Original Article

Maxillary canine retraction with self-ligating and conventional brackets

A randomized clinical trial

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ABSTRACT

Objective: To measure space closure during the retraction of upper permanent canines with self-ligating and conventional brackets.

Materials and Methods: Fifteen patients who required maxillary canine retraction into first premolar extraction sites as part of their orthodontic treatment completed this study. In a random split-mouth design, the retraction of upper canines was performed using an elastomeric chain with 150 g of force. The evaluations were performed in dental casts (T0, initial; T1, 4 weeks; T2, 8 weeks; T3, 12 weeks). The amount of movement and the rotation of the canines as well as anchorage loss of the upper first molars were evaluated.

Results: There was no difference between self-ligating and conventional brackets regarding the distal movement of upper canines and mesial movement of first molars ($P > .05$). Rotation of the upper canines was minimized with self-ligating brackets ($P < .05$).

Conclusion: Distal movement of the upper canines and anchorage loss of the first molars were similar with both conventional and self-ligating brackets. Rotation of the upper canines during sliding mechanics was minimized with self-ligating brackets. (*Angle Orthod.* 2011;81:292–297.)

KEY WORDS: Self-ligating brackets; Canine retraction; Friction

INTRODUCTION

The systematic evolution of dental materials has led to a constant pursuit of technological innovations in orthodontics. Appliance biocompatibility, orthodontic treatment efficiency, and patient convenience are the major issues confronting today's orthodontists. The orthodontic diagnosis and treatment plan often require retraction of upper anterior teeth. In these cases, premolar extractions or molar distalization can provide the required spaces. One of the biomechanical alternatives to space closure is the retraction of canines with sliding mechanics performed prior to incisor retraction.

Sliding mechanics produces friction at the bracket-wire-ligature interface. Frictional forces, which act in opposite direction to the desired movement, are generated whenever a force is applied to bodies in contact, even in the absence of movement.[1] In clinical terms, any force applied to achieve a desired movement must exceed the frictional force inherent in the appliance.[2] Friction between archwires and brackets varies according to ligation method (elastomeric/steel ligatures, active/passive self-ligating brackets),[3–5] which in turn affects the rate of tooth movement during sliding mechanics.[6]

Self-ligating brackets were first introduced in orthodontics in the 1930s. Thanks to faster archwire ligation, these appliances decrease chair time while increasing clinical efficiency.[7] As early as the 1970s, self-ligating brackets have been recommended to reduce friction between brackets and wires, deliver forces in more biological levels, reduce overall treatment time, improve plaque control, and enhance patient comfort.[8,9] Nevertheless, most of these allegations are still controversial.[8,10]

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DOI: 10.2319/062510-348.1

Figure 1. Clinical views of canine retraction. Conventional bracket: initial (A) and (C) after 3 months of retraction. Self-ligating bracket: (B) initial and (D) after 3 months of retraction.

The aim of this split-mouth randomized clinical trial was to compare the retraction of upper canines with sliding mechanics using self-ligating brackets (Smart-Clip) and conventional brackets (Gemini). More specifically, the rates and total amount of distal movement and rotation of the upper canines, as well as the mesial movement of the upper first molars, were measured.

MATERIALS AND METHODS

The sample comprised 15 healthy patients (10 girls and five boys), between the ages of 12 and 26 years (mean, 18 years), with Class I or Class II malocclusion. All of the patients were treated with bilateral extraction of the first premolars and retraction of the maxillary canines with full fixed standard edgewise appliance. This research was approved by the Committee of Ethics in Research, PUC-RS. The patients or their legal guardians agreed to participate in the research by signing a consent form.

The initial records included anamnesis, clinical examination, intraoral and extraoral photos, dental casts, lateral cephalograms, and panoramic and wrist and hand radiographs.

The orthodontic treatment was performed with a full fixed standard edgewise appliance (3M-Unitek, Monrovia, Calif; 0.022 × 0.028 inch). However, brackets bonded to the upper canines had MBT prescription (8° angulation, 0° torque). In a random, split-mouth design, self-ligating brackets (SmartClip, 3M-Unitek) and conventional brackets (Gemini, 3M-Unitek) were bonded to the right and left sides of all patients by raffle.

