EGYPTIAN
DENTAL JOURNAL

Vol. 64, 1999:2006, July, 2018

I.S.S.N 0070-9484

Orthodontics, Pediatric and Preventive Dentistry

www.eda-egypt.org • Codex : 168/1807

A COMPARATIVE STUDY OF THE FRICTIONAL FORCES BETWEEN METALLIC BRACKET AND CERAMIC BRACKET USING CONVENTIONAL AND UNCONVENTIONAL ELASTOMERIC LIGATURE

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ABSTRACT

Back ground Friction is defined as the force tangential to the common boundary of two bodies in contact that resists the motion of one relative to the other. frictional forces should be kept to a minimum so that lower levels of force can be applied to obtain an optimal biological response for effective tooth movement .The most popular bracket was stainless steel which presents in the form of cast or sintered stainless steel bracket, it The main disadvantage of stainless steel bracket is the inferior esthetics **Aim** the purpose of this study is to evaluate the frictional forces of stainless brackets and ceramic brackets with nickel titanium (Ni-Ti) and stainless steel (St.St) arch wires using conventional elastomeric ligature (CEL) and unconventional elastic ligature (UEL). Materials and Methods The samples including pre-adjusted metal bracket pre-adjusted ceramic bracket In this in vitro study, each bracket incorporating +17 torque and +4 angulation with 0.022" x 0.028" slot diminutions. The archwires used was 0.014" super elastic nickel titanium [SE NiTi] wire 0.019" × 0.025" stainless steel [St.St.] wire. Two types of ligation were used; conventional ligation (O-Tie) and unconventional ligation The frictional forces between bracket and wire is tested in a vertical planner by a tension load using Universal testing machine Each sample was inserted into the machine to measure the friction between wire and bracket in each case. The speed is 6mm/min and the traveling distance is 5mm. The measurements of all samples was performed under dry state Data were presented as mean and standard deviation (SD) values. One-way Analysis of Variance (ANOVA) was used for comparison between aging periods. Tukey's post-hoc test was used for pair-wise comparison between the means when ANOVA test is significant. Student's t-test was used for comparisons between two groups. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with SPSS 16.0® (Statistical Package for Scientific Studies) for Windows. **Result** Unconventional elastomeric ligature are able to produce significantly lower frictional forces compared with conventional elastomeric ligature (CEL) on conventionally ligated brackets the clinical advantages that arise from the use of Unconventional elastomeric ligature(UEL) is that they can be placed on every type of conventionally ligated brackets with considerable cost reduction the clinician can apply friction and low-friction mechanics simultaneously on the same archwire by using CEL and UEL only in particular segments. For example, during en masse space closure on a rectangular stainless steel archwire, UEL can be used in the posterior segments to reduce friction, while CEL is used in the anterior segment to maximize torque expression and control.

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INTRODUCTION

Friction is defined as the force tangential to the common boundary of two bodies in contact that resists the motion of one relative to the other. The amount of friction is proportional to the force with which the two surfaces are pressed together and dependent on the nature of the surfaces in contact.[1, 2]

The orthodontist may select a type of archwire that meets the best demands of a particular clinical situation.[3] During mechanotherapy involving movement of the bracket relative to the wire, friction at the bracket wire interface may prevent the attainment of optimal force levels in the supporting tissues. Hence, an understanding of forces required to overcome friction is important so that the appropriate magnitude of force can be used to produce optimal biologic tooth movement .[4, 5]

The most common technique used in orthodontic treatment for closure of interdental spaces is termed sliding mechanics in which the bracket moves along the arch wire.The major disadvantage with the use of sliding mechanics is the friction that is generated between the bracket and the archwire during orthodontic movement.[6] Friction in clinical orthodontics now is receiving much attention because orthodontic companies have decided that low friction is good and are using that concept to market their self-ligating brackets.[7, 8]

During orthodontic treatment with fixed appliances, frictional forces should be kept to a minimum so that lower levels of force can be applied to obtain an optimal biological response for effective tooth movement.[9]

Several factors can influence frictional resistance directly or indirectly. Among these factors, features of archwire and bracket (in terms of size and material), methods and properties of archwire ligation, which have an important role in generating friction.[10,11,12]

The friction coefficient of a given material couple is the ratio between the tangential force (frictional force) and the normal or perpendicular load applied during the relative motion.[13, 14, 15]

