EJONS International Journal on Mathematic, Engineering and Natural Sciences | ISSN 2602 - 4136

Article Arrival Date	Article Type	Article Published Date
16.02.2023	Research Article	20.03.2023

EVALUATION OF THE EFFECTS OF SELF-LIGATING BRACKETS ON THE ORTHODONTIC TOOTH MOVEMENT

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ABSTRACT

Objective: The aim of this study was to compare effect on tooth movement and rate of canine distalization accomplish with self-ligating brackets (Gemini SL) and conventional brackets (Gemini).

Methods: Self-ligating brackets group (SLB) (18 individuals) and control group (CONT) (15 individuals) were created with cases who need fixed orthodontic treatment with exraction of first premolar in this study. Canine distalization was performed on 0.019×0.025 inch stainless steel wire using nickel-titanium (NiTi) closed coils that applied approximate force of 150 gr after levelling and aligning. Plaster models and photographic recordings were taken at the 1st, 4th and 8th weeks of distalization. The resulting plaster models were scanned with three-dimensional scanning device. The amount of canine distalization, canine distopalatinal rotation, canine tipping, molar mesialization and extraction spaces were measured.

Results: While there was no statistically significant difference in terms of can
ine distalization, distopalatal rotation, tipping and extraction space in the maxilla, a significant difference was observed in molar mesialization. Different from the maxilla, there was a significant difference in canine tipping values in the mandibula.

Conclusion: There was no difference in rate of orthodontic tooth movement between self-ligating brackets and conventional brackets.

Keywords: Accelerated tooth movement, Canine distalization, Friction, Model scanning, Self-ligating bracket.

*This study was carried out within the scope of the project numbered 114S510 supported by Tubitak.

INTRODUCTION

Optimal force level in tooth movement is very important in terms of tooth and surrounding tissues. Various methods have been developed to increase the rate of tooth movement at optimal force limits. One of them is the applications that reduce friction at the bracket/arch wire interface, such as brackets/arch wires, coated brackets/arch wires and self-ligating brackets made of different materials.

In mesiodistal tooth movement, friction occurs between the bracket and the wire, as occurs in all mechanics in nature. Approximately 40%–50% of the force applied for tooth movement is used to overcome frictional resistance (1, 2). Friction occurs between the bracket slot and the arch wire surface in the leveling of the teeth, canine movement with sliding mechanics and into the extraction cavity, and orthodontic tooth movements while the braces are working (3, 4). Overcoming this frictional force is important for proper tooth movement (5). Reducing the static and kinetic friction between the bracket and the arch wire reduces the side effects of orthodontic treatment and shortens treatment time (6). In addition, less friction reduces the force required for tooth movement in sliding mechanics—which, in turn, decreases the corresponding force on the anchor teeth (7).

The method of attaching the bracket to the arch wire is one of the factors that affect friction in sliding mechanics. Self-ligating brackets were produced to eliminate the effect of the ligature process on the frictional resistance of conventional brackets. The self-ligating bracket system involves the closure of the bracket slot without ligature using caps and similar mechanical tools (8). The manufacturers claim that self-ligating brackets have advantages such as fast attachment of the bracket and arch wire, less friction, reduced treatment time, and low force application. Other advantages highlighted include reducing or eliminating the need for headgear or expansion apparatus, improving facial aesthetics, reducing material costs and pain, improving lip comfort, preventing tooth decay, and reducing the risk of carpal tunnel syndrome (9). There are two types of self-ligating brackets: active and passive. For passive systems, it is argued that by creating a large gap to the arch wire in the bracket slot, using the cover of the brackets, they do not apply any active force, thus reducing the frictional forces (10). However, force control can be more difficult with passive self-ligating brackets (11).

The aim of this study is to compare the frictional resistance between a self-ligating bracket type of the same manufacturing company and the conventionally attached bracket type with the arch wire and its effect on tooth movement rate in vivo.

