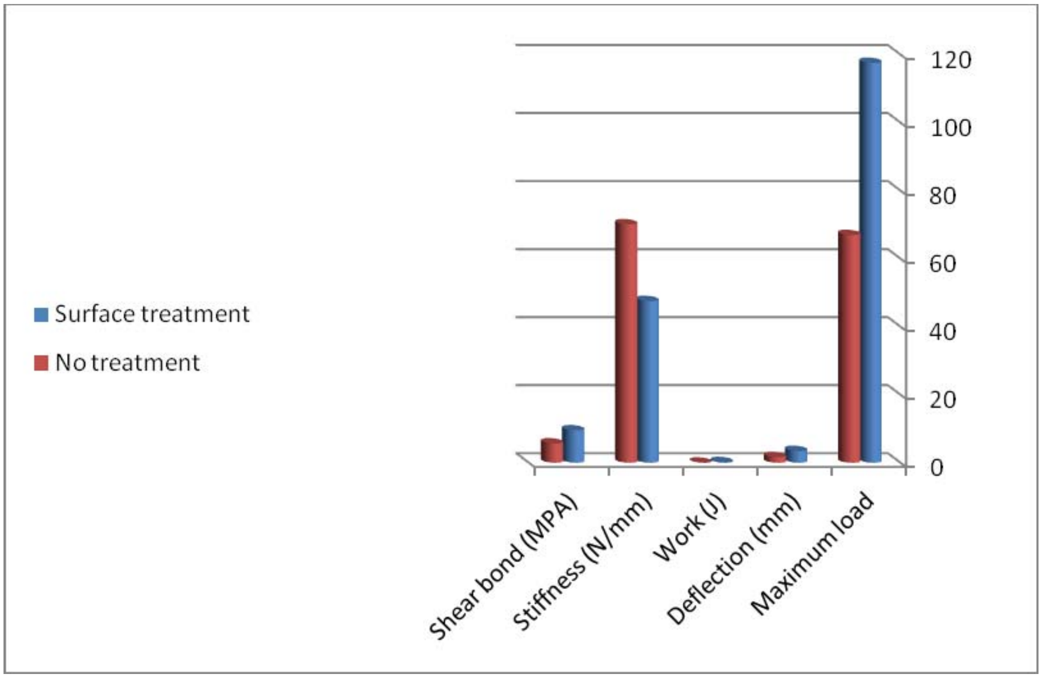


Fig 5: Comparison between parameters of the push out test in both groups

Viewing the results of SEM, the original brackets inspected at 35 xx (Fig 10) before treatment exhibited surface micropores when magnification increased at 1800xx. (Fig 12)

Treated brackets exhibited increased roughness when viewed at 35 xx (Fig 9) & 180 xx (Fig 11). Moreover, pores were converted into grooves when magnification increased to 1800 xx. (Fig 13)

