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Evaluation of Rotation, Tipping and Extrusion During Canine Retraction by Sliding Mechanics Using Different Arch Wires.

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ABSTRACT

Aims: To evaluate the amount of rotation, tipping and extrusion using different wires and to Estimate the difference in the amount of tipping, rotation and extrusion between Stainless steel and Teflon ligature in different wires. **Materials and Methods:** The standardizing criteria were all Typodont teeth situated in well–aligned, covered and immobilized by the acrylic bite except canine; The available space for canine sliding was (14 mm) measured by digital vernia. Elastic chain exerting 180 gm of force on canine measured carefully by tension gauge. In both vertical and horizontal direction a photographs that were taken for Typodont using digital camera. The angle between bite plane extension bar and Canine extension bar were (90^o) measured by protractor directly on the photograph. Preformed band with its attachments, ready made stainless steel, composite coated and TMA arch wires all were (0.018×0.025) with the use of stainless steel and Teflon ligature, Standard titanium spring 11 mm length, Typodont components, within six types of connection the two types of ligation material had been applied to the three different wires then the 1^{st} premolar space tend to be closed by distal canine displacement then the resultant rotation, tipping and extrusion were measured. Statistical Descriptive analysis: One–way and, Two–ways Analysis of Variance were done to detect the variability between methods and which is the best. **Results:** Three important results showed in the study: First, canine sliding over the composite coated arch wire with the use of stainless steel ligature gave rise to significant decrease in rotation, tipping and extrusion when compared with other methods. Second, stainless steel ligature when compared with Teflon ligature of the same corresponding method gave rise to a significant decrease in the degree of rotation tipping and extrusion. Third, Composite coated arch wires showed lowest degree of rotation then followed by TMA arch wires ordinarily this is due to their rough surface. The largest rotation seen in the stainless steel arch wire this is due to its smooth surface texture, and the same thing for the tipping of the composite coated wires that gave rise to the lowest degree of tipping followed by the stainless steel wires, these result possibly due to their stiffness then higher tipping seen at TMA wires ordinarily a result of their flexibility this sequence were the same for both types of ligations. **Conclusions:** Best method of space closure is the use of either composite coated arch wire or stainless steel arch wire with stainless steel ligature that give us highest resistance to tipping, lowest extrusion and relatively little rotation when compared with other methods.
Key Words: Rotation, tipping, extrusion.

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INTRODUCTION

During space closure using sliding mechanics (which involve moving bracket along an arch wire or sliding the arch wire through the brackets and tubes). Friction is the main problem that could be encounterred, so it plays a significant role in sliding space closure there fore the name friction mechanics is often associated with it [(1)].

Friction must be over came to elicit periodontal response for tooth movement. Recent advances in orthodontic wire alloys have resulted in a varied array of wires that exhibit a wide spectrum of properties.

Up until the 1930s, the only orthodontic wire available were made of gold presently the orthodontist may select, from all the available wire types, one that best meets the demands of particular clinical situation. The selection of an appropriate wire size and alloy type in turn would provide the benefit of optimum and predictable treatment results [(2)].

In sliding mechanics, if frictional forces could be reduced, tooth movement could be accomplished with lighter forces. A large number of variable affecting friction resistances during tooth movement that can be directly or indirectly contribute to friction between bracket and wire, these variables may be either mechanical or biological.

After first premolar extraction canine retraction is a very common orthodontic procedure, if there is to be done as a bodily distal movement, a fixed appliance is necessary to produce a moment on the tooth into distal driving force. When bracket slides over the wire, the angulations of the brackets are dependents on the combination of 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 tipping [(3)].

Several types of arch wire materials are available to orthodontist, each have special characteristics, recognize one from the other in the end result carry special use, for sliding procedure. Best wire that has enough stiffness, less flexibility and smother surface as possible, this feature best seen in stainless steel [(4)].

The use of more than one orthodontic arch wire in an orthodontic practice can significantly increase treatment capability in different stages of treatment sequence [(3)].

