

FRICIONAL RESISTANCE OF FOUR SELF-LIGATING METALLIC BRACKETS IN COMBINATION WITH TWO DIAMETERS OF STAINLESS STEEL ARCHWIRES

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ABSTRACT

Aim: This study was conducted to evaluate and compare the dynamic frictional resistance of stainless steel archwires in combination with 4 types of self ligating brackets (IOS ,3 M, American and Damon Q, brackets).

Materials and methods : The sample of the study included forty eight pre-adjusted brackets for maxillary right canine (Roth prescription) with 0.022 × 0.028 inch slot. The sample was divided into eight groups, each one included six brackets. Groups 1 and 2 were IOS brackets, groups 3 and 4 were 3 M brackets, group 5 and 6 were American Orthodontics brackets while groups 7 and 8 were Damon Q brackets .Groups 1, 3,5 and 7 were tested in combination with 0.016x0.022 inch diameter stainless steel arch wires while , groups 2, 4 ,6 and 8 tested in combination with 0.018 inch stainless steel arch wires. Universal testing machine with a new design simulating the oral cavity were used. The statistical mean and standard deviation of the kinetic frictional of eight groups were calculated to evaluate the significant difference between the groups during canine retraction.

Essential results : showed that IOS brackets using 0.016x0.022 stainless steel arch wire produced the highest frictional force followed by 3M brackets in combination with 0.016x0.22 archwire while the Damon Q brackets using 0.018 stainless steel brackets produced least frictional force.

Conclusions : Rectangular stainless steel archwires produced higher frictional resistance with all bracket types than the round ones. Damon Q brackets with round archwire produced the least frictional resistance.

INTRODUCTION

The increasing use of sliding mechanics in orthodontics has lead to considerable research interest in friction. ⁽¹⁾ . Friction is the resistance to

motion when an object moves tangentially against another ^(2,3) . friction is encountered during retraction of teeth into extraction area, active torque, leveling and alignment when the archwire must slide through bracket slots and tubes ^(4,5,6) . A successful

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orthodontic movement is directly related to the ability of orthodontic wires to slide through these brackets slots and tubes. During sliding mechanics, the biologic tissue responds and tooth movement occurs only when forces applied exceed the friction on bracket wire interface. For this reason sufficient forces are needed to overcome frictional forces between bracket and archwire ⁽⁶⁾. There are multiple factors that affect either directly or indirectly the frictional resistance of orthodontic appliances in the oral cavity such as: bracket and archwire properties plus mode of ligation. The following factors of the wire were found to affect friction magnitude in decrease order, surface roughness of wire, wire size (vertical dimension) and elastic properties of wire ⁽⁷⁾. Regarding mode of ligation, conventional ligation produced higher static and kinetic frictional forces than self-ligation mode. Elastomeric ligatures produced less frictional forces than steel ligation under dry conditions. Recently many brands of self-ligated brackets had been produced and not only make archwire placement more convenient and secure, but also have lower kinetic frictional force than conventional brackets. ^(6,8,9) The Damon low-friction bracket was described by Damon ⁽⁵⁾. It is a biologically compatible straight wire system with low friction mechanics. More studies are still needed for proper evaluation of these new bracket system generations regarding frictional resistance and other properties.

MATERIAL AND METHODS

The present study was conducted in the Department of Orthodontics, Faculty of Oral and Dental medicine, Fayoum University, Egypt. The study was performed to evaluate the friction between different types of orthodontic brackets and orthodontic wires.

All brackets used in the study were preadjusted 0.022 x 0.028 inch slots. The sample of the study consisted of forty eight pre-adjusted (Roth prescription) brackets for maxillary right canine. The sample was divided into eight groups every one consisted of six brackets and named as the following: 1, 2, 3, 4, 5, 6,7 and 8. Twenty four segments of stainless steel 0.018 inch archwire, divided into four groups (six segments in each group), were used in combination with the brackets of four groups 2,4,6 and 8. Another twenty four segments of 0.016 x 0.022 inch arch wires were used in combination with the brackets of 1,3,5 and 7 groups (six segments for each one), table number (I). A special design was used to hold and attach the sample components into the Universal testing machine (Instron, Model-5848), figure number (1).

