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Maxillary incisor torque with conventional and self-ligating brackets: a prospective clinical trial

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Structured Abstract

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Objectives – To test the hypothesis that the engagement mode of wire to bracket affects the buccolingual inclination of maxillary incisors in extraction and non-extraction treatment with self-ligating and conventional brackets.

Design – A randomized clinical trial employing a random distribution of variables among the studied populations.

Setting and Sample Population – Private practice of one author. A total of 105 patients followed prospectively, were divided into two groups based on the inclusion of extraction in the treatment planning. These groups were further divided in two subgroups each, one receiving a self-ligating bracket and the other treated with a conventional Edgewise appliance of the same slot size and prescription.

Experimental Variable – Difference in the buccolingual inclination of maxillary incisors before and after treatment with the two appliances across the two treatment groups (extraction and non-extraction).

Outcome Measure – Angular measurements of the Sella-Nasion and Nasion-A point to maxillary incisor axis.

Results – No difference was found in the mean difference of the two angles measured for the two bracket groups studied.

Conclusion – Self-ligating brackets seem to be equally efficient in delivering torque to maxillary incisors relative to conventional brackets in extraction and non-extraction cases.

Key words: biomechanics; orthodontic brackets; prospective study; torque; treatment outcome

Introduction

The buccolingual inclination of maxillary incisors is critical in establishing an aesthetic smile line, proper anterior guidance, and a molar class I relationship. Insufficiently, inclined incisors preclude the distal movement of the anterior maxillary dentition, and deprive the dental arch from arch space; it has been shown that on average, a 5° anterior inclination, generates 1 mm of arch length (1–2). It is interesting to note that there is a high variability among various prescriptions with respect to anterior dentition torque values. Thus, the maxillary central incisor torque in pre-adjusted appliances ranges from 12° in the Roth discipline to 22° for the Bioprogressive prescription.

Self-ligating brackets have received much attention during the past few years. The introduction of a wide variety of these appliances by almost every manufacturer is indicative of the increased interest placed on this product by the industry and clinicians. The basic advantages of these brackets involve the elimination of ligation media such as elastomeric modules along with the process or tools associated with their application. This feature is associated with a number of favorable effects in treatment, the most important of which is supposedly, the achievement of consistent wire engagement without the undesirable force relaxation of elastomeric modules, thereby maintaining a constantly active status of engaged wires.

Despite the presentation of much empirical and anecdotal evidence, no documented evidence exists on the manufacturer's claims on the efficiency of self-ligating brackets in both, space closure and torque control. This is particularly intriguing because of the contradictory demands involved in the mechanotherapeutical setup for these cases, as space closure with sliding mechanics requires low friction, whereas torque control necessitates the development of frictional forces between the wire and the bracket slot walls.

The literature lists a limited number of studies on the performance of self-ligating brackets, of which even fewer satisfy the criteria of a prospective trial and none that of a randomized clinical trial, whereas no study has assessed the torque transmission of self-ligating brackets (3–7). Most investigations have been conducted *post mortem* based on treatment records of more than one practitioner, or questionnaires filled out by patients. Retrospective studies include the possibility of outcome bias, since the treatment results with each appliance are known before assignment of bracket type to patient group. On the other hand, data collection in this type of studies relies on the accuracy of treatment records, whereas multicenter trials present the additional complicating factor of inter-operative variability in materials handling and clinical management. Moreover, even the few comparative trials available involve a large variety of malocclusions treated with a wide array of methods and modalities, thus precluding a means to isolate confounding variables. Treatment auxiliaries and utilities such as intermaxillary elastics, incorporation of treatment variability in the form of extractions, or extraoral appliance introduce additional variables, which may complicate the extrapolation of results.

Currently, there is a lack of evidence derived from prospective clinical trials on the performance of self-ligating brackets as it relates to the transmission of torque. The purpose of this study was to assess the relative efficiency of self-ligating and conventional brackets in delivering torque in extraction and non-extraction cases.

Materials and method

Sixty-nine female and 36 male patients, with a mean age of 16 years were selected from the practice of the first author. The demographics of patients are shown in Table 1. Patients were informed on the objectives of the study and a informed consent was obtained.

From the 105 patients included in the study, 54 were treated without extractions and 51 with extractions of the maxillary premolars. Participants were selected from a large pool of patients using the following inclusion criteria: no contributory medical history, absence of trauma in the maxillary anterior teeth, no oral habits reported, irregularity index not higher than 4 (in the non-extraction group); minor or no spacing in the maxillary arch (non-extraction group); and no use of class II elastics or other auxiliary or utility during treatment. Similar criteria were used for the extraction group, where the two maxillary first premolars were removed.