So, the aims of this study were to evaluate the amount of rotation, tipping and extrusion using different wires, and to estimate the difference in the amount of tipping, rotation and extrusion between Stainless steel and Teflon ligature in different wires.

MATERIALS AND METHODS

Preformed band (Dentaurum, Germany) with its attachments: Molar bands with (gingival hook and extraoral tube for 1st molars), and bands for (central, lateral, canine and 2nd premolars) with prewelded standard twin brackets of slot size: 0.022×0.030. Ready made stainless steel arch wires, composite coated wires, TMA wires all were 0.018×0.025 (Bonwill–Hawley arch form, Dentaurum Co.; Germany). Ligatures, of two types: Preformed stainless steel ligature wire and preformed Teflon ligature wire, both were 0.010 (Dentaurum Co., Germany). Standard titanium spring 11 mm length (Dentaurum Co., Germany). Typodont components (ormo, Japan): articulators, wax forms (Maxillary arch) with additional accessories wax and set of metal teeth (all teeth except 1st premolars and third molars). Ordinary water bath with thermometer in addition to ordinary vernia.

The method used in this study include Construction of acrylic bite plane as a guidance after positioning of Typodont teeth, a primary impression had been taken for Typodont teeth with an alginate impression material that's loaded in a stock tray of appropriate size. Then pouring the impression with dental plaster material. Perforated special tray was made on the plaster model from cold cure acrylic material; the special tray was extended to cover all teeth, the simulated palatal surface and the distal extension of the Typodont base. Another impression was taken with alginate impression material to prepare master cast from stone material with a more precise details. Wax applied on the master stone cast to cover all teeth including: The incisal and occlusal third of facial surfaces, incisal edges and occlusal surfaces of all teeth, distal aspect of the lateral incisors, mesial aspect of the second premolars; simulated palatal surface and till the distal extension of the Typodont base. Replace the wax by hot cure acrylic resin by the usual laboratory procedures.

Force magnitude source includes: Titanium spring was stretched between molar hook and canine bracket about 180 gm of force, slightly less than usual (200 gm). Spring was stretched between canine bracket hook and hook of molar band. Ligatures were used are stainless steel and Teflon ready made ligatures. Conventional ligation technique that includes two steps the half turn lock and pigtail knot was performed.

After banding of Typodont teeth, these could be placed in their wax's sockets, were the manufacture was prepared these sockets in such away that Typodont teeth is appeared in (Cl II D1) malocclusion and in approximately well aligned position. Precise final alignment for these teeth was done, with stainless steel rectangular arch wire of size: 0.018×0.025, this arch wire was ligated to Typodont teeth with stainless steel ligature. The purpose of this step to idealize Typodont teeth sitting to be ready for fixation by acrylic bite plane in the following step and then canine could be slid over the arch wire, the criterion for success alignment is passive insertion. The extension of acrylic bite plane must be in such a way that all the incisal and occlusal third of facial surfaces, incisal edges and occlusal surfaces of all typodont teeth, distal aspect of the lateral incisors, mesial aspect of the second premolars, palatal surfaces, till the distal extension of the Typodont base.

Immobilization of Typodont Teeth:

An acrylic block was fabricated, into which the four anterior teeth were processed, making them immobile Hoeve *et al.*[5], the acrylic bite plane also was extended in such a way that premolars and molars can be involved to make them immobile, leaving canine area free from acrylic coverage to facilitate sliding movement. The heat distortion temperature of acrylic resin material was 95ºC, Craig *et al.* [6].

The acrylic bite plane was further stabilized by adding thin layer of cold–cure acrylic directly on its tissue surface to be one unit with Typodont teeth, this require slight relief and some tiny perforations in the tissue site of the Typodont to get rid of excess of cold cure acrylic. Two small screws were used through the acrylic bite plane to be tightened into the metallic base of the Typodont, the distance between these two screws was (2cm). Both of these aid in immobilization of Typodont teeth while movement of canine is happened.

