



## Predictability of the Expression of Torques in Preadjusted Brackets-A Critical Review

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### Abstract

To evaluate the hypothesis that the amount of build-in torque of preadjusted brackets is the same as obtained at the end of orthodontic treatment, the authors searched the databases Pubmed, Medline and Google Scholar with the Keywords: orthodontics, corrective, AND orthodontics, brackets AND orthodontics, tooth movement translated into Portuguese and Spanish with the filters: clinical trial and review, with the types of article: systematic review, Technical report and Randomized controlled Trial in the last twenty years. 379 articles that were manually selected to filter those referring to the initial and final comparison of the bracket torques. Of this search, there were 21 articles that referred directly to the incorporation of buccolingual movement with the application of rectangular arches in preadjusted brackets.

Due to the overlap of evaluation types on different dates, we divide the topics into three blocks. *In vitro* studies were used to access the factors related to the physical characteristics of the materials, clinical articles with comparison of models and cephalometric tracings and by the comparison of images segmented by cone beam computed tomography to find the differences of predict and obtained torque. It was concluded that:

- The predictability of obtaining the torques provided for in preadjusted bracket prescriptions can be challenged by variables related to the composition of the materials used, the design of the arches used, the malleability of the strands and the relationship between the bracket slot capacity and the size of the arches. The difference of trademarks does not seem to change these factors.
- The degree of crowding and leveling of the curve of Spee increased labial torque in cases made without extractions and most studies done by comparison of models and cephalometry seems to indicate that the predominant movement in the treatments is the proclination of the teeth.
- The studies done by segmentation of the teeth by cone beam tomography indicate that the treatment without extractions made with self-ligating brackets causes the effect of greater labial torque in the anterior teeth.

**Keywords:** Torques; Preadjusted Brackets; Expression

**Proposition:** To evaluate the hypothesis that the amount of build-in torque of preadjusted brackets is the same as obtained at the end of orthodontic treatment.

### Introduction

Torque in orthodontics is defined as the buccolingual movement of the teeth resulting from the application of a moment. There are several ways to achieve this goal, but with the advent of the preadjusted brackets by Andrews [1], the obtaining of torque was mostly made by the insertion of rectangular arches in the slots of brackets whose shape of the base incorporated a certain inclination for each tooth.

Hypothetically, when inserting the arch compatible with the dimensions of the slots the torque would be automatically obtained. This means that the use of wires with a section smaller than that of the slot would not be able to express the totality of the intended inclination.

Another variable to consider is that the brackets and arches are made of several metal alloys or even polymeric compounds whose interaction could alter the moment of force required. In addition, anatomic factors and the characteristic of malocclusion could induce a distinct biological response in each case.

The purpose of this work is to verify the variables that really count in the predictability of the torque movement, as well as to investigate if there is enough evidence to support the hypothesis that there is a type of bracket or technique whose application can generate the same values between the incorporated torque and the torque obtained in orthodontic treatment.

### Material and Method

A search was carried out in the following databases: PubMed using the terms orthodontics, corrective AND orthodontics brackets AND orthodontic tooth movement with the filters: clinical trial and review, with the types of article: systematic review, Technical

report and Randomized controlled Trial in the last twenty years. Search was also done in Google Scholar with the same keywords translated into Portuguese and Spanish. It was found 379 articles that were manually selected to filter those referring to the initial and final comparison of the bracket torques. Of this search, there were 21 articles that referred directly to the incorporation of buccolingual movement with the application of rectangular arches in preadjusted brackets.

Among these, six were articles related to the comparison between the torque incorporated in the preadjusted brackets and the torque obtained *in vitro* with different combinations of arch gauges, metal alloy of brackets and arches, type of connection of self-ligating brackets and incorporation of load-deflection in the arches and the torque obtained at the end.

One of the articles refers to the movement of labial torque in the lower incisors, which happens automatically when leveling the curve of Spee, regardless of the prescription of the preset brackets. Another article studied the influence of the degree of initial crowding with the torque expression. Three others describe ways to standardize the position of the images obtained by computed tomography in the evaluation of dentoalveolar structures in orthodontic treatment.