The two groups were subdivided into two samples each, depending on the appliance type used: half of the extraction and non-extraction cases were treated with a conventional 0.022 in, Roth prescription, edgewise bracket (Microarch, GAC, Bohemia, NY, USA), whereas the remaining received a self-ligating bracket of identical

Table 1. **Demographic and clinical characteristics of the sample studied**

	Total (n = 105)		Conventional (n = 53)		Self-ligating (n = 52)		
	Mean or %	SD	Mean or %	SD	Mean or %	SD	*p*-value*
Demographic characteristics							
Age (mean years)	16.14	2.9	16.64	3.54	15.63	2.09	NS
Gender (%)							
Male	34.3		35.8		32.7		
Female	65.7		64.2		67.3		
Treatment characteristics							
Extraction	48.6		49		51		NS
Male	41.2						
Female	58.8						
Non-extraction	51.4		50		50		NS
Male	27.8						
Female	72.2						

*p-value for comparison with t-test or chi-square test, where applicable. NS, non-significant.

slot size and prescription (12° and 8° of torque for maxillary central and lateral incisors, respectively) appliance (Damon2; ORMCO, Glendora, CA, USA) bonded by the same operator who had received training in both systems. Arch wire sequence for the non-extraction group consisted of an initial arch wire of 0.014 or 0.016-in NiTi (ORMCO), where applicable, finishing with a 0.019×0.025 stainless steel, for both bracket groups. For the extraction group, arch wire sequence included the above-mentioned wires with the addition of the incisors-retracting arch wires, which consisted of a 0.019×0.025 NiTi reverse curve of Spee and elastomeric chain, finishing with a 0.019×0.025 stainless steel in both groups.

Cephalometric radiographs were taken before Treatment (T1) and at the end of treatment (T2), by the same operator on the same cephalostat (Orthophos 10, Sirona, Germany). All cephalograms were traced by hand, by the same clinician. The maxillary incisor was traced using the protractor template, after the tip and the apex of the tooth were identified on the film. The following angular measurements were selected for the assessment of incisor buccolingual inclination before and after treatment between the two appliance groups: (a) Nasion-A (NA) point line to maxillary central incisor long axis; and (b) Sella-Nasion (SN) line to maxillary central incisor long axis. The differences in the angular measurements induced by treatment, were analyzed with two-way ANOVA ranks with treatment (extraction, non-extraction), and bracket (conventional, self-ligating) serving as discriminating variables.

After the initial measurements, 20 cephalometric radiographs were randomly selected, retraced and the angles were re-measured to establish the method error. The reproducibility of the measurements was investigated with paired t-test. The analysis revealed a lack of statistical significance between the first and second recordings for the NA to U1 measurement, and a statistical significant but negligible error of 1.5% of the recorded value, for the SN to U1 measurement.

Results

Table 2 presents the initial cephalometric findings for the four groups included in the study. No difference with respect to initial NA to U1 and SN line to maxillary central incisor axis angle was found among the two bracket groups suggesting the random distribution of the variable 'bracket' in the population studied.

Tables 3 and 4 depict the ANOVA table for the Nasion-point A line to maxillary central incisor axis angle dif-

Table 2. **Initial central maxillary incisor inclination of the sample studied**

Measurement	Self-ligating/ non-extraction mean (SD)	Conventional/ non-extraction mean (SD)	Self-ligating/ extraction mean (SD)	Conventional/ extraction mean (SD)
Groups				
NA to U1 (°)	24.8 (5.7)	24.40 (7.9)	22.8 (4.6)	22.1 (7.2)
SN to U1 (°)	106.3 (7.8)	105.14 (8.4)	101.6 (5.2)	102.1 (7.9)

No difference exists between the initial values of angles within each treatment group (extraction and non-extraction) for each appliance group (row comparisons).

Table 3. **ANOVA table for the NA to U1 changes induced by treatment**

Source of variation	DF	SS	MS	*F*	*p*-value*
Extraction	1	71.28	71.28	2.74	0.10
Bracket	1	3.42	3.42	0.13	0.72
Extraction × bracket	1	24.78	24.78	0.95	0.33

*The probability that the results could have occurred by random chance.

Table 4. **Group differences for the NA to U1 changes before and after treatment**

Bracket-treatment group	Mean (°)	SD	Grouping*
Self-ligating/extraction	6.9	1.0	A
Self-ligating/non-extraction	4.3	0.9	A
Conventional/extraction	6.2	0.9	A
Conventional/non-extraction	5.6	0.9	A

*Means with same letters are not significantly different at the 0.05 level.

ferences induced by treatment, respectively. No statistically significant effect of extractions or bracket is shown, whereas the interaction term is also insignificant. Thus, the use of different brackets and associated mechanotherapy seems to have no effect on altering the torque of the maxillary incisor. Because the analysis of variance indicated a lack of significance for either one of the tested variables (extraction or bracket) no test was employed to investigate individual group differences.

In Tables 5 and 6, the ANOVA table and group comparisons for SN line to maxillary central incisor axis angle are demonstrated, indicating a similar effect of bracket or extractions on the axial inclination of teeth.

Discussion

In this study, a lack of effect of ligation mode on the maxillary incisor buccolingual inclination was found.

