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Case Report Article

Passive self-ligating metal brackets: evaluation of torque and slot measurements

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Abstract

Introduction: New orthodontic bracket designs have been regularly developed. Their clinical performance depends on reliability of measures, among other factors. **Objective:** The aim of this study was to evaluate slot measures and torque angle of different passive self-ligating metal brackets, while comparing them with measures provided by manufacturers. **Material and methods:** Five different passive self-ligating metal bracket brands were selected (n = 10 each): Tellus EX, Tellus EX New, Damon Q, Easy Clip and ID-Logical. Bracket slots images were obtained with the aid of Starrett, MV300 Galileo Vision System. For slot digital measurement, Software M3 Metrology Reabout IV was used. Slot measures were evaluated in cervico-occlusal direction (slot height), buccolingual depth (in-out), and bottom-slot inclination (torque angle). Difference between obtained and provided measures was estimated and expressed as a percentage. Data were subjected to descriptive statistical analysis. **Results:** Most brackets evaluated by the present study revealed variation in both torque angle and slot measures which were confirmed to be greater than those provided by the manufacturer (Easy Clip, Damon Q and Tellus EX), except for two brackets (Tellus EX New and ID-Logical). The latter presented variation within normality with values accepted by ISO standards (± 1 degree and ± 1 mm variation). **Conclusion:** Most brackets assessed herein (Easy Clip, Damon Q and Tellus EX) presented variation in torque angle and slot measures. Tellus EX New and ID-Logical brackets remained within standards. Better standardization and control should be assumed by manufacturers in order to promote more reliability and predictability of the orthodontic treatment results.

Introduction

Pre-adjusted brackets were developed with a view to minimizing orthodontic arch bends; however, individual third-order bends are sometimes necessary [15]. This can be caused by several factors, such as: orthodontic biomechanics effects, morphological differences on buccal surfaces of teeth, mistaken bracket placement, variation in bracket design, bracket material properties, types of bonding, slot size and consequent play between wire and bracket [10].

According to Archambault *et al*. [2], torque can be determined as torsion in orthodontic wire of which resultant force produces root inclination movement in buccolingual direction whenever the wire is inserted into the bracket. Torque is expressed when wire diameter gradually increases during treatment [2]. Any change in slot measures and torque angle of brackets can have some interference in torque expression, thus decreasing reliability to torque value provided by the manufacturer [10, 22].

Recently, several studies have pointed to variations in the dimensions of the slots [1, 6, 13, 19, 23] and in the torque angle [20] compared to the manufacturer's specifications. Non-standardization among different commercial brands can affect orthodontic treatment finishing. Accuracy of values provided by manufacturers cannot be taken as guaranteed. At finishing phase, the orthodontist often needs to make correction bends, as well as first-order, second-order and third-order bends [1, 12, 22].

Metal brackets can be manufactured by means of the machining method or impression filled with molten metal. The machining process is carried out by cutting metal, which might produce roughness and straight angles. On the other hand, the process of molding molten metal results in smoother and better finished surface with both straight and round angles, depending on what is required by the design [12]. Brackets manufacturing process, whether by molding molten metal or by drilling, can also affect torque accuracy. Molding can expose the material to enlargement and compression, whereas drilling can incorporate granules to the surface, thus resulting in porosities, roughness, imperfection and micro structural defects affecting the dimensional accuracy of slot walls. This can hinder complete filling by the wire [4, 22]. Additionally, dimensional instability of bracket bottom and slots can affect crown buccolingual position [27].

Technological innovations in bracket manufacturing and the quality of alloy have improved strength to torsion [15, 17]. The introduction of brackets manufactured by metal molding increases reliability of prescription and tends to minimize issues relative to final positioning of teeth [16, 27]. However, major torque-determining factors, such as tooth tipping, slot size, variations in tooth morphology, and bracket placement accuracy also affect treatment finishing [5].

As stated by Joch et al [12], reliability of torque and angulation of bracket prescription are deeply associated with accurate sectioning in the machining method and with exact proportion of impression size to retraction of the metal alloy used. According to the International Organization for Standardization (ISO), tolerance of ± 1º towards angulation and torque, and tolerance of slot depth and width not greater than ± 0.01 are acceptable [5, 11, 26]. Such manufacturing tolerance results in play between slot and bracket, which also has some influence over torque expression [11].

Thus, knowledge about accessories and orthodontic wires accuracy makes choice for the most appropriate finishing material easier, with some reduction of the need for additional bends to achieve the a nearly ideal occlusion. Therefore, the present study aimed at evaluating slot measures (in cervico-occlusal direction and in depth) and inclination (torque angle) of different passive self-ligating metal brackets, while comparing them with measures provided my manufacturers. The research tests a hypothesis about absence of significant difference in torque angle and slot measures between the different brackets assessed and measures provided by manufacturers.

