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Evaluation of space closure rate, tipping and rotation of canine during it's retraction with sliding mechanics(An In vitro study).

Hussain A Obaidi
BDS, MSc, (Prof)

Dept of Pedod, orthod, and Prev Dentistry
College of Dentistry, University of Mosul

Yonis M Saeed
BDS, MSc (Assist Lect)

Dept of Pedod, orthod, and Prev Dentistry
College of Dentistry, University of Mosul

ABSTRACT

Aim: To evaluate of the effects of using different methods of elastic chain attachment, different shapes of base arch wire (round and rectangular) and different ligation techniques on the rate of space closure, degree of tipping and degree of rotation of canine during translatory displacement of canine's bracket via wire using Typodont simulation system. **Materials and Methods**: Typodont teeth situated in well–aligned position, The criteria of the subject are covered and immobilized by the acrylic bite except canine; Elastic chain exerting 180gm of force on canine measured carefully by Tension Gauge; The available space was (14 mm) measured by digital vernia; The angle between bite plane extension bar and canine extension bar were (90°) measured by protractor directly on a photograghs that were taken for Typodont using digital camera from both vertical and horizontal direction. The data were subjected to the statistical analysis at $P \leq 0.05$ significant level. **Results:** Canine sliding over rectangular arch wire gave rise to significant decrease in degree of tipping and rotation with significant reduction in rate of space closure, Second, stainless steel ligature and elastomeric ties of conventional ligation technique gave rise to a significant decrease in the degree of tipping and rotation with significant reduction in rate of space closure, elastic chain onto hook of canine bracket, gave rise to significant decrease of tipping and rotational degree with significant increase in rate of space closure. **Conclusions**: the methods in which elastic chain is attached to canine's hook using rectangular wire with elastomeric ties and the elastic chain is attached to canine's hook using rectangular wire with stainless steel ligature are favorable affecting canine sliding, where both were produced significantly the lowest degree of tipping and rotation with satisfactory rate of space closure.

Key Words: Canine retraction, Sliding mechanics.

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INTRODUCTION

The art of moving teeth in the correction of irregularities has been regarded in the past as so nearly the whole of orthodontia.[1]

Orthodontic tooth movement during space closure is achieved through two types of mechanics, the first type, segmented type or sectional that involves closing loops fabrication either in full or sectional arch wire, the second type sliding mechanics involves either moving bracket along an arch wire or sliding the arch wire through brackets and tubes, one of the main differentiating factors between two types of mechanics pertains to friction, so friction play significant role in sliding space closure therefore the name friction mechanics is often associated with it.[2–3]

The majority of the force used to slide the tooth along the arch wire is lost to friction. Excessive force is counterproductive because of increased bracket friction and potential loss of posterior anchorage.[4,5] When the bracket slides over the wire, the angulations of the bracket are dependent on the combination of the point of force application and the retarding force. The center of resistance is theoretically located on the long axis of the tooth, but the point of force application is buccal or labial to the long axis. This causes the rotational ti-

pping.[6] Loftus *et al*. [7] stated that frictional forces during simulated sliding tooth movement can be measured with a model that was representive of the clinical condition. A Typodont simulation system can be used in orthodontics practice to show possible effects of using variable factors on canine position and rate of movement during sliding mechanics using standard edgewise mechanics.

The aims of this study were to evaluate the effects of using different methods of elastic chain attachment, to evaluate the effects of using base arch wire of different shapes (round and rectangular), and to evaluate the effects of using different ligation techniques on the rate of space closure, degree of tipping and degree of rotation of canine during sliding mechanics.

MATERIALS AND METHODS

Typodont and teeth(Ormco, Japan): situated in well–aligned position (CL II division 1), banded with Preformed central , lateral , canine and second premolar bands with prewelded standard twin brackets of slot size (0.022× 0.030")and molar bands with (gingival hook and extra oral tube for first molars) (Dentaurum, Germany). The ready made stainless steel arch wires was used (Bonwill–Hawley arch form) of round (0.018") and rectangular (0.01× 0.025") (Dentaurum, Germany). The ligatures utilized Preformed SS ligature wire of (0.010") diameter and elastomeric ligature (Dentaurum, Germany) The retraction aids is elastic chain (Dentaurum, Germany)

Procedure standardization Involves: Construction of Acrylic Bite Plate as Guidance; hot acrylic bite plate was constructed which was covered and immobilized the teeth except canines. Fixation canine extension bar (CEB); is an (L–shape) bar made from SS rectangular wire of size (0.018 ×0.025"), the short arm was inserted in a groove made in the simulated rugae area of the acrylic bite, and then cold cure acrylic was painted over the bar's part that was placed in the groove to make it immobile.