The other ten articles are systematic reviews or clinical trials where predicted and obtained torque were studied in patients who used conventional, active and passive self-ligating brackets.

Since there is an overlap of evaluation types on different dates, we divide the topics into three blocks. In the first one the proposal was to evaluate the factors related to the physical characteristics of the materials through *in vitro* studies.

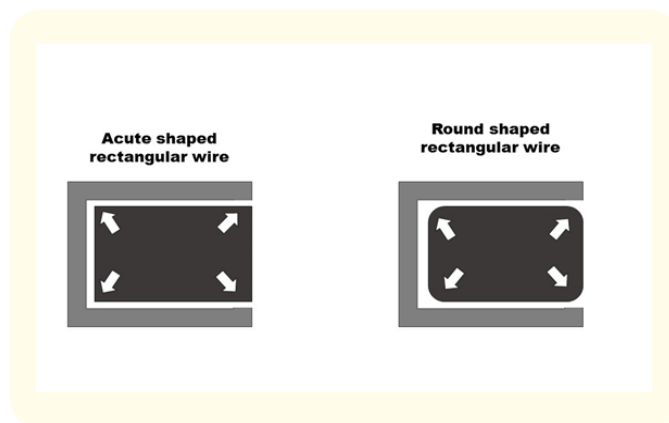
In the second, to study the articles related to the expression of torque in treatments by means of comparison of models and cephalometric tracings and in the third block to study the same effects by the comparison of images segmented by cone beam computed tomography.

### Literature Review

Several factors may contribute to the positioning of the teeth in the orthodontic treatment, especially in the axial inclination in the buccolingual direction, called torque.

Sebank., *et al.* [2] observed that the shape of the edges of the rectangular arches varied from supplier to others, being possible to find arches with ninety-degree corners and arches with rounded ends.

Figure 1 schematic representation of the interaction between the channel of the brackets and the type end of the rectangular arches. To the left, arch with sharp corners and, to the right, arch with rounded corners.



Using a test machine and a torque wrench they concluded that this variation is very important for the torque expression, since the play between the arch and the slot could cause a variation of 0.2 to 12.9 degrees in the same thickness. Analyzing the composition of the alloy, they concluded that the beta-titanium arches translated this difference more sharply than those of stainless steel and nickel-cobalt.

Gioka and Eliades [3] postulated that the expression of torque in preadjusted brackets could be influenced by the following variables:

- 1) Inability to fully fill the bracket slot by the arch.
- 2) Irregularities in the manufacture of brackets or lack of standardization.
- 3) Difference in the malleability of the arches used in the treatment.
- 4) Difference in the number reported by the manufacturers and the true torque measured.
- 5) Methods of connection between the arches and the brackets that cause variation between the two.

According to this study, in one hundred percent of the cases the amount of torque proposed would be different from that expected at the end of the treatments.

Archambault., *et al.* [4] made a systematic review where eleven articles were selected to compare the initial and final torques with the use of passive and active self-ligating brackets with 0.018 "and 0.022" slots and different combinations of arches with varied alloys, thicknesses and shape.

The conclusion is that the variation between the torques proposed by the prescriptions and those obtained *in vitro* are predominantly different, especially when considering the thicknesses of the wires in relation to the capacity of the slot.

Major, *et al.* [5] measured the force applied in 3-degree increments through a test machine with rectangular wires in self-ligating brackets of three different trade marks, concluding that, despite the difference in measurements obtained, from the clinical point of view would be insignificant.

To evaluate the shape of ligature and torque production, Brauchli, *et al.* [6] analyzed nine different brands of active self-ligating brackets in combination of 0.019" X 0.025" steel arches. The measurements were made with the clips open and closed and resulted in the conclusion that the closing of the clips influenced only a 10% difference compared to the same open brackets.

Franco, *et al.* [7] also studied the torque expression in sets of six different brands of conventional and self-ligating brackets with moments of 12°, 24°, 36° and 48° and concluded that the expression of the final torque varied slightly in the type of connection or the trade mark.

