

Assessment of orthodontic brackets slot size accuracy in different commercially available brackets: An in vitro study

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Abstract

Aim and Objective: To evaluate the dimensional accuracy of the metal brackets slot size from two different manufacturers.

Materials and Methods: A total of 20 upper right first premolar brackets of 0.022-inch slot, 10 each from manufactures (Forestadent and 3M) were divided into 2 groups of 10 brackets each. Stereomicroscope (Inverted Research microscope, ultrascope IX71, IX2 series, Olympus) was used to obtain the images under 40x magnification. Images were taken and transferred to Oct view software (Make 2020, Germany, Version 2:345:117@. System 9B) and the base height and slot depth were measured.

Results: When compared for slot height between the two groups, a statistically significant difference was observed. Forestadent group showed less variation from the mean value when compared with 3M. When compared for slot depth between the two groups, a statistically significant difference was observed. Forestadent group showed less variation when compared with 3M.

Conclusion: The results obtained concluded that, none of the brackets showed the exact dimensions as stated by the manufacturer according to the MBT prescription. There was a considerable difference observed in the manufacturer stated slot dimensions when compared to ideal value. Most errors were seen in slot height and less errors were observed in slot depth.

Keywords: Slot dimensions, Torque, MBT, SEM, Accuracy, Orthodontic brackets

Introduction

The 0.022-inch slot was the first to be introduced. Pioneers like Angle, Kingsley and Farrar devised appliances that has evolved into what is now known as preadjusted edgewise appliance and described the wire dimensions using American standard wire gauze. The ongoing appliance evolution resulted in two orthodontic bracket slot sizes that a clinician may choose to use when correcting a patient's malocclusion today¹.

The 0.022 bracket slot has a dimension of 0.022 x 0.028 inches where 0.022 inch is the height of the slot and 0.028 inch is the depth of the slot. This slot size remained uncontested until the middle of the century when some orthodontists promoted a 0.018-inch slot. This downsizing of the bracket slots to 0.018 inch happened in the 1950s when non traditional clinicians began employing smaller sized stainless steel wires and introduced the light wires. Both the systems had their own advantages and disadvantages. The 0.022-inch system offers a more option in archwire size selection. With the use of undersized archwire, one can facilitate the free sliding of archwire through the bracket slot. Being able to use larger diameter archwires for treatment provides increased stiffness and allows to keep the teeth upright during alignment.²

Slot dimensions are a critical factor in bringing the desired orthodontic tooth movement. In the edgewise system, dimensional accuracy of slot geometry was less significant as the movements were incorporated using bends in the wire, but in preadjusted edgewise brackets the tooth movements are achieved by the interaction of the wire and the bracket slot. Any discrepancy in slot dimensions or may affect the result & esthetics³.

All these shortcomings like the shape of the bracket, manufacturing anomalies, different materials used for manufacturing, difference in the slot size led to a need for standardization protocol for the bracket slot size. Inaccuracy of slot size might directly or indirectly affect the planned tooth movement.³

Thus, the aim of this study was to measure the accuracy of the brackets slot size of two different manufacturing companies in India and comparing them with their prescribed MBT values of 0.022 x 0.028 inch.

Aim and Objective

Aim

This study aimed to evaluate the metal bracket slot size of two different manufacturing companies in India and comparing them with their prescribed MBT value.

Objective: 1) To measure the base height of the slot of each bracket in the groups. 2) To measure the depth of the slot of each bracket in the groups.

Materials and Methods

1. **Source of Data:** This investigation was carried out on 2 different commercially available brackets with slot size 0.022 x 0.028 inch with MBT prescription in India.
2. **Sample design:** In-vitro study
3. **Study period:** 6 months
4. **Sample size:** 20

Inclusion criteria

1. Commercially available metal brackets in India with tooth number 14.
2. Bracket slot size of 0.022 x 0.028 inch each (MBT Prescription)

Exclusion criteria

1. Distorted and reused bracket.
2. Self ligating brackets and Ceramic bracket

Materials

1. Two commercially available brackets in India (10 brackets each)
 - a. Forestadent Mini Sprint® II (Fig 1)
 - b. 3M Victory Series low profile (Fig 2)
2. Stereomicroscope (Inverted Research microscope, ultrascop IX71, IX2 series, Olympus) (Fig 3)
3. 3) Oct View software (Make 2020, Germany, Version 2:345:117®. System 9B)
4. Tweezer and bracket holding tweezers (Fig 4)
5. Modelling wax and adhesive tape (Fig 5)