Material and methods

For the present study, a total of 50 passive self-ligating metal brackets of five different commercial brands (n=10 each) were used. The determination of the sample size was based on previous studies [1, 5, 13, 19]. Data on material are shown in table I.

Table I – Passive self-ligating brackets of the right central incisor (11) selected for this study

Brackets	Prescription/Torque angle	Slot*	Manufacturer
Tellus EX	MBT/+17 degree	.022"x .028"	Eurodonto/Protect, Zheijiang, China
Tellus-EX new	Roth/+12 degree	.018" x .028"	Eurodonto/Protect, Zheijiang, China
Damon Q	Damon/+15 degree	.022" x .028"	Ormco, Glendora, USA
Easy Clip	MBT/+17 degree	.022" x .027"	Aditek, Cravinhos, Brazil
ID-Logical (ID-L)	Capelozza I. /+7 degree	.020" x .024"	ID-Logical, São José do Rio Preto, Brazil

* 0.018" = 0.457 mm, 0.020" = 0.508 mm, 0.022" = 0.558 mm, 0.024" = 0.609 mm, 0.027" = 0.685 mm, 0.028" = 0.711 mm

Brackets were randomly purchased at different places (dental material shops) to prevent having brackets from the same lot, which could interfere in slot measuring outcomes.

For passive self-ligating metal brackets image taking, Starrett, MV300-Z-M3-3L-LED Galileo Vision System (Athol, MA, USA) was used (figure 1). This piece of equipment allows the bracket to be positioned over a glass table through which light produced from bottom to top crosses. As a result, an enhanced image is projected through objective lens, thus increasing bracket size by 20 times. This allows for measurement of slot details in different sizes.

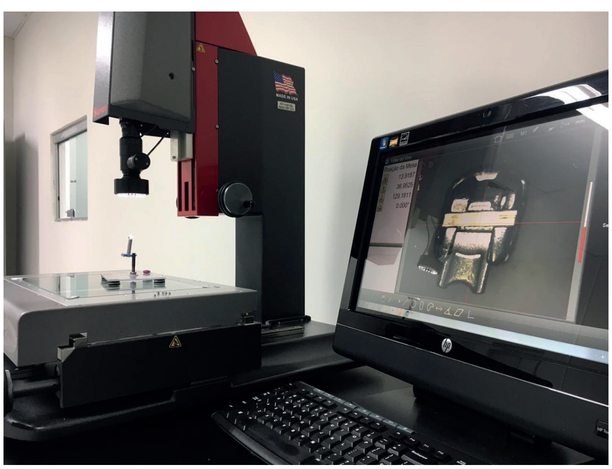

Figure 1 – Starrett, MV300-Z-M3-3L-LED Galileo Vision System (Athol, MA, USA) with Software M3 Metrology Reabout IV

Slot and torque angle measures of the different brackets assessed herein were taken with the aid of digital measuring device Software M3 Metrology Reabout IV (Automation and Metrology Inc. Metronics, Cinccinati, OH, USA). Slot measurement was carried out in cervico-occlusal direction and in depth in buccolingual direction. The device also allows for checking angulation and torque, since its screen is rotary and displays a graduated scale from 1º to 360º. The projection screen is divided into X (horizontal) and Y (vertical) lines. Software M3 Metrology Reabout IV records bracket angulation and torque variations in degrees. X and Y lines cross each other and can be manipulated on the screen. They are moved towards the bracket to measure angles and torque. Angular difference between lines is expressed by Software M3 (figure 2).

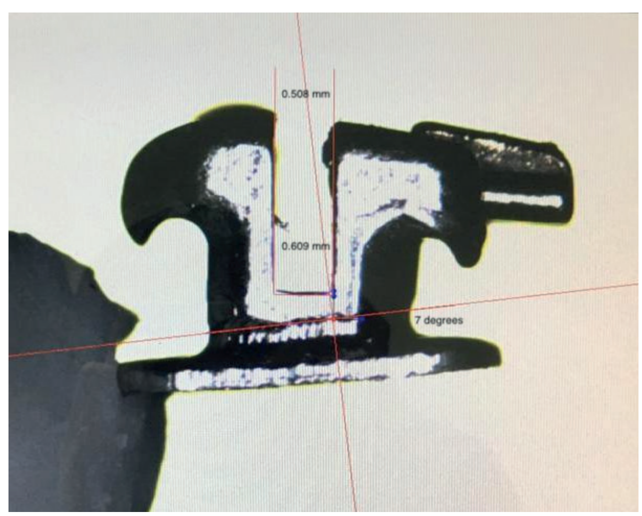

Figure 2 – ID-Logical bracket photograph in Software M3 Metrology Reabout IV. Torque angle 7 degrees (from bracket bottom to slot back), slot height 0.609 mm (from slot back to clip) and slot width 0.508 mm (from cervical to occlusal slot portions)

For torque analysis, Y-line coordinate is tangent to bracket tie-wings, while the X line remains in 90º relative to the Y line. Software M3 is then set at zero. The X coordinate is manipulated up to the slot back overlap and the desired angle is recorded by Quadra Chek. Measures were taken following DIN standards (German Institute for Standardization). Tolerance variation not only for torque, but also for angulation was ± 1º. Additionally, ISO 27020 (International Standard-ISO 27020-2010(E)) and ABNT NBR ISO 27020:2014 (Brazilian Association of Technical Specifications) tolerance standards were also taken into consideration. Furthermore, measures were compared with information provided by manufacturers.