Bite Plane Extension Bar and Canine Extension Bar:

Bite plane extension bar (PEB): 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. This bar emerges upward for 10mm distance, then it was bended at right angle to extend facially 20mm in a canine direction making right angle with canine extension bar, from horizontal and vertical direction [7].

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 that was extended upward incisally for 10 mm distance, then it bended at right angle to extend interiorly 20 mm, and 5 mm over the canine cusp tip and under the bite plane extension bar, by about 5 mm. These two bars were used as a guide for determining degree of tipping, extrusion and rotation of canine following sliding movement. This method is a modification of Huffman and Way procedure for determining degree of tipping and rotation of the canine following sliding movement [7].

Titanium spring of 11 mm length was stretched between the molar hook and canine bracket hook. The gauge 11 mm was selected according to the suitable and required amount of force exerted by the spring by the aid of tension gauge that standardized in all methods.

Before starting movement of canine (Right Canine only) into first premolar site, criteria of four important points should be established [8]:

1. All Typodont teeth situated in well aligned position and covered by the acrylic bite plane.
2. The distance between the distal wing of canine's bracket and the mesial wing of second premolar's bracket was 14 mm; this distance is considered as: Available space.
3. The angle between PEB and CEB should be 90° from both vertical and horizontal direction; this angle is considered as: Canine's bar original angle.
4. Vertically the distance from canine cusp tip to CEB should be 5mm, and the distance from CEB to PEB also should be 5 mm.

Statistical Analysis:

When the sixth methods of canine rotation, tipping and extrusion evaluation using 3 types of wires and 2 types of ligation materials have been tested, ten times the test was repeated for each method, statistical analysis were done, that included:

1. Descriptive statistics to show minimum and maximum mean values, Standard deviation and Standard error for each variable and in each method of measurements. Analysis of variance (ANOVA): Data achieved from previous measurement were initially analyzed by using the One–way ANOVA test.
2. Duncan test: These data were then analyzed by Duncan‘s Multiple Range Test, to locate the significant differences among the groups.

RESULTS

The descriptive statistics that includes: Mean, Standard deviations, Standard errors, minimum and maximum values of canine rotation for 6 methods used were listed in Table (1). The finding showed that stainless steel arch wire/ Teflon ligature method gave rise to the highest mean for rate of rotation, while composite coated arch wire/ Teflon ligature achieved the lowest mean. The remaining methods distributed on statistical levels between higher and lower levels of mean. The analysis of variance (ANOVA) for the 6 methods used showed significant difference ($p \leq 0.000$) among them as in Table (2). The results of Duncan Multiple Range Test, Table (2) and Figure (1) showed: That the method of composite coated arch wire/ steel ligature had the lowest rate of rotation, with significant difference ($p \leq 0.05$) from other methods. On the other hand, stainless steel arch wire/ Teflon ligature method showed the highest rate of rotation with significant difference from other method except TMA arch wire/ steel ligature and composite coated arch wire/ Teflon ligature.

Table (1) Descriptive analysis of rotation measurements.

Number	Method Tested	Number	Mean	± SD	SE	Minimum	Maximum
1	S.S.A./S.L.	10	22.00	1.55	0.50	19.00	24.00
2	TMA.A./S.L.	10	21.90	2.07	0.65	18.00	25.00
3	C.C.A./S.L.	10	12.95	1.85	0.85	10.00	16.00
4	S.S.A./T.L.	10	24.60	1.37	0.43	22.50	27.00
5	TMA.A./T.L.	10	20.70	1.40	0.44	18.50	23.00
6	C.C.A./T.L.	10	17.65	1.30	0.41	16.00	20.00

S.S.A. / S.L.: Stainless steel arch wire with steel ligature; TMA.A. / S.L.: Titanium Molybdenum arch wire with steel ligature; C.C.A. / S.L.: Composite coated arch wire with steel ligature; S.S.A. / T.L.: Stainless steel arch wire with Teflon ligature; TMA.A. / T.L.: Titanium Molybdenum arch wire with Teflon ligature; C.C.A. / T.L.: Composite coated arch wire with Teflon ligature.

