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**Original Research**

# Comparative evaluation of orthodontic bracket base shapes on shear bond strength

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***ABSTRACT:***

**Background:** To compare and evaluate orthodontic brackets base shape on shear bond strength. **Materials & methods:** A total of 70 maxillary central incisor orthodontic brackets (n=10/shape) were enrolled. SBS in Newtons (N) at bracket failure was recorded for each sample. The results were analysed using SPSS software. P- value less than 0.05 was considered statistical significant. **Results:** There was no statistical differences in mean SBS (N) between control (68.12 N) and all other test groups. There was statistically significant difference in mean SBS (N) between all base shapes of brackets ($p<0.05$). **Conclusion:** Higher SBS (N) for rectangle, flower, and football base shape indicates even stress distributions throughout the bracket base.

**Keywords:** Shear bond strength, Orthodontic brackets, flower base.

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## INTRODUCTION

The development of adhesive technique leads to transition from banded to bonded edgewise appliances. The minimum shear bond strength range of 6-8 MPa is often cited in the literature as necessary to avoid bracket deboning during application of orthodontic forces. [1] Silverman and Cohen first introduced the indirect bracket bonding technique in 1972. [2] They bonded plastic brackets on the plaster model using a methyl methacrylate adhesive, while adhesion between the etched tooth surface and preset adhesive on the bracket was achieved using unfilled Bis-GMA resin. Revolution in the indirect technique was made by Thomas who introduced a method called custom base indirect bonding technique. [3] The main characteristic of this technique is the formation of Bis-GMA composite layer (custom base) at a bracket base, shaped according to belonging tooth surface. After removing the transfer tray from the model, the brackets with polymerized composite base adhere to the teeth with two components of sealant. Introduction of custom base indirect technique enabled unlimited operating time and greatly reduced the problem of excess adhesive. However, one of the limitations is the possibility of bond failure because of inadequate share bond strength between custom base and adhesive primer. [3] A recent development of orthodontic

adhesives especially designed for the usage with the indirect bonding technique has helped a greater applicability of this technique in orthodontics. [4,5]
The introduction of shaped orthodontic bracket has been relatively new. WildSmiles® (Omaha, NE, USA) is credited with the development of this unique and innovative product. Shaped bracket encompasses similar components as the traditional bracket, the difference being the incorporation of unique base shape as follows: flower, soccer (round), heart, diamond, star, and football. Since the bracket base directly attaches to the enamel surface, the effect of this modification on tooth adherence needs to be investigated. Ideally, an orthodontic bracket must be able to withstand normal masticatory forces without being dislodged. [6] Maximum occlusal force for children between the ages of 6-11 and adults with normal facial height is approximately 5.01 Kg and 13.5 Kg respectively. [6] Clinically acceptable shear bond strength (SBS) within the range of 5.8-7.9 MPa has also been suggested to be ideal. [7] Hence, this study was conducted to compare and evaluate orthodontic brackets base shape on shear bond strength.

**Materials & methods**

A total of 70 maxillary central incisor orthodontic brackets (n=10/shape) were enrolled. The control group consisted of an orthodontic bracket with a traditional rectangular base shape. The test groups were comprised of shaped brackets with six different base shapes; flower, soccer (round), heart, diamond, star, and football. Shear bond test was performed using the Instron testing machine. SBS in Newtons (N) at bracket failure was recorded for each sample. The results were analysed using SPSS software. P- value less than 0.05 was considered statistical significant.

**Results**

Samples where the brackets were sheared off at force level of N<10 were omitted as it represented total bracket failure. The mean SBS (N) with respect to different bracket base shapes was collected. There was no statistical differences in mean SBS (N) between control (68.12 N) and all other test groups. There was statistically significant difference in mean SBS (N) between all base shapes of brackets (p<0.05). The highest mean SBS (N) observed was football and flower base shape (80.14 N and 71.20 N respectively) whereas the lowest mean SBS (N) was observed with diamond and heart shape (29.34 N and 35.46 N respectively).

Table 1: Mean Shear Bond Strength of Brackets with different base shapes in Newtons (N).

| Shape of Brackets | Mean SBS (N) |
|---|---|
| Rectangle (control) | 68.12 |
| Flower | 71.20 |
| Star | 45.85 |
| Football | 80.14 |
| Round | 41.06 |
| Heart | 35.46 |
| Diamond | 29.34 |