Alignment and leveling of the arches were performed using 0.0155-inch and 0.0175-inch stainless-steel (SS) coaxial followed by 0.016-inch and 0.018-inch SS round archwires. Elastic ligatures were employed for ligation of the conventional brackets. The first molars and second premolars were tied together with SS 0.010-inch ligatures. No additional anchorage was used for posterior teeth.

Retraction of the canines was accomplished with elastomeric chain (Memory Chain, American Orthodontics, Sheboygan, Wis), started 28 days after insertion of SS 0.018-inch archwire (Premier Plus, TP Orthodontics, LaPorte, Ind). The force of 150 g was checked with a dynamometer (Zeusan, São Paulo, Brazil). To avoid interference with ligation and friction forces, an elastomeric chain was attached to the hooks of the canine brackets in both conventional and self-ligating brackets (Figure 1).

Patients were evaluated before (T0) and after 4 weeks (T1), 8 weeks (T2), and 12 weeks (T3) of canine retraction. At each appointment, impressions of the upper jaw were taken with alginate (Orthoprint, Zhermack, Badia Polesine, Italy) to obtain the dental casts.

All study measurements were performed on the dental casts. The movement of the upper permanent canines was based on measurements of the distance between the contact points on the distal surface of the canines and the mesial surface of the second premolars.

Measurements were made in both the right and left sides with a digital caliper (Digimess, São Paulo, Brazil) by the same investigator. After 7 days, the measurements were repeated to check reproducibility. The amount of monthly movement was found by calculating the differences between sequential measurements (T0–T1, T1–T2, T2–T3). The total amount of movement was considered to be the difference between the values of T0 and T3. The mean monthly movement was obtained by dividing the total amount of movement by three (number of evaluations).

The rotation of upper canines was represented by the angle formed between the median palatine suture and a line passing through the mesial and distal contact points of the canines (Figure 2). Total rotation
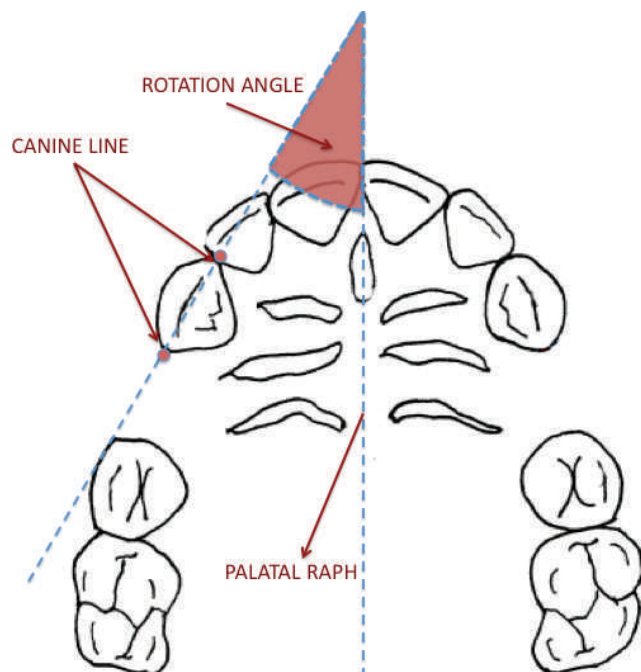
Figure 2. Measurement of canine rotation: angle between the median palatine suture and the line passing through the distal and mesial contact points of the canines.

was considered to be the difference between the values of T0 and T3. The rotation measurements were taken with a protractor and repeated after 7 days to check reproducibility.

The mesial movement of first molars (anchorage loss) was evaluated through a transfer guide made up individually in the initial models of each patient (T0). A plate of autopolymerizing acrylic resin adapted to the region of the palatine rugae had a 0.7-mm SS wire extending as far as the tip of the mesiopalatal cusp of the first molar. The guide made on T0 models was then positioned in models obtained at T3. The distance between the mesiopalatal cusps of the molars and the tip of the wire was considered to be the amount of mesial movement of the molars (Figure 3). Again, measurements made with a caliper were repeated after 7 days.

