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Original Research

Effect of Different Bracket Base Retention Features on Tensile Bond Strength- An In-vitro Study

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ABSTRACT:
Introduction: Bond failures during orthodontic treatment is common. To increase the bond strength many improvements have been made over the years. Bracket retention mechanism, is one of the factors which determine the bond strength of the adhesive. The aim of this study was to evaluate the effect of different bracket base retention features on shear bond strength . **Materials and methods**: Brackets with four different base features were tested: polymer coated base {Nu Edge (TP Orthodontics)}, Foil mesh pad { Mini Diagonali (Leone)}, Photochemically etched base {Minimaster (American Orthodontics)}, Laser structured base {Discovery (Dentaurum)}. An optical and a scanning electron microscope was used to examine the base design. Brackets were bonded to human teeth and then debonded on the Universal testing machine. **Results**: The results show that the Group A2 showed the highest mean tensile bond strength of all the groups. The lowest individual TBS of a bracket was 4.8MPa which belonged to group B2. The average mean tensile bond strength of different groups was in the following order: A2>D2>C2>B2. **Conclusions**: Polymer coated base brackets showed the highest and foil mesh pad brackets showed the lowest tensile bond strength.
Key words: tensile bond strength, bracket base design, laser structured base, polymer coated base, bonding.

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INTRODUCTION

Bond failures during orthodontic treatment are common. To increase the bond strength many improvements have been made over the years. Bracket retention mechanism,[1] is one of the factors which determine the bond strength of the adhesive. To increase the bracket base retention various mechanisms have been devised i.e. mechanical or chemical means or a combination of both .[2]
In Mini Master brackets of American Orthodontics, 80-gauge mesh is placed over a foil base which has been thoroughly etched via photochemical etching.The resultant porosities created by the etching increases the surface area for retention.[3] The TP Orthodontics company (La Port, IN) incorporates their patented Primekote polymer[4] into the base of the Nu-Edge bracket, promised to increase bond strength of the bracket . The Discovery (Dentaurum, Germany) brackets are a new type of brackets having a laser structured base[5] produced by metal injection molding of stainless steel AISI 316 L and sintering to theoretical density. Thanos et al.[6] compared mesh-base and metal-base brackets and found that mesh-base brackets had more tensile bond strength, whereas metal-base brackets had more shear bond strength.
In literature extensive research has been conducted on shear bond strength. At the same time very few research articles exist on tensile bond strength. Tensile forces play a major role during the initial phases while seating and ligating an archwire into bracket slots. In tensile bond strength the force is directed perpendicular to the bracket pad and a minimum tensile bond strength of 6–8 MPa according to Reynolds is adequate to withstand normal

orthodontic forces. This study was done to evaluate the effect of different types of bracket bases on tensile bond strength and to determine which type of base presents the highest success rate.

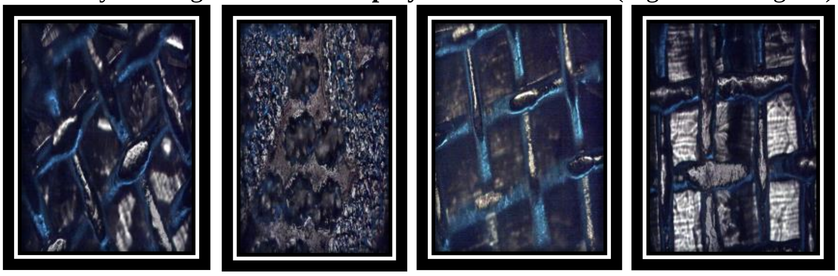
MATERIALS AND METHODS

This study was conducted on 120 extracted human premolar teeth which were non-carious, with no fracture lines on the enamel surface and had intact buccal tooth surfaces. The extracted premolars were obtained from patients who had undergone therapeutic orthodontic extraction. This study was cleared by the Ethical Committee of the institute. The extracted teeth that were collected were cleaned, washed and stored in a solution of 0.1% (wt/vol) thymol to prevent dehydration and bacterial growth.

Brackets under study:

One hundred and twenty orthodontic brackets with different bracket retention mechanisms were chosen for evaluation.