TABLE (I) Different bracket groups and wire combination:

Group	Bracket type, wire type and ligation type
Group 1	IOS brackets in combination with 0.018 inch stainless steel arch wire
Group 2	IOS brackets in combination with 0.016x0.022inch stainless steel arch wire
Group 3	3M brackets in combination with 0.018inch stainless steel arch wire
Group 4	3M brackets in combination with 0.016x0.022inch stainless steel arch wire
Group 5	American Orthodontics brackets in combination with 0.018 inch stainless steel arch wire
Group 6	American Orthodontics brackets in combination with 0.016x0.022 inch stainless steel arch wire
Group 7	Damon Q brackets in combination with 0.018 inch stainless steel arch wire
Group 8	Damon Q brackets in combination with 0.016x0.022 inch stainless steel arch wire

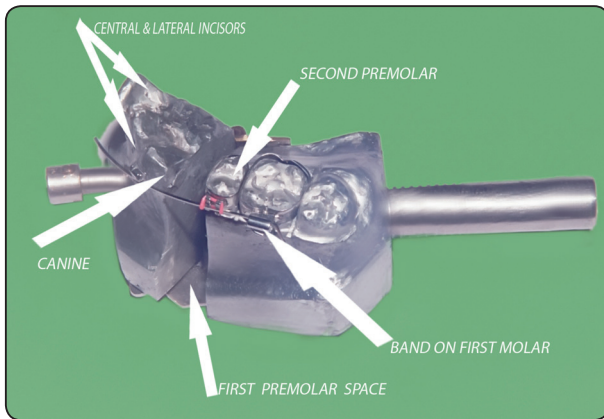


Fig. (1) The design with brackets and wires

The holding system is simply the right half of a metallic cast for well aligned maxillary human dentition and was constructed to simulate the canine retraction system in oral cavity i.e, it could be moved mesially and distally in a curved path at the position of the first premolar which was removed to separate the model into two segments ⁽¹⁰⁾. Metallic joint connected these two segments together and by this way they could be driven simply in contact with each other. Band on the first molar, brackets on the second premolar and canine (of the same type) were adapted and the design was mounted to the testing machine through upper and lower bars where downward movement was applied allowing distalization the canine containing segment. A vertical force was applied at a cross –head to overcome the frictional resistance which was changeable according to the type bracket and wire, figure (1). The sliding speed used for this study was 0.5 mm / min for 7mm total distance i.e, each test was carried out for 14 minutes . Each bracket and arch wire segment were used for only one time .

Statistical analysis :

Data were statistically analysed with SPSS software. The statistical mean and standard deviation of the kinetic frictional forces of eight groups were calculated and tested by F-test for analysis of variance ANOVA followed by Scheffe test to evaluate the significant difference between the groups.

RESULTS

Size of the archwires:

For all groups , the 0.016x0.022 inch stainless steel arch wire produced higher frictional forces than 0.018 inch stainless steel archwires.

Bracket-wire combination

IOS bracket type in combination with 0.016x0.022 stainless steel archwire produced the highest frictional values (191.53 N) followed by 3M bracket type in combination with the same previous archwire (158.200 N). Damon Q bracket in combination with 0.016x0.022 inch stainless steel archwire produced nearly the same frictional values produced from American bracket group in combination with 0.018 inch stainless steel archwire (100.70 and 103.98 N respectively). The least frictional resistance was obtained from the Damon Q bracket group in combination with 0.018 inch stainless steel archwire. Table (II) and figure (2)

TABLE (II) Mean and Std Dev of frictional force values for each group

Value Label	Mean	Std Dev
1	151.86	42.348
2	191.53	53.89
3	115.89	15.95
4	158.200	49.74
5	103.986	16.7944
6	126.88	37.95
7	100.76	14.88
8	81.66	11.99

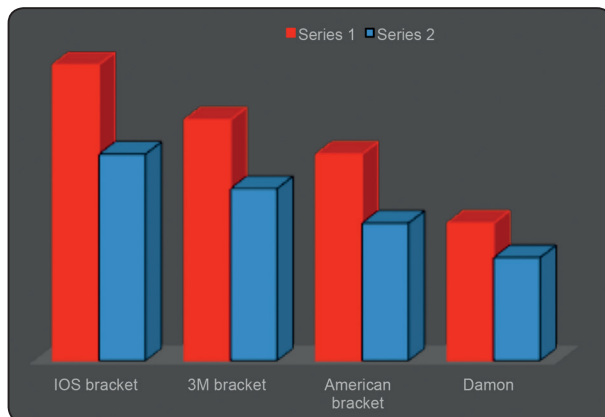


Fig. (2) A bar- cart showing the effect of round and rectangular wires on frictional resistance for the four bracket types