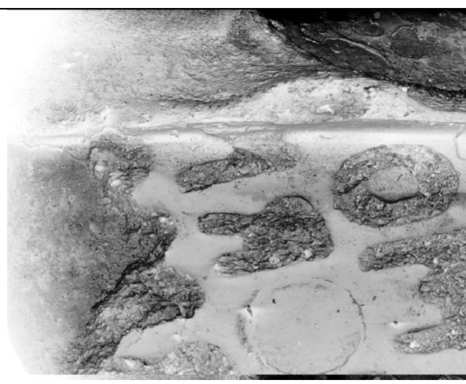


Fig 6: Composite on treated Bracket 35 xx

Fig 7: Composite on treated brackets 180xx

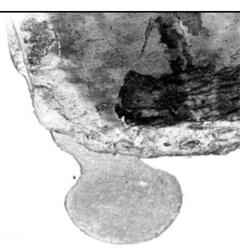


Fig 8: Non-treated bracket 35 xx

Fig 9: Treated bracket 35 xx

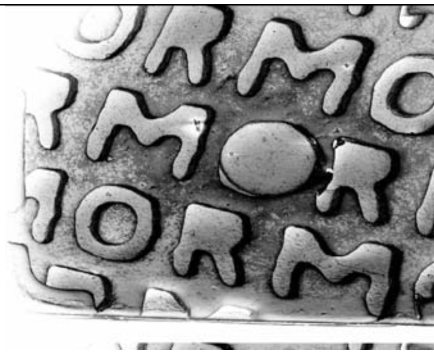


Fig 10: Original bracket 35 xx

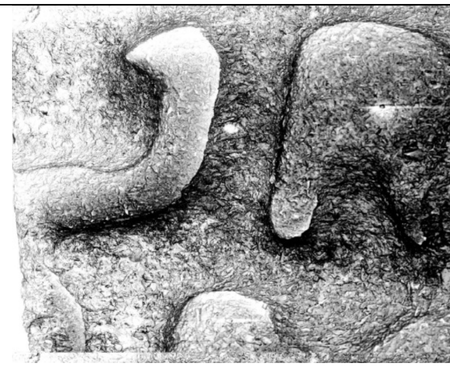
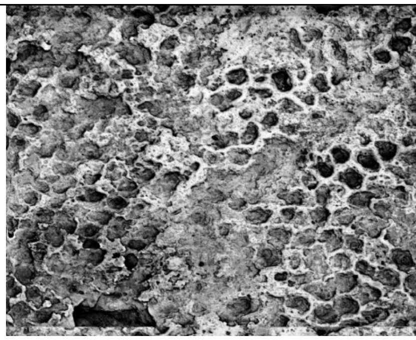


Fig 11: Treated bracket 180 xx



12: Non-treated bracket 1800xx

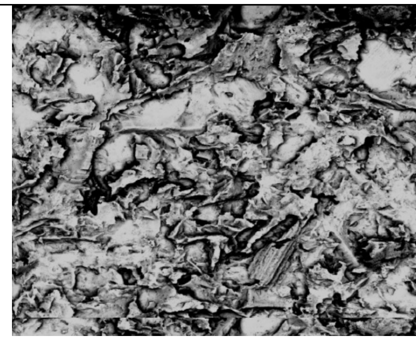


Fig 13: Treated bracket 1800 xx

4. Discussion:

Bond strength of brackets to enamel surface is a major demand for treatment stability and progress. Enamel is a reliable bonding substrate owing to its high inorganic content which forms a retentive pattern by acid etching [(19)] . Not only composite took a great part of importance in research studies concerning bond strength, but also bracket base.

Different systems which vary in chemistry and complexity of application were used to achieve optimum bonding and sealability. [(2, 28, 29)] However, the constant and rapid evolution in the development of materials had focused on obtaining high bond strengths with the simplest procedure possible.

Therefore, combination of the multiple components into fewer containers became lately the state of art and a requirement in bonding technology. On the other hand, this fast pace in development constitutes a dilemma for their evaluation as the combination of steps may lead to compromised bonding results.

Various bond-enhancing agents had also been applied with a view to increasing bond strength. **Siomka and Powers** (1985) [(26)] and **Newman *et al.*** (1995) [(17)] found that the application of silane improved the bond strength of new meshed brackets by as much as 21 per cent. Silanation and etching together also led to an increase in bond strength.

Certain bond enhancers, such as Enhance Adhesion Booster and Enhance LC (Reliance Orthodontic Products) failed to improve bond strength when debonded brackets had their composite bases roughened or sandblasted (**Egan *et al.*,** 1996) [(7)]. All-Bond 2 (Bisco, Schaumburg) significantly increased the bond strength of sandblasted rebonded brackets, but did not increase the bond strength of new brackets (**Chung *et al.*,** 2000). [(6)]

From the other side, many manufacture shapes were designed to increase the mechanical interlock between composite and bracket. The bracket base had evolved from perforated to foil-mesh base. Moreover, surface treatment was depended upon to increase the bond strength. One of the major modalities is sandblasting. This latter was also considered the most effective in removing composite without a significant change in bond strength compared with new attachments. [(1)]

This study was carried out to assess the influence of sandblasting on one type of brackets (Integra, RMO). It included two groups of thirty brackets in each one. All brackets were bonded to extracted upper premolars inserted in plaster moulds. Same tooth (upper premolar) was selected in this study to avoid any variation concerning enamel surface of different teeth in the mouth (**Hobson and Mattick**; 1997 [(11)] and **Hobsen *et al***; 1999 [(14)]).

In the first group, brackets were conventionally bonded. In the second group, bracket bases were sandblasted before being bonded. This technique of surface treatment was carried out since it is easily performed in the dental clinic. Bracket debonding was performed by applying an occluso-gingival load from an instron machine.