Table (2) One–way ANOVA analysis and Duncan‘s test
for 6 groups tested for degree of canine rotation measurements.

Source of variation	Sum of square	Degree of freedom	Mean square	F–test	Sig.
Between group	844.783	5	168.957	65.099	≤0.001
Within group	140.150	54	2.595		
Total	984.93	59			

Number	Methods	Mean ± SE	Duncan group
1	S.S.A. / S.L.	22.0 ± 0.49	C
2	TMA.A. / S.L.	21.9 ± 0.65	C
3	C.C.A. / S.L.	12.95 ± 0.58	A
4	S.S.A. / T.L.	24.6 ± 0.43	D
5	TMA.A. / T.L.	20.7 ± 0.41	B
6	C.C.A. / T.L.	17.65 ± 0.44	C

S.S.A. / S.L.: Stainless steel arch wire with steel ligature; MA.A. / S.L.: Titanium Molybdenum arch wire with steel ligature; C.C.A. / S.L.: Composite coated arch wire with steel ligature; S.S.A. / T.L.: Stainless steel arch wire with Teflon ligature; TMA.A. / T.L.: Titanium Molybdenum arch wire with Teflon ligature; C.C.A. / T.L.: Composite coated arch wire with Teflon ligature.

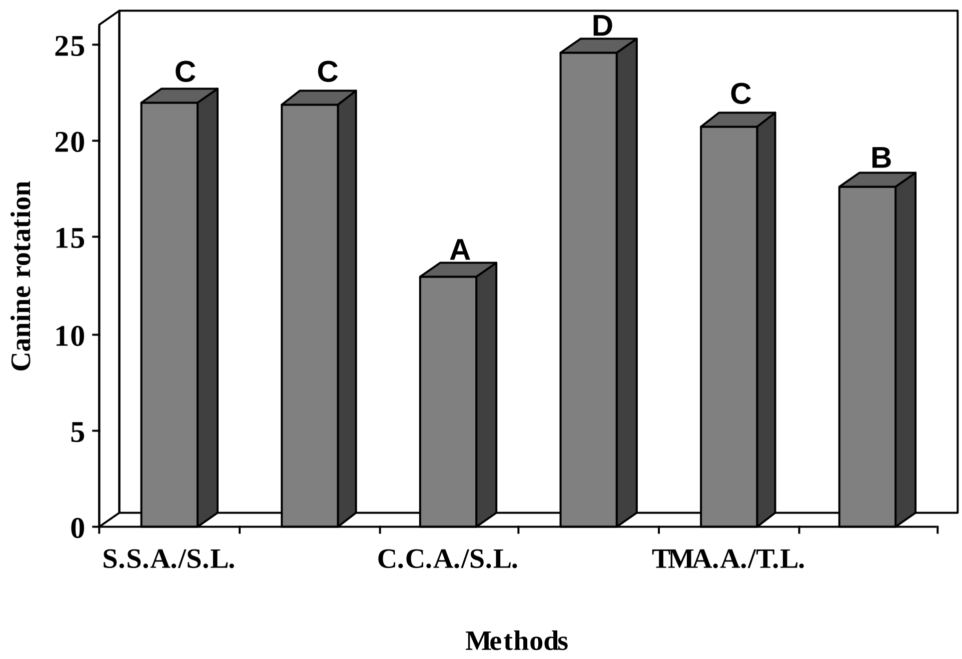

Figure (1): Duncan Multiple Rang Test with 6 groups tested for degree of canine rotation.

S.S.A. / S.L.: Stainless steel arch wire with steel ligature; TMA.A. / S.L.: Titanium Molybdenum arch wire with steel ligature; C.C.A. / S.L.: Composite coated arch wire with steel ligature; S.S.A. / T.L.: Stainless steel arch wire with Teflon ligature; TMA.A. / T.L.: Titanium Molybdenum arch wire with Teflon ligature; C.C.A. / T.L.: Composite coated arch wire with Teflon ligature.