In the statistical analysis, the nonparametric Kolmogorov-Smirnov test showed normal data distribution. Readings at 7-day intervals were compared by the intraclass correlation coefficient (ICC). Paired Student's *t*-test was used for comparison between groups. Significance level was 5%. Data analysis and processing were performed by the statistical software SPSS, version 18.0.

RESULTS

Readings with a 7-day interval were in agreement (ICC > 0.9). Sliding mechanics—whether with self-
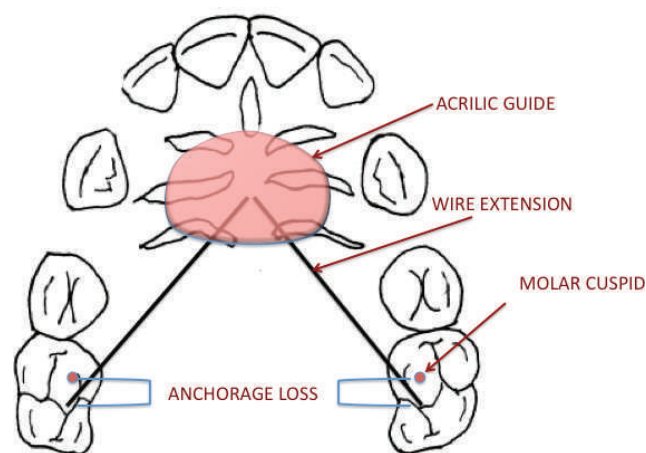
Figure 3. The acrylic guide made in the initial dental cast (T0), with two wires extending as far as the mesiopalatal cusp of the first molars. Adaptation of the final dental cast (T3) allowed the measurement of anchorage loss.

ligating or conventional brackets—caused distal movement and rotation of the upper canines and mesial movement of the first molars (Table 1). Initial measurements (T0) were similar in both groups (Table 2). The total movement of the upper canines and first molars did not differ between self-ligating or conventional brackets (Table 3). Otherwise, there was less rotation of upper canines ($P < .05$) with self-ligating brackets (Table 3).

DISCUSSION

Interest in self-ligating brackets has grown in recent years. In vitro studies have demonstrated a substantial decrease in the coefficient of friction of self-ligating brackets, a possible clinical advantage over conventional brackets, especially for sliding mechanics.[9,11] From this standpoint, it is important to evaluate these brackets[12] clinically, and this split-mouth randomized clinical trial set out to evaluate this alleged performance clinically.

Some studies used a retraction system for the canines in each side of the maxillary arches.[13] Others randomized the side in which each system would be employed to reduce clinical research bias.[14–16] In the present study, randomization was chosen because the precision in bracket positioning could vary according to the patient's side. Such bias could influence the results, especially the evaluation of canine rotation.

The evaluation of space closure can be accomplished through intraoral measurements,[15,17] unlike the analysis of anchorage loss of molars and canine rotation. Radiographic methods, although effective for determining canine retraction and loss of anchor,[18] expose patients to unnecessary radiation and do not

Table 1. Average Rates of Distal Movement of Upper Canines, Total Rotation of Canines, and Anchorage Loss of Upper First Molars in Each Subject in 3 Months

Subject	Self-ligating Brackets			Conventional Brackets		
	Distal Movement, mm/mo	Rotation, °	Anchorage Loss, mm	Distal Movement, mm/mo	Rotation, °	Anchorage Loss, mm
1	0.78	14	0.6	0.63	12	0.3
2	0.87	13	0.8	0.80	14	0.7
3	0.54	4	1.0	0.96	14	0.7
4	1.35	19	0.8	0.99	16	0.7
5	0.58	3	0.7	0.70	4	0.3
6	0.75	4	0.6	0.50	9	0.8
7	1.10	9	0.3	0.80	15	0.3
8	0.85	4	0.1	0.60	9	0.1
9	1.50	7	0.8	1.24	12	0.5
10	1.23	10	0.6	1.23	14	0.7
11	0.6	9	0.9	0.74	14	0.9
12	0.88	8	0.5	0.88	10	0.7
13	0.94	6	0.7	0.90	10	0.7
14	0.61	18	0.5	0.82	18	0.5
15	0.87	9	1.0	0.82	13	1.0

allow the evaluation of canine rotation. As in many other studies,[15,16,18–22] plaster models were used here to obtain the measurements.

