Original Article

Comparison of Canine Movement Between Self-Ligating Brackets and Conventional Brackets in Corticotomy-Assisted Orthodontic Patients

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Abstract

The purpose of this study was to compare the efficiency of maxillary canine movement when using self-ligating brackets with conventional brackets in corticotomy-assisted orthodontic patients. The study was performed on 18 sites in 9 patients (6 women, 3 men) with severe crowding who underwent first premolar extractions and corticotomy on maxillary canine areas. A conventional bracket was placed on one canine and a self-ligating bracket on the other side. Upper canines were retracted using elastomeric chains with 150 grams of force. After 3-months, impressions were taken every month and lateral cephalograms were taken at the beginning and the end of the experimental period. The results showed that in the self-ligating brackets group, the rate of maxillary canine movement was 1.62±0.27 mm/month and the canine distal tipping was 11.66°± 5.01°. Distopalatal rotation was 9.44°± 5.50°. In the conventional brackets group, the rate of maxillary canine movement was 1.37±0.39 mm/month. The canine distal tipping was 13.27°±5.71° and the distopalatal rotation was 9.22°± 6.07°. The difference in rates of maxillary canine movement, distal tipping and distopalatal rotation between the 2 groups were not statistically significant (p>0.05). Distal movement and rotation of the upper canines reinforced with corticotomy were similar when comparing conventional and self-ligating brackets. Rotation of the upper canines during sliding mechanics was minimized with conventional brackets

Key words: Canine retraction, Corticotomy, Self-ligating brackets

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Introduction

As part of conventional orthodontic treatment, a patient who has severe crowding of anterior teeth often requires premolar extraction and retraction of canines into extracted spaces. With ectopic or severely displaced canines, undesirable side effects such as bone loss, dehiscence, fenestration and gingival recession may occur.

To reduce the risk from these complications, corticotomy-assisted orthodontics should be considered. Wilcko *et al.*[1,2] have noted that orthodontic tooth movement is accelerated by the increase of bone turnover and the decrease of bone density because osteoclasts and osteoblasts are increased by a regional acceleratory phenomenon (RAP). They also developed the newly effective technique called Periodontally Accelerated Osteogenic Orthodontics (PAOO) and claimed that decortications combined with augmentation grafting created greater alveolar volume, which eliminated bony dehiscence and fenestrations and also accelerated tooth movement.[1-5] Other factors that may affect treatment duration are timing of treatment, distance of tooth movement, technique employed, extraction or non-extraction treatment,[6] and factor that mainly affects canine movement by sliding mechanics, is friction.[7]

Self-ligating brackets have been used in orthodontics since 1935 and gained popularity in recent years.[8-12] Information from previous studies shows that self-ligating brackets produced lower friction when compared with conventional brackets.[13-17] The benefit of low friction bracket systems was that they may facilitate tooth movement in sliding mechanics. Many previous studies showed that self-ligating brackets required an average lower treatment time and fewer appointments than conventional brackets.[18-21] Although self-ligating brackets were claimed to have advantages, evidence was still lacking.[22]

At present, many orthodontists would like to have a faster technique in orthodontic tooth movement. However, comparative studies of self-ligating brackets and conventional brackets are still controversial and studies of corticotomy-assisted orthodontics are merely case reports. A comparative study on the rate of canine movement between self-ligating brackets and conventional brackets in corticotomy-assisted orthodontic patients has not been documented. This study was therefore undertaken.

Material and Methods

In this study, the inclusion criteria for participants were (1) Age between 18-30 years, (2) Skeletal class I, dental class I malocclusion with severe crowding (Little's irregularity index>7), (3) Patients required therapeutic extraction of upper first premolars in the treatment plan, (4) All patients had inadequate bone support in upper canine-premolar area, (5) No allergies or medical problems especially uncontrolled osteoporosis or other bone diseases, no long-term use of medications such as anti-inflammatory, immunosuppressive, bisphosphonates or steroid drugs, no active periodontal diseases, and no signs or symptoms of temporomandibular disorders.

Nine patients fulfilling the criteria were selected from the orthodontic clinic at the Faculty of Dentistry, Prince of Songkla University. This research was approved by the Committee of Ethics in human experimental research of the Faculty of Dentistry, Prince of Songkla University. All patients were informed of the purpose of the study and they signed the proper informed consent forms.