*Fixation canine extension bar (CEB)***:** is an (L–shape) bar made from SS rectangular wire of size (0.018×0.025"), the short arm was welded to distal aspect of canine's band. These two bars are used as a guide for determining position, degree of tipping and rotation of canine following sliding movement. This method was a modification of Huffman and Way[8] procedure for determining position, degree of tipping and rotation of the canine following sliding movement.

Elastic Chain Force Magnitude: elastic Chain was stretched between the molar hook and canine bracket in all methods of sliding the EC exert 180gm of force on canine. Tension Gauge was used to standardize the measurement in all methods.

Canine Position Measurements after Movement: (A) Rate of Canine Movement (Space Closure) Measurement**;** Rate of space closure was measured after each method of canine movement, Rate of space closure = available space – remaining space.

(B) Degree of Canine's tipping after Movement; A Typodont was photographed using Digital camera[9] with transverse projection from right side of Typodont, directly toward right canine where the angle between CEB and PEB was exposed and then can be measured directly on the photograph using Protractor; this angle was considered as canine's bar inclination angle. (Degree of Canine's tipping = canine's bar original angle – canine's bar inclination angle),

(C) Degree of Canine's Rotation after Movement; A Typodont was photographed with vertical projection from occlusal side of Typodont, directly toward right canine where the angle between CEB and PEB was exposed and then can be measured directly on the photograph using Protractor; this angle was considered as canine's bar rotation angle. (Canine's rotation = canine's bar original angle – canine's bar rotation angle).

Therefore, twelve methods were conducted for canine sliding, which are: (Table 1)

The results were analyzed by using the descriptive Statistics to show minimum and maximum values, mean, standard deviation and standard error, Analysis of Variance (ANOVA) and Duncun's test to locate the significant differences.

Table (1): Methods of canine sliding

ReE:	Elastic chain is attached to canine's bracket over rectangular wire using elastomeric ties in a conventional ligation technique.
ReHE:	Elastic chain is attached to canine's hook using rectangular wire with elastomeric ties
ReHL:	Elastic chain is attached to canine's hook using rectangular wire with stainless steel ligature
ReL:	Elastic chain is attached to canine's bracket over rectangular wire using stainless steel ligature in a conventional ligation technique.
ReT:	Elastic chain is attached to canine's bracket under rectangular wire using stainless steel ligatures wire on a distal wing of canine's bracket in a twist ligation technique.
ReWo:	Elastic chain is attached to canine's bracket using rectangular wire without ligatures
RoE:	Elastic chain is attached to canine's bracket over round wire using elastomeric ties in a conventional ligation technique.
RoHE:	Elastic chain is attached to canine's hook using round wire with elastomeric ties.
RoHL:	Elastic chain is attached to canine's hook using round wire with stainless steel ligature.
RoL:	Elastic chain is attached to canine's bracket over round wire using stainless steel ligatures wire in a conventional ligation technique.
RoT:	Elastic chain is attached to canine's bracket under round wire using stainless steel ligatures wire on a distal wing of canine's bracket in a twist ligation technique.
RoWo:	Elastic chain attach to canine's bracket using round wire without ligatures

RESULTS

*Rate of Space Closure***:** Figure (1) and Table (2) showed that method (RoT) had the highest rate of SC, with significant difference ($P \leq 0.05$) from other methods except the methods (RoWo and RoHL), the (ReE) method showed the lowest level of SC, with significant difference from other methods except the method ReL.

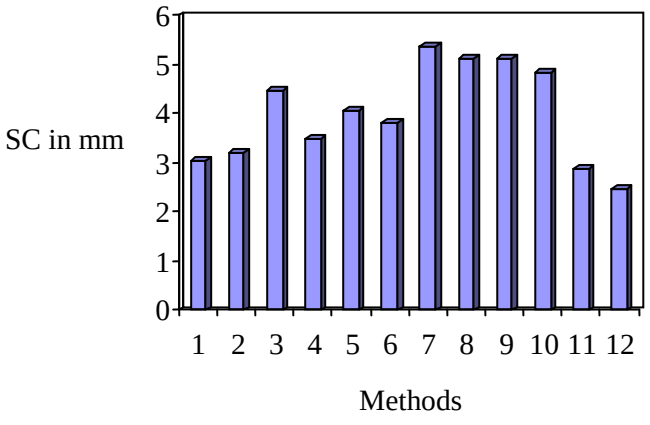

Figure (1) A histogram showing the rate of space closure.

Table (2): Descriptive Analysis and Duncan's multiple range test of space closure.