MATERIALS AND METHODS

This study was carried out on a total of 33 patients, 19 girls and 14 boys, aged between 13 and 25. Ethics committee approval of the study was obtained from XXX University Clinical Research and Ethics Committee (Reference number: XXX). Inclusion criteria for the study were: (1) All permanent teeth erupted into the mouth, (2) The canine teeth need to be moved to the first premolar extraction area due to crowding, (3) The pubertal period has been completed, (4) No missing teeth, (5) Absence of craniofacial and dento-alveolar syndromes, (6) Absence of any clinically detectable temporomandibular joint problem. In addition to these criteria, patients who could not comply with the appointment and treatment requirements and could not improve their oral hygiene were excluded from the study. The self-ligating bracket (SLB) group consisted of 10 girls and 8 boys, and the mean age was 16.94 ± 1.37 years. The control group (CONT) consisted of 9 girls and 6 boys, and the mean age was 16.13 ± 1.28 years.

T0 initial records of all patients included in the study, anamnesis and examination forms were filled, upper-lower orthodontic models were obtained, extraoral and intraoral photographs were taken, panoramic and lateral cephalogram x-ray films were recorded. In the SLB group, treatment was planned with the extraction of only the upper first premolars of 10 patients and the upper-lower first premolars of 8 patients. In the CONT group, treatment was planned with the extraction of the upper first premolars in 8 patients and the upper-lower first premolars in 7 patients.

Brackets were attached to the upper and lower jaw teeth of the patients in the SLB and CONT groups in the same session. Gemini SL (3M Unitek, Monravia, Calif., USA) passive self-ligating brackets with a slot width of 0.022×0.025 inches were used in the patients in the SLB group, and Gemini (3M Unitek, Monravia, Calif., USA) conventional brackets were used in the patients in the CONT group. Ready and various lengths of transpalatal arches were inserted. During the treatment period until canine distalization, 0.019×0.025 inch HANT archwire was inserted when the crowding was sufficiently resolved with 0.014 inch HANT (Heat Activated Nickel Titanium) (3M Unitek, Monravia, Calif., USA). Afterwards, 0.019×0.025 inch brass posted (3M Unitek, Monravia, Calif., USA) wires were placed. It was waited for 4 weeks in this wire for the teeth to receive sufficient torque. In the session when the wires were placed, 8 mm long and 1.6 mm diameter mini screws (Tasarımmed, Turkey) were placed to protect the anchorage. In the initial session (T1) of the canine distalization, firstly, 0.019×0.025 inch brass posted arch wires were removed and the plaster models were obtained. Afterwards, the removed archwires were reinserted. One end of the sentalloy closed springs applying 150 gr force (3M Unitek, Monravia, Calif., USA) was connected to the mini screw and the other end to the hook of the canine bracket. Model and photographic records were collected from the patients at the 1st week (T2), 4th week (T3) and 8th week (T4) after the start of canine distalization (Figure 1). Model records were scanned with a three-dimensional model scanning device (Orthoanalyzer, 3Shape, Copenhagen, Denmark).

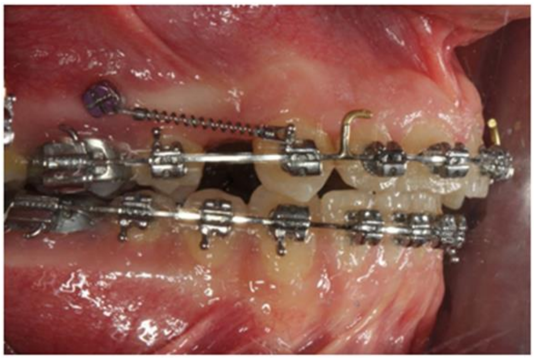

Figure 1. Mechanical used to distalize the canine.

Digital Orthodontic Model Measurements

The models obtained from the same individual were superimposed as T1-T2, T1-T3 and T1-T4 using the medial and lateral points of the maxillary palatal rugae (12, 13). The mandibular models were matched by marking the gingival contact point of the central teeth and the mesial contact points of the right and left second molars.

While measuring the amount of canine distalization (CD), the cusp tips of the canine on the same side were marked on the functional occlusal plane formed by the occlusal contact point of the central incisors and the mesiopalatinal tubercles of the upper right and left first molars, and the distance between the two tubercle tips was measured in mm (Figure 2a) (14-16).

While measuring the amount of molar mesialization (MM), the distance between the mesiopalatinal tubercle tips of the same side first molars on the occlusal plane was measured in mm (Figure 2a).