Data were assessed by means of descriptive statistics (mean, standard deviation, minimum, maximum, variation coefficient) and compared to measures provided by manufacturers.

Results

Table II shows torque angle measures of the different brackets evaluated in the present study and difference (%) relative to measures provided by manufacturers.

Table II – Measured torque angle of different brackets and the difference (%) found from the manufacturer parameters

Brackets type/ Prescription	Parameter (torque angle)	Measured torque angle		
		Mean (SD)	Coefficient of variation (MIN-MAX)	% difference
Tellus EX (MBT)	17	16.12 (1.57)	9.73% (14-18)	- 5.17
Tellus EX-New (Roth)	12	11.9 (0.7)	5.88% (11-13)	- 0.83
Damon Q (Damon)	15	16.10 (1.66)	10.3% (14-18)	+ 7.3
Easy Clip (MBT)	17	19 (1.25)	6.57% (17-21)	+ 11.7
ID-All (Capelozza I)	7	7.03 (0.02)	0.28% (7-7.07)	+ 0.42

According to data presented on table II, all brackets presented variation in torque angle relative to the measure provided by manufacturers. The highest percentage of difference was for Easy Clip (+ 11.7%), followed by Damon Q (+ 7.3%), Tellus EX (- 5.17%), Tellus EX New (- 0.83%) and ID-Logical (+ 0.42%). The last two are considered null, as they were within ISO standards. Variation was positive (values greater than those provided by manufacturers) for Easy Clip and Damon Q, whereas it was negative (values lower than those provided by manufacturers) for Tellus EX and Tellus EX New.

As regards torque angle variation coefficient (Table II), results are as follows and in descending order: Damon (10.3%), ranging from 14 to 18 degrees, with 15 degrees informed by the manufacturer; Tellus EX (9.73%), ranging from 14 to 18 degrees, with 17 degrees informed by the manufacturer; Easy Clip (6.57%) with greater variation in comparison to other brands, ranging from 17 to 21 degrees, with 17 degrees informed by the manufacturer; Tellus EX New (5.88%), ranging from 11 to 13 degrees, with 12 degrees informed by the manufacturer; and ID-Logical (0.28%), ranging from 7 to 7.07 degrees, with variation considered null.

Table III shows slot measures (height and depth) expressed in mm of the different brackets assessed, as well as difference (%) relative to measures provided by the manufacturer. According to data, brackets presented variation in slot measures in both directions (height and depth) when compared to values informed by manufacturers, except for ID-Logical and Tellus EX New brackets which did not present significant variation of slot measures. The most significant changes were in slot height measures. Brackets with the greatest variation were as follows and in descending order: slot height – Tellus EX (23.6%), Damon Q (12.7%), Easy Clip (9.09%), and Tellus EX New (4.4%); slot depth – Easy Clip (7.3%), Damon Q (5.6%), and Tellus EX / Tellus EX New (both with 2.8%). All values were positive; in other words, brackets had slots with dimensions greater than those informed by manufacturers.

Table III – Slot measurements (height and deep - in mm) of different brackets and the difference (%) found from the manufacturer parameters

Brackets type	Parameter (Slot measurements)	Slot height (mm)			Slot deep (mm)		
		Mean (SD)	Coefficient of Variation (MIN-MAX)	% difference	Mean (SD)	Coefficient of variation (MIN-MAX)	% difference
Tellus EX	.022" x .028" (0.55 x 0.71 mm)	0.68 (0.02)	2.94% (0.66-0.72)	23.6	0.73 (0.03)	4.13% (0.72-0.8)	2.8
Tellus EX-New	.018" x .028" (0.45 x 0.71 mm)	0.47 (0.01)	2.12% (0.42-0.5)	4.4	0.73 (0.03)	4.11% (0.68-0.75)	2.8
Damon Q	.022" x .028" (0.55 x 0.71 mm)	0.62 (0.02)	3.22% (0.59-0.68)	12.7	0.75 (0.04)	5.33% (0.7-0.82)	5.6
Easy Clip	.022" x .027" (0.55 x 0.68 mm)	0.6 (0.01)	1.66% (0.59-0.68)	9.09	0.73 (0.04)	5.74% (0.71-0.84)	7.3
ID-All	.020" x .024" (0.50 x 0.60 mm)	0.5 (0.01)	2.0% (0.49-0.51)	0	0.63 (0.02)	3.17% (0.61-0.59)	0,01

Discussion

One of the major challenges of pre-adjusted appliances is determining torque and torque expression, which depends on a number of factors, such as arch characteristics and dimensions, bracket slot dimension, bracket design, and degree of arch play inside the slot [25, 26]. Thus, self-ligating bracket quality and reliability of groove dimensions are of paramount importance to torque expression. Additionally, knowledge about the type of wire used and the importance of personalization are also part of orthodontic treatment [15].

