10.5005/jp-journals-10021-1030
ORIGINAL ARTICLE
JIOS

Evaluation of Slot Size in Orthodontic Brackets: Are Standards as Expected?

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ABSTRACT

The early pioneers of orthodontics, like Angle, Kingsley and Farrar, devised appliances that have now evolved into what is known as the pre-adjusted edgewise appliance. With the introduction of preadjusted appliances, the focus has moved to customization of brackets to achieve specific and exact positioning of the dentition. These preprogramed features of the orthodontic bracket can be completely effective only if the bracket slot is accurate.

Aims and objectives: The purpose of this study is to evaluate the slot size of eight different commercially available straight wire brackets of 0.018 inch slot and 0.022 inch slot with two different measuring devices.

Materials and methods: Out of 80 straight wire brackets (Roth), 40 each of 0.018 inch slot and 0.022 inch slot from four commercially available manufacturers (3M Unitek, TP, Ortho Organizers and Ormco) were used for the study. Each bracket sample from all the eight groups was measured for its slot size at the top and the base of the slot using two different measuring devices namely Starrett profile projector and PrakaVision profile projector. Both the measuring devices give a digital read out to the accuracy of 0.001 mm. Data obtained were subjected to statistical analysis.

Results: The slot size for ortho organizer—0.018 inch slot brackets was very close to the standard, whereas the other brackets were either oversized or undersized as compared to the standard.

Keywords: Brackets, PrakaVision profile projector, Slot size, Starrett profile projector, Standard.

How to cite this article: Pai VS, Pai SS, Krishna S, Swetha M. Evaluation of Slot Size in Orthodontic Brackets: Are Standards as Expected? J Ind Orthod Soc 2011;45(4):169-174.

INTRODUCTION

Standardization is an essential tool requirement for technological progress.[1] Edward H Angle introduced edgewise bracket of 0.022 inch as the standard slot size for brackets.[2] This slot size remained uncontested until the middle of this century when some orthodontists promoted a 0.018 inch slot.

The 0.022 inch system offers more options 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 space closure with different retraction mechanics. The 0.018 inch system provides a contrasting set of benefits. Although there may be fewer choices in archwire dimensions, filling the bracket slot is more easily accomplished. The capacity to fill the bracket slot allows for a greater use of the program or prescription built into the bracket.[3]

With the introduction of preadjusted appliances, the focus has moved to customization of brackets to effect specific and exact positioning of the dentition. The bracket system will only reproduce their prescription when slots and wires are as intimately fitting as is clinically practical and possible to guarantee by the manufacturers.[4]

In the orthodontic speciality, the placing of the maximum prescription 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 the 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.[2] Inaccurate machining of bracket slot dimensions and use of undersized archwires may directly and adversely affect the three-dimensional tooth positioning.

Slots could remain uncut leading to unnecessary or excessive wire bending, or be cut at improper angles and depths leading to level misalignment. Unevenly cut slots within the same twin bracket are quite common with a resulting level difference of as much as 2 mm from one pair of tie wings to the other. Some brackets despite being correctly machined have an excess of brazing material that clogs the slot, rendering difficulty or even making the insertion of the archwire

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Received on: 30/6/11
Accepted after Revision: 6/9/11

impossible.[5] Though the bracket systems have multiple variations in how it is programed, the effect on the mechanics may not vary to a great extent.

AIMS AND OBJECTIVES

1. To measure and check the accuracy of 0.018 and 0.022 inch slot brackets of different manufacturers, both at the top and base of the slot and to evaluate the extent of variation between the reported and actual slot width.
2. To comparatively assess whether the variation in slot dimension is more pronounced in the 0.018 or 0.022 inch slot bracket of the same manufacturer as well as between manufacturers.