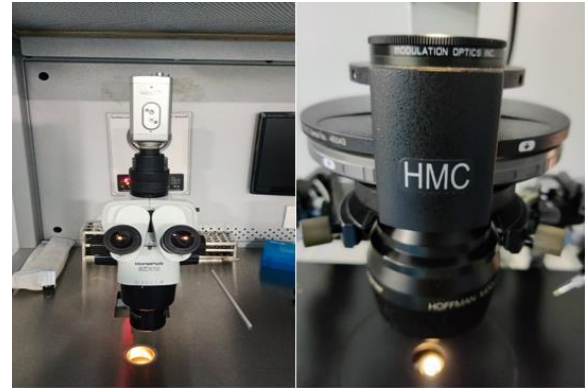


Fig 3: Stereomicroscope (Inverted Research microscope, ultrascop IX71, IX2 series, Olympus)



Bracket irt 14

Bracket kit

Fig 1: Forestadent Mini Sprint® II



Fig 4: Tweezers and bracket holding tweezers



Fig 5: Modelling wax and adhesive tape



Bracket irt 14

Bracket kit

Fig 2: 3M Victory series low profile

Methodology

In this present study, ten upper right first premolar brackets with 0.022-inch bracket slot size were investigated of two different brackets manufacturers in India that is Forestadent and 3M. Each bracket was placed on paper and marked from number 1-10. The brackets were stabilized using modelling wax so as to provide a clear view of the slot walls from the side of the bracket when viewed under the stereomicroscope (Fig 8). The paper was then secured to the viewing plate of stereomicroscope with the help of adhesive tape and the brackets were viewed under 40x magnification. Images were

taken and transferred to Oct view software and the slot height at the base (Fig 6) and slot depth (Fig 7) were measured. The Oct view software used was accurate upto a least count of 1 micron or up to 5 decimals in inches. Measurements were collected and stored in Excel and rounded off at 4th decimal. The dimensions were evaluated and a comparison was made to calculate the difference between slot height and slot depths. The values obtained were compared to the dimensions published by each manufacturer. Comparisons were also made between the two manufacturers.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp. Results on continuous measurement are presented as Mean±SD. Inferential statistics like Analysis of Variance (ANOVA) was used to compare the difference between the groups.

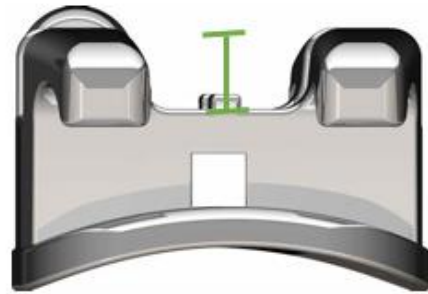


Fig 7: Slot depth of a bracket



Fig 6: Slot height of a bracket



Fig 8: Bracket being viewed under stereomicroscope.

Results

Table 1: Overall comparison of slot height between the groups

	N	Minimum	Maximum	Mean	Std. Deviation	P value
3M	10	0.0209	0.0259	0.0228	0.0014	0.003*
Forestadent	10	0.0211	0.0234	0.0223	0.0007	

*statistically significant (p<0.05) (ANOVA)

Inference: When compared for slot height between the groups, a statistically significant difference was observed between Forestadent and 3M group. Forestadent group showed less variation from the mean value in comparison to 3M.

Table 2: Overall comparison of slot depth between the groups

	N	Minimum	Maximum	Mean	Std. Deviation	P value
3M	10	0.0272	0.0299	0.0289	0.0007	0.027*
Forestadent	10	0.0260	0.0294	0.0283	0.0009	

*statistically significant (p<0.05) (ANOVA)

Inference: When compared for depth between the groups, a statistically significant difference was observed between 3M and Forestadent groups. Forestadent group showed less variation in comparison to 3M.

Discussion

Orthodontist should be aware of the bracket and wire system which they are using in their clinical practice. The effect of oversized bracket on anterior torque loss was assessed by Siatkowski and it was noticed that anterior teeth suffered torque loss and it might not result in desirable tooth movement⁴.

There are various methods to evaluate the slot size of brackets, both manually and digitally. To determine the accuracy of the slot pin gauges, leaf gauges were used in the earlier studies. The manual calibration methods have their own drawback and to overcome this, equipment's like stereomicroscope, electron microscope, profile projector were implemented. These equipments reduce the chances of error.

