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Evaluation of different types of self-ligating brackets guided by electromagnetic field simulator on rotational control

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Aim: The objective of this study was to measure and compare the in vitro performance of active and passive self-ligating brackets in orthodontic rotation by means of an electromagnetic field simulation. **Methods:** The study sample consisted of 32 mandibular right central incisor brackets (n=8), slot 0.022”, that were divided into the following groups: 1) BioQuick® (Forestadent, Pforzheim, Germany) active brackets; 2) In-Ovation®R (Dentsply-GAC, Central Islip, New York, USA) active brackets; 3) Damon-Q® (Ormco, Orange, California, USA) passive brackets, and 4) Smartclip® (3M, Monrovia, California, USA) passive brackets. The orthodontic wire used was CuNiTi round section 0.016”, thermoactivated at 35° C (ORMCO-Orthodontics Glendora, California, USA). The experiment was performed in a simulator machine, composed of two fixed lateral axes and a movable central axis, which simulated the dental rotation. Qualitative analysis (n = 4) was performed using SEM. After the descriptive and exploratory analysis, the yield and grade data were submitted to one-way analysis of variance (ANOVA) followed by the Tukey test, considering the level of significance of 5%. **Results:** In-Ovation®R brackets showed significantly higher yield than BioQuick® and Damon-Q®. Damon-Q® brackets presented a significantly lower mean value than In-Ovation R and Smartclip®. BioQuick® did not differ significantly from Damon-Q® and Smartclip®. In-Ovation®R did not differ significantly from Smartclip®. **Conclusion:** In the present study, it was observed that there is a difference in rotational control in the different self-ligating brackets tested being the best rotational control was the In-Ovation R® group (active), followed in descending order by the groups Smartclip® (passive), Bioquick® (active) and Damon Q® (passive).

Key Words: Rotation. Electromagnetic fields. Orthodontic brackets.

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Introduction

The dental rotation or gyroversion is characterized by the tooth movement around its own axis, with this phenomenon being a common problem in the orthodontic clinic routine, and highly susceptible to relapse, producing deleterious effects such as crowding, occlusal traumas and greater accumulation of biofilm[1-4].

During orthodontic therapy, it is extremely important for the gyroversion to be completely corrected in the initial phases of treatment, as this will allow time for the supra-alveolar fibres to reorganize, thus reducing the tendency towards relapse[3,5-7].

Recently, with the introduction of active and passive self-ligating brackets, there have been changes in attendance protocols due to the new bracket/wire connection model. These self-ligating devices have some advantages, such as lower friction, shorter service time, lighter forces, and shorter treatment time[2,8-13].

With active brackets there are two possibilities: when the clip is active, it is in contact with the wire by applying a connecting force to fit the arc into the slot; when the clip is in its passive moment, there is no contact with the thread and no force is applied on it. Therefore, the clip is active or passive depending on the size of the arc in relation to the size of the slot and on the position of the arc within the bracket[2,10,14-16].

Due to the space between the self-ligating brackets and levelling wires, and the short distance between the fins of some bracket models, rotational control is mainly impaired in passive self-ligating brackets[5,9,17,18]. In contrast, this rotational control is obtained by the progressive exchange of arcs[8,17,19,20], but this is totally or partially achieved only at the end of the process levelling and alignment, when a larger gauge wire almost fully fills the bracket slot[16,21,22]. This technological advance has been demonstrated in the development of different bracket models to reduce this problem, such as clip sizes and clips, as well as the composition of these in CrNi or NiTi accessories. Within this context new clinical protocols have been adopted to minimize rotation control failure, such as the use of rectangular wires in the early stages of treatment[15,17,21,23], and/or the use of two overlapping round wires to better fill the bracket slots[22].