There has been confusion in the literature over the unit of measurement most appropriate for describing bond strength (**Fox and McCabe,** 1994)[(9)]. Units such as Pascals, MegaPascals, Newtons per millimeter squared or Mega Newtons per metre squared have been used. These units provide an indication of the force per unit area required to dislodge the bracket.

The use of force as an indicator of bond strength is only appropriate where the area is well controlled, but difficult to measure. **Richardson** (2009)[(22)] advocated that as long as the dimensions of the bracket base are quoted, the use of Newtons or MegaPascals is appropriate in quoting bond strength.

Accordingly, the bracket base dimension of the used bracket was determined using a measuroscope. MegaPascal unit was chosen to calculate the mean bond strength. The shear bond strength was assessed by dividing the maximum load on the base dimension.

In addition, scanning electron microscopy was depended upon to assess the structural integrity of the bracket base after debonding. SEM technique was chosen to provide a large depth of focus that allows a wide area of specimen to be examined. All observations on changes caused in the mesh area were observed by SEM micro graphs that were set at different magnifications.

The untreated bracket showed an almost smooth surface where the bracket brand could be read. When magnification increased, micropores were denoted. Viewing the sandblasted brackets, rough surface was denoted. However, when magnification increased, grooves of different orientation were seen.

Surface treatment results showed higher shear bond strength (almost double) than untreated brackets. This may be explained by the induced complexity in the bracket base. Accordingly, higher surface area and different orientation of the grooves were obtained. This helped in a more mechanical interlock between composite and the mesh area.

The results are in accordance with those carried out by **Hudson *et al.,*** (2011) [(15)] who concluded that the size and design of the bracket adhesive surface do play a significant role in bond strength of brackets. In addition, **Faltrermeier and Behr** (2009)[(8)] proved that sandblasting and tribochemical treatment of stainless steel brackets improves their shear bond strength.

Moreover, it is a common belief that clinically adequate bond strength for a stainless steel bracket to enamel should be 6 to 8 MPa [(5, 10, 18)]. Consequently, on viewing the results of the present study, it can be denoted that the average shear bond strength exceeded that value.

From all the previously mentioned, it can be concluded that surface treatment is an effective method in increasing shear bond strength of the bracket.

Conclusions:

1- The more complex the bracket base, the more increased shear bond strength.
2- Sandblasting proved to be an effective method to increase the shear bond strength.

Acknowledgement:
We are really grateful to:
1- Dr Yasser Fathi Mohamed, Associate professor of Dental Materials for his cooperation in sandblasting procedure.
2- Dr Ezz Ibrahim Hamed, MSc in Orthodontics for his valuable assistance in the measuroscope.

Corresponding author
Wael M Refai
Department of Orthodontics, Faculty of Dentistry, Minia University, Minia, Egypt
W_refai_67@hotmail.com

References:

1. Andrew N. Quick, Angela M. P. Harris and Vince P. Joseph (2005): Office reconditioning of stainless steel orthodontic attachments. Eur J Orthod; 27 231–236.
2. Amaral CM, Hara AT, Pimenta LAF, and Rodrigues AL Jr (2001): Microleakage of hydrophilic adhesive systems in Class V composite restorations. Am J Dent.; 14: 31-33.
3. Bishara SE, Olsen ME, VonWald L, BA, and Jakobsen JR(1999): Comparison of the debonding characteristics of two innovative ceramic bracket designs. Am J Orthod Dentofacial Orthop.; 116:86-92.
4. Bishara S E, Soliman M M, Oonsombat C Laffoon J F and Ajlouni R(2004): The effect of variation in the mesh base designon the shear bond strength of orthodontic brackets. Angle Orthod.; 74(3): 400-404.
5. Bourke BM, Rock WP(1999): Factors affecting the shear bond strength of orthodontic brackets to porcelain. Br J Orthod.;26:285-90.
6. Chung C-H, Fadem BW, Levite HL, and Mante FK (2000): Effect of two adhesion boosters on the shear bond strength of new and rebonded orthodontic brackets. Am J Orthod Dentofacial