MATERIALS AND METHODS

Source of Data

Out of 80 straight wire brackets (Roth), 40 each of 0.018 inch slot and 0.022 inch slot from four commercially available manufacturers (3M Unitek, TP, Ortho Organizers and Ormco) were used for the study. The brackets were divided into eight groups of 10 brackets each. Each bracket was pasted on a white cardboard piece and was marked with a number from 1 to 10. Slot size and the manufacturing company to which the bracket belongs to (3M, TP, Ortho Organizers, Ormco) was also marked on the cardboard for easy identification (Table 1 and Fig. 1).

Method of Collection of Data

Each bracket sample from all the eight groups was measured for its slot size at the top and the base of the slot using two different measuring devices namely:

1. Starrett profile projector (Fig. 2)
2. PrakaVision profile projector (Fig. 3)

Table 1: The brackets were divided into eight groups of 10 brackets each

Group 1	0.022 inch slot brackets from 3M Unitek
Group 2	0.022 inch slot brackets from TP
Group 3	0.022 inch slot brackets from Ortho Organizers
Group 4	0.022 inch slot brackets from Ormco
Group 5	0.018 inch slot brackets from 3M Unitek
Group 6	0.018 inch slot brackets from TP
Group 7	0.018 inch slot brackets from Ortho Organizers
Group 8	0.018 inch slot brackets from Ormco

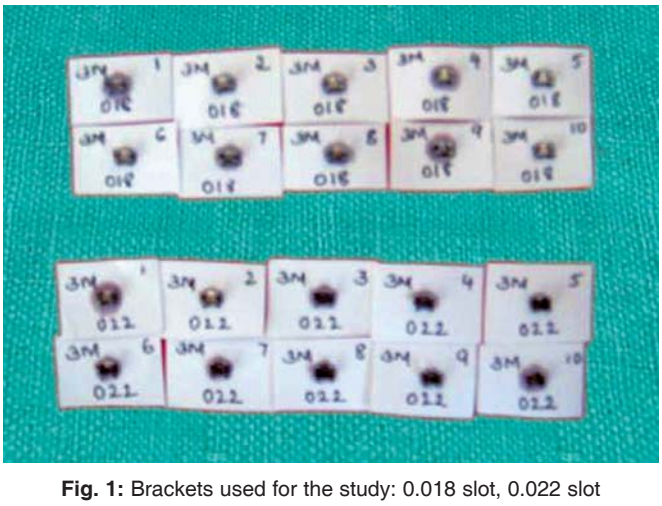


Fig. 1: Brackets used for the study: 0.018 slot, 0.022 slot

Both the measuring devices give a digital read out to the accuracy of 0.001 mm.

Method of Measuring the Slot Size with Starrett Profile Projector and PrakaVision Profile Projector

The bracket was mounted on the measuring table of the profile projector. Modeling clay was placed at the base of the cardboard on which the bracket is pasted for stability. Once the bracket is stabilized on the measuring table, the image of the bracket appears on the projector screen. The measuring table is adjusted such that one of the wall of the slot at the top coincides with the Y-axis. Once this is done, the measuring table is moved such that the other wall of the slot coincides with the Y-axis. The distance between the two walls can be read on the digital screen. Once the slot width at the top is measured, the procedure is repeated to measure the slot width at the base (Figs 4 to 6).

RESULTS

The result shows that the width of the slot was either more than or less than the standard. The width at the top and the base was also not equal. There was no significant difference between the measurements obtained from the two different profile projectors.

Fig. 2: Starrett profile projector

Fig. 3: PrakaVision profile projector

Fig. 4: Image of the bracket as seen on the screen of Starrett profile projector

Fig. 6: Reading as seen on Starrett profile projector

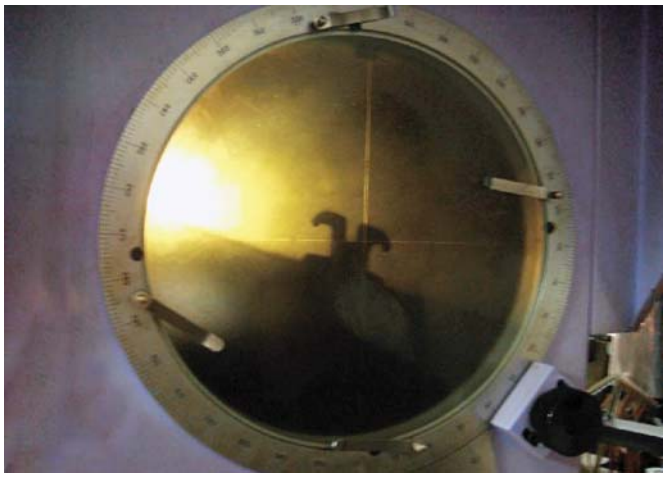


Fig. 5: Image of the bracket as seen on the screen of PrakaVision profile projector