In measuring the amount of canine rotation (CR), the angle formed by the line passing through the mesial and distal of the canine in each half jaw with the midline (ML) of the orthodontic model was recorded (Figure 2b) (17).

Measuring the amount of canine tipping (CT) was measured in each half-jaw separately when viewed from the sagittal plane. The angle difference between the long axis of the upper right canine in the first model and the second model was calculated and recorded (Figure 2c) (16, 18).

In this study, 33 digital measurements were repeated 2 weeks later by the same researcher in order to calculate the margin of error in digital measurements.

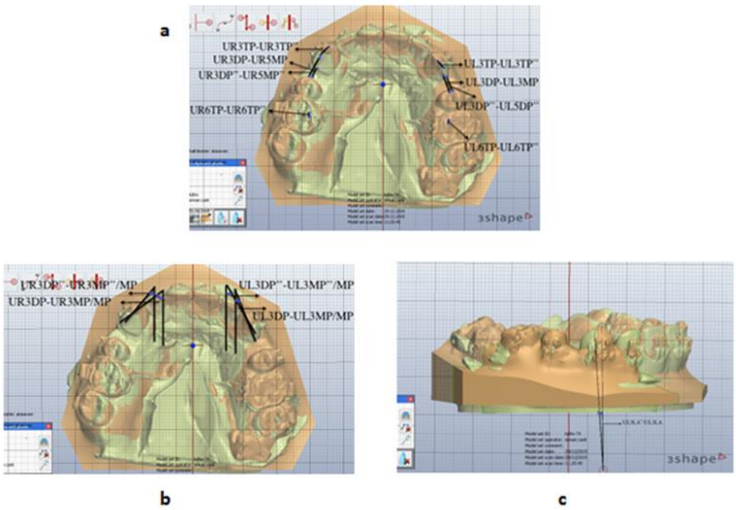

Figure 2. a) Measurement of canine distalization and molar mesialization on digital orthodontic models **b)** Measuring the rate of canine rotation on digital orthodontic models **c)** Measurement of canine tipping on digital orthodontic models.

Statistical analysis

Statistical analysis was performed using SPSS (IBM SPSS Statistics for Windows, Version 23.0, SPSS Inc., Chicago, IL, USA) program. According to the Dahlberg formula, the margin of error in the angular and linear measurements was determined, and it was determined that these margins of error did not exceed ± 0.3° for angular measurements and ± 0.1 mm for linear measurements.

Paired t-test was applied for in-group comparisons in SLB and CONT groups. Students' t-test was used for comparison between groups. In non-normally distributed data, in-group comparisons were made using the Wilcoxon Signed and between-group comparisons were made using the Mann-Whitney U-test. All tests were performed within 95% (p=0.05) confidence limits.

RESULTS

When the data obtained from the upper and lower jaws in the SLB group were compared, it was found that there were statistically significant differences in some measurements between the two jaws, but no statistically significant difference was observed in the CONT group. In both SLB and CONT groups, when right-left data in the same jaw were compared, no statistically significant difference was found in any data group. Therefore, data from right and left measurements of the same jaw (upper or lower) were pooled. Data were evaluated within and between groups.

Intra-Group Evaluations

Intra-group evaluation of CD rate data obtained from digital models in T3 and T4 periods from SLB and CONT groups was made. In the SLB group, mean CD rate was 1.44 mm/month in the first four-week period (T1-T3) and 1.00 mm/month in the second four-week period (T3-T4) (p=0.001). The mean canine distalization rate in the lower jaw was 1.02 mm/month in the first four-week period, and 0.56 mm/month in the second four-week period (p=0.003). In the CONT group, no significant difference was found in both periods.

Intergroup Evaluations

Intergroup evaluation data are given in Table 1. There was no significant difference in the amount of CD between the SLB and CONT groups. When the amount of MM was evaluated, a significant difference was observed in the upper jaw at T2 and T4 periods (p=0.035; p=0.044) (Figure 3). While more mesial movements were observed in the SLB group in the T2 period, more movements were detected in the CONT group in the T4 period. The amount of CR in the mandible showed a significant difference in the T1 period (p=0.049). In the amount of CT, higher values were measured in the CONT group, and a significant difference was found in the T2 period in the upper jaw (p=0.008) and in the T2, T3, T4 periods in the lower jaw (p=0.043; p=0.004; 0.005).