Orthop., 118: 295-299.
7. Egan FR, Alexander SA, Cartwright GA (1996): bond strengths of rebounded brackets. Am J Orthod Dentofacial Orthop.; 109: 64-70.
8. Faltermeier A and Behr M (2009): Effect of bracket base conditioning. Am J Orthod Dentofacial Orthop; 135:12.e1-12.e5.
9. Fox NA, McCabe JF and Buckley JG (1994): A critique of bond strength testing in orthodontics. British Journal of Orthodontics; 21: 33-43.
10. Gillis I, Redlich M (1998): The effect of different porcelain conditioning techniques on shear bond strength of stainless steel brackets. Am J Orthod Dentofacial Orthop.; 114:387-92.
11. Hobson RS and Mattick CR (1997): A quantitative *in-vivo* study of the acid etch pattern on the buccal surfaces of teeth. Journal of Dental Research; 76: 1046.
12. Hobson RS and Mattick CR(1998): *In vivo* acid etch patterns on tooth buccal surfaces. Journal of Dental Research;, 77: 979.
13. Hobson RS and McCabe JF (2002): Relationship between enamel etch characteristics and resin-enamel bond strength. British Dental Journal; 192: 463-468.
14. Hobson RS, McCabe JF and Hogg SD (1999): Orthodontic bond strength on different teeth. Journal of Dental Research; 78: 547.
15. Hudson AP, Grobler SR and Harris AMP (2011): Orthodontic molar brackets: The effectof three different base designs on shear bond strength. Int J Biomed Sci.; 7 (1): 27-34.
16. McColl G A, Rossouw P E, Titley K C and Yamin C (1998): The relationship between bond strength and orthodontic bracket base surface area with conventional and microetched foil-mesh. Am J Orthod Dentofacial Orthop.; 113:276-81.
17. Newman G V, Newman R A, Sun B I, Ha J-L J, and Ozsoylu S A (1995): Adhesion promoters, their effect on bond strength of metal brackets. Am J Orthod Dentofacial Orthop., 108: 237-241.
18. Özcan M, Vallittu PK, Peltomäki T, Huysmans MC, Kalk W(2004): treatment on bond strength. Am J Orthod Dentofacial Orthop.; 126:220-7.
19. Pilo R and Ben-Amar A (1999): A comparison for three one-bottle and three multiple-step dentine bonding agents. J Prosthet Dent.; 82:209-213.
20. Quick A N, Harris A M and Joseph V P (2005): Office reconditioning of stainless steel orthodontic attachments. Eur J Orthod.; 27 231–236.
21. Reynolds IR and von Fraunhofer JA (1977): Direct bonding in orthoodontics: a comparison of attachments. British Journal of Orthodontics; 4: 65-69.
22. Richardson EM (2009): *In Vitro* investigation into bond strength of metal and ceramic orthodontic brackets. Degree of Master Philosophy (Orthodontics)
23. Seema K. Sharma Sayal, P Emile Rossouw, Gajanan V Kulkarni, and Keith C Titley (2003): The influence of bracket base design on shear bond strength. Am J Orthod Dentofacial Orthop.; 124:74- 82.
24. Sharma-Sayal S K, Rossouw P E, Kulkarni G V and Titley K C (2003): The influence of bracket base design on shear bond strength. Am J Orthod Dentofacial Orthop.; 124(1): 74-82.
25. Sheykholeslam Z and Brandt S (1977): Some factors affecting the bonding of orthodontic attachments to tooth surface. Journal of Clinical Orthodontics; 11: 734-743.
26. Simoka L V and Powers J M (1985): *In vitro* bond strength of treated direct-bonding metal base. Am J Orthod.; 88: 133-136.
27. Sunna S and Rock W P (2008)**:** Effect of Sandblasting on the Retention of Orthodontic Brackets: A Controlled Clinical Trial Effect of Sandblasting on the Retention of Orthodontic Brackets: A Controlled Clinical Trial. Journal of Orthod.; 35(1): 43-48
28. Van Meerbeek B, Vargas S, Inoue S, Yoshida Y, Peumans M, Lambrachts P and Vanherle G (2001): Adhesives and cements to promote preservation dentistry. Oper Dent.; (supplement 6): 119-144
29. Wakefield CW, Draughn RA, Sneed WD and Davis TN (1998): Shear bond strength of six bonding systems using the push out method of *in vitro* testing. Oper Dent.; 23:69-76.

12/12/2011