3M Unitek

The slot size of the 3M Unitek brackets both 0.022 inch and 0.018 inch are greater than the standard. The mean slot width at the base is in the range of 0.557 to 0.558 mm. The mean slot width at the top of the slot is 0.563 mm. The standard width is 0.558 mm. The Z-value at the base is in the range of 0.000 to 0.527. The Z-value at the top is in the range of 2.474 to 2.751. The slot is wider at the top than at the base. The Z-value is greater than 2.58 which shows that the inaccuracy is statistically highly significant. The walls of the slot are divergent from the base (Tables 2 to 4 and Graphs 1A to 2B).

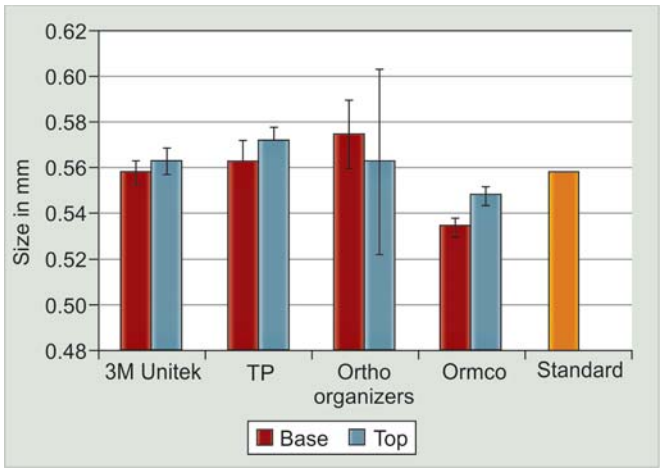
TP Brackets

The slot size of TP brackets 0.022 inch slot was greater than the standard. The mean slot width at the base of the slot is in the range of 0.438 to 0.441 mm. The mean slot width at the top of the slot is in the range of 0.463 to 0.464 mm. The standard slot width is 0.460 mm. The Z-value at the base of the slot is in the range of 5.217 to 5.667. The Z-value at the top of the slot is in the range of 0.759 to 1.580. The Z-value is less than 1.96 at the top. Therefore, the slot width at the top is more accurate. The Z-value is more than 2.58 at the base which indicates that the inaccuracy of the slot size is statistically highly significant. The slot is wider at the top than at the base. The walls of the

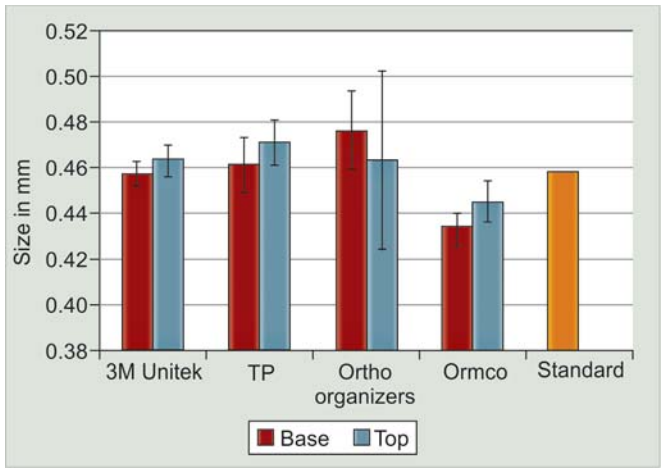
Table 2: Comparison of slot 0.022 brackets and type with standard results in mm