DISCUSSION

The biologic tissue responds and tooth movement occurs only when forces applied exceed the friction on bracket wire interface during sliding movement. Therefore, an understanding of the forces required to overcome friction is important so that the appropriate magnitude of force can be used to produce optimal biological tooth movement. To elucidate the nature of friction between archwire and bracket, several variables such as bracket material, wire alloy, and wire section should be studied⁽³⁾. Most techniques evaluating the dynamic frictional resistance were performed where the brackets slide against the arch wire in a straight linear movement while clinically the bracket slides against the arch wire (mainly during space closure) within some curvature which increases at canine region. In other words, when the canine is moved mesially or distally, it usually moves in a curve. From the above mentioned, it is preferred to measure the frictional resistance in a curved not in linear manner to obtain results more representative for the clinical situation. The design used in this study made it possible for reasonable kinetic frictional forces evaluation.⁽¹⁰⁾ This study was performed to compare the kinetic frictional forces produced by two diameters of stainless steel arch wires using four types from the most recent generations of self-ligating brackets.

(American, IOS, 3M and Damon Q). Slot size of both canine and premolar brackets was 0.022×0.028 inch as **Schudy and Tidy**^(11,12) demonstrated that slot size had little effect on frictional resistance. **Ireland et al**⁽¹³⁾ stated that: no significant difference in friction measurement using speed from 0.5 to 50 mm/min. So, the sliding speed used for this study was 0.5 mm/min .

The results of all groups in this investigation were of high magnitude, in comparison to the other studies,^(6,14,15) which could be attributed to the difference in the model employed with curved path and hence a significant higher values were produced.

In the present study , the rectangular archwires produced higher frictional values in comparison to the round archwires for all bracket types. This was in agreement with **Baccetti and Franchi**,⁽⁴⁾ **Tidy**⁽¹²⁾ and **Drescher**⁽⁷⁾

The results show a high significant difference between four bracket types. This is due to the high value of mean kinetic frictional resistance of IOS group in comparison to those produced by the Damon group. For Damon Q brackets, the present study recorded the lowest frictional force when using 0.018 inch stainless steel archwire .This was in agreement with **Kapur R, Shinha PK, and Nanda RS**⁽⁶⁾ who reported lower frictional values for Damon brackets in comparison to the other used bracket types.

These reported values of Damon SL brackets were higher than the finding values of **Thomas et al**⁽¹⁴⁾, **Kapur et al**⁽⁶⁾ and **Pizzoni et al**⁽¹⁵⁾ who found that frictional forces of Damon SL brackets were 0.111 Newton when using 0.018 inch stainless steel archwire

However, it should be noted that Damon Q showed the lowest level of friction with round wires, compared with all the other combinations, suggesting that, among the considered archwire – bracket combinations it remains the bracket of

choice when lower frictional force is required during the alignment phase.

There is a limitation of this *in vitro* testing model concerns the lack of reproducibility of tipping, that always occurs when orthodontic force is applied to a tooth, even when a fixed appliance is used. In addition, the functional forces of the stomatognathic muscles, which could affect tooth orthodontic movement and the effect of the saliva were not considered.

SUMMARY AND CONCLUSION

The samples were selected to be from the recent generations of four self-ligating brackets. Stainless steel archwire were used in combination with the brackets in rectangular and round cross sections. The universal testing machine was used for the evaluation through a design simulating the clinical situation in sliding of the brackets. 0.5 mm per min sliding velocity.

The results showed the following:

- 1- IOS brackets in combination with 0.016x0.022 stainless steel archwire produced the highest frictional force
- 2- Damon brackets in combination with 0.018 stainless steel archwire produced lowest frictional forces.
- 3- The assembly (used for attachment to the instron machine) in this study evaluating frictional resistance is an accurate novelty in itself, representing the clinical movement.

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