



## Variations in slot size of self-ligating brackets

### *Variación en el tamaño de la ranura de brackets de autoligado*

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#### ABSTRACT

The purpose of this study was to assess four different self-ligating bracket designs to determine which has the most accurate slot dimensions in the 0.022" dimension. Forty brackets of four different self-ligating bracket designs (Damon 3, Damon 3 MX, InOvation, Forestadent) were randomly selected. The brackets were measured at the slot height 2 times on each side, in the internal portion of the slot and in its most external portion using a Nikon Profile Projector model V-16D. The mean value of the slot height measurement at the internal portion was for Damon 3 brackets:  $0.02332" \pm 0.00030"$ ; for Damon 3 MX,  $0.02305" \pm 0.00040"$ ; for InOvation,  $0.02264" \pm 0.00032"$ , and for Forestadent,  $0.02341" \pm 0.00032"$ . At the height measurement in the outer portion of the slot, the mean value for Damon 3 was  $0.02333" \pm 0.00038"$ ; for Damon 3 MX,  $0.02337" \pm 0.00044"$ ; for InOvation,  $0.02295" \pm 0.00032"$ ; and for Forestadent,  $0.02345" \pm 0.00025"$ . The slot walls in the Damon bracket were parallel and in the other three self-ligating bracket designs, they were divergent. The results showed that there were statistically significant differences in terms of internal and external slot dimensions of the four different designs of self-ligating brackets ( $p < 0.05$ ).

**Key words:** Slot, brackets, self-ligating.

**Palabras clave:** Ranura, brackets, autoligado.

#### RESUMEN

El propósito de este estudio es valorar cuatro diferentes diseños de brackets de autoligado para determinar cuál es el que tiene las dimensiones más exactas de la ranura en dimensión 0.022". Se seleccionaron de manera aleatoria 40 brackets de cuatro diferentes diseños de brackets de autoligado, Damon 3, Damon 3 MX, In-Ovation, Forestadent. Los brackets se midieron en la altura de la ranura dos veces en cada lado, en la porción interna de la ranura y en su porción más externa utilizando un proyector de perfiles marca Nikon modelo V-16D. El valor promedio de la medición de la altura de la ranura en la porción interna fue para Damon 3  $0.02332" \pm 0.00030"$ ; para Damon 3 MX  $0.02305" \pm 0.00040"$ ; para In-Ovation  $0.02264" \pm 0.00032"$ , y para Forestadent  $0.02341" \pm 0.00032"$ . En la medición de la altura en la porción externa de la ranura el promedio para Damon 3 fue  $0.02333" \pm 0.00038"$ ; para Damon 3 MX fue  $0.02337" \pm 0.00044"$ ; para In-Ovation fue  $0.02295" \pm 0.00032"$ ; y para Forestadent fue  $0.02345" \pm 0.00025"$ . Las paredes en Damon fueron paralelas; y en los otros tres diseños de brackets de autoligado fueron divergentes. Los resultados demostraron que existen diferencias estadísticamente significativas en términos de la dimensión interna y externa de la ranura de los cuatro diferentes diseños de brackets de autoligado ( $p < 0.05$ ).

#### INTRODUCTION

The correct labial-lingual inclination of the anterior and posterior teeth is essential for stability and proper occlusal relationships during orthodontic treatment. Torque in the upper incisors is critical for establishing a pleasant smile curve and for aesthetics, a correct anterior guidance as well as a well-settled class I relationship. Lack of torque in the posterior teeth has a compressive effect over the arch that does not allow an appropriate cusp-fossa relationship between the upper and lower teeth.<sup>1</sup>

There are numerous mechanical and physical properties of orthodontic appliances that directly and indirectly affect the effectiveness of torque implementation, such as: the hardness and elasticity module, the manufacturing process, which may be sintered or cut and clinical procedures such as elastomeric ligation.<sup>1,2</sup>

When brackets with torque in the base are used, one depends importantly in bracket positioning and placement. If brackets with the torque programmed on the surface, a torque increment is needed in approximately 80% of the cases.<sup>3</sup>