Analysis of anchorage loss was based on the stability of the region of the palatine rugae during orthodontic mechanics.[23] The use of an acrylic guide adapted to the anterior palate was proposed by Lotzof et al.[24] and reused by Shpack et al.[16]

Constituent material and orthodontic archwire diameter can influence tooth movement during sliding mechanics. It is known that stiffer wires can better resist the tendency of teeth tilting during sliding.[19,20] Therefore, thicker SS wires would be best suited for these mechanics. It should be emphasized that friction increases as bracket slots are filled.[11] For this reason, a round, extra hard 0.018-inch SS archwire (Premier Plus, TP Orthodontics) was selected.

To standardize the friction produced by the tying strength of conventional brackets, elastic ligatures of the same color and brand were applied to all patients. SS ligatures might exhibit greater variation in tying strength and friction.[21]

The literature reports that the space resulting from premolar extractions or from the distal movement of posterior teeth can be closed with different devices. The choice of elastomeric chains was based on their clinical effectiveness, which, although similar to that of

nickel-titanium springs, affords more convenient installation and less patient discomfort.[22]

Optimal orthodontic force produces excellent biological response with minimal tissue damage, resulting in rapid tooth movement with little discomfort, avoiding or minimizing hyalinized areas.[25] However, the magnitude and duration of the ideal force remain controversial.[26] The force of 150 g employed in the present study followed recommendations found in the literature to apply forces between 100 g and 200 g for canine retraction.[24]

Individual variations in biological response and tissue reactions to orthodontic movement, as well the influence of the environment and habits inherent in each patient of a given scientific sample, make it difficult to extrapolate the results to the general population.[26–28] However, the results in this study indicate a tendency to be expected by orthodontists during treatment.

Both space closure methods using upper canine distalization have proven effective. No statistical differences were found between their rates of movement (Table 2). Significant individual variation was found in the rates of tooth movement, with some individuals reaching twice as much displacement as

Table 2. Means, Standard Deviations, and Student's *t*-Test Comparing Initial Measurements (T0)

Measurement	Self-ligating Bracket		Conventional Bracket		P
	Mean	SD	Mean	SD	
Total space, mm	6.08	1.57	5.84	1.60	.209
Initial angle, °	30.87	6.16	29.00	3.85	.178

Table 3. Means, Standard Deviations, and Student's *t*-Test Comparing Measurements of Self-ligating and Conventional Brackets in 3 Months

Measurement	Self-ligating Bracket		Conventional Bracket		P
	Mean	SD	Mean	SD	
Total movement , mm	2.68	0.86	2.53	0.62	.354
Rate of movement, mm/mo	0.90	0.29	0.84	0.21	.356
Rotation, °	9.15	4.98	12.27	3.45	.003
Anchorage loss, mm	0.66	0.25	0.59	0.25	.157
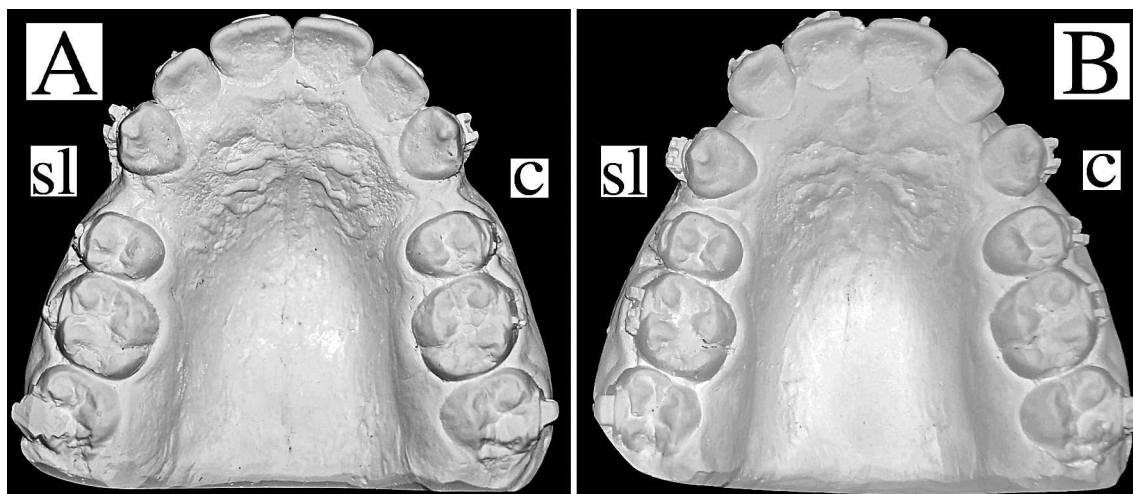
Figure 4. Occlusal views of dental casts. (A) Initial and (B) after 3 months of retraction (c = conventional bracket, SL = self-ligating bracket).