Although *in vitro* studies have studied the interactions between the mechanical properties of the brackets and the arches, clinical studies have not yet studied the behavior of preset brackets *in vivo*.

A systematic review that studied, among others, the amount of torque exerted by self-ligating brackets compared to conventional brackets was made by Chen, *et al.* [8]. The electronic search over the period 1966 to 2009 resulted in 16 clinical trials, including two randomized, ten cohort studies with moderate bias risk, and four cross-sectional studies with moderate to high risk of bias.

In the torque question, it was concluded that there was a difference in the labioversion of the lower incisors of the order of 1.5 degrees less in the self-ligating brackets, while all other occlusal characteristics had similar results between the two modalities of ligation.

A relevant clinical data on torque variation of the lower incisors was addressed in the study by Pandis, *et al.* [9]. Fifty patients were treated consecutively without extractions and with minimal crowding of 2.5 mm in the lower arch. They related the leveling curve of Spee with the labioversion of the lower incisors and concluded that for every 1 mm of rectification of the curve the incisors proclined 4 degrees.

Vajaria, *et al.* [10] compared with lateral cephalometry and scanned plaster models a group of 27 patients treated without extraction with self-ligating brackets with Damon prescription and 16 treated with conventional Roth prescription brackets and demonstrated a transversal increase in all cross-sectional comparisons.

They observed especially the labioversion of the lower incisors, concluding that the effect "lip bumper" proposed by Damon and that theoretically would cancel this effect could not be demonstrated.

Atik and Ciger [11] compared a group of 17 patients treated with quad helix followed by alignment with Roth prescription brackets and 16 patients treated with self-ligating brackets with Damon 3MX prescription. No significant differences were found regarding treatment time, periodontal patterns or pain perception, but the self-ligating brackets showed a higher labioversion of the lower incisors than the conventional ones.

Another randomized clinical trial, this time multicenter, was done by Fleming, *et al.* [12] to study the dimensional changes and inclination of upper arch teeth in patients treated with conventional brackets and active and passive self-ligated brackets randomly divided into three groups, for a total of 90 individuals.

Despite the difference in ligature type, the authors used the same sequence of archs for 34 weeks. No significant differences were found in any occlusal pattern including torques.

Linenberger, *et al.* [13] studied the results of scanned models by comparing 63 three-dimensional dots from 25 patients treated with Damon self-ligating brackets before and after therapy with 25 patients from a control group.

While the other teeth maintained an adequate torque control, it was observed that the upper and lower premolars had a labial inclination associated with an increase in the width of the arches in this sector.

Yitschaky, *et al.* [14] used the initial and final models of 96 patients who underwent no extractions or proximal reduction to relate alignment to the lower incisor inclination and found an increase of 0.5° of labioversion and 0.2 mm of protrusion for every 1.0 mm decrease in crowding.

Recently, Thomali, *et al.* [15], made a systematic review to evaluate the expression of torques with conventional, self-ligating active and passive brackets. In total, 87 studies were identified, of which 2 were considered of good quality and 7 of moderate quality, out of 9 selected.

They concluded that conventional brackets showed greater torques expression when compared to self-ligatures, which, in turn, did not show significant differences between active ou passive ligation, although the general comparison was not significant.

A new perspective to compare the predicted torque in preadjusted prescriptions with that obtained at the end of treatment was opened whith CT scan was evaluation. Buccolingual axial angles measurements can be made at the beginning and end of treatment and compared as long as they are obtained in a standardized way.

Garib., *et al.* [16-18] described standardization methods for obtaining similar tomography images, including for comparison of thickness and inclination of the buccal bone plates and the teeth with cone beam tomography.

Figures 2, 3 and 4 were provided by Dr. Nelson José Rossi of a case treated without extractions in a patient with discrepancy in the inferior arch of 5.0 mm using self-ligating brackets with Voudouris prescription.