Table 5. **ANOVA table for the SN to U1 changes induced by treatment**

Source of variation	DF	SS	MS	*F*	*p*-value*
Extraction	1	61.19	61.19	2.40	0.12
Bracket	1	23.37	23.37	0.92	0.34
Extraction × bracket	1	31.34	31.34	1.23	0.27

*The probability that the results could have occurred by random chance.

Table 6. **Group differences for the SN to U1 changes before and after treatment**

Bracket-treatment group	Mean (°)	SD	Grouping*
Self-ligating/extraction	6.9	1.0	A
Self-ligating/non-extraction	4.3	0.9	A
Conventional/extraction	6.3	0.9	A
Conventional/non-extraction	6.7	0.9	A

*Means with same letters are not significantly different at the 0.05 level.

In general, maxillary incisor crown torque has been proven to vary between untreated and orthodontically treated dentitions, with the latter showing a larger lingual crown inclination relative to control population (8). On the other hand, no difference has been found in crown inclination between brackets of standard edgewise configuration relative to Roth prescription, emphasizing the role of wire-slot clearance in minimizing the torque built-in the slot (9). It has been reported that aside from the position of the bracket, tooth morphology may affect the torque transmitted to teeth (10–12). This is particularly important with treatment of patients with ethnic background other than Caucasian, where significant variations apply to soft-tissue, lip posture tooth morphology and crown spatial orientation relative to norms derived from Caucasians (13). Furthermore, the highly individual variability of torque has been noted by a study, which reported the variation of torque with age in the same population, thus introducing a variable, which if not weighted in both populations, may complicate the extrapolation of conclusions on relevant research (14). In the present study, both populations had similar age, and therefore the effect of the foregoing variable is not expected to have influenced the results.

Filling the bracket slot by incrementally increasing the wire cross-section has been the basic mechanotherapeutic sequence of therapeutic protocols. Alternative treatment schemes such as the variable modulus orthodontics (15), advocate filling the slot in the initial stages of treatment with a low modulus wire alloy and progressively increasing the stiffness of the wire instead of its size. However, in clinical conditions, the cross-section of the terminal arch wire almost never reaches the actual size of the slot because of the associated patient discomfort and difficulty in inserting very large rectangular wires on the slot. Inevitably, a fraction of the torque, that is built in the bracket remains

unexpressed, giving rise to slot-wire 'play' or third-order clearance (16). The effect of this clearance factor, which was brought up early in appliance evolution (17), was theoretically estimated to range as high as 10°. However, the results of the theoretical torque loss do not represent the actual 'play' between the slot and the wire (18–20). The apparent discrepancy between the estimated and measured torque loss arises from the manufacturing processes of brackets and wires. Bracket slot manufacturing introduces inclusion of metallic particles and formation of grooves and striations, which may preclude the full engagement of the wire in the slot walls (21–22). Although it has been shown that reported torque differs from the actual one by 5–10%, which represents roughly 1–1.5°, the net effective torque may be lower than expected. Various bracket manufacturing processes involving injection-molding, casting or milling may also affect the accuracy of the prescribed torque values. Molding exposes the material to expansion and shrinkage, whereas milling may incorporate a rough grained surface. A recent study demonstrated a high variability in the shape of the slot which deviated from the rectangular cross-section as well as in the torque reported and the actual one built-in the appliance (23).

Currently, the only evidence available on the relative torque-transmitting efficiency of self-ligating brackets derives from a single laboratory study, which showed a large torque loss for the passive self-ligating brackets, and lower for the active version of them, in contrast to the results of this study (24). The contradicting evidence may be explained on the basis of the clinical application of materials and the factors intervening in clinically handling the torque stages. Treatment of patients involves application of reversed curve of Spee arch wires, a fact which was not considered in the laboratory setup. Moreover, the clinician has the option of adding torque to the wire a factor, which cannot be standardized in *ex vivo* experimental configurations. Lastly, in fully bonded dentitions the forces and moments applied to teeth may be different compared with the simplified form of laboratory setups, because of the simultaneous presence of second-order bends (25).

All patients received a 0.019 × 0.025-in stainless steel arch wire as a final wire in a 0.022-in bracket slot. This configuration presents a free play of almost 14° (20). The choice of NiTi arch wire for torque application, in addition to the problem of free play, is accompanied by another disadvantage in expressing the full range of torque prescribed in the bracket: the decreased stiffness of the wire, relative to the stainless steel alloy (26). The lack of stiffness for the NiTi wires has been reported to account for the requirement that wire torque exceed 25° to induce a deactivation plateau (18). Because such high torque values cannot be found in any prescription, it is postulated that the clinical efficiency of low-modulus wires in delivering torque is questionable if no wire twisting is incorporated, where this is applicable, as with β-Ti (TMA) wires. Alternatively, a reversed curve of Spee wire configuration may counteract the disadvantage of poor torsional stiffness of NiTi arch wires, enhancing its performance as applied in the treatment of patients participated in the present study, prolonging however the treatment, since additional time would be required to facilitate torque expression.

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