Each randomly chosen subject received a 0.022-inch slot conventional bracket (pre-adjusted edgewise bracket; Mini Twin™ Roth brackets, Ormco Corporation, Glendora, Calif.) on one canine and a 0.022-inch slot self-ligating bracket (passive self-ligating bracket; Damon 3MX™ system, Ormco Corporation, Glendora, Calif.) on the other with the left or right side using a randomization sequence. Brackets were placed on all teeth except incisors and second molars were bonded with buccal tubes. The sequence of placing brackets and wires was done according to the manufacturer's recommendations. A polyvinyl–siloxane impression (Silagum™ putty soft, DMG, Hamburg, Germany) was made to act as a matrix in case of bracket failure in order to facilitate re-bonding in the original bracket position. NiTi arch wire and temporary anchorage devices (TAD, AbsoAnchor™ system, Dentos Inc., Daegu, Korea) were placed 1 week prior to surgery. The position of TAD was located between second premolar and first molar. The height level was 5 mm from the bracket slot.

Alveolar decortications were done on the maxillary canine areas and bone grafts were added. Two weeks after first premolar extraction, the first step was to level and align upper and lower arches with 0.012-inch NiTi and 0.016-inch NiTi, respectively, for 2 months. After that, 0.018-inch stainless steel wires were placed and canine retraction was started with 150 g of force[23] by using power chains (Continuous chains Bobbin, 3M Unitek™, Monrovia, USA) between canine brackets and TADs (Fig. 1). The patients were activated every 2 weeks. Impressions were taken before canine movement (T_0), 1 month (T_1), 2 months (T_2) and 3 months (T_3) after tooth movement for the reference models. Lateral cephalometric radiographs were taken before canine movement (T_0) and 3 months (T_3) after movement.

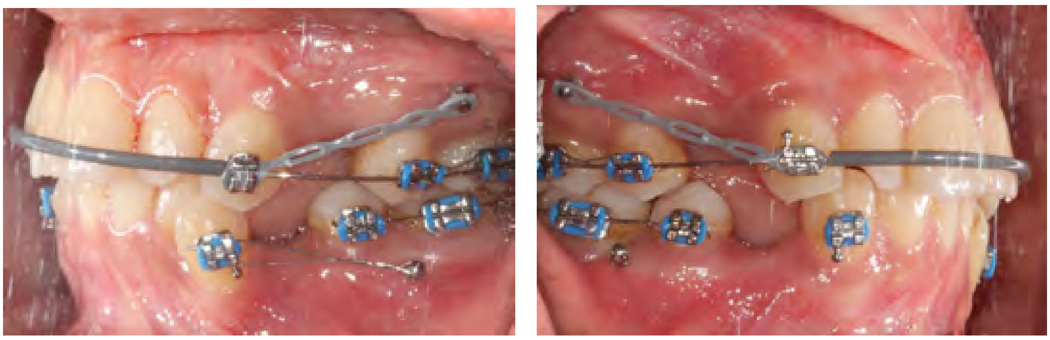

Figure 1 *Canine retraction performed by the use of c-chain between canine brackets and TADs.*

The movement of the canines was performed directly on the dental casts. An acrylic palatal plug fabricated from acrylic with reference wires (0.018-inch stainless steel) extended to the canine cusp tip was made for each maxillary arch (Fig. 2). This plug could thus be transferred from the initial cast to the final cast on the same patient. This allowed for direct observation of the amount of canine movement. Measurements were performed with a digital caliper by the same investigator. The amount of monthly movement was measured by calculating the difference between sequential measurements (T_0–T_1, T_1-T_2, T_2-T_3). The total amount of movement was considered to be the difference between the values of T_0 and T_3.