Many studies have evaluated the torque expression of both these passive and active brackets[14,16,20,24-27], but there has been little research in evaluating the rotation expression[1,4,16,19]. Therefore, knowledge of the characteristics of each bracket is of great importance to enable professional to select the type with characteristics best suited the orthodontic problems of each patient. The shortage of researches to verify the efficiency of self-ligating brackets in rotational control, and the large number of self-ligating brackt designs available, the present study aim was to measure and compare the performance and efficacy of active and passive self-ligating brackets in correcting orthodontic rotation by means of an electromagnetic field simulator

In the present study, it was adopted as null hypothesis that the active and passive self-liganting brackets would not present difference in the rotational control.

Materials and Methods

Experimental Design

In the present study, 32 mandibular right central incisor brackets, slot 0.022 ", were divided into four experimental groups (n = 8). By means of a pilot study, followed by making a sample calculation, the sample size was defined. The study factor was the influence of the bracket attachment system on the orthodontic wire; and the response variable, the amount of rotational movement during a given time. An electromagnetic field motion simulator was used to standardize the tests for all samples surveyed. The bracket/wire sets (n = 4) from the experimental groups were submitted to SEM. The experimental design is presented in Figure 1.

Sample Preparation

Based on a previous study adapted[4], the 32 self-ligating brackets were fixed on brass pulleys, 15mm in diameter by 11mm deep, transfixed by Allen screws. Each of the pulleys was screw retained into the fixed side axes and the movable central axis; arranged side by side, 23mm apart between their centres, and 40mm from the rear surface to the front panel. Retention and orthogonal grooves were made on the pulleys by means of knurling, to guide the centralization and alignment of bracket bonding with Superbonder® Flex Gel (Henkel Loctite Adhesives Ltda., Itapevi, SP, Brazil). The three axes were embedded in the front, so that the central axis extended in the rear direction, supported by self-centring ball bearings, until it was incorporated into the solenoid responsible for friction or resistance to its rotation.

The orthodontic wires were fixed on fixed pulleys by means of Edgewise prescription tubes (Morelli, Sorocaba, SP, Brazil), for the right and left lower molars. These tubes

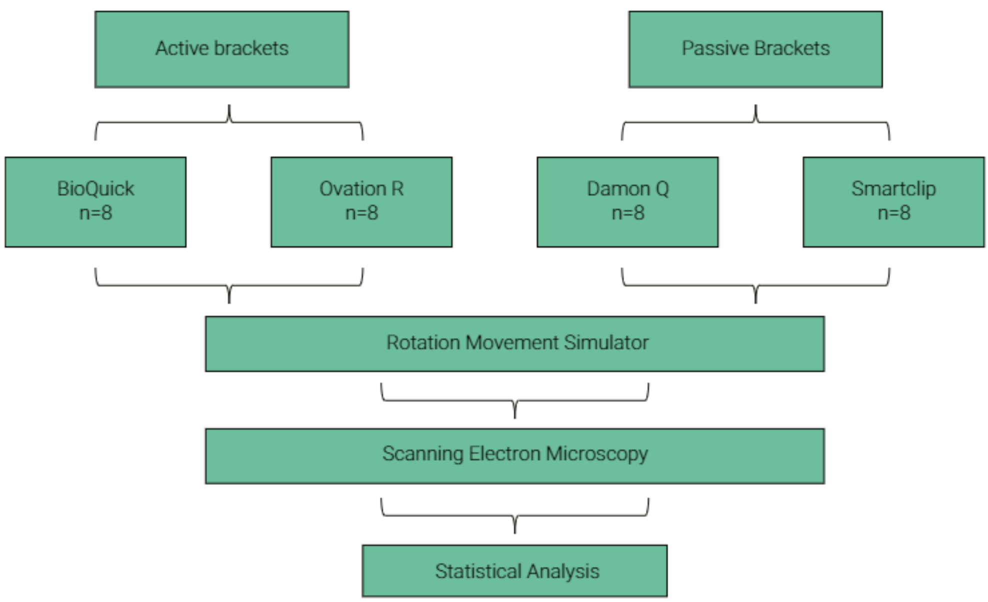

Figure 1. Flowchart of Experimental Design

were bonded to the pulleys by using the same methodology as that used for fixing the brackets, as described above. The bracket/wire assembly was then fitted into a movable central pulley with programmable rotation. (Figure 2)