Bracket's slot size and design are partially responsible for bracket deformation. The contact

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between the arch wire and the bracket slot is higher among brackets with smaller slots and straight internal angles than larger slot brackets with rounded internal angles. This phenomenon occurs because the arch wire has more freedom inside of the slot and has a smaller contact area of the applied force.<sup>2,4</sup>

Inevitably, a fraction of the prescribed torque in the bracket remains without expression, mainly due to a freedom or play of the archwire inside the slot. The amount of torque that remains without expression is relative to the slot size and its interaction with the selected arch wire. Gioka et al mentioned that in a 0.018" slot 6.0° of torque are lost when using a 0.017" x 0.025" archwire. If a 0.022" slot was used, 10.5° torque will be lost when using a 0.019" x 0.025" archwire.<sup>1</sup>

In a study conducted by Kusy and Whitley variations were found in the slot size of different brackets. Regarding torque expression, one of the variables that has the most influence on it is the interaction between slot and archwire that is introduced. However, there is a variation from the actual size of the bracket slot as well as variations in slot shape, particularly, in the slot walls which should be parallel but exhibit a convergency or divergency towards the center of the bracket.<sup>5,6</sup>

The design of self-ligating brackets affects their properties. If the arch wire is in contact with the slide or safety clip of the bracket, this influences the resistance to sliding and the contact angle between the arch wire and the bracket slot. Besides, the amount of deflection of the security clip determines the active ligature that is exerted over the arch wire.<sup>7</sup>

The purpose of this study was to assess four different self-ligating bracket designs to determine which has the most accurate slot size in a 0.022" dimension.

## MATERIAL AND METHODS

Forty brackets of four different self-ligating bracket designs: Damon 3<sup>®</sup> (Ormco Corp. Orange, California), Damon 3 MX<sup>®</sup> (Ormco Corp. Orange, California), InOvation<sup>®</sup> (GAC International Inc.) and Forestadent<sup>®</sup> (Forestadent, Pforzheim, Germany) were randomly selected. The brackets were measured in slot height 2 times for each side, in the internal portion of the slot and in its most external portion using a Nikon Profile Projector model V-16D and number 77507 (Nikon, Japan). The measurements were then compared with those specified by the manufacturer to assess whether the measurements were as expected or if there was a variation in height (Figure 1).

The selected brackets were manufactured according to the prescriptions of each manufacturer; the selected

brackets had a 0.022" slot measurement in height. The condition and shape of the inner angles of each slot were assessed since brackets with rounded internal angles have less interaction with the arch wire.

A one-way ANOVA test was used for bracket measurements with a statistically significant difference of  $p < 0.05$ . For the slot wall shape the following terms were used: parallel when the slot height was the same in the surface and in its deepest portion; divergent when the height of the slot was higher at the surface and less divergent towards its deepest portion; and convergent when the height of the slot was smaller in the surface and larger in the deepest part of the slot.

## RESULTS

The dimension values obtained in this study are shown in *table 1*.

The mean value of the slot height measured in its internal portion for the Damon 3<sup>®</sup> bracket was 0.02332"  $\pm$  0.00030"; for Damon 3 MX<sup>®</sup>, 0.02305"  $\pm$  0.00040"; for InOvation<sup>®</sup>, 0.02264"  $\pm$  0.00032", and for the Forestadent<sup>®</sup> bracket, 0.02341"  $\pm$  0.00032".

Regarding the height measurement in the outer portion of the slot, the mean value for the Damon 3<sup>®</sup> bracket was 0.02333"  $\pm$  0.00038"; for Damon 3 MX<sup>®</sup>, 0.02337"  $\pm$  0.00044"; for InOvation<sup>®</sup>, 0.02295"  $\pm$  0.00032"; and for Forestadent<sup>®</sup> it was 0.02345"  $\pm$  0.00025".

The wall shape found in Damon brackets was parallel. In the other three self-ligating bracket designs they were divergent.

