A Comparison of the Accuracy of 0.022 Slots at Face, Base and Mesial and Distal Surface of Brackets marketed by Different Manufacturers

Karan Tangri, Piush Kumar, Payal Sharma, Kiran Kumar, Dinesh Kumar Bagga, Rakesh Sharma

ABSTRACT

The aim of the present study was to compare the accuracy of the bracket slot dimension at base and at face and at the mesial and distal surfaces of conventional 0.022 slot metal brackets marketed by different manufacturers.

Materials and methods: Twenty brackets each of 0.022 inch upper left central incisor brackets from five different manufacturers were taken for evaluation of slot dimensions with a stereomicroscope. The images obtained were calibrated with a software (Dewinter Biowizard 4.3). The bracket slot at the base and the face were measured at both the mesial and distal tie-wings. The values obtained were subjected to ANOVA and paired t-tests.

Results: The size of the slots ranged from a minimum of 0.0201" to maximum of 0.0248". In general, the size of the slots was greater at the face than at the base. The mean percentage loss of symmetry from base to face for different manufacturers ranged from 2.589 to 8.958%. There was a significant difference in the slot size between the mesial and distal aspects for all the brackets except 3M and Ortho Organizer.

Conclusion: The results of this study indicate that orthodontic bracket slots were different than stated by the manufacturers. All the brackets were larger at the face than at the base.Clinicians should be aware that there may be a three-dimensional loss of tooth positioning as a result of the inadvertent use of orthodontic brackets with inaccurate slots.

Keywords: Bracket slot dimension, Accuracy, DIN 13971-2, Slot size.

INTRODUCTION

Orthodontic brackets are an essential component of modern fixed appliances. In order to deliver the exact force from the wire to the teeth, brackets should have the correct hardness and strength. They should have a smooth archwire slot to reduce frictional resistance, and an overall smooth surface to reduce plaque deposition. Because most orthodontic brackets are produced with a three-dimensional prescription for each tooth, they should be accurately manufactured to reflect this. The placing of archwires in a preadjusted bracket is designed to produce three-dimensional tooth moving forces. These forces are created as a result of the intimate fit of wire into the bracket slot, and any ‘play’ or ‘slop’ between these components will result in incomplete transmission of the bracket prescription to the tooth and its supporting tissues.1

Achieving a satisfactory inclination or torque of the incisors is important for the final esthetic result.2 Torque expression depends upon a number of factors including the size of the bracket slots and archwires. A number of studies have investigated the effects of various factors on torsional play. These include bracket and archwire material,3,4 irregularities in tooth morphology,5 errors in bracket placement5 and beveling of archwires.6,7 Kusy and Whitley8 suggested that there should be an exact description of slot geometry and standardization in SI units.9,10 The binding angle between the wire and the bracket is also important, as resistance to sliding mechanics can occur, if contact angle between archwires and bracket increases. For this the bracket slot dimension and the archwires dimensions should be precise.

Various studies have been conducted to evaluate the slot dimensions of brackets of different manufacturers.1,11 The results of these studies have been inconsistent with some of them showing bracket slot dimensions as much as 0.02526 inches.11 Also there have been no studies done to study the slot dimensions of brackets supplied or manufactured in India.

The aim of this study was to investigate the precision of the slot size and geometry of commercially available metal orthodontic brackets in the 0.022 inch dimension, to compare the measured dimensions with the manufacturers published
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dimension of 0.022 inch, and to determine if the walls of the slots were parallel.

MATERIALS AND METHODS

0.022 inch upper left central incisor metal brackets from five different manufacturers were taken for evaluation of slot dimensions. Twenty brackets of each manufacturer were selected at random.

The brackets used for the study were as follows:

- Gemini MBT 0.022-inch (3M Unitek, Monrovia, Calif)
- Opti MIM MBT 0.022-inch (Ortho Organizers, San Marcos, Calif)
- Metal Brackets MBT 0.022-inch (Leone, Italy)
- Equilibrium MBT 0.022-inch (Dentaurum, Pforzheim, Germany)
- Sapphire, MBT 0.022-inch (Modern, Ludhiana, India)

The brackets were viewed under a stereomicroscope (Olympus SZX7) at 40× magnification. The positioning of the brackets was stabilized using a putty so as to provide a clear view of the slot walls from the side of the bracket when viewed under the microscope. Each bracket was scanned and captured individually in the stereomicroscope on both the mesial and distal sides to produce a digital image. The images were exported and calibrated with Dewinter Biowizard 4.3 (Dewinter Optical Inc. India). The software used was accurate up to a least count of 1 micron or up to 5 decimals in inches. The slot dimension was measured at the face and at the base from both the mesial and the distal aspect (Fig. 1). The measurements were rounded off at 4th decimal. Each bracket was measured thrice at both the base and at the facial end of the slot and a mean value was obtained.

The values obtained were compared to the dimensions published by each manufacturer. Comparisons were also made between brackets of different manufacturers. The dimensions of brackets from base to face were evaluated and a comparison was also made to calculate the difference between the mesial slot and the distal slot of the brackets within the same manufacturer to evaluate slot symmetry.

To check for inter-operator error, paired t-test was applied and for other comparisons the values obtained were subjected to analysis of variance.