Round, arc-shaped 0.016" CuNiTi Orthodontic wires, thermo-activated at 35ºC (ORMCO Orthodontics, Glendora, CA, USA), stabilized by the manufacturer were used. They were inserted into the tubes and brackets, with their concavity facing upwards. The wire was introduced into the brackets and tubes with the use of hemostatic forceps, and the wire was aligned with the bracket and tubes that were bonded onto the three pulleys. This was realized by means of the reference mark in the centre of the

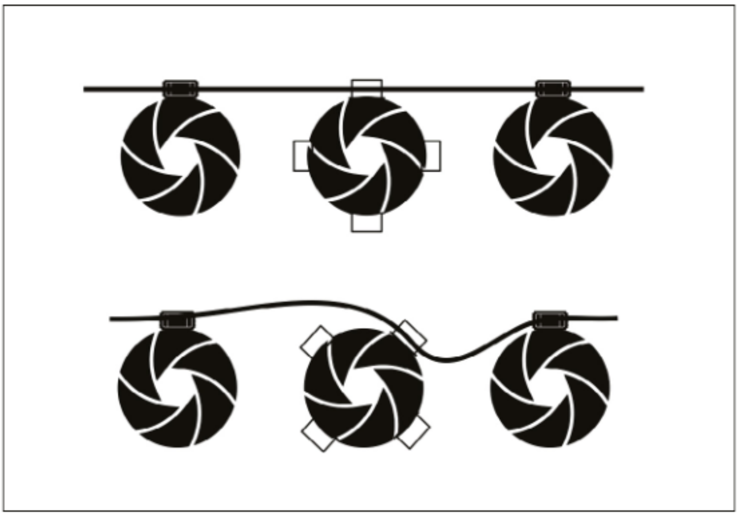

Figure 2. Illustration of the system bracket, pulley and arc in rotation until its considered position within the normality in the electromagnetic simulator

Figure 3. Front view of the electromagnetic field simulator

wire that was aligned with the central pulley, for the purpose of standardizing the position of the wires in relation to each bracket to avoid friction.

Rotational Electromagnetic Simulation

The simulation of Tooth rotation was simulated by means of an electromagnetic field simulator. This machine had three pulleys representing three teeth, assembled for the tests of each set of brackets. The two pulleys of the extremities were fixed, and the central movable pulley representing the dental rotation. The differents brackets groups, was changed on the pulley central, where the measurement was performed. The tests were standardized and performed for each self-ligating, active and passive bracket model, using a new orthodontic wire in each test, taking into account the hypothesis of some loss of its properties. For the experiment a new bracket and new wire were used for each test, performed by means of turning the pulley.

For rotational correction, the effect of each biomechanical resource was evaluated by means of individual performance, presented in degrees, in a predetermined time of 3 minutes, based on a pilot study.

The electronic simulator was located in a room with the temperature set at 25ºC; that is, the thermoactivated wire underwent martensitic transformation and remained in this crystallographic configuration in 100% of the experimental time. The electromechanical simulator transformed the mechanical force generated by rotational motion into electric pulses, which in turn generated an exact amount of pulses per revolution, which were interpreted as an angular variation at a given time that was recorded by the digital timer.

After the descriptive and exploratory analysis, the rotational performance data were submitted to one-way ANOVA and the Tukey test, considering a significance level of 5%. The analyses were performed in the SAS program (SAS Institute Inc., Cary, NC, USA, Release 9.2, 2010).

