

Evaluation of Dimensional Accuracy of Slot Size in Passive Self-Ligating Brackets From Three Different Orthodontic Companies-An Invitro Study

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Abstract

Objective: To evaluate of dimensional accuracy of the slot size in passive self-ligating brackets from three different orthodontic companies. **Material and method:** Total of 90 upper right central incisor self-ligating brackets, 30 each of 0.022 inch slot from three commercially available manufactures (American orthodontics, Forestadent, Damon Q) were divided into 3 groups of 30 brackets each. Stereomicroscope was used, coupled to a computer with a Charge Coupled Device (CCD) camera to obtain the images. After insertion, the brackets were adjusted with a segment of 0.016" x 0.022" stainless steel wire. The images obtained by the microscope were analyzed in the Image analysis software (MVG 2005) by a laboratory technician as instructed by the authors. Images (90) captured for slot dimension measurement had total magnifications 15X for all samples size. **Results:** The result showed that the mean values for slot width at base of brackets were: American orthodontic (0.02384 inch), Damon Q (0.0245667 inch), and Forestadent (0.0238267 inch). The mean value of group 1 and group 2 had variation as compared to group 3 as specified by the manufacturer. The mean values slot width at top of brackets was: American orthodontic (0.0249133 inch), Damon Q (0.0250067 inch), and Forestadent (0.0242533 inch). The mean value of group 1 and group 2 had more variation as compared to group 3 as specified by the manufacturer. **Conclusion:** The results obtained conclude that the width of the slot was either more or less than specified by the company and the width of the bracket slot at top and the base was also not equal.

Keywords: Passive self-ligating brackets, slot size, archwire.

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Introduction

Standardization is an essential tool requirement for technological progress[1]. Pre-adjusted self-ligating edgewise orthodontics brackets are claimed to be accurately manufactured to each manufacturer's prescription, allowing tooth to be moved predictably in three dimension[2]. We have dozens of brands with an almost endless variety in design of brackets to move the teeth. Despite the near universal use of brackets in orthodontic treatment, there are few scientific studies of the bracket slot's tolerances, which are especially important when using a preadjusted appliance. "The brackets and tubes for an edgewise appliance must be precisely manufactured so that the internal slot dimensions are accurate to at least 1 mil (1 mil=.001 inches)." Bennett stated, "Oversize slots undermine the whole basis of preadjusted edgewise, which is intended to minimize wire bending." Past bracket studies that are frequently cited that deal with bracket slot dimension and shape were limited to either relatively small sample sizes and/or the inclusion of just a single tooth-specific bracket (i.e. upper left central) from a bracket series. This may or may not be representative of all the other individual

tooth brackets in the series. In a metal injection moulded bracket series, for example, each specific tooth bracket is manufactured from a separate and unique mold[3]. In the orthodontic specialty, the placing of maximum prescription archwire 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[4]. 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 from one pair of tie wings to 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 impossible[5]. Orthodontic bracket slot profile variances have an impact on torque play and third-order torque expression. Typically the bracket slot height will be stated as a nominal height; previous studies have found variations between the nominally stated sizes and the measured sizes, with some brands being oversized up to 27%[6]. When Edward H. Angle introduced the edgewise fixed appliance system, he reoriented the slot from vertical to horizontal and inserted a rectangular archwire in the slot. After extensive experimentation with the edgewise appliance, Angle adopted the dimensions of 0.022-inch x 0.028-inch as his slot size

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because it allowed better control of crown and root position in all three planes of space using the precious metal archwires available to him at the time[7].The aim of this study is to measure the slot dimension of 0.022 inch self –ligating upper central incisor brackets from three different manufactures, to compare the measured dimensions with the manufacturers’ published dimension of 0.022 inch, and to determine if the walls of slot is accurate or not.