The descriptive statistics for the degree of tipping, for 6 methods that used; were listed in Table (3). The findings of this study showed, that the method of composite coated arch wire gave rise to the lowest degree of tipping. The remaining methods distributed on statistical levels between the higher and lower levels of mean. The analysis of variance (ANOVA) for 6 methods showed significant difference ($p\leq 0.000$) among them, as in Table (4). The results of Duncan Multiple Range Test, Table (4) and Figure (2) showed: That method of composite coated arch wire/ steel ligature has the lowest degree of tipping, with significant difference ($p\leq 0.05$) from other methods. On the other hand, the highest level for degree of tipping in Duncan results includes the composite coated arch wire/ Teflon ligature and TMA arch wire/ Teflon ligature methods with significant difference from other methods.

The descriptive statistic for the degree of extrusion of 6 methods that used; were listed in Table (5). The finding of this work showed that composite coated arch wire/ steel ligature method gave rise to the lowest mean for degree of extrusion while the TMA arch wire/ Teflon ligature gave rise to highest one. The remaining methods distributed on statistical level between higher and lower level of mean except stainless steel arch wire/ Teflon method. The analysis of variance (ANOVA) for 6 methods that used, also showed a significant difference ($p\leq 0.000$) among them as in Table (6). The results of Duncan Multiple Range Test, as in Table (6) and Figure (3), showed that method of composite coated arch wire/ steel ligature was at the lowest degree of extrusion, with a significant difference ($p\leq 0.05$) from other methods. On the other hand the highest level for degree of extrusion in Duncan results includes: The method TMA arch wire/ Teflon ligature with a significant difference from other method, except stainless steel arch wire/ Teflon ligature methods.

Table (3) Descriptive analysis for the degree of tipping measurements.

Number	Method Tested	Number	Mean	± SD	SE	Minimum	Maximum
1	S.S.A./S.L.	10	5.55	1.01	0.32	4.5	7.5
2	TMA.A./S.L.	10	7.55	0.55	0.17	6.5	8.0
3	C.C.A./S.L.	10	1.45	0.44	0.14	1.0	2.0
4	S.S.A./T.L.	10	15.9	0.66	0.21	15.0	17.0
5	TMA.A./T.L.	10	18.95	1.09	0.35	17.0	20.0
6	C.C.A./T.L.	10	17.55	0.44	0.14	17.0	18.0

S.S.A. / S.L.: Stainless steel arch wire with steel ligature; TMA.A. / S.L.: Titanium Molybdenum arch wire with steel ligature; C.C.A. / S.L.: Composite coated arch wire with steel ligature; S.S.A. / T.L.: Stainless steel arch wire with Teflon ligature; TMA.A. / T.L.: Titanium Molybdenum arch wire with Teflon ligature; C.C.A. / T.L.: Composite coated arch wire with Teflon ligature.

Table (4) One–way ANOVA analysis and Duncan's test for 6 groups tested for degree of canine tipping measurements.

Source of variation	Sum of square	Degree of freedom	Mean square	F–test	Sig.
Between group	2627.72	5	525.54	945.192	≤0.001
Within group	30.025	54	0.556		
Total	2657.75	59			

Number	Methods	Mean ± SE	Duncan group
1	S.S.A./S.L.	5.55 ± 0.32	B
2	TMA.A./S.L.	7.55 ± 0.17	C
3	C.C.A./S.L.	1.45 ± 0.14	A
4	S.S.A./T.L.	15.9 ± 0.21	D
5	TMA.A./T.L.	18.95 ± 0.35	E
6	C.C.A./T.L.	17.55 ± 0.14	F

S.S.A. / S.L.: Stainless steel arch wire with steel ligature; MA.A. / S.L.: Titanium Molybdenum arch wire with steel ligature; C.C.A. / S.L.: Composite coated arch wire with steel ligature; S.S.A. / T.L.: Stainless steel arch wire with Teflon ligature; TMA.A. / T.L.: Titanium Molybdenum arch wire with Teflon ligature; C.C.A. / T.L.: Composite coated arch wire with Teflon ligature.