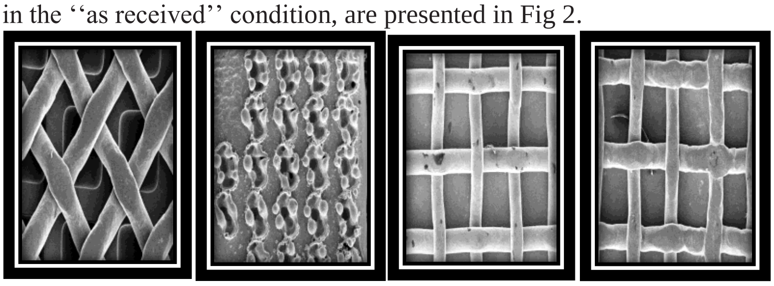
1. Thirty Minimaster brackets with **photochemically etched** base (Fig 1A and Fig 2A)
2. Thirty Discovery brackets with **laser structured** base (Fig 1B and Fig 2B)
3. Thirty Mini-Diagonali brackets with **sintered foil mesh** pads (Fig 1C and Fig 2C)
4. Thirty Nu-Edge brackets with **polymer coated** base (Fig 1D and Fig 2D)



A B C D

Fig 1. Under 10X Optical microscopy A) Photochemically etched base B) Laser structured base C) Sintered foil mesh pad base D) Polymer coated base

Field emission scanning electron microscopy photographs at 225X magnification for the different bracket bases, in the ‘‘as received’’ condition, are presented in Fig 2.



A B C D

Fig 2. A) Photochemically etched base B) Laser structured base C) Sintered foil mesh pad base D) Polymer coated base

Gouping of sample: A2) Polymer coated base B2) Sintered foil mesh pad base C2) Photochemically etched base D2) Laser structured base **.** To help in easy identification, the sample groups were color coded with different colors. The acrylic blocks belonging to group A2, B2, C2 and D2 were color coded with black, orange, blue and pink respectively.

A2 B 2 C2 D2

Testing of tensile bond strength:

Instron universal testing machine was used to evaluate the tensile bond strength of the specimen in different groups. The prepared acrylic blocks were positioned in the Instron Universal Testing Machine with the long axis of the tooth perpendicular to the direction of the load application. For this purpose, acrylic specimens were positioned in the lower part of the device and a four stranded 0.010 ligature wire was looped around the bracket.

Two strands of 0.010" ligature wires were wound together. Then this double stranded wire was ligated to one half of bracket wings. The other half wings of the brackets were ligated in a similar fashion with a double stranded wire. Left and right sided double stranded wires were further twisted together to make a firm, stiff structure of four wires which was stiff enough to resist deformation and elongation. The second purpose of this method of ligation was to apply the tensile forces through the geometric centre of the bracket. The free end of the twisted ligature wire was attached to the upper holder so that the ligature wire was pulled upwards at a cross-head speed of 1 mm to apply tensile force.

RESULTS AND DISCUSSION:

Mean tensile bond strength with respect to different bracket bases were listed in **Table 1A and Fig 3.**

Table 1A: Tensile bond strength (Mpa) in various groups

Group	Mean	SD	Minimum	Maximum	F-value	P-value
A2	8.60	1.72	5.2	11.7	8.991	0.002*
B2	6.09	0.95	4.8	8.1		
C2	7.53	1.41	5.2	9.3		
D2	7.85	1.24	6.2	10.1		

Statistically Significant Difference (P-value<0.05)

The results show that the Group A2 showed the highest mean tensile bond strength of all the groups. The lowest individual TBS of a bracket was 4.8MPa which belonged to group B2. The average mean tensile bond strength of different groups was in the following order: A2>D2>C2>B2.

P-value of these different groups was found to be 0.002 which signifies that the groups under study have a significant difference in tensile bond strength. To find out where the differences exist intergroup comparisons were made.

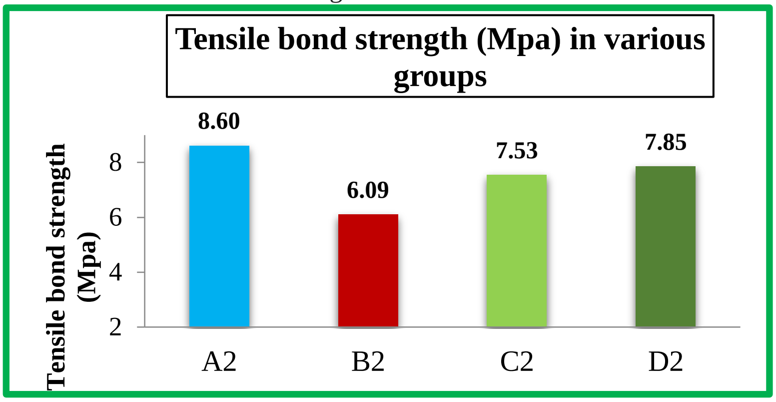


Fig. 3: Tensile bond strength (Mpa) in various groups

Intergroup comparison of tensile bond strength was done and the result is shown in **Table 1B.**

Table 1B: Intergroup comparison based on tensile bond strength in various groups

Group comparison	Mean difference	P-value	Significance
A2 vs B2	2.51	<0.001	S
A2 vs C2	1.07	0.036	S
A2 vs D2	0.75	0.134	NS
B2 vs C2	-1.44	0.005	S
B2 vs D2	-1.75	0.001	S
C2 vs D2	-0.31	0.531	NS

NS: Not significant; S: Significant

Comparison of TBS of group A2 with other bracket groups:

There was a significant difference in tensile bond strength between group A2 and B2 with a mean difference of 2.51MPa and P-value of 0.001. A significant difference in tensile bond strength was also found between A2 and C2 with a mean difference of 1.07MPa and P-value of 0.036. While as when tensile bond strength of group A1 was compared with group D1, no significant difference was found between their tensile bond strengths. There was a mean difference of only 0.75MPa with a P-value of 0.134.