others (Table 1). These behaviors have already been reported and result from the fact that biological response to the application of well-controlled orthodontic forces is extremely broad with wide variation in rates of tooth movement.[27,29]

Few clinical studies have compared space closure with self-ligating and conventional brackets. Miles et al.[17] found similar rates of tooth movement whether self-ligating or conventional brackets were used for en mass retraction of the six anterior teeth.

Sirinivas[30] found higher rates of distal movement of canines with self-ligating brackets compared with conventional brackets. Nevertheless, measurements were taken only at canine cusps so that tooth inclination might have overestimated the performance of self-ligating brackets.

Self-ligating brackets showed better rotational control during distal movement of the canines compared with conventional brackets tied with elastomeric ligature (Table 3 and Figure 4). The tendency toward rotation is related to the point of application of the force, which does not pass through the center of resistance of the teeth.

Sirinivas[30] found similar results, with a better rotational control for self-ligating brackets during canine retraction. The author used an archwire with a larger diameter (0.018 × 0.025 in.), with less slack between the wire and the cover of the self-ligating brackets. However, rotation values were not affected. Other procedures, such as tying the distal tie-wings of the brackets with SS ligature or applying additional lingual forces, are routinely used in orthodontic practice. The latter, although effective in most cases, may increase patient discomfort.

Loss of anchorage occurred in this study regardless of the system used (Table 3). Sirinivas[30] found greater loss of anchorage than was found in this study using SS 0.018- × 0.025-inch wires and nickel-titanium springs loaded with 150 g force. The rate of movement of molars in the mesial direction was 0.43 mm/mo with self-ligating brackets and 0.53 mm/mo with conventional brackets. Other studies did not consider anchorage loss.[15,17] It is noteworthy that loss of anchorage can often be desired by clinicians. Orthodontists must control the amount of mesial movement of posterior teeth according to each patient's unique treatment plan.

In addition to the statistical results found in this clinical research, it would be fair to include the qualitative findings related to orthodontic practice (Figures 1 and 2). During canine retraction, bracket rebonding was never required. None of the elastomeric chains was broken or lost, and none required replacement before the scheduled appointment.

Some patients reported sensitivity during the insertion of archwires in the self-ligating brackets, especially those with larger diameters. This was probably related to the force needed to open the clips. On the other hand, there was no report of discomfort to archwire removal.

The amount of space closure as a result of canine retraction did not differ between the two bracket ligation systems, but canine rotation was greater with conventional brackets. Clinical evaluation and stone model analysis disclosed that rotations greater than 10° may be critical for treatment sequence. If the archwire disengages from the bracket slot distally, the retraction needs to be stopped until canine rotation is corrected. Such an interval would extend treatment time and eventually compromise finishing quality.

Twelve (80%) of the 15 patients displayed canine rotation greater than 10° with conventional brackets. It

occurred in only five (33%) of the patients with self-ligating brackets. From this standpoint, alternative techniques should be applied to prevent canine rotation during sliding mechanics with conventional brackets.

CONCLUSIONS

- The rates of distal movement of the upper canines were similar with both conventional and self-ligating brackets.
- Rotation of the upper canines during retraction was minimized with self-ligating brackets.
- Anchorage loss of the upper molars was similar with both conventional and self-ligating brackets.

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