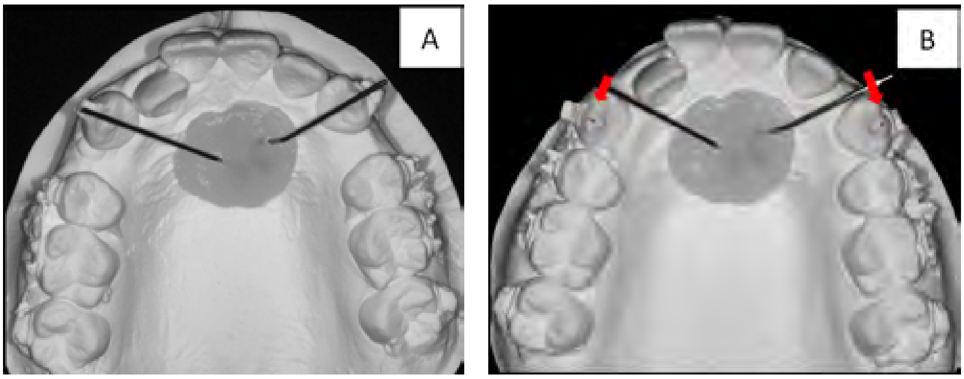

Figure 2 *Measurement of canine movement. A. Before canine movement (T_0). B. 3 months after canine movement (T_3).*

The amount of rotation of upper canines was determined by measuring the angle formed between the line passing through the midpoint between fovea palatine and the third rugae and a line passing through the mesial and distal contact points of the canines (Fig. 3). The canine rotation was considered to be the difference between the angular values of T_0 and T_3. The rotation measurement was repeated after 7 days to check the reproducibility of the measurement.

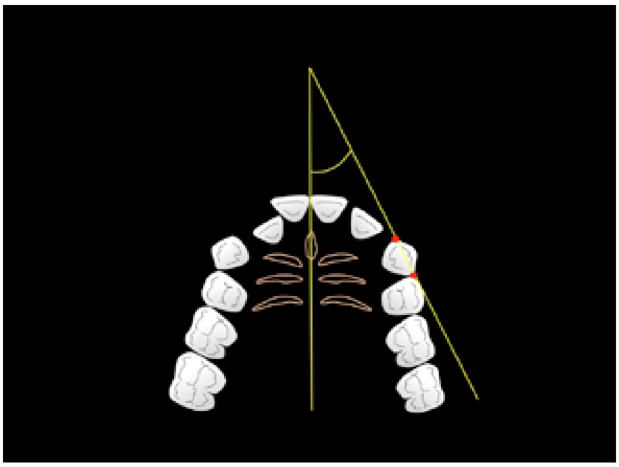

Figure 3 *Measurement of canine rotation.*

The lateral cephalometric radiographs were taken with jigs made of 0.016 x 0.022-inch stainless steel wire inserted in the vertical slots of the canine brackets. Maxillary canine angulation defined as the angle formed by the intersection of the SN line and a line extending from the jig placed into the vertical slots of each canine (Fig. 4). The tipping of canines was the difference between the angular parameters measured on the initial and the final lateral cephalometric radiographs (T_0-T_3).

Figure 4 *Canine angulation measurements by using reference jig line and the SN plane. S (Sella): The center of Sella turcica, N (Nasion): The most anterior point of the frontonasal suture in the midsagittal plane.*

Statistical analysis

For statistical analysis, the models and lateral cephalometric radiographs were measured and compared between the initial and the final data. From the Shapiro-Wilk test, data was found to be suitable for non-parametric analysis. The non-parametric Kolmogorov-Smirnov test showed normal data distribution. The significance of the differences on canine movement between the low-friction side and the conventional side was evaluated by Wilcoxon signed-ranks test with the significant level of 0.05. Calculating method error from the difference between two measurements taken at least 4 weeks apart to evaluate the intra-class correlation coefficient (ICC).

Results

A total of 18 extraction sites from 9 patients were compared. There were 3 males and 6 females, between the ages of 13 and 25 years. Mean and standard deviation of age at the beginning of the treatment was 18.7±1.0 years. Eighteen models and cephalometric radiographs were re-measured and retraced. The random measurement error (ME) was calculated according to Dahlberg's formula. The linear measurement error was found to be less than 0.4 mm, while the angular measurement error was less than 0.3°. Interclass correlation coefficient showed no significant difference between the two series of measurements. The method was found to reach sufficient reliability. Pretreatment data of canine angulation and rotation showed no significant difference between the 2 groups (p=0.149 and p=0.953 respectively).