Comparison of TBS of group B2 with other bracket groups:

As already mentioned in the above paragraph that there was a significant difference in tensile bond strength between group B2 and A2. When group B2 was compared with group C2 a significant difference in tensile bond strength of -1.44MPa was found with a P-value of 0.005. A significant difference in tensile bond strength was also found between group B2 and D2 with a mean difference of -1.75MPa and P-value of 0.001.

Comparison of TBS of group C2 with other bracket groups:

A significant difference in tensile bond strength was found between group C2 and group A2, and between group C2 and B2. But there was no significant difference found between tensile strength of group C2 and group D2. A mean difference of -0.31MPa and a P-value of 0.531 was found between them.

Comparison of TBS of group D2 with other bracket groups:

Group D2 showed a significant difference in tensile bond strength with respect to group B2 only with a mean difference in tensile bond strength of -1.75MPa and P-value of 0.001. A non significant difference was found between between tensile bond strengths of group D2 with respect to group A2 and group C2.

Bond strength of orthodontic brackets depends on many variables, such as: material and surface structure of the bracket, type of bonding agent used and quality of the enamel.[7] Additionally, some aspects of the experimental condition can also play a significant role. Finnema et al.[8] observed, throughout a meta-analysis, that higher curing time leads to stronger bond strength. The authors found that each additional second of light-curing increased in vitro bond strength by 0.077MPa, but they were not able to find the optimal curing time for bonding. A curing time of 20 seconds adopted in the present study was determined by the manufacturer of Transbond XT bonding system.

The shear strength is the ability of objects to survive while receiving load parallel to the object surface. The tensile strength is ability of the current object survives, receives force perpendicular to the object surface.[9] The pressure distribution in the shear bond strength test is complex and uneven because there are concentrations of pressure on certain areas. Tensile strength tests allow distribution of pressure evenly across the surface so it is more accurate in assessing the characteristics of adhesive attachment .[10] Tensile forces play a major role during the initial phases while seating and ligating an archwire into bracket slots. Because of this dislodgement problem tensile bond strength was evaluated to find out which brackets reached the ultimate tensile strength immediately after light curing and if it was required to wait a certain amount of setting time before the archwire can be placed.

In the literature very few studies have compared the shear bond strength of types of bracket bases that we had included in the study. And when it comes to evaluation of tensile bond strength, there was hardly any literature which had included these brackets in their study. In the present research, all of the groups showed optimal mean values of the TBS. The lowest mean value of the TBS was 6.09MPa (exhibited by group B2 with sintered foil mesh pad), and the highest mean value of the TBS was 8.60MPa (in the group A1 with polymer coated base). The mean value of SBS in D2 (laser structured base) and C2 (photochemically etched base) was 7.85MPa and 7.53MPa respectively. It has been determined that the minimum tensile bond strength required by a bracket to resist debonding forces is 2.86MPa, and, with all the brackets, the bond strengths recorded in current study exceeded this amount.[11,12] Vikram et al. [13] in their research found a similar value of TBS of brackets with polymer coated base (7.31MPa). According to Rajesh et al.[14] The laser etched bracket showed superior tensile bond strength (8.47MPa) than the mesh-based bracket (5.53MPa). It has been found that larger bracket bases provide stronger bond strength.[15] But this was not confirmed by the present study, which was in accordance with the study of Dickinson et al. [16] which found tensile bond strength to be independent of nominal area and mesh size for the bases tested. The highest mean bond strength values (8.6 ± 1.72MPa) were obtained by Group A2, which had the smaller bracket bases; in contrast to Group D2, which had the largest base area but obtained the lower mean value for bond strength (7.85 ± 1.24MPa). This suggests that, although the bracket base area may influence bond strength, the type of bracket base design can have a more important influence. The values obtained in the study were similar to values noted by Reynolds[17] where he suggested tensile bond strength values between a range of 5.9 and 7.9MPa was adequate to withstand orthodontic treatment forces.

CONCLUSION

Tensile bond strength of all four types of brackets tested was within the normal range of clinically acceptable values. Polymer coated base brackets showed the highest and foil mesh pad brackets showed the lowest tensile bond strength.

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