Brackets	*Type*	*Mean*	*SD*	*Standard*	*Z-value*
3M Unitek	SPP-base	0.558	0.005	0.558	0.000 (NS)
	SPP-top	0.563	0.006	0.558	2.751**
	PPP-base	0.557	0.005	0.558	0.527 (NS)
	PPP-top	0.563	0.007	0.558	2.474*
TP	SPP-base	0.563	0.009	0.558	1.790 (NS)
	SPP-top	0.572	0.006	0.558	7.514**
	PPP-base	0.561	0.012	0.558	0.641 (NS)
	PPP-top	0.571	0.010	0.558	4.015**
Ortho Organizers	SPP-base	0.575	0.015	0.558	3.565**
	SPP-top	0.563	0.041	0.558	0.384 (NS)
	PPP-base	0.576	0.017	0.558	3.353**
	PPP-top	0.563	0.039	0.558	0.418 (NS)
Ormco	SPP-base	0.534	0.004	0.558	16.877**
	SPP-top	0.548	0.004	0.558	8.502**
	PPP-base	0.533	0.007	0.558	12.106**
	PPP-top	0.545	0.009	0.558	4.651**

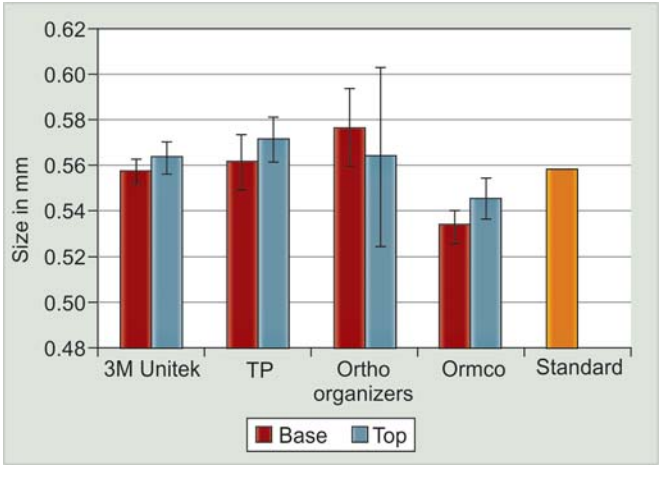
Z-value: Inaccuracy; up to 1.96: Not significant (NS); 1.96 to 2.58: Moderately significant (*); above 2.58: highly significant (**)



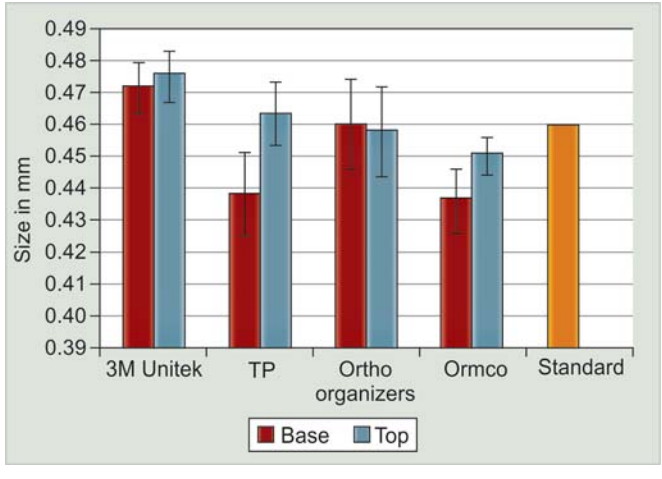
Graph 1A: 0.022 slot—Starrett profile projector (base and top)



Graph 1B: 0.018 slot—Starrett profile projector (base and top)



Graph 2A: 0.022 slot—PrakaVision profile projector (base and top)



Graph 2B: 0.018 slot—PrakaVision profile projector (base and top)

Table 3: Comparison of slot 0.018 , brackets and type with standard results in mm