RESULTS

Repeated measure method was used to assess the reliability of measurements. A total of 20 brackets, four brackets of each manufacturer, were selected randomly and measured by two different observers to evaluate inter-operator variation. A paired t-test was done to assess the reliability of measurements. The p-value obtained was 0.089 (t = 1.723), i.e. there was no statistical difference between the measurements indicating that the measurements obtained were reliable.

Analysis of variance was used to check for difference in the slot dimensions of different manufacturers (Table 1 and Fig. 2). The size of the slots of different brackets ranged from a minimum of 0.0201” on the distal base of Sapphire brackets to a maximum of 0.0248” on distal face of Opti MIM brackets. In general, the size of the slot was greater at the face than at the base. ANOVA showed a significant difference (p < 0.001) in the bracket slot sizes of all the manufacturers and this difference was present at the base as well as the face on both the mesial and distal aspect.

The mean percentage differences from the stated size of 0.022” were calculated for all the brackets (Table 2 and Fig. 3). These differences were found to be statistically significant between all the manufacturers.

The mean percentage loss of symmetry from base to face (Table 3) was calculated. The values obtained were found to be least in Gemini brackets with a percentage of 2.7037% and was maximum in Sapphire brackets with a percentage of 8.9583%.

When the mesial and distal aspects of the brackets were compared within each group (Table 4), a difference was found between the slot size at the mesial and distal sides. At the base, there was a significant difference in the slot size of the Equilibrium brackets while at the face, Equilibrium, Leone and

Fig. 1: Bracket as seen in a stereomicroscope
Fig. 2: Mean absolute difference from standard
Sapphire brackets showed a significant difference. There was no significant difference in the mesial and distal slot sizes in the Gemini and Opti MIM brackets either at the base or at the face.

**DISCUSSION**

Three-dimensional orthodontic tooth positioning occurs as a result of the interaction between orthodontic archwires and pre-programmed brackets on teeth within a healthy supporting periodontium.

Kusy and Whitley\(^8\) examined 24 brackets from eight manufacturers and found three bracket slots smaller and 20 others larger than the dimensions stated by their manufacturers. Cash et al\(^1\) evaluated slots of five upper left central incisor brackets from 11 commercially available bracket systems and found that orthodontic bracket slots were all larger than stated by the manufacturers.

Bhalla et al\(^11\) measured slot dimensions of 0.022 inch self-ligating upper central incisor brackets from six manufacturers using electron microscopy and concluded that dimensions were larger than stated and the walls of the slots diverged from the bracket bases.

Siatkowski\(^12\) calculated the loss of anterior torque control due to variations in bracket slots. He reported inaccuracies in
Table 4: Within group comparison of mesial and distal slot sizes

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Gemini</th>
<th>Equilibrium</th>
<th>Leone</th>
<th>Sapphire</th>
<th>Opti MIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesial base vs mesial face</td>
<td>t' -1.099</td>
<td>p' 0.286</td>
<td>t' -4.360</td>
<td>p' &lt;0.001</td>
<td>t' 1.594</td>
</tr>
<tr>
<td>Distal base vs mesial face</td>
<td>t' -0.427</td>
<td>p' 0.674</td>
<td>t' -3.732</td>
<td>p' 0.001</td>
<td>t' 4.037</td>
</tr>
</tbody>
</table>

Many researchers have evaluated the dimensions and the accuracy of the bracket slot sizes but no study has been done to calculate the slot dimensions of mesial and distal aspect of the bracket separately. In the present study we measured the difference in the slot sizes at the mesial and distal tie wings at the base as well as the face. A difference in the mesial and distal slot size will alter the tip that is produced by the archwires within the bracket. This alteration in tip would depend on the width of the brackets and would be less pronounced in wider brackets than in mini brackets or smaller sized brackets like the mandibular incisors and maxillary lateral incisor brackets.

When mesial and distal aspects of the brackets were compared, Equilibrium, Leone and Sapphire showed significant difference at face. At base, there was significant difference between the mesial and distal slot sizes at base in the Equilibrium brackets. Gemini and Opti MIM brackets showed no significant difference between the mesial and distal slots either at the base or at the face.

Based on these findings we may conclude that clinicians should be aware that the preadjusted bracket and wire systems widely used in clinical practice may not produce the three-dimensional control required to produce an acceptable result. This may be particularly evident in cases that require correction of incisor inclination correction, such as division II cases. The clinician should be aware that additional root torque may have to be added to the upper incisors to overcome inaccurate manufacturing dimensions.1 So, inspite of using straight wire brackets a perfect ‘finishing’ may still require additional bends to be put in by the orthodontist.

Also brackets and wires that have been used in sliding mechanics show evidence of considerable wear and tear.15 The brackets should not be reused, no matter how well recycled, if 3rd-order control is a clinical goal.

CONCLUSION

The results of this study indicate that the size of the orthodontic bracket slots were different than stated by the manufacturers. All the brackets were larger at the face than at the base. The percentage loss of symmetry from base to face was minimum in 3M brackets and maximum in modern brackets. There was a significant difference in the slot size between the mesial and distal aspects for all the brackets except 3M and Ortho Organizer. Clinicians should be aware that there may be a three-dimensional loss of tooth positioning as a result of the inadvertent use of orthodontic brackets with inaccurate slots.

REFERENCES