The results of this present study are in agreement with the study done by Kusy et al (1999)⁵, Pai VS et al (2011)⁶, Cash et al (2004)¹ and Major et al (2010)⁷ where they found that orthodontic bracket slots are mostly larger than stated by the manufacturers. Kusy et al⁵ observed that 75% of their sample had oversized and 20% undersized in slot height whereas in our study 82% were oversized and 18% were undersized. They concluded that the bracket slots were not rectangular as per orthodontists' expectations. Pai et al⁶ evaluated slot size of various brackets and found that the slot size of ortho organizer bracket was very close to the standard, whereas the other (3M Unitek, TP, Ormco) brackets were oversized as compared to the standard. Similar results were found in our study where Forestadent bracket was very close to the standard whereas the other brackets 3M was oversized. Similarly, Cash et al¹ found a larger bracket slot with respect to height, when compared to manufacturer's specification in all of the 11 commercially available bracket systems which is similar to the present study.

Studies conducted by Demling et al (2009)⁸ and Bhalla et al (2010)⁹ confirmed that the slot dimensions were larger than the value prescribed by the manufacturer. Bhalla et al⁹ in their study reported that the brackets were 5% - 15% larger in depth than the nominal values. In our study the brackets were 1.6%-10.8% oversized in depth than the nominal values. It was also noted that the brackets from the same manufacturer may vary in size as well which is in accordance with our study.

Another study conducted by Tangri K et al (2012)¹⁰ showed similar results where all the bracket slots showed statistically significant difference in slot depth dimension from the standard values with 80% of brackets oversized and the remaining 20% undersized. This is in accordance with the present study where 82% bracket slots are oversized while 18% are undersized.

Silitonga PL et al (2013)¹¹ also found that the slot size of all the slots used in their study was larger than the prescribed value which is exactly in case of our study also. However, the statistics could not be correlated as they, in their study used 15 types, (i.e, metal brackets along with other type of brackets) of brackets from 8 different manufacturers while in our study only one type of bracket was used that is the metal brackets.

Our results showed that Forestadent brackets showed the most accurate values in comparison to 3M. Similar results

were seen in the studies conducted by Awasthi E et al (2015)¹², Kumar M et al (2021)¹³ and Alqatahini ND (2021)¹⁴. Kumar M et al¹³ found the brackets to be larger than the nominal value which is in accordance with our study. They also found that best bracket slot size in respect to accurate dimension, is provided by Forestadent which is also the result of our study. Alqatahini ND¹⁴ stated that 3M-Victory were 11.99% larger (0.02509 inch) and the closest to the stated dimension whereas in our study 3M- Victory were 3.7% larger, Forestadent were 1.6% oversized.

Brown et al (2015)¹⁵ found that 36% of the brackets were undersized and were not large enough to insert a full size wire, whereas in our study we found that only 18% brackets slots were undersized. The authors also found that the slot dimension differed greatly from series to series as well as within the series. Size of bracket slot were different even among the brackets by same manufacturer, that is to say no two brackets had same slot size which is also a result of our study.

The results of this present study are not in accordance with the studies conducted by Rajashekar K et al (2017)³, Araujo AVP et al (2019)¹⁶, Daga et al (2017)¹⁷, Park JS et al. (2020)¹⁸ and Tepedino et al (2020)¹⁹. Rajashekar K et al³ found that 50% of brackets were larger and the remaining 50% were smaller than the stated dimension and all brackets were statistically significant ($p \leq 0.05$).

Since this is an in vitro study the clinical impact of these errors on tooth movements was not measured and further studies are required which may highlight the clinical effects of error in slot dimensions.

Conclusion

Following conclusions were drawn from this study:

1. On evaluation of the slot height of the samples under stereomicroscope, Forestadent brackets showed less variation than 3M when compared with the standard MBT prescribed values. The actual slot height of all the brackets were larger than the MBT prescribed values.
2. On evaluation of slot depth of the samples under stereomicroscope, Forestadent brackets showed less variation than 3M when compared with the standard MBT prescribed values.

Hence, both of the brackets didn't show the exact dimensions as stated by the manufacturer. Most errors were seen in slot height and less errors was observed in slot depth.

Source of Funding

None.

Conflict of interest

None.

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