Biomechanical behavior of self-ligating interactive systems

Abstract

The purpose of this study was to determine if various bracket clips are strong enough to provide a proper archwire/slot engagement. If yes, then we wanted to determine if the active clip shows lack of power after loading.

Introduction

If a bracket system is not capable of offering an efficient and strong ligation to properly engage the archwire, the orthodontist will encounter varying degrees of difficulty during treatment. These problems will not occur during the leveling phase, when the force delivered by the archwire deflection is not so powerful. Therefore, during the initial phase, the ligation system doesn’t need to exert the same level of force.

However, during the phases that demand rectangular-geometry-archwires utilization for the torque incorporation, we must consider the ability — or not — of the clip to press and hold the wire firmly engaged to the bracket slot, bringing the desired prescription details needed for ideal positioning.

There are many reasons correct torque expression is important. The use of an interactive bracket system, whose clips are made of a reliable material that offers enough resilience and flexibility, is necessary for the application of constant and physiologic forces. These forces will guarantee proper control of the dental movements in the three planes of the space.

By understanding the importance of the affirmations above, this study aims to evaluate four different models of interactive self-ligating brackets in order to verify which group will show the best performance. In this case, “best” will be represented by the least force loss after being submitted to a certain load during a period of time.

Materials

In this trial, both metallic and ceramic self-ligation interactive brackets (second premolars, 0.022-inch by 0.028-inch slots, Roth prescription) were tested (Table 1). In all the groups, the clip is composed by Cr-Co stainless-steel alloy. A number of eight brackets composed each group.

Methods

Specific methodology was created based on a load cell machine. A custom metallic cylinder that held all eight brackets was designed for this experiment,
with a piece of rectangular 0.019-inch by 0.025-inch SS wire being used as a caliper to dampen any torque or angular interference during the measuring of the forces (Fig. 1).

This ensured that the wires used in the test could be passively inserted into the slots.

The cylinders were positioned in an EMIC DL 2000 (Tesc software version 3.01/05) for load/unload trials. Each bracket was tested in three different steps:

- M1 – Moment 1 – (Pull Out). Measurement of the force that the clip exerts over the wire when pulled until the limit.
- M2 – Moment 2 – (Load). Maintaining strength of a constant load of 20 N during a period of two hours.
- M3 – Moment 3 – (Pull Out). Repetition of step No. 1 after the two previous steps.

For each bracket, a new piece of the SS wire was used. In total, 120 measurements were performed. Force values that caused maximum and minimum deflection of the clips of five brands of self-ligating brackets were collected.

From these values (eight brackets per group), a mean score was calculated, representing the force...
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that the clip exerts on the rectangular wire for each of steps Nos. 1, 2 and 3. The data allowed the researcher to compare the mean scores between steps Nos. 1 and 3, after subjecting the clips to the force of 20 N for two hours in step No. 2 (Table 2).

The purpose of step No. 2 was to submit the clip to a sustained effort, similar to what occurs in a complete orthodontic treatment. This made it possible to check the difference in the mechanical behavior of the clips between the initial and final stages.

Results

ANOVA (analysis of variance) was utilized to provide statistical calculation, complemented by the Tukey test of multiple comparisons, with a significance level at 5 percent.

Among the metallic interactive brackets, the In-Ovation R group showed the highest average, being significantly different than the other groups BioQuick and Empower (Table 3).

Discussion

Higher levels of force represent a disadvantage from the traditional systems of brackets when the load applied directly to the crowns exceeds biological limits. It is important to emphasize that the force generated by the clip is not delivered to the teeth. The importance is related to a proper engagement of the archwire into the slot, putting together the characteristics of the prescription in straight wire appliances.

It’s interesting to observe that it’s not just the initial force generated by the clip that’s relevant, but also how constant the force is maintained. Although some brands of interactive brackets showed initial forces apparently strong enough to maintain the archwire in position, they also showed that this strength is lost and dissipates over time, meaning the efficiency of an interactive bracket is related to the consistent power generated by the clip and not to the initial force provided by a brand new bracket.
The efficiency of an interactive system of self-ligating brackets is directly related to the uniformity and continuity of the spring clip activity over time. Excessive loss of force brings clinical difficulties during the treatment phases that require the utilization of rectangular-geometry archwires, such as the space closure and the finishing stage.

Therefore, from the clinical point of view, the most important data is the difference between the averages of steps Nos. 1 and 3 of the test (Table 4).

Through the test T at the level of significance of 5 percent, we can verify that for the majority of the groups, the means scores M1 were significantly bigger than M3, which means that there is always some lack of effectiveness of the spring clips, regardless of brand.

When the calculated p value (minimum significance level) allowed rejection of the nullity hypothesis, an asterisk (*) was used to denote this. The nullity hypothesis was rejected only on the In-Ovation C group, which showed no statistical difference between M1 and M3. This situation reflects a better mechanical stability of its spring clips.

Among the metallic self-ligating brackets, the mean score for step No. 3 (M3) was the highest for the In-Ovation R group. The group Empower suffered the greatest loss of tension, generating the lowest strength. The BioQuick group performed intermediate values at the end of the third moment of the test (M3). In the chart (Table 5), it is possible to observe and compare the mean scores for steps Nos. 1 and 3 of the test for each group of brackets.

Considering the differences in gf (grams of force) between the moments M1 and M3 (Table 6), the highest loss in terms of force magnitude between the metallic accessories after a 20 N load during two hours was shown by the BioQuick group (82.5 gf), quite similar to the Empower group (80.9 gf). The best performance (lowest lack of strength) was presented by the In-Ovation R group (33.6 gf).

Among the esthetic brackets, the highest loss of magnitude of force was shown by the QuickKlear group (77.8 gf), while the group In-Ovation C presented the lowest (27.5 gf).

**Conclusion**

From the above results, we can draw the following three conclusions:

- It’s important for clinicians to understand that the main component of an interactive self-ligation system is the spring clip, which is supposed to provide flexibility and resilience along the treatment time. Therefore, the choice among the different brands offered by the current market should be focused on this point.
- The spring clips of the interactive self-ligating brackets are not free from loss of force exertion.
power after being subjected to a load of 20 N for a period of two hours.

- The differences between the stages M1 and M3 were statistically non-significant only for In-Ovation C group (GAC–DENTSPLY, United States), which denoted greater mechanical stability.

There is not a perfect and ideal interactive self-ligating bracket system. However, both groups In-Ovation R and In-Ovation C performed better than the other brands in all the trials when the magnitude of force loss was considered.

References


About the Author

Dr. Celestino Nobrega completed his general dental training at Sao Paulo State University, Brazil, in 1984. He completed his certificate in orthodontics at Rio de Janeiro State at Brazilian Dental Association. His masters of dental science degree came in 1996, after publishing material about MRIs of TMJs. After taking the Roth-Williams continuing education course at Burlingame in 1997, he received the position of educator at several academic associations in Brazil, organizing courses as post-graduate program director. The search for innovative technologies led Nobrega to Dr. Elliot Moskowitz, who introduced him to NYU Ortho Department Chairman Dr. George Cisneros. Months later, Nobrega began bringing groups of his students and former students to NYU for one-week programs created especially for them. During these programs, Nobrega was able to have a closer and definitive contact with ISL mechanics, learning about biological and mechanical details. Today, Nobrega is leading a project in his country focusing on 19 biomechanical studies regarding characteristics of the interactive self-ligating system. The research is based on friction and flexibility studies and also on low-intensity laser and vibration therapy during orthodontic treatment.