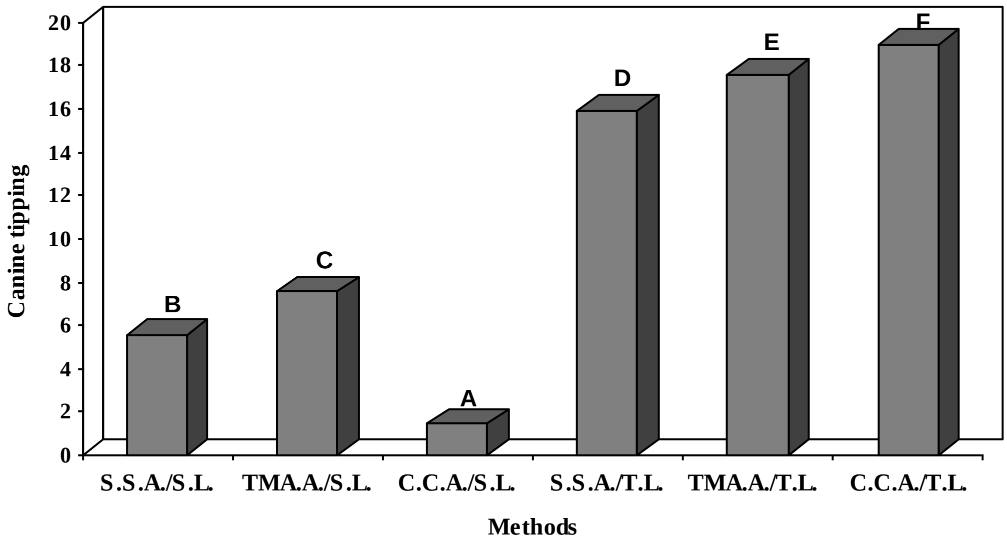

Figure (2): Duncan Multiple Rang Test with the 6 groups tested for degree of canine tipping.

S.S.A. / S.L.: Stainless steel arch wire with steel ligature; TMA.A. / S.L.: Titanium Molybdenum arch wire with steel ligature; C.C.A. / S.L.: Composite coated arch wire with steel ligature; S.S.A. / T.L.: Stainless steel arch wire with Teflon ligature; TMA.A. / T.L.: Titanium Molybdenum arch wire with Teflon ligature; C.C.A. / T.L.: Composite coated arch wire with Teflon ligature.

Table (5) Descriptive analysis for the degree of extrusion measurements.

Number	Method Tested	Number	Mean	+ SD	SE	Minimum	Maximum
1	S.S.A./S.L.	10	0.7	0.35	0.11	0.0	1.0
2	TMA.A./S.L.	10	1.35	0.53	0.17	0.5	0.2
3	C.C.A./S.L.	10	0.25	0.26	0.08	0.0	0.5
4	S.S.A./T.L.	10	3.23	0.45	0.14	2.5	3.75
5	TMA.A./T.L.	10	3.6	0.52	0.16	3.0	4.5
6	C.C.A./T.L.	10	2.95	0.37	0.12	2.5	3.5

S.S.A. / S.L.: Stainless steel arch wire with steel ligature; TMA.A. / S.L.: Titanium Molybdenum arch wire with steel ligature; C.C.A. / S.L.: Composite coated arch wire with steel ligature; S.S.A. / T.L.: Stainless steel arch wire with Teflon ligature; TMA.A. / T.L.: Titanium Molybdenum arch wire with Teflon ligature; C.C.A. / T.L.: Composite coated arch wire with Teflon ligature.