Figure 4 representation of the cut standardization method proposed by Garib., *et al.* [18]. The smaller figures on the right show the inclination of the tooth 31 before (above) and after (below) the treatment. Note the labioversion at the end of treatment.

Araujo [19] evaluated the buccolingual inclination of the upper and lower anterior teeth by means of computed tomography in ten patients who presented an irregularity index of 4,0 mm or more, treated without extraction with Damon 2 self-ligating brackets, finished with 0,019" X 0.025 " stainless steel wires.

The predominant final inclination was greater than that provided for in the prescription, with markedly more labial torques.

Cattaneo., *et al.* [20] also evaluated the initial and final variation of incisors and canines in patients treated with active and passive self-ligating brackets.

They found that the anterior teeth labioversion was much higher than the one programmed by the prescription of the brackets used in the research and the variation was more significant in the patients treated with passive self-ligated brackets than in the active ones.

Rhoden., *et al.* [21] analyzed concomitant computed tomography images of twenty patients with an irregularity index greater than 5.0 mm, treated with self-ligating brackets with MBT prescription before and after alignment with 0.019" X 0.025" stainless steel wires. According to the authors, the maxillary and mandibular incisors showed a mean buccal inclination of 6.55° and 7.24° respectively. The upper lateral incisors also tilted from 4.90° to 8.72° respectively, while the lower canines showed a mean increase of 3.88° in the labioversion. Paradoxically, the lower canines had an average lingual inclination of -0.36°.

## Discussion

The physical properties of the materials employed, the interaction between the arches and the slots of the brackets and the type of ligature, whether conventional, self-ligating active or passive can represent important variation in torque expression. In table 1 we can see a summary between the propositions and the results obtained.

Authors	Proposition of the study	Findings
Sebank., <i>et al.</i> (1984)	Influence of the shape of the edges of the arcs X torque The shape of the edges of the arcs influence the amount of torque	The shape of the edges of the arcs influence the amount of torque
Gioka e Eliades (2004)	To evaluate the variables that influence the Torque torque expression	Variables that influence in the amount of torque: Inability to fill the bracket through the arch, irregularities in the brackets or lack of standardization, difference in the malleability of the arches used in the treatment, difference in the number reported by the manufacturers and the actual measured torque and methods of connection between the arches and the brackets
Archambault., <i>et al.</i> (2010)	Systematic review of <i>in vitro</i> study of torques expression	The variation between the torques proposed by the prescriptions and those obtained <i>in vitro</i> are predominantly different, especially when considering the thickness of the wires and the slots
Major., <i>et al.</i> (2011)	Measure the force exerted by self-ligating switch brackets on different brands	From a clinical point of view, the differences are insignificant.
Brauchli., <i>et al.</i> (2012)	To analyze different brands of self-ligating active brackets with open and closed clips in combination of steel arches	Closing of the clips influences only a 10% difference compared to the same open brackets
Franco., <i>et al.</i> (2015)	To study the expression of torque in sets of six different brands of conventional and self-ligating brackets with moments of 12°, 24°, 36° and 48°	The expression of the final torque varied very little according to the type of connection or trademark

**Table 1:** In vitro studies of torque expression in different combinations of brackets and arches.

Taking into account the diversity of trade marks, the composition of the alloys used in the manufacture of arches and brackets, the surface finish of these products, the way of ligature and the incorporation of moments, it is apparently difficult to infer that there is a way to accurately predict the result of a particular combination in relation to torque expression.

It is not possible to say that there is a supremacy of some system of connection between the material of production, as well as to pre-

dict what is the result of a certain way of generating a moment and the expression of torque.

The torque expression is also influenced by factors related to the biological response of the patient, so we separated in another block the group of articles that sought to study these variables by clinical studies.

The summary of the findings can be visualized in table 2.