Material and method

Total of 90 upper right central incisor self-ligating brackets, 30 each of 0.022 inch slot from three commercially available manufactures (American orthodontics, Forestadent, Damon Q) were divided into 3 groups of 30 brackets each.The brackets were placed on acrylic plate that served as template. A hole was made in this plate to fix these brackets, hole was filled with modeling clay so that half of bracket in profile would be inserted and the other half would be exposed for the assessment (Figure 1). Stereomicroscope was used, coupled to a computer with a Charge Coupled Device (CCD) camera to obtain the images.After insertion, the brackets were adjusted with a segment of 0.016” x 0.022” stainless steel wire. This adjustment allows the proximal view of the bracket to be parallel to the template base and perpendicular to the optic visor of the microscope. (Figure. 2)The images obtained by the microscope were analysed in the Image analysis software (MVIC 2005) by a laboratory technician as instructed by the authors. Image (90) captured for slot dimension measurement had total magnifications 15X for all samples size.After getting the pictures, with help of the image analysis system lines were marked on the bracket such that one line was marked on the base and other line marked on the top of the bracket. (Figure3). Now the linear measurement between these two lines were measured which gave the value of slot size of the bracket and the process was measured for the other two groups in the same manner.

Statistical Analysis:Statistical analysis for the comparison of torque of three different companies was carried out to find the significant

difference between these values and to compare the mean of these slot size values with the standard values prescribed by the manufacturer. The statistical tests used for the analysis were: One sample t test and One way ANOVA test.

Results

The result shows that the width of the slot was either more or less than the standard as specified by the manufacturer. The width of the bracket slot at top and the base was also not equal. The mean values slot width at base of brackets was found to be as: American orthodontics (0.02384 inch), Demon Q (0.0245667 inch), and Forestadent (0.0238267 inch). The mean value of group 1 and group 2 had more variation as compared to group 3. While comparing the slot width at base of the brackets from one group to other two group, the result showed that the group 1 and group 3 were statically not significant (P=0.997). While comparing the group 1 with group 2 and group 3 were statically significant (0.000). The mean values slot width at top of brackets was found as: American orthodontic (0.0249133 inch), Demon Q (0.0250067 inch), and Forestadent (0.0242533 inch). The mean value of group 1 and group 2 showed more variation as compared to group 3 when compared to the values claimed by the manufacturer. The values of mean for all the three groups (P<0.05) were found to be statistically significant.When compared the slot width at base of the brackets one group to other two group, the result showed that the group 1 and group 2 were statically not significant (P=0.850). When compared the group 1 with group 2& group 3 and group 2 & group 3 were statically significant (0.000). While comparing the slot width at base and top of the brackets for three groups with standard slot size 0.022 inch it was found that the slot on tops were significantly wider than the slot bases. The slot base was divergent and slot size was more at top of slot. The values of mean for all the three groups (P<0.05) were found to be statistically significant.

Table 1: The mean values of slot width at base of brackets as: American orthodontic (0.02384 inch), Demon Q (0.0245667 inch), and Forest adent (0.0238267 inch)

GROUP	MEAN	MINIMUM	MAXIMUM	±SD	P-Value
American Orthodontic	0.02384	0.02260	0.02540	0.00066	0.000
Demon Q	0.02456	0.02370	0.02550	0.00050	0.000
Forest Adent	0.02407	0.02170	0.02570	0.00079	0.000

Table 2 :The mean values of slot width at top of brackets were found as: American orthodontic (0.0249133 inch), Demon Q (0.0250067 inch), and Forestadent (0.0242533 inch)

GROUP	MEAN	MINIMUM	MAXIMUM	±SD	P-Value
American Orthodontic	0.02491	0.02380	0.02610	0.00060	0.000
Demon Q	0.02500	0.02410	0.02610	0.00059	0.000
Forest Adent	0.02425	0.02260	0.02610	0.00077	0.000



Fig1:The brackets were placed on acrylic plate that served as template.



Fig 2:The brackets were adjusted with a segment of 0.016” x 0.022” stainless steel wire. This adjustment allows the proximal view of the bracket to be parallel to the template base and perpendicular to the optic visor of the microscope.