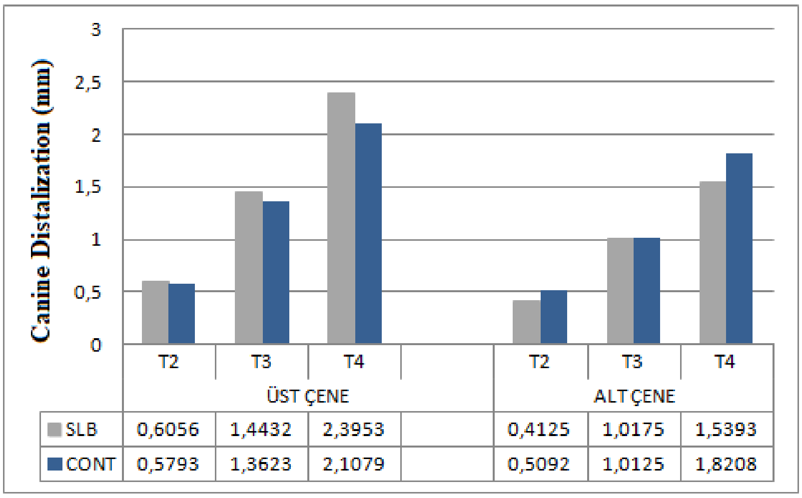

Figure 3. Mean rate of canine distalization in SLB and CONT groups.

DISCUSSION

It is known that the type of bracket used affects the rate of tooth movement in friction systems. In the studies, it was observed that stainless steel, as the bracket material, produced less friction values than the others (19-21). Some studies have demonstrated a reduction in friction—as the locking that may occur between the arch wire and the bracket, which remains in a wide lumen, is minimized with self-ligating brackets (9, 22-24). In this study, the effects of conventional and self-ligating brackets belonging to the same manufacturing company on the rate of canine tooth movement were compared. The data we obtained by measuring the mesial molar movement indicated supported and improved canine rotation and tipping.

Intraoral or extraoral appliances can be used in cases where maximum anchorage is required.(25, 26) Although anchorage can be maintained at the desired level with extraoral appliances, poor patient cooperation may result in anchorage loss (27). Miniplates, miniscrews, and dental implants used for skeletal anchorage provide maximum

Table 1. Data of intergroup comparison.

		Maxilla						Mandibula					
Measurement Groups	**Study Groups**	**T2**		**T3**		**T4**		**T2**		**T3**		**T4**	
		Mean±SS	***P***	**Mean±SS**	***P***	**Mean±SS**	***P***	**Mean±SS**	***P***	**Mean±SS**	***P***	**Mean±SS**	***P***
CD	**SLB (mm)**	0,61±0,16	0,727	1,44±0,41	0,613	2,40±0,53	0,120	0,41±0,14	0,468	1,02±0,34	0,981	1,54±0,42	0,315
	CONT (mm)	0,58±0,40		1,36±0,82		2,11±0,82		0,51±0,50		1,01±0,72		1,82±0,92	
MM	**SLB (mm)**	0,12±0,05	0,035	0,19±0,11	0,052	0,23±0,10	0,044*	0,16±0,18	0,748	0,18±0,08	0,849	0,28±0,16	0,790
	CONT (mm)	0,09±0,06		0,33±0,40		0,37±0,37		0,15±0,09		0,18±0,09		0,30±0,20	
CR	**SLB (º)**	32,16±7,17	0,722	30,22±6,97	0,662	27,56±6,34	0,973	30,53±5,92	0,065	29,16±5,43	0,470	28,46±5,64	0,717
	CONT (º)	31,53±6,86		29,45±7,16		27,62±6,21		34,91±6,04		30,89±7,10		27,55±6,97	
CT	**SLB (º)**	1,12±0,55	0,008**	2,31±1,06	0,069	4,37±1,83	0,758	0,93±0,30	0,043*	1,79±0,82	0,004**	2,77±1,15	0,005**
	CONT (º)	1,86±1,45		3,25±2,72		4,21±1,83		1,66±1,33		3,39±1,82		4,88±2,25	

CD, Canine distalization; MM, Molar mesialization; CR, Canine rotation; CT, Canine Tipping; SLB, Self ligating brackets group; CONT, Control group; SS, Standart deviation; * significant at 95% level ($p<0.05$), **, significant at 99% level ($p<0.01$)

anchorage in tooth movement (28). Since we aimed for maximum anchorage in this study, miniscrews were placed before the canine distalization stage. In addition, prefabricated transpalatal arches were used in the maxilla.