Treatments Number	Method tested	N	Mean (mm)	SD	SE	Minimum	Maximum	Duncan's Groups
1.	ReHL	10	3.03	0.80	0.25	1.90	3.96	GH
2.	ReHE	10	3.21	0.39	0.12	2.47	3.90	GH
3.	ReT	10	4.46	0.40	0.12	3.39	5.09	CD
4.	ReWo	10	3.50	0.64	0.20	2.69	4.59	FG
5.	RoL	10	4.07	0.62	0.19	3.00	4.70	DE
6.	RoE	10	3.83	0.55	0.17	2.79	4.39	EF
7.	RoT	10	5.37	0.81	0.25	4.30	6.62	A
8.	RoWo	10	5.12	0.45	0.14	4.50	6.05	AB
9.	RoHL	10	5.10	0.56	0.17	4.29	5.85	AB
10.	RoHE	10	4.82	0.31	0.10	4.48	5.25	BC
11.	ReL	10	2.88	0.42	0.13	2.24	3.31	HI
12.	ReE	10	2.47	0.37	0.11	2.01	3.39	I

N: Number of samples; SD: Standard deviation; SE: Standard error; Different letters mean significant different

*Degree of Tipping***:** Table (3) and Figure (2) showed that method (ReHE) has the lowest degree of tipping, with significant difference ($P \leq 0.05$) from other methods except the methods (ReHL and ReE).

Table (3)**:** Descriptive analysis and Duncan's Duncan's multiple range test of degree of tipping.

Treatments Number	Method tested	N	Mean (mm)	SD	SE	Minimum	Maximum	Duncan's groups
1.	ReHL	10	2.95	0.68	0.21	2.00	4.00	A
2.	ReHE	10	2.70	0.58	0.18	2.00	4.00	A
3.	ReT	10	6.60	0.65	0.20	6.00	8.00	C
4.	ReWo	10	5.65	1.28	0.40	4.50	6.50	C
5.	RoL	10	11.45	1.01	0.32	10.00	13.50	E
6.	RoE	10	12.00	2.39	0.75	8.00	15.50	E
7.	RoT	10	15.75	0.97	0.30	14.50	17.50	G
8.	RoWo	10	14.00	1.47	0.46	11.50	16.50	F
9.	RoHL	10	11.10	0.62	0.19	8.50	12.50	DE
10.	RoHE	10	10.35	1.49	0.47	7.50	12.00	D
11.	ReL	10	4.50	0.62	0.19	3.50	5.50	B
12.	ReE	10	3.75	0.88	0.28	2.50	5.50	AB

N: Number of samples; SD: Standard deviation; SE: Standard error; Different letters mean significant different

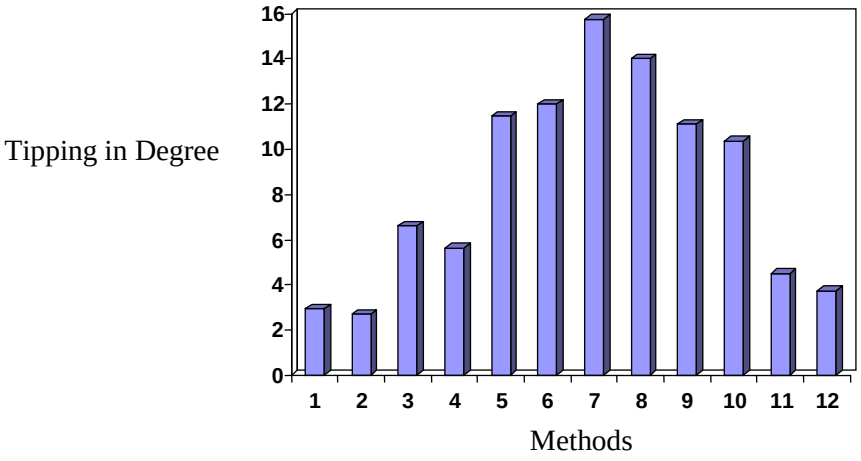

Figure (2): A histogram showing degree of the twelve methods.

Degree of Rotation: Table (4) and Figure (2) showed that method (ReL) has the lowest degree of rotation, with significant difference (P≤0.05) from other methods.

Table (4): Descriptive analysis and Duncan's Duncan's multiple range test of degree of rotation.