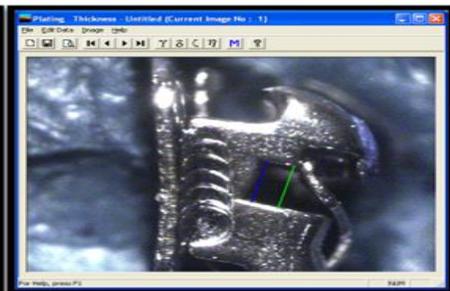


Fig 3:After getting the pictures, with help of the image analysis system lines was marked on the bracket such that one line was marked on the base and other line marked on the top of the bracket.

Discussion

A self-ligating bracket is a ligature less system with a mechanical device built-in to close off the edgewise slot. Secure engagement may be produced by a built-in metal labial face or by a clip mechanism replacing the stainless steel ligature ties or elastomeric ligature. The slot must be of adequate hardness, low roughness, consistent size, shape and possess consistency in prescribed tip and torque in the slot are expressed in a predictable manner. Manufacturing of brackets allows for an acceptable variation in their size and characterized including dimensional accuracy and torque consistency. Various brackets manufacturing processes involving injection mould casting or milling may also affect the accuracy of the prescribed torque value. Moulding exposes the material to expansion and shrinkage, whereas milling may incorporate a roughness. Slot size consistency is important in ensuring that the wire engagement is properly achieved and that the slots are expressed in predictable manner. The preadjusted appliance was a great development in orthodontic mechanics. However, preadjusted brackets provided with standard slot size would be influenced by many factors and among them would be the precision of manufacture by the industry. The real value of the slot size of the brackets should be in accordance with the nominal values informed by the manufacturers. Clinically the oversized slot can change the net effective torque i.e. the play between the wire and the slot is increased. If the slot is oversized although the in-built torque is accurate the torque will not be expressed because of the increased play between the wire & the slot. This situation is particularly of disadvantage in cases of under torqued anterior & during retraction. On the other hand an undersized slot results in binding of the wire to the slot which increases the friction while sliding ultimately causing molar taxation. With regard to the methodology, various possibilities were investigated. Some authors that studied orthodontic materials developed mechanical devices to conduct their researches. Others used computerized systems or graphic computation systems (CAD) or profile projector, electron scanning microscope [2-5]. In view of this, to measure the slot size of the brackets, the precision of the stereo microscope was used in conjunction with image analysis software for measured the slot size. Although the results of our study agree with the previous study studies of the slot sizes of self-ligating brackets. For being small parts, orthodontic brackets would be difficult to be handled by the operator. Thus, various templates were tested to handle the brackets, until one of them was as close as possible to the ideal. In principle, the brackets were immersed, in profile, in modelling wax but this material did rigid the brackets to be precisely adjusted. Furthermore, some brackets presented better finishing on one proximal surface than on the other, and if they were permanently fixed, it would limit observation to only one of its proximal faces. In view of this, acrylic plates with holes filled with clay was chosen as the method of fixation because of presenting an adequate consistency and less variation to thermal stimuli. The bracket were inserted in this template in profile and adjusted so that the proximal surface would parallel to the template base. 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. This may be particularly evident in cases requiring incisor inclination correction, by root torquing upper incisors to overcome inaccurate manufacturing dimensions [4]. The findings of the present study is in confirmation with the study conducted by Bhalla et al [2]. In the study, they compared five upper left central 0.022-inch self-ligating brackets from each of six different bracket series that represented four different manufacturers. They reported the brackets to be between 5% and 15% larger than the nominal values and that slot walls diverged from the base to the top of all the brackets. It was noted that brackets from the same manufacturer may vary in size as well. In our study, the slot width at base of brackets were found as: American orthodontic 8%, in