Table 1 lists the distance of canine movement between self-ligating brackets and conventional brackets in the 3-month period (T_0 to T_3). The mean of total canine movement in the self-ligating group was 4.87±0.81 mm and the mean of total canine movement in the conventional group was 4.09±1.21 mm. There was no significant difference between the 2 groups (p>0.05).

Table 1 Means and standard deviations of the distance of canine movement between self-ligating brackets and conventional brackets at different periods

Bracket Type (N=9)	Accumulative distance of canine movement (mm.)			
	T_0	T_1	T_2	T_3
Self-ligating	0	1.41±0.64	2.87±1.16	4.87±0.81
Conventional	0	1.42±0.77	2.78±0.92	4.09±1.21
p		0.953	0.859	0.139

The rate of canine movement in a 3-month period was shown in Table 2. The rates of canine movement in the self-ligating brackets group at T_1, T_2 and T_3 were 1.41±0.64 mm, 1.46±0.92 mm, and 2.00±0.89 mm, respectively, and the rates of canine movement in the conventional brackets group at T_1, T_2 and T_3 were 1.42±0.77 mm, 1.10±0.56mm, and 1.20±0.79mm, respectively. The difference of the rates of canine movement between groups in T_1, T_2 and T_3 was not statistically significant (p>0.05). The mean rate of canine movement of the self-ligating brackets group was 1.62±0.27 mm/month and the mean rate of conventional brackets was 1.37±0.39 mm/month. A statistically significant difference was not found between self-ligating brackets and conventional brackets (p>0.05).

Table 2 *Rates of canine movement between self-ligating brackets and conventional brackets*

Bracket type	Rate of canine movement (mm/month)			Mean rate of canine movement
	T_1	T_2-T_1	T_3-T_2	
Self-ligating	1.41±0.64	1.46±0.92	2.00±0.89	1.62±0.27
Conventional	1.42±0.77	1.10±0.56	1.20±0.79	1.37±0.39
p	0.96	0.57	0.64	0.92

The mean change of canine angulation before and after canine retraction (canine tipping) in the self-ligating group was 11.66°±5.01° and 13.27°±5.71° in the conventional group. A statistically significant difference on angulation change was not found between the 2 groups (p>0.05).

Table 3 *Canine tipping between self-ligating brackets and conventional brackets before and after canine movement*

Bracket type	Canine tipping (degree)		
	T_0	T_3	T_0-T_3
Self-ligating	89.83°±8.19°	78.16°±8.98°	11.66°±5.01°
Conventional	93.61°±7.54°	80.33°±7.12°	13.27°±5.71°
p			0.553

The mean change of rotational angle before and after canine retraction (canine rotation), in the self-ligating group was 9.44°±5.50° and 9.22°±6.07° in the conventional group. A statistically significant difference of rotational change was not found between the 2 groups (p>0.05).

Table 4 *Canine rotations between self-ligating brackets and conventional brackets before and after canine movement*

Bracket type	Canine rotation (degree)		
	T_0	T_3	T_0-T_3
Self-ligating	31.33°±8.55°	21.88°±6.23°	9.44°±5.50°
Conventional	30.44°±7.77°	21.22°±7.10°	9.22°±6.07°
p			0.722

Discussion

In this study, patient's characteristics were skeletal Class I, dental Class I with crowding that was prone to have dehiscence and fenestration before, during or after orthodontic treatment especially at canine areas. However, in some cases, dehiscence or fenestration can be seen from cone beam computed tomography (CBCT) or during a surgical approach. Although conventional orthodontic mechanics could be done, undesirable side effects such as bone loss, dehiscence, fenestration and gingival recession may occur. Corticotomy-assisted orthodontics with bone grafts is the recommended option. According to Wilcko *et al.,* this technique not only increases bone volume, but also accelerates tooth movement.