Various methods have been used to measure the amount and rate of canine movement, such as using a millimetric ruler (23), measuring on radiographic records (6, 29), and evaluating with digital calipers over plaster models (30). In Hayashi et al.'s (14) evaluation of canine retraction, plaster models were transferred to digital media with a scanning device. We used this method in our study because it has the necessary magnification possibilities, determines the reference points, and can be reflected in the measurement values, even very small amounts, while measuring on the models scanned in the computer environment.

The four-week movement amounts of the SLB and CONT groups in our study were comparable to those of similar studies. Herman et al. (31) also performed canine distalization using miniscrew implants, and the mean canine movement was 1.3 mm per month. Miles (32) measured monthly distalization of the canine as 1.1 mm in the group that used self-ligating brackets and 1.2 mm in the group that used conventional brackets. In this study, the difference between the mean canine distalization rate for the first and second four-week periods in the upper and lower jaws of the SLB group was statistically significant. This difference may be due to the "binding" and "notching" on the wire, as well as the construction and destruction events in the tissues that occur during and after tooth movement.

In the comparison between the groups, there was no significant difference in the mean amount of canine movement during the eight-week period. Regarding the distalization rate of the canine, there are studies with results that support this study (6, 32-34). Conversely, Burrow (23) with a split-mouth design, found a statistically significant difference between self-ligating and conventional brackets. He found tooth movement to be faster with conventional brackets, ascribing the increase to their wider width.

da Costa Monini et al. (29) examined the amount of canine retraction and anchorage loss and found no significant differences in canine distalization and anchorage preservation when conventional and self-ligating brackets were compared. In their evaluation of the loss of anchorage in the upper jaw, de Almeida et al. (35) found no statistically significant difference between the two groups. When the mesialization of the molar teeth in the upper jaw was compared between the SLB and CONT groups, a statistically significant difference was observed between the two groups in the T2 and T4 stages but not in the T3 stage. The fact that the mesial movement of the molar teeth was less in the T4 stage in the SLB group compared to the CONT group indicates that self-ligating brackets reduce anchorage loss better than conventional brackets.

Hassan et al. (36) observed the amount of rotation in the canine as 5.93° ± 2.49 in the self-ligating bracket group and 10.00° ± 3.40 in the conventional bracket group. Mezomo et al. (33) evaluated the rotation of the canine in a three-month period in their study. The mean three-month rotation amount was determined as 9.15° in the self-ligating bracket group and 12.27° in the conventional bracket group. Finding more rotation values in conventional brackets is similar to our study. In this study, it was concluded that the rotation control in the distalization of the canine in self-ligating brackets is higher than in conventional brackets that are tightly tied with elastomeric ligatures, and some rotation occurs as a result of tooth movement, since the application point of the force does not pass through the center of resistance of the tooth.

When the amount of tipping was evaluated in this study, the higher values in the CONT group and the significant difference in the T2 period in the upper jaw and the T2, T3, T4 periods in the lower jaw may be associated with the valve structure in the self-ligating brackets. In conventional brackets, the arch wire is attached to the bracket slot with elastics. The amount of tipping and rotation in the canine in conventional brackets may have occurred in a higher amount than in self-ligating brackets due to the stretch in the elastic connectors.

CONCLUSIONS

1. When the effect of conventional and self-ligating brackets on the rate of movement of the canine was evaluated, no significant difference was found between the two groups.

2. While there was no difference in terms of rotation of the canine and mesialization of the molar tooth, self-ligating brackets were found to be more successful in tipping values.

Conflict of Interest

There is no conflict of interest between the authors.

Financial Disclosure

This study was carried out within the scope of the project numbered 114S510 supported by Tubitak.

Authors Contributions

Plan, design: SA, SA, NA; Material, methods and data collection: SA; Data analysis and comments: SA, SA; Writing and corrections: SA, SA.

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