Demon Q 11%, and in Forest adent 8% smaller than slot width. At top of brackets the slot width were found as: American orthodontic 13%, Demon Q 13%, and Forestadent 10%, when compared the results with standard slot size 0.022". The Best bracket slot size in respect to accurate dimension, according to our study is provided by forestadent. The study conducted by Paul Brown et al [3] to measure the slots dimension of ten bracket series approximating five complete sets of brackets in which each were imaged and measured. They reported that the actual slot size and shape of an orthodontic bracket are likely to vary both larger and smaller from the advertised nominal value within a bracket series. Using conventional wire sizes and a straight wire approach, some brackets marketed as preadjusted clearly are not able to produce a torquing tooth movement without additional wire bending. In our study, their is variation of slot size in different manufacture scan and show that out of all three groups forest adent bracket slot scans more close to manufactured claim. Similar findings were found by Cash et al [4]. They measured the slots of five upper left central 0.022-inch brackets from 11 bracket series representing six different manufacturers. They reported that all bracket systems were oversized with a range of 5% to 24%. Four systems had parallel slot walls, five systems converged from the base to the top of the slot, and two systems showed diverging slot walls. Moreover, Pal et al⁵ evaluated slot size of various brackets and found that the slot size of ortho organizer (0.018" slot) bracket was very close to the standard, whereas the other (3MUnitek, TP, Ormaco) bracket were oversized as compared to the standard. Similar findings were found by Major et al [6] They found that the speed brackets to be slightly undersized at the base 0.556mm (0.0219 inches) with "pronounced rounding" and "large fillets" and the base meets the wall with slight convergence. Such bases-to-wall issues were also present throughout this sample. Major et al., reported that the GAC In-Ovation measured 0.564mm (0.0222 inches) at the base and "most closely resembles a trapezoidal shape." They also reported that Damon Q's base was 0.572 mm (0.0225 inches), with the "highest measured manufacturing tolerance" among the three tested and "nearly 90-degree corners." While there are examples of Damon Q brackets in the current sample with 90 corners, the great majority have large rounded internal line angles. The study by Kusy and Whitley [8] measured three brackets (unspecified as per tooth) from 24 unique bracket series from eight different companies. Their sample included brackets manufactured from four different materials and included three different slot sizes 0.018, 0.0185, and 0.022 inches. They reported that 15% of the brackets were smaller than reported and slot sizes exceeded the nominal value by as much as 16% and 8% (in the cases of nominal 0.018-inch and 0.022-inch slots, respectively). Finally, they underscored the need for the practitioner to know the exact dimension of the bracket in order to avoid compromising treatment mechanics. The study conducted by Siatkowski et al [9] showed loss of anterior torque control due to variations in bracket slot and archwire dimensions. If undersized rectangular wires are placed into oversized bracket slots bonded to the incisors, the impact can be severe. If a .022" slot bracket is .0235" less than the maximum error measured, than a .018" × .025" archwire will have 5° of wire bracket play which is beyond that usually anticipated. A .0215" × .028" archwire, which should fill a .022" slot, will have 5° or more of wire-bracket play when protracting posterior teeth, as the mechanics depend upon moments generated at the incisor brackets with rectangular archwires, the above slot-size errors can induce lingual tipping of the incisors. Fischer-brandies et al [10] measured five commercially available archwires and brackets with computer aided light microscopy and reported that although the brackets were on average 0.8 % larger than the dimension quoted by manufacturers, the archwires and significantly smaller cross sections. In our study it was found on examination of images that bracket slot size in different companies was oversized as was found in other studies. The results of our study had the brackets to be between 8% and 13%

larger than the nominal values and that slot walls diverged from the base to the top of all the brackets. The slot size at top was more as compared the base. The slot base was divergent. The standardization of the bracket slot size is essential to consolidate certain technological advances, such as the clinical option of using the straight wire technique. Such decision is usually based on angular values that vary according to the chosen prescription and, theoretically, manufactures should establish such value with precision. This research doesn't consider the evidence of the standardization in alloy constituents on their manufacture process. So further studies are required to check the manufacturing defect related to bracket slot in regards to more precision and standardization of bracket slot in order express the accurate torque.

Conclusion

In our study it was found that the actual dimension of tested archwires is significantly different from what is claimed by companies. There was considerable variation in the slot sizes between different bracket systems. The walls of the slots diverged from the bracket bases. Best bracket slot size in respect to accurate dimension, is provided by forestadent.

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