Scanning Electron Microscopy (SEM)

The relationship of distance between the wire and the slot of 16 samples (n = 4) in the simulated rotational motion was evaluated qualitatively by means of the Quanta 250 FEG (FEI Company, The Netherlands) Electronic Field-SEM Scanning Microscope. Images of the arc distance with the bottom of the slot were captured laterally and enlarged to 60 × and 1000 × according to the images that may be observed in Figure 4.

Results

In Table 1, it may be observed that the In-Ovation R brand brackets (active) showed significantly higher mean yield values than those of BioQuick (active) and Damon Q (passive) ($p < 0.05$). Brackets of the Damon Q brand (passive) presented significantly lower mean values than those of In-Ovation R (active) and Smartclip (passive) ($p < 0.05$). The BioQuick brand (active) did not differ significantly from the Damon Q (passive) and Smartclip (passive) brands ($p > 0.05$).

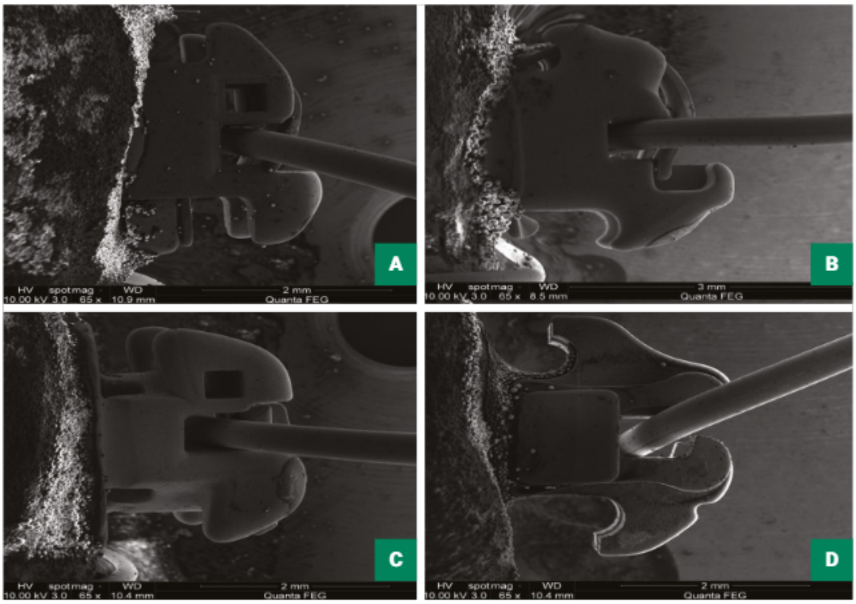

Figure 4. Wire/slot interface; a - BioQuick (active); b - In-Ovation R (active); c - Damon Q (passive); d - Smartclip (passive)

Table 1. Mean and standard deviation of the yield, in degrees, according to the brand of self-ligation brackets

Brackets	Mean	Standard Deviation
BioQuick (Active)	18.91 bc	2.51
In-Ovation R (Active)	22.55 a	3.24
Damon Q (Passive)	16.63 c	1.11
Smartclip (Passive)	19.85 ab	1.81

Means followed by different letters differ from each other ($p \leq 0.05$)

Discussion

Studies have suggested that self-ligating bracket mechanics could replace conventional binding methods for metal ties and elastomers, leading to increasing clinical efficiency[1,2,15]. Consistent fit of the archwire throughout orthodontic treatment eliminates the need for frequent visits for ligature replacement and is the main advantage of this method[2,8,11,28,29]. In addition, lower friction and reduction in interbracket arch deflections produce gradual and precise tooth movement, which in severe rotations lead to a biocompatible response by periodontal tissues[2,8,10].

Bednar and Gruendeman[1] demonstrated that the method of attachment can affect the momentum associated with tooth rotation and may alter the slip resistance[2,18,28]. The bracket geometry and tooth physiology can also influence the slip resistance[10,14,15,30], so that in this context, the self-ligating brackets are superior to conventional brackets[1-3,10].