There is another possible way to reduce friction during canine movement besides corticotomy. The property that influences resistance to sliding is of great interest to the orthodontic community because lower resistance to sliding could lead to increased efficiency and possibly shorter treatment times. Self-ligating brackets that have been proven to produce lower friction than conventional brackets may be beneficial to facilitate tooth movement in sliding mechanics. Previous clinical studies on self-ligating brackets and conventional brackets were still controversial. Scott *et al.* found that self-ligating brackets were no more efficient than conventional ligated brackets.[24] On the other hand, Shivapuja *et al.* reported that significant difference in the time required to correct mandibular crowding was found between the 2 groups[25]. Nevertheless, those studies were done in the leveling stage among non-extraction patients with mild mandibular crowding. However, for an irregularity index value <5, self-ligating brackets had 2.7 times faster correction. For extraction patients, few clinical studies have compared space closure between self-ligating and conventional brackets. Mezomo et al. found that the rate of canine retraction between self-ligating brackets and conventional brackets was not significantly different between the two groups.[26] The aims of this study were to compare the rates of maxillary canine movement, canine tipping and rotation between self-ligating brackets and conventional brackets in corticotomy-assisted orthodontic patients. From the results, we found that self-ligating brackets could change canine distalization similar to conventional brackets. The individual variations were controlled by a split mouth design. The initial angulation and rotation of canines were similar. The age range of the patients was narrow. However, other factors which could affect the rate of tooth movement were such as tooth size, tooth length, and occlusal force that should be controlled to decrease these variations.

The results demonstrated that the distance of canine movement using self-ligating brackets and conventional brackets was not statistically significant different. The difference in distance of canine movement may affect the tipping and rotation of canines. In accordance with this study, there was no significant difference of canine tipping and canine rotation between the 2 groups.

There was no significant difference in the rate of canine movement between self-ligating brackets and conventional brackets. The rate of tooth movement ranged from 1.37 to 1.62 mm/month, compared with 0.84 to 0.90 mm/month canine movement in previous studies .[25,26] The rate of canine movement in this study was higher than in previous studies because this study was performed using corticotomy-assisted orthodontic patients, which causes the rate of tooth movement to be much higher than when the conventional method is employed. The study in corticotomy-assisted patients done by Aboul-Ela *et al.*[27] evaluated canine retraction with and without corticotomy-assisted technique and found that the rate of maxillary canine retraction in corticotomy side was 0.89-1.89 mm/month. This rate is comparable to the rate of canine movement in this study. The rate of canine movement using corticotomy-assisted orthodontic methods combined with self-ligating brackets was not higher than corticotomy alone.

According to Profit and Fields[23], bracket width played an important role in the control of angulation space closure by sliding mechanics. A wider bracket and a smaller contact angle will thus better control tooth angulation during sliding along the arch wire. Even though the width of self-ligating brackets was less than that of the conventional brackets, canine tipping in both groups was not statistically different. Rotation of the upper canines during sliding mechanics was minimized with self-ligating brackets compared to the conventional group in the study of Mezomo[26]. However, in this study, no significant difference was found on the degree of rotation. Besides the previously mentioned factors, the direction and magnitude of force, wire size and corticotomy procedure may affect the results. In this study, an elastomeric chain was used to generate force, but the force decay from an elastomeric chain occurs rapidly compared to a coil spring that generates more continuous force decay. Elastomeric chain has been used in this study because of low cost, ease of use, and wide range of colors, a means of individual expression. The vertical height of TADs was controlled at the same level to produce a similar force direction. Although canine tipping between conventional and self-ligating brackets may occur, we can control the tipping of canines by using lever arm with the same height of TADs to create parallel force vectors during canine retraction.

The small round wire used in this study was smaller than the slot size so the friction could be lowered due to reduced wire contact area. With lower frictional forces, the space-closing phase of orthodontic treatment can be rapidly accomplished.

In term of anchorage preservation, the posterior teeth in this study were not used as anchorage for canine retraction, which corresponded to other studies comparing anchorage loss and found no significant reduction in the crest bone height and no marked apical root resorption.[28]

Further study is needed to compare the difference in the treatment effect between the various patterns of corticotomy and different types of bone grafting on tooth movement. Furthermore, an increased sample size would enhance the accuracy of the results in this study.

Conclusion

This investigation was performed under the conditions of small sample size and short time period. It showed that the rate of tooth movement, distal tipping and rotation of upper canines combined with corticotomy were similar in both conventional and self-ligating brackets.

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