Friction is a factor in sliding mechanics, such as during the retraction of the teeth into an extraction area, active torque, leveling, and alignment, when the archwire must slide through the bracket slots and tubes.[16] friction can reduce the available force by almost 40%, resulting in an anchorage loss.[4,17] Therefore, it is essential to understand the impact of friction between the bracket and the wire so that the proper force can be applied to obtain adequate dental movement and optimum biologic tissue response.[5,9,14]

Ceramic brackets have superior esthetics, but several studies reported that the friction is higher with ceramic brackets than with stainless steel brackets.[1, 4, 18]

The conventional ceramic brackets generated significantly higher friction than the other brackets tested. Beta titanium arch wires. Produced higher frictional forces than nickel titanium arch wires.[19] Brackets had frictional force values that were statistically significant in this progressive order: stainless steel bracket, ceramic bracket with a metal reinforced slot, and traditional ceramic bracket with a ceramic slot. The beta-titanium wire showed the highest statistically significant frictional force value, followed by the nickel-titanium and the stainless steel archwires, in decreasing order. The frictional force values were directly proportional to the angulation increase between the bracket and the wire .[20, 21]

Aim of study

The purpose of this study is to evaluate the frictional forces of stainless brackets and ceramic brackets with nickel titanium (NI-TI) and stainless steel (ST.ST) arch wires using conventional elastomeric ligature (CEL) and unconventional elastic ligature (UEL)

MATERIALS AND METHODS

The samples including pre-adjusted metal bracket (3M Unitek™ Gemini Bracket), pre-adjusted ceramic bracket (Ortho organizer product) In this in vitro study, each bracket incorporating +17 torque and +4 angulation with 0.022“ x 0.028” slot diminutions.

The archwires used was 0.014" super elastic nickel titanium [SE NiTi] wire(Ortho organizer product).0.019" × 0.025" stainless steel [St.St.] wire (Ortho organizer product). These wire dimensions were chosen because round wires of small size are recommended during the aligning and leveling phase of orthodontic treatment while rectangular wires of larger size are required during the final phase of treatment when a remarkable torque control is necessary.[12]

Two types of ligation were used; conventional ligation (O-Tie) (Ortho organizer product) and unconventional ligation (slide low friction system) (Leone orthodontic product, Italy).

The frictional forces between bracket and wire is tested in a vertical planner by a tension load cell (5 Kg.) using Universal testing machine (LLOYD INSTRUMENTS a trademark of Ametek, inc.); Each sample was inserted into the machine to measure the friction between wire and bracket in each case. The speed is 6mm/min and the traveling distance is 5mm. The measurements of all samples were performed under dry state.

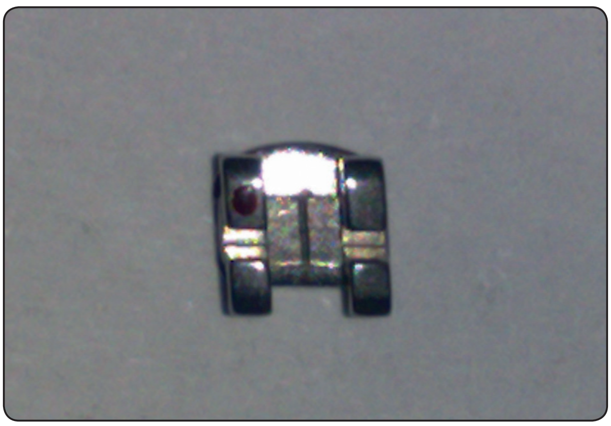

Fig. (1) Pre-adjusted upper central incisor metal bracket (3M Unitek™ Gemini Bracket).

Fig. (2) Pre-adjusted upper central incisor ceramic bracket (Ortho organizer product).

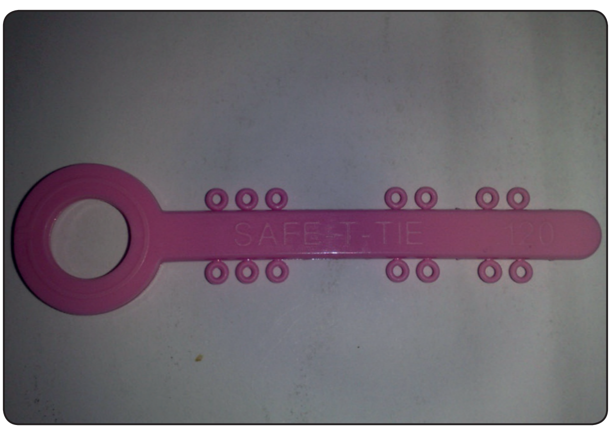

Fig. (3) Conventional elastomeric ligature (Ortho organizer product).