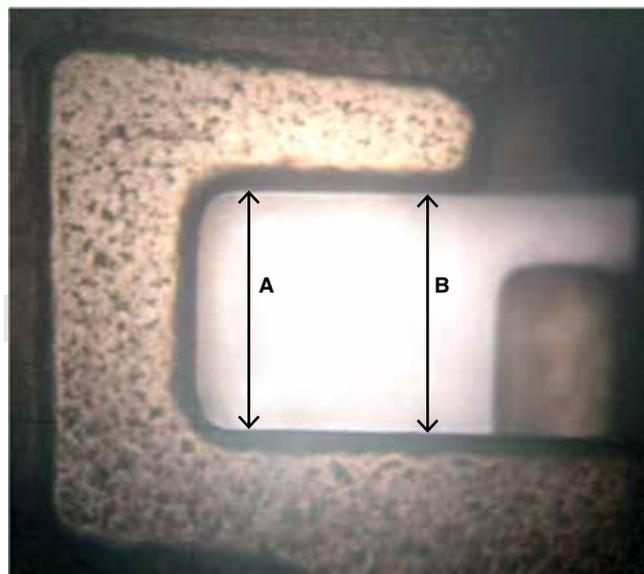


Figure 1. Internal (A) and external (B) measurements.

**Table I.** Slot dimensions and wall shape.

Bracket	Internal	External	Walls
Damon 3®	0.02332" ± 0.00030"	0.02333" ± 0.00038"	=
Damon 3 MX®	0.02305" ± 0.00040"	0.02337" ± 0.00044"	<
InOvation®	0.02264" ± 0.00032"	0.02295" ± 0.00032"	<
Forestadent®	0.02341" ± 0.00032"	0.02345" ± 0.00025"	<

= parallels, < divergent, > convergent

The results of the ANOVA test showed that there were statistically significant differences in terms of the internal dimension of the slot between the four different designs of self-ligating brackets ( $p < 0.05$ ).

When assessing the external dimensions of the four different self-ligation bracket designs statistically significant differences were found ( $p < 0.05$ ) between them.

## DISCUSSION

Tridimensional orthodontic teeth position occurs as a result of the interaction between archwires and pre-adjusted brackets in teeth with a healthy periodontium.<sup>6</sup>

In the medical aspect, the pursuit of excellence in patient care and in treatment, do not always agree to be found and in some cases, orthodontic appliances may be manufactured without sufficient accuracy.<sup>6</sup>

Anterior torque loss may happen when bracket deformation exists due to the material with which it was manufactured and the manufacturing process itself. There may also be torque loss when using small dimensions of rectangular wires or when the internal angles of the bracket slot are rounded, which prevents an intimate contact angle between arch wire and slot.<sup>2,4</sup>

In the study conducted by Witley and Kusy variations were found in the 0.018" slot size and also in the 0.022". For brackets with 0.018" slot, the obtained variations were up to 0.0209" and for the 0.022" slot a variation of up to 0.0237" was found. In this study, the maximum variation occurred within the Forestadent® bracket in the internal portion (0.02341") and in the external portion (0.02345").<sup>5</sup>

Cash et al observed that all the bracket slots dimensions they examined were increased between 5 to 24%, which was the largest observed variation. In our study it was found that all self-ligating brackets have.

Cash et al observed that all the slots in the brackets they examined were increased from 5 to 24%, which was the most comprehensive variation. In our study, we found that all self-ligating brackets have slots with larger dimensions than the ideal (0.022"); the bracket



**Figure 2.** Bracket In-Ovation®.

with the slot that was closest to that ideal was the InOvation® bracket (*Figure 2*), with 0.02264" in its internal portion and 0.02295" in its external portion.

The amount of play or freedom that exists between the arch wire and the slot in the bracket is much larger than what would be expected and it is highly unpredictable. This is why the ideal slot should be 0.022" but variations of up to 0.02345" have been found.

## CONCLUSIONS

The results of this study indicate that the slots of self-ligating brackets are larger than those established by the manufacturers. The design of the walls also presents variations between different self-ligating brackets.

Orthodontists should be aware that there is a loss in the three-dimensional position of the teeth as a result of the use self-ligating brackets with increased slot size.

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