Table (6) One–way ANOVA analysis and Duncan‘s test for 6 groups tested for the degree of canine extrusion measurements.

Source of variation	Sum of square	Degree of freedom	Mean square	F–test	Sig.
Between group	101.37	5	20.27	113.09	≤0.001
Within group	9.68	54	0.18		
Total	111.05	59			

Number	Methods	Mean ± SE	Duncan group
1	S.S.A. / S.L.	0.70 ± 0.11	A
2	TMA.A. / S.L.	1.35 ± 0.17	C
3	C.C.A. / S.L.	0.25 ± 0.08	B
4	S.S.A. / T.L.	3.23 ± 0.14	DE
5	TMA.A. / T.L.	3.60 ± 0.16	E
6	C.C.A. / T.L.	2.95 ± 0.12	D

S.S.A. / S.L.: Stainless steel arch wire with steel ligature; MA.A. / S.L.: Titanium Molybdenum arch wire with steel ligature; C.C.A. / S.L.: Composite coated arch wire with steel ligature; S.S.A. / T.L.: Stainless steel arch wire with Teflon ligature; TMA.A. / T.L.: Titanium Molybdenum arch wire with Teflon ligature; C.C.A. / T.L.: Composite coated arch wire with Teflon ligature.

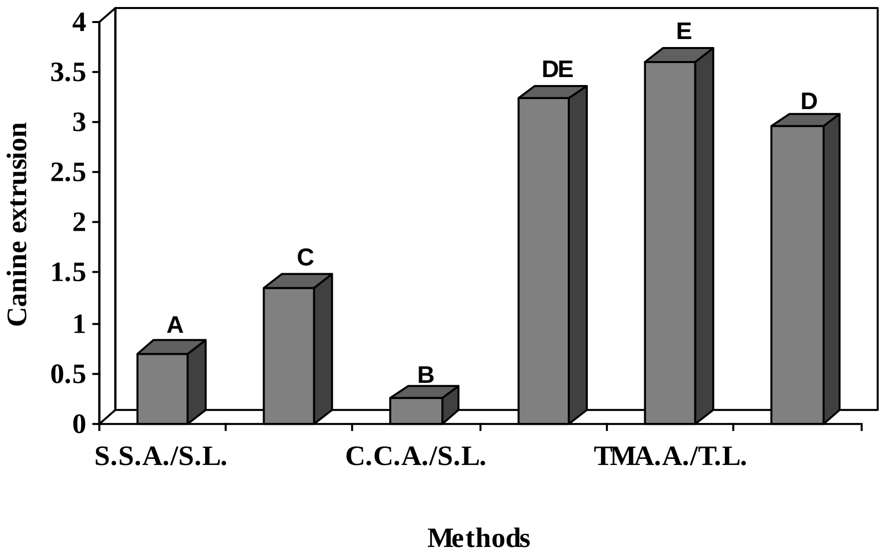

Figure (3): Duncan Multiple Rang Test with the 6 groups tested for degree of canine extrusion.

S.S.A. / S.L.: Stainless steel arch wire with steel ligature; TMA.A. / S.L.: Titanium Molybdenum arch wire with steel ligature; C.C.A. / S.L.: Composite coated arch wire with steel ligature; S.S.A. / T.L.: Stainless steel arch wire with Teflon ligature; TMA.A. / T.L.: Titanium Molybdenum arch wire with Teflon ligature; C.C.A. / T.L.: Composite coated arch wire with Teflon ligature.

DISCUSSION

This study showed, that composite coated arch wire/ steel ligature method had the lowest mean for degree of the rotation, such finding could be attributed to the following reasons: The first is related to the type of arch wire which composite coated metal arch wire, that is to say: The large friction possibility resulted from the composite coating that give rough surface this agreed with Huang *et al.* [8], Zuffall *et al.* [9]. The composite coated wires had the higher kinetic coefficient of friction than stainless steel.