Fig. (4) Unconventional ligation (slide low friction system) (Leone orthodontic product, Italy).

Method of Testing:

In each group the frictional forces between bracket and wire is tested in a vertical planner by a tension load cell (5 Kg.) using Universal testing machine (LLOYD INSTRUMENTS a trademark of Ametek,inc.);

Each sample was inserted into the machine to measure the friction between wire and bracket in each case. The speed is 6mm/min and the traveling distance is 5mm.

Statistical Analysis

Data were presented as mean and standard deviation (SD) values. One-way Analysis of Variance (ANOVA) was used for comparison between aging periods. Tukey's post-hoc test was used for pair-wise comparison between the means when ANOVA test is significant. Student's t-test was used for comparisons between two groups.

The significance level was set at $P \leq 0.05$. Statistical analysis was performed with SPSS 16.0® (Statistical Package for Scientific Studies) for Windows.

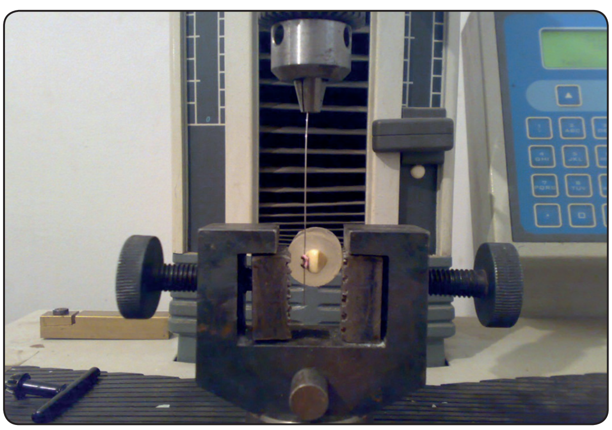

Fig. (5) One end of the wire is attached to the machine and the other path through the bracket

RESULTS

The resulted data of the current study were collected, tabulated and statistically analyzed to investigate the effect of bracket,during orthodontic tooth movement.

Instantaneous force

Comparison between brackets

Table (1): The means, standard deviation (SD) values, results of ANOVA and Tukey's test for the comparison between instantaneous forces induced by different types of brackets with conventional ligation.

TABLE (1):

Wire \ Bracket	Metal		Ceramic		P-value
	Mean	**SD**	**Mean**	**SD**	
SE NiTi	250.0 [b]	0.8	297.7 [a]	3.7	**<0.001***
St.St.	330.2 [b]	1.2	585.5 [a]	4.6	**<0.001***

: Significant at P ≤ 0.05, Means with different letters are statistically significantly different according to Tukey's test

With SE NiTi wire, ceramic bracket showed the statistically significantly highest mean force.

Table (2): The means, standard deviation (SD) values, results of ANOVA and Tukey's test for the comparison between instantaneous forces induced by different types of brackets with unconventional ligation

TABLE (2):

Wire \ Bracket	Metal		Ceramic		P-value
	Mean	**SD**	**Mean**	**SD**	
SE NiTi	74.5 [b]	0.5	93.9 [a]	0.8	**<0.001***
St.St.	172.8 [b]	0.8	193.6 [a]	1	**<0.001***

: Significant at P ≤ 0.05, Means with different letters are statistically significantly different according to Tukey's test

Comparison between ligation

Table (3): The means, standard deviation (SD) values, results of ANOVA and Tukey's test for the comparison between instantaneous forces induced by different types of ligation with metal brackets

TABLE (3):

Ligation / Wire	Conventional		Unconventional		P-value
	Mean	SD	Mean	SD	
SE NiTi	250.2 [a]	0.8	74.5 [b]	0.5	**<0.001***
St.St.	330.2 [a]	1.2	172.8 [b]	0.8	**<0.001***

****: Significant at P ≤ 0.05, Means with different letters are statistically significantly different according to Tukey's test***

Table (4): The means, standard deviation (SD) values, results of ANOVA and Tukey's test for the comparison between instantaneous forces induced by different types of ligation with ceramic brackets

TABLE (4):

Ligation / Wire	Conventional		Unconventional		P-value
	Mean	SD	Mean	SD	
SE NiTi	279.7 [a]	3.7	92.8 [b]	0.8	**<0.001***
St.St.	585.5 [a]	4.6	192.5 [b]	1	**<0.001***