In alignment of the teeth with severe rotations, the ability of the wire to slide through the brackets of the teeth adjacent to the gyroversion facilitates this process significantly. This low friction allows faster mechanics to be obtained, ensuring greater effectiveness in closing spaces[8,11,12,28].

The distance of brackets with passive clip (between the walls of the slot and the arc, between the clip and the wire), results in values of resistance to slip close to zero. This distance between the clip and the wire may, for example, allow rotation, tilting and twisting of the tooth, depending on the size of this space[6,14].

In the present study, it was observed that the performance of the Bioquick (active) brand of brackets did not differ statistically from the Smartclip and Damon Q brands of passive brackets. With this hypothesis null, in which the experimental groups tested would not present difference in the rotational control, was denied. The data obtained may be justified, since the slip resistance between active self-adhesive brackets, which exceeded the critical angle, had more resistance to sliding than those tested with low angles[14]. Passive self-ligating brackets at critical angles showed less resistance to slippage, but did so at the cost of a certain loss of control, as seen in other studies[9,21].

Pandis et al.[30] studied the force exerted by self-ligating and conventional brackets capable of performing first and second order movements, as well as intrusion and extrusion movements. The forces generated by first and second order corrections in the self-ligating brackets did not show a consistent pattern between these types of devices, which were dependent on the wire and the direction of movement.

In this study, because the In-Ovation-R brand brackets presented the highest level of force, they were observed to be capable of having a greater capacity to move the arch to the depth of the slot and thus transfer all the characteristics present in the bracket to the final position of the tooth[30]. This data corroborated the findings of this study, and justified the fact that the In-Ovation R (active) brand bracket obtained statistically higher yield than Damon Q (passive), because of the feature of the design, the active bracket makes the wire fill the entire slot, generating a more favourable moment for the correction of tooth rotations[30].

The robustness of the clips ensures non-opening[2,28] and this is an advantage over elastomeric and metal ligatures, which both lose force after placement[14]. Pesce et al.[18] confirmed that the differences in connection between conventional and self-ligating brackets influenced arc selection at the beginning of treatment. The normal force elastomers exerted on the arc at a conventional wire/bracket interface played a key role in the activation of the wire in first order arc deflection. This quality was demonstrated in the present study, which found that the yield of the BioQuick (active) brand did not differ significantly from the Damon Q (passive) and Smartclip (passive) brands ($p > 0.05$).

The importance of knowing this data lies in the fact that the amount of displacement of this clip can, for example, interfere in a rotational correction movement, as reported by Benetti et al. [4]. In their research simulating the correction of a dental rotational movement, they compared a conventional bracket with a self-ligating bracket made from an apparatus created for this purpose. They also confirmed that in the initial stages when the rotation was more pronounced, the interactive self-ligating brackets (active), in this case In-Ovation R, obtained better results than the passive types, which emphasized the possible influence of the clip ability to move this type of correction[1,4,12,15,16,30].

The results obtained pointed to greater strength of the clip of the In-Ovation R bracket[2,4], capable of moving the arc to the bottom of the slot, confirmed in the electron microscopy images, producing a better binary effect, and consequently better effect on correcting the rotation. We concluded that not only is spin control influenced by the clip being active, but that the design could change the result, since the results with Smartclip were close to those obtained with BioQuick, although the latter (Smartclip) was a passive bracket and the former (BioQuick) was active.

Due to the limitations of the study with respect to the distal mesial sample sizes, clip/bracket connection methods and their compositions, the results of this research suggest that the foregoing factors (i.e. distal mesial sample sizes, clip/bracket connection methods and their compositions) justified the close values found between the active and passive types of brackets.

In the present study, it was observed that there is a difference in rotational control in the different self-ligating brackets tested being the best rotational control was the In-Ovation R® group (active), followed in descending order by the groups Smartclip® (passive), Bioquick® (active) and Damon Q® (passive).

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