**Discussion**

Rectangular base shape yielded the highest, statistically significant SBS (MPa) when compared against all other base shapes: flower, round, heart, diamond, star and football. However, football and flower yielded a higher total SBS (N) than rectangle base shape. The contributory cause of these contradictory results is potentially due to discrepancy in base size. Since MPa is calculated as a function of its respective nominal base surface area (mm2), different bond values are achieved for different bonding area. [8] Despite the previous claim of linear correlation between increased base size and ability of bracket to withstand dislodging forces, this relationship may only be accurate for a typical standard bracket with base surface area in the range of 6.82 – 12.35 mm2. [6,9] Hence, this study was conducted to compare and evaluate orthodontic brackets base shape on shear bond strength.
In the present study, samples where the brackets were sheared off at force level of N<10 were omitted as it represented total bracket failure. The mean SBS (N) with respect to different bracket base shapes was collected. There was no statistical differences in mean SBS (N) between control (68.12 N) and all other test groups. A study by Phamm D et al, statistically significant difference in mean SBS in Newtons was observed for multiple base shapes (p<0.05). The highest mean SBS (N ± SD) was observed in football and flower base shapes (73.83 N ± 53.46; 65.82 N ± 37.89 respectively); the lowest mean was observed with diamond and heart shapes (30.51 N ± 11.73; 33.28 N ± 16.89 respectively). When reported in Megaspascals, statistically significant difference was observed for rectangle base shape (3.54 MPa ± 2.69) when compared to all other base shapes. [10]
In the present study, there was statistically significant difference in mean SBS (N) between all base shapes of brackets (p<0.05). The highest mean SBS (N) observed was football and flower base shape (80.14 N and 71.20 N respectively) whereas the lowest mean SBS (N) was observed with diamond and heart shape (29.34 N and 35.46 N respectively). Another study by Patel N et al, debonding force values (N ± SD) ranged from 205.51 ± 49.12 (Star) and 275.96 ± 69.05 (Soccer). SBS values (MPa ± SD) ranged from 13.34 ± 3.18 (Star) and 17.77 ± 6.94 (Rectangle). Even though intergroup comparison of SBS in Newtons revealed statistical significance (p = 0.014) between Star-Soccer and Star-Football group, it does not have any clinical significance since ranges of SBS of all groups are clinically acceptable. Analysis of ARI scores showed no significant differences in mode of bond failure among groups (P = 0.82). [11] WildSmiles® offer six shaped brackets: star, heart, soccer ball, flower, football, and diamond. They share many of the design similarities as the traditional metal braces other than bracket pad shape. Previous research studies

determined that shear bond strength testing results can be influenced by a variety of factors, such as mesh wire gauge and mesh layer, bracket base surface area, bracket base design and bracket pad shape. [6,12-14] However, no research study has tested effect of bracket pad shape on shear bond strength on human enamel. Cucu et al. [12] investigated the in vitro shear bond strength of orthodontic brackets with 80- and 100-gauge mesh bases as well as mini and standard-size bases. They found no significant differences in the shear bond strength of any of the brackets compared. MacColl et al. [6] 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 micro etching of foil-mesh bases increased the shear bond strength. In addition, they found no significant differences in the shear bond strength of bracket base surface areas between 6.8 mm2 and 12.4 mm2 but decreased when the surface area was at 2.4 mm2. The minimum bond strength required for clinical success is related to the forces of occlusion and not to the forces generated by an orthodontic arch wire. [15] The use of a thin transducer to measure the maximum biting force during chewing by a patient on command has been reported that, in children with normal lower face heights between the ages of 6 and 11 years, this force is 49N and in adults 149 N. [15] These results are similar to the values reported by another study where thick strain gauges were used. [6] It would thus be reasonable to infer from these studies that bracket displacement forces may range from 49 to 149 N. Bond strengths have been measured by multiple testing types; most commonly shear, peel, tension and torsion. Tension and shearing tests are the most common methods of testing bracket bond strengths. Both are considered to provide similar and clinically comparable values. The shearing force created by mastication and occlusal forces, if greater than bond strengths, will result in bracket failure. It has been determined that clinically acceptable SBS ranges from 5.9-7.8 MPa. [15] Lastly, the location of applied force may have contributed significantly to large range in SBS recorded. Typically, for in vitro bond study, shear force is applied at the enamel-resin interface. For this study, shearing force was applied at the ligature groove to maintain consistent location of force for all base shapes. As the distance of applied force from the enamel surface is increased, a moment of force is being introduced. [16] As a result, shifting of shear stress to tensile, compressive, and peel stress becomes increasingly large. [16] Studies have shown statistically significant difference between shear strength (7.71 MPa) compared to tensile (2.29 MPa) and compressive (2.98 MPa) bond strength. [17] Fracture is most likely to occur at the region exhibiting the lowest force carrying capacity, ultimately resulting in bond failure. Klocke et al. observed a 49.3% reduction in SBS as well as 25% increase in bracket failure when an applied force was moved from the bracket-resin to the ligature groove. [16]

## Conclusion

Higher SBS (N) for rectangle, flower, and football base shape indicates even stress distributions throughout the bracket base.

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