Treatments Number	Method tested	N	Mean (mm)	SD	SE	Minimum	Maximum	Duncan's groups
1.	ReHL	10	10.35	1.49	0.47	7.50	12.00	A
2.	ReHE	10	10.15	1.15	0.36	8.50	11.50	A
3.	ReT	10	18.40	1.04	0.33	17.50	21.00	H
4.	ReWo	10	14.95	1.55	0.49	12.50	17.50	D
5.	RoL	10	16.05	.98	0. 31	14.50	17.50	E
6.	RoE	10	15.80	.63	0.20	15.00	17.00	E
7.	RoT	10	19.10	.93	0.29	17.50	20.50	H
8.	RoWo	10	17.20	1.00	0.31	16.00	19.00	F
9.	RoHL	10	13.55	1.27	0.40	12.00	16.00	C
10.	RoHE	10	12.60	1.22	0.38	11.00	15.00	C
11.	ReL	10	12.20	1.13	0.35	10.00	13.50	BC
12.	ReE	10	11.45	1.01	0.32	10.00	13.50	B

N: Number of samples; SD: Standard deviation; SE: Standard error; Different letters mean significant different

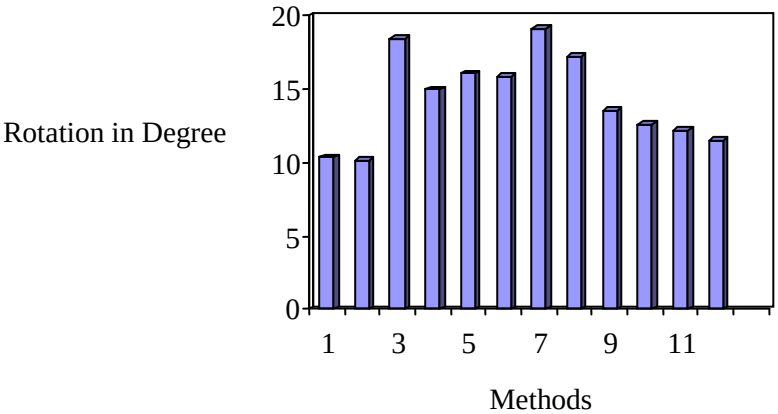

Figure (3): A histogram showing degree of rotation

DISCUSSIONS

*Rate of Space Closure***:** *Influnce of arch wire shape*; All the methods that slide canine over round arch wire demonstrate significant increase in the rate of SC in comparison with those used rectangular one. Such significant difference is in agreement with many authors who attributed this finding to the frictional forces were generally greater with rectangular wire than with round wire.[4,9,10]

*Influnce of ligature***;** The use of twist ligation technique: RoT showed a significant increase in the rate of SC in compareison with remaining methods except (RoWo and RoHL), While ReT showed a significant increase in the rate of SC in compareison with (RoE, ReWo, ReHE, ReHL, ReL and ReE). This is similar to the result, which was reported by Pollit [11] who used rectangular arch wire in his study and found that twist ligation technique has the adventage of reduced–friction appliances in that lighter forces can be used.

*Influnce of attaching elastic chain onto canine's bracket***;** The sliding techniques in which EC was attached to bracket's hook showed a significant difference in comparison with others which made EC attachment directly onto canine bracket, where (RoHL) had a significant increase in rate of SC in comparison with (ReT, RoL, RoE, ReWo, ReHE, ReHL, ReL and ReE). Such significant difference is in agreement with Charles and Jones [12,13] who cited that power arm could be used to help decrease binding when using elastic traction.

*Degree of Tipping: Influence of arch wire shape***:** All the methods that slide canine over round arch wire demonstrate significant increase in degree of tipping in comparison with those used rectangular one, Such significant difference is in agreement with findings of many authors.[9,14]

*Influence of ligatures***;** The use of twist ligation techniques like RoT and ReT give rise to a significant difference in degree of tipping in comparison with other ligation technique that's used SS ligature or elastomeric tie. RoT showed a significant increase in comparison with the remaining methods. ReT showed a significant increase in comparison with (ReHE, ReHL, ReE and ReL), this is in agreement with Researchers. [11,13–16]

*Influnce of attaching elastic chain onto canine's bracket***;** The ReHE showed no significant difference with ReHL, but both methods showed a significant decreese in degree of tipping in comparison with the remaining methods except (ReE) where both of them showed no significant difference with the latter. This finding is in agreement with Authors[17–18)] who cited that because the force systems of sliding mechanics are usually applied to the buccal surfaces and to tooth surfaces that can be in different planes.

*Degree of Rotation: Influence of arch wire shape: Influence of ligatures***;** The conventional ligation technique resulted in better control of canine position than twist ligation technique during sliding movement. The higher level of canine rotation in case of twist ligation was attributed to the method of ligation, as mentioned by researchers.[11,15,16]

*Influence of attaching elastic chain onto canine's bracket***:** The ReHE and ReHL showed a significant decrease in rotation as comparison with remaining methods. This could be attributed to the rotational effect of SM that can be minimized via altering the attachment of EC from direct application onto canine bracket to the hook of the bracket of the same tooth, which makes the point of force application closer to the center of rotation as described by Authors.[3, 18]

CONCLUSION

the most favorable methods for canine sliding that can achieve satisfactory rate of SC and lowest level of canine tipping and rotational degree were those methods that attach EC onto bracket's hook of the canine, these are ReHE and ReHL.

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