Authors	Proposition of the study	Findings
Chen., <i>et al.</i> (2010)	Systematic review comparing torque with conventional and self-ligating brackets	Difference in the inclination of lower incisors of 1.5 degrees less in self-ligating brackets
Pandis., <i>et al.</i> (2010)	Influence of leveling of the curve of Spee in the expression of torque	For each 1 mm of rectification of the curve the incisors procline 4 degrees
Vajaria., <i>et al.</i> (2011)	Clinical comparison of patients treated with Damon and conventional self-ligating brackets	Labioversion of the lower incisors and increase of the transverse distances in both systems
Atik and Ciger (2014)	Clinical comparison of a group of patients treated with quadrilateral and Roth prescription brackets and 16 patients treated with Damon 3MX prescription	Self-ligating brackets showed higher labioversion of the lower incisors than the conventional ones.
Fleming., <i>et al.</i> (2016)	To study the dimensional changes and inclination of upper arch teeth in patients treated with conventional and self-ligating brackets active and passive	No significant differences were found in any occlusal pattern including torques.
Linenberger., <i>et al.</i> (2016)	To study the models of patients treated with self-ligating brackets with Damon prescription with 25 patients from a control group	The upper and lower premolars showed proclination associated with the increase in the width of the arches in this sector
Yitschaky., <i>et al.</i> (2016)	Relate the alignment to the degree of inclination of the lower incisors	Increase of 0.5° of labioversion and 0.2 mm of protrusion for each 1.0 mm decrease in crowding
Thomali., <i>et al.</i> (2017)	Systematic review to evaluate the expression of torques with conventional, active and passive self-ligating brackets	Conventional brackets show greater torques expression when compared to self-ligatures, which, in turn, did not show significant differences between then



Taking into account clinical studies and systematic reviews, most of the studies seem to indicate that two factors of unpredictability in the expression of torque are: the degree of crowding and the leveling of the curve of Spee, with a predominance of the result of greater labial torque in case made without extractions.

With the exception of one article that showed less proclination and another that did not show important changes in the initial and final torques, the others concluded that the use of self-ligating brackets causes greater proclination than conventional brackets.

The torque expression in the aforementioned studies was measured predominantly by cephalometric tracings and measurements in models, but the real angulation between the axes of each tooth

and the alveolar bone can not be correctly measured by these procedures due to the limitation of separating the teeth in the cephalometry and to measure the angles of the roots in the plaster models.

The use of computerized tomography with the standardization of the position allowed the generation of segmented images of each tooth and the evaluation of the effects on the buccal, palatine and lingual bone plates, as well as the individual axial inclination.

From then on the torque expression can be measured in vivo by some researchers, as can be seen in table 3.

Authors	Proposition of the study	Findings
Araujo (2008)	Evaluated the expression of upper and lower anterior toothed teeth by computerized tomography	The application of Damon 2 self-ligating brackets produced a larger final inclination than prescribed, with markedly more labial torques.
Cattaneo., <i>et al.</i> (2013)	Evaluate initial and final variation of incisors and canines in patients treated with active and passive self-ligating brackets	The anterior teeth 'labioversion was much higher than that programmed by the prescription of the brackets used in the research.
Rhoden., <i>et al.</i> (2016)	Analyze the torque expression in patients with an irregularity index greater than 5.0mm, treated with self-ligating brackets with MBT prescription.	All anterior teeth suffered greater labial torque, except for canines.

**Table 3:** Studies of torque expression performed by cone beam computed tomography.

The studies cited seem to show that the torque predicted in the prescriptions was always different from that obtained in the treatment with self-ligating brackets, notably provoking a greater proclination than at the beginning of the therapy.

**Conclusions**

According to the review, we can conclude the following:

1. The predictability of obtaining the torques provided for in preadjusted bracket prescriptions can be challenged by variables related to the composition of the materials used, the design of the arches used, the malleability of the strands and the relationship between the bracket slot capacity and the size of the arches. The difference of trademarks does not seem to change these factors.
2. The degree of crowding and leveling of the curve of Spee increased labial torque in cases made without extractions and most studies done by comparison of models and cephalometry seems to indicate that the predominant movement in the treatments is the proclination of the teeth.

3. The studies done by segmentation of the teeth by cone beam tomography indicate that the treatment without extractions made with self-ligating brackets causes the effect of greater labial torque in the anterior teeth.

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