Brackets	*Type*	*Mean*	*SD*	*Standard*	*Z-value*
3M Unitek	SPP-base	0.471	0.007	0.460	4.845**
	SPP-top	0.474	0.007	0.460	5.953**
	PPP-base	0.471	0.008	0.460	4.423**
	PPP-top	0.475	0.008	0.460	5.567**
TP	SPP-base	0.441	0.010	0.460	5.667**
	SPP-top	0.464	0.009	0.460	1.580 (NS)
	PPP-base	0.438	0.013	0.460	5.217**
	PPP-top	0.463	0.010	0.460	0.759 (NS)
Ortho Organizers	SPP-base	0.459	0.014	0.460	0.207 (NS)
	SPP-top	0.465	0.037	0.460	0.462 (NS)
	PPP-base	0.460	0.014	0.460	0.090 (NS)
	PPP-top	0.458	0.014	0.460	0.465 (NS)
Ormco	SPP-base	0.436	0.010	0.460	7.266**
	SPP-top	0.447	0.005	0.460	8.738**
	PPP-base	0.436	0.010	0.460	7.865**
	PPP-top	0.450	0.006	0.460	5.444**

Z-value: Inaccuracy; up to 1.96: Not significant (NS); 1.96 to 2.58: Moderately significant (*); above 2.58: highly significant (**)

slot are divergent from the base. The slot size of TP 0.018 inch slot is greater than the standard at the top and lesser than the standard at the base. The slot is wider at the top than at the base. The walls are divergent from the base (Tables 2 to 4 and Graphs 1A to 2B).

Ortho Organizers

The slot size of Ortho Organizers 0.022 inch slot is greater than the standard at the base and lesser than the standard at the top. The slot is wider at the base than the top. The walls are convergent from the base. The slot size for Ortho Organizer

Table 4: Comparison of slot 0.022 and 0.018, brackets and type with standard based on bias and inaccuracy

Brackets	*Type*	*0.022 slot*		*0.018 slot*	
		Bias	*Inaccuracy*	*Bias*	*Inaccuracy*
3M Unitek	SPP-base	0.000	0.004	0.011	0.012
	SPP-top	0.005	0.007	0.014	0.014
	PPP-base	–0.001	0.004	0.011	0.012
	PPP-top	0.005	0.007	0.015	0.015
TP	SPP-base	0.005	0.008	–0.019	0.019
	SPP-top	0.014	0.014	0.004	0.007
	PPP-base	0.003	0.009	–0.022	0.022
	PPP-top	0.013	0.014	0.003	0.008
Ortho Organizers	SPP-base	0.017	0.018	–0.001	0.011
	SPP-top	0.005	0.026	0.005	0.022
	PPP-base	0.018	0.019	0.001	0.011
	PPP-top	0.005	0.024	–0.002	0.011
Ormco	SPP-base	–0.024	0.024	–0.024	0.024
	SPP-top	–0.010	0.010	–0.013	0.013
	PPP-base	–0.025	0.025	–0.024	0.024
	PPP-top	–0.013	0.013	–0.010	0.011

Z-value: Inaccuracy; up to 1.96: Not significant (NS); 1.96 to 2.58: Moderately significant (*); above 2.58: highly significant (**)

0.018 inch slot brackets was very close to the standard both at the top and at the base. The walls of the slot were also parallel. The mean slot width at the base of the slot is in the range of 0.459 to 0.460 mm. The mean slot width at the top of the slot is in the range of 0.458 to 0.465 mm. The standard slot width is 0.460 mm. The Z-value at the base of the slot is in the range of 0.090 to 0.207. The Z-value at the top of the slot is in the range of 0.462 to 0.465. The Z-value is less than 1.96 both at the top of the slot and the base of the slot which indicates the accuracy of the slot prescribed by the manufacturer (Tables 2 to 4 and Graphs 1A to 2B).