The composite coated arch wire/ steel ligature showed higher resistance to rotation than TMA arch wire/ steel ligature, although TMA should show higher roughness than composite coating; because the cross section of surface particles are rhomboidal, were as composite coating are spherical. Wires that contain certain percentage of titanium such as: TMA present a rougher surface compared to steel wires and composite coated steel wires Zuffall *et al.* [9] and Bazakidou *et al.* [10]. Here the higher friction for composite coating than TMA, may be due to effect of the heat generated to water bath which reach to 55˚C that may cause dislodgment to some of surface particle of composite coating or even may lead to change in surface characteristics of coating. The second reason is the tightness of steel ligature.

In comparison on other side, stainless steel arch wire/ Teflon method gave rise to the highest mean for degree of rotation, this was due to the following reasons: The first is the smoothness of stainless steel wire when compared with TMA and composite coating; the second reason is that the Teflon ligature is loosen after force application increasing tendency of tooth rotation. Nishio *et al.* [11] stated that, stainless steel wire has a low frictional level. Friction in TMA is higher than stainless steel, Kusy *et al.* [12] and Keith *et al.* [13]. This study showed that composite coated arch wire/ steel ligature method had the lowest mean for degree of canine tipping, such finding could be attributed to the following reasons: The first one is related to the type of ligating material that the steel ligatures provide firm and tight ligation when compared with Teflon which loosen after force application the second reason is that the composite coating may increase the stiffness of steel wire to certain degree when compared with steel uncoated wire of same thickness. The third reason is that the steel wire underlying the composite coating is stiff wire when compared with TMA wire, Kusy and Green berg [14]. Kusy [15] explaind that stainless steel wire has stiffness higher than TMA.

On the other side TMA/ Teflon ligature method gave rise to the highest mean for the degree of tipping, this was certainly due to the following reasons: The first one is the type of arch wire, TMA wire can therefore be deflected almost twice as much as stainless steel wire Kapila and Sachdeva [16]. Proffit *et al.* [17] stated that: TMA has nearly twice the elastic range that of steel. The stiffness of TMA is approximately 1/3 that of stainless steel of same size Ireland and McDonald [18] Kula *et al.* [19]. The second reason is that the resiliency of Teflon ligature when compared with steel ligature usually Teflon ligature is lighten during force application in the end result lead to loosening attachment of arch wire with the bracket thus increasing displacement of bracket with the tooth along arch wire leading to increase tendency of tipping same reason in case of extrusion Al–Mukhtar [20].

The composite coated arch wire/ steel ligature method achieved the lowest mean for the degree of canine extrusion, such result probably attributed to the following reasons: First one, could be the result of ligation material were steel ligature give tight (firm) ligation when compared with Teflon ligature, the second one is that underneath the coating is steel wire and steel wire is stiff that resist force of extrusion although there was another variable, which was stainless steel arch wire /steel ligature; but the reason of highest resistance in case of composite coating may be due to two thing first one is that coating material is composite (resin material) may add rigidity increase stiffness, second one is that the wire beneath the coating not so fit in size (variable) that even larger than limited thus with the coating may increase the rigidity Zuffall and Kusy [21]. On the other hand TMA/ Teflon ligature method gave rise to highest mean for degree of extrusion; this was certainly due to the following reasons: The first is the flexibility of TMA wire, Nelson *et al.* [22] stated that TMA wire exhibit excellent prosperities, of them is high spring back in addition it shows a higher friction tendency as it is postulated, thus this increase critical angle of bind (angle formed between arch wire and bracket slot wall) which formed by engagements of arch wire and bracket after force application this ordinarily increase in case of flexible and rough surface wire due to increase engagement in the end result increase possibility of extrusion and tipping. The second one is the resiliency or loose fitting of Teflon ligature when compared with steel one.

CONCLUSIONS

As a conclusion the best method for space closure in sliding mechanics is the use of either stainless steel with steel ligature that benefit from the smoothness of steel wire and nearly firm ligation of steel ligature or the composite coated arch wire with stainless steel ligature.

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