****: Significant at P ≤ 0.05, Means with different letters are statistically significantly different according to Tukey's tes***

Overall comparison between the groups

Table (5): The means, standard deviation (SD) values, results of ANOVA and Tukey's test for the comparison between instantaneous forces induced by all groups

TABLE (5):

	Mean	SD	P-value
Metal bracket x SE NiTi wire x Conventional ligation	251.3 [c]	0.7	**<0.001***
Metal bracket x SE NiTi wire x Unconventional ligation	75.6 [g]	0.4	
Metal bracket x SS wire x Conventional ligation	331.3 [b]	1.1	
Metal bracket x SS wire x Unconventional ligation	173.9 [e]	0.7	
Ceramic bracket x SE NiTi wire x Conventional ligation	280.8 [c]	3.6	
Ceramic bracket x SE NiTi wire x Unconventional ligation	93.9 [f]	0.7	
Ceramic bracket x SS wire x Conventional ligation	586.6 [a]	4.5	
Ceramic bracket x SS wire x Unconventional ligation	193.6 [d]	9.9	

****: Significant at P ≤ 0.05, Means with different letters are statistically significantly different according to Tukey's test results***

DISCUSSION

The results of the current study show that there was statistically significant difference between different types of brackets regardless the type of ligation or type of arch wire. Ceramic brackets showed the statistically significant highest mean frictional forces this is followed by stainless steel bracket.

The results of the present study confirm previous findings by Baccetti and Franchi.[22] who reported significantly lower levels of friction for conventionally ligated brackets with UEL compared with conventionally ligated brackets with CEL during sliding mechanics with 0.014// SE NiTi wire and 0.019// x 0.020// St.St. wire.

Conventional ceramic brackets generated higher frictional forces than that of conventional stainless steel bracket this is in agreement with other previous studies[23 - 27] It has been reported that the friction resistance of ceramic brackets is increased by their rough surface conditions. In addition, the chemical characteristics of alumina on a ceramic surface can cause a metal wire to adhere to the alumina surface.[28]

In the present study it was found that the friction increased with an increase in wire size, whereas rectangular wires produced greater friction than round wires in agreement with previous studies[23, 29, 30, 31]. While the archwire material has a significant role in friction in which stainless steel wire has lower friction resistance than nickel titanium archwires.[21]

The results demonstrated that there was high significant difference between the types of ligation; conventional elastomeric ligation (CEL), low-friction ligation (unconventional elastomeric ligature UEL).

The method of ligation can highly influence friction as the conventional elastomeric ligatures increasing friction significantly when compared with unconventional elastomeric ligatures.[32] In an effort to reduce the effect of metal and elastomeric ties on the resistance to sliding, manufacturers in recent years have produced self –ligating brackets and low friction ligatures which have been shown to generate negligible friction.[12,17]

Low-friction ligatures show lower friction when compared with conventional ligatures when coupled with round archwires, and when coupled with rectangular ones.[33]

Based on the results of the present study, UELs are able to produce significantly lower levels of frictional forces than CEL when applied on conventionally ligated brackets; thus, UELs may represent a valid alternative to passive self-ligating brackets for low-friction biomechanics. One of the clinical advantages that arise from the use of UELs is that they can be placed on every type of conventionally ligated brackets with considerable cost reduction compared with self-ligated brackets (SLBs).

Another advantage is that the clinician can apply friction and low-friction mechanics simultaneously on the same archwire by using CEL and UEL only in particular segments. For example, during en masse space closure on a rectangular stainless steel archwire, UELs can be used in the posterior segments to reduce friction, while CELs are used in the anterior segment to maximize torque expression and control.

CONCLUSION

1- Unconventional elastomeric ligature are able to produce significantly lower frictional forces compared with conventional elastomeric ligature (CEL) on conventionally ligated brackets when coupled with 0.014// Super elastic nickel titanium (SE NiTi) wire and with 0.019// x 0.025// Stainless steel (St.St.) wire.

2- The clinical advantages that arise from the use of Unconventional elastomeric ligature (UEL) is that they can be placed on every type of conventionally ligated brackets with considerable cost reduction.

3- The clinician can apply friction and low-friction mechanics simultaneously on the same archwire by using CEL and UEL only in particular segments. For example, during en masse space closure on a rectangular stainless steel archwire, UEL can be used in the posterior segments to reduce friction, while CEL is used in the anterior segment to maximize torque expression and control.

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