Ormco

The slot size for Ormco both 0.022 inch and 0.018 inch is lesser than the standard. The slot is wider at the top than at the base. The walls are divergent from the base. The mean slot width at the base of the slot is 0.436. The mean slot width at the top of the slot is in the range of 0.447 to 0.450 mm. The standard slot width is 0.460 mm. The Z-value at the base of the slot is in the range of 7.266 to 7.865. The Z-value at the top of the slot is in the range of 5.444 to 8.738. The Z-value is greater than 2.58 which indicates that the inaccuracy of the slot width is statistically highly significant (Tables 2 to 4 and Graphs 1A to 2B).

DISCUSSION

Orthodontic 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 incisor inclination correction, and the clinician should be aware that additional root torque may have to be added to the upper incisors to overcome inaccurate manufacturing dimensions.

The effects of oversized brackets on anterior torque loss were illustrated by Siatkowski who noted that maxillary and mandibular incisors may suffer unexpected loss of torque when protracting the buccal segments during space closure with the preadjusted edgewise appliance. These anterior teeth may suffer a loss of torque of 5° to 10° and this equates to 1.9 mm of lingual retrusion of incisal edges during space-closing protraction.[6]

A clinician unhappy with a bracket and wire system that consistently produces over retraction of the incisors may attempt to circumvent this problem by using a preprogramed bracket system with increased incisor torque values. This may be a way around the problem, but it would seem logical that bracket systems will only reproducibly produce their prescription when slots and wires are as intimately fitting as is clinically practical and possible to guarantee by the manufacturers.

The above finding of the present study is in confirmation with the study conducted by AC Cash, SA Good et al.[2] It was found that the geometry of the bracket slot wall was not necessarily parallel. Some were convergent and some were divergent. One of the brackets even had a 7% variation between the width at the slot top and base. Robert P Kusy and John Q Whitley[7] found that three bracket slots were smaller and others larger than the dimensions stated by the manufacturer. Only one bracket (New ceramic 3M) was found to be dimensionally accurate. The largest 0.018 inch slot measured 16% larger than stated and the largest 0.022 inch slot measured 8% larger than stated. The results in our study show that 3M Unitek 0.018 inch slot and 0.022 inch slot, Ortho Organizers 0.022 inch slot, TP 0.018 inch slot and 0.022 inch slot brackets were oversized than the prescribed value, whereas Ormco brackets both 0.018 inch slot and 0.022 inch slot were undersized than the prescribed value. Only Ortho Organizers 0.018 inch slot brackets were more or less accurate to the prescribed value.

According to Kusy and Whittey et al,[8] the largest 0.018 inch slot actually measured 0.0209 inch nearly 0.003 inch oversized. The largest 0.022 inch slot measured 0.0237 inch or almost 0.002 inch oversized. It was also found that European

manufacturers used metric tooling as a result of which their target values are 0.5 mm (0.0197 inch) for 0.018 inch slot and 0.6 mm (0.0236 inch) for 0.022 inch slots. Therefore, the brackets from European manufacturers are oversized.[9,10] The results in our study show a similar finding. This clearly reduces the simplicity and effectiveness of a straight wire preadjusted system and may encourage a clinician to favor the use of zero-base edgewise type brackets.

CONCLUSION

From this study, following conclusions were made:

- The slot size of the 3M Unitek brackets both 0.022 inch and 0.018 inch are greater than the standard. The slot is wider at the top than at the base. The walls of the slot are divergent from the base
- The slot size of TP brackets 0.022 inch slot was greater than the standard. The slot is wider at the top than at the base. The walls of the slot are divergent from the base
- The slot size of TP 0.018 inch slot is greater than the standard at the top and lesser than the standard at the base. The slot is wider at the top than at the base. The walls are divergent from the base
- The slot size of Ortho Organizers 0.022 inch slot is greater than the standard at the base and lesser than the standard at the top. The slot is wider at the base than the top. The walls are convergent from the base
- The slot size for Ortho Organizer 0.018 inch slot brackets was very close to the standard both at the top and at the base. The walls of the slot were also parallel
- The slot size for Ormco both 0.022 inch and 0.018 inch is lesser than the standard. The slot is wider at the top than at the base. The walls are divergent from the base.

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