Previous studies have reported difficulties with the finishing phase when self-ligating brackets are used, especially as regards rotations and torque [24]. The reason behind those issues could be the shorter width of self-ligating brackets associated with larger slots, thus allowing for more significant play, particularly of passive self-ligating brackets [3, 24]. The degree of play completely depends on geometric parameters, such as slot actual height, wire dimensions, and bevel angles. Nevertheless, orthodontic devices available at the market sometimes do not present the aforementioned measures according to what has been informed by the manufacturer.

Based on the present outcomes, most brackets revealed variation in torque angle which was confirmed to be greater than those provided by the manufacturer (Easy Clip, Damon Q and Tellus EX), except for two brackets (Tellus EX New and ID-Logical). The latter presented variation within normality with values accepted by ISO standards (± 1 degree and ± 1-mm variation). Therefore, this study's hypothesis was rejected.

Difference relative to values informed by manufacturers was positive for two brackets: Easy Clip (+ 11.7%) and Damon Q (+ 7.3%), while negative for Tellus EX (-5.17%). This means that for Easy Clip and Damon Q brackets, torque angle informed by the manufacturer is greater than that presented by the bracket in the present study. As for Tellus EX bracket, torque angle was smaller than that informed by the manufacturer. Clinically, there are two scenarios: negative variation will produce less torque and might reduce play; whereas positive variation can increase play, thus hindering torque measurement and expression. For Tellus EX New and ID-Logical brackets, difference between actual torque angle and torque angle informed by the manufacturer, as well as data variation coefficient were basically taken as null. In other words, within values accepted by ISO standards. In terms of torque angle, those brackets were considered the most reliable relative to information provided by manufacturers.

The most important bracket part is its slot where it meets with the wire and has the effect of force with consequent tooth movement produced. A major characteristic of slots is their dimension. Should the latter be changed, it might affect orthodontic-mechanics-related factors, such as frictional resistance and application of torque momentum. As a result, first-, second- and third-order movements can be influenced [16, 24]. According to present data, brackets presented variation in slot measures in both directions (height and depth), when compared to values informed by manufacturers, except for ID-Logical brackets which did not present any variation. Most changes were found in slot height measures (table III). All values were positive; in other words, brackets had slots with dimensions greater than those informed by manufacturers. This is in accordance with other studies which also found brackets with greater dimensions than those informed by manufacturers [1, 3, 5, 6, 12, 13, 19, 23].

According to Pacheco *et al*. [18], passive brackets have more effective friction control, regardless of arch section. However, according to Sathler *et al*. [21], less friction can result in more significant torque control loss [9, 21].

Most brackets assessed herein have 0.022 x 0.028-in slots, which can raise difficulties to passive self-ligating brackets torque control. Tellus EX New brackets have 0.018-in slots. For this slot system, although little is the options for arch dimension, the bracket slot can be more easily filled. This allows bracket programming or prescription to be fully exploited, in addition to improving torque control of anterior teeth. Torque control is key to accurate positioning of anterior teeth and to extraction treatment during retraction. Should the latter be the case, there is lingual anterior torque of the crown or buccal torque of the root. The expertise to keep anterior torque will produce resistance to such an undesired movement [7-11, 14].

Imprecision found in brackets evaluated by the present study will inevitably affect play between bracket and slot and, thus, the appliance torque expression. However, in the present study, torque angle and bracket slots were the only measures assessed, without taking their interaction with orthodontic wires used during orthodontic mechanics into account. Furthermore, there are other factors clinically interfering in torque expression and final treatment outcomes, which should be considered. Therefore, based on these study outcomes, clinicians should be aware to potential loss of anterior torque resulting from inappropriate use of orthodontic brackets with different slot dimensions.

Conclusion

Among brackets assessed herein, most of them presented variation in torque angle and slot measures, which were different from those informed by manufacturers (Easy Clip, Damon Q and Tellus EX), except for Tellus EX New and ID-Logical brackets which remained within standards.

Better standardization and control should be assumed by manufacturers in order to promote more reliability and predictability of results achieved by different orthodontic biomechanics carried out with the aid of those brackets.

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