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The Influence of Different Ligature Materials on Frictional Coefficient of Slided Bracket on Arch Wire

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ABSTRACT

Aims: To evaluate the frictional coefficients of different ligature materials with combination of stainless steel arch wire and bracket**. Materials and methods:** Ten ligatures were used for each of stainless steel, elastotomeric and teflon utilized with stainless steel arch wires and brackets. A simulated half arch fixed apparatus was designed for measuring the static and kinetic frictional coefficient of the slide bracket incorporated with tensile testing machine. The data were analyzed by using the descriptive and variance analyses of tests (ANOVA and Duncan's Multiple Range test at $p \leq 0.05$) to reveal the significant difference of the frictional coefficient among the three types of ligature materials. **Results**: It was disclosed that the elastomeric ligature had a very highly significant increased mean value of the static and kinetic frictional coefficients as compared with other ligatures. **Conclusions:** The elastomeric ligature is not recommended for use with sliding stainless steel bracket on the arch wire.

Keywords: Coefficient, Static, Kinetic, Friction**.**

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INTRODUCTION

Friction is resistance to motion when one object moves tangentially against another(1). It is recognized by most clinicians to be very harmful to tooth movement, as frictional resistance imposes the need for increased force and greater anchorage results(2).

The type of bracket, wire or ligature utilized during the treatment might determine how quickly the teeth will move and consequently the duration of treatment(3). Several factors exist that can directly or indirectly contribute to the frictional force levels between bracket and arch wire, those are: Arch wire material, ligation of arch wire to bracket including ligation technique and material used; and bracket material(4); reduction in frictional force might be achieved by verifying them(5).

The purpose of this study is to evaluate the values of the frictional coefficients of stainless steel, elastomeric and teflon ligatures fixed on sliding bracket on stainless steel arch wire.

MATERIALS AND METHODS

The sample comprised three groups, each group comprised 10 ligatures. The first group included stainless steel ligature wires (soft 0.010 inch wire diameter). The second group included teflon coated ligature wires (soft 0.012 inch wire diameter) and the third group included elastomeric ligature (1.3 mm inner diameter). The stainless steel arch wire (0.017 X 0.025 inch dimension) tied to the stainless steel standard edgewise brackets of upper right canine (0.022 X 0.030 inch slot dimension). All the experimental materials are products of Dentaurum Company, Isprengen, Germany.

The methods used in this study have been quoted from a previous work on the friction measurement carried out by other researchers(6,7). Four (zero torque– and zero angulations) stainless steel standard edgewise brackets of 0.022 X 0.030– inch slot size were bonded to a rigid metal base plate in a straight line at 8 mm spans (represent the inter bracket space) with a 16 mm space (represent the extraction space) for the movable canine bracket at the center, and their slots oriented to accommodate the sample arch wire piece. The metal base plate is a 25 cm 3 cm dimension plate, prepared to provide a room for the movable bracket (Attached with power arm of 10 mm length) and the suspended load (150 grams) to move freely. The straight part of the ready made arch formed rectangular 0.017 X 0.025–inch size of the three arch wire samples was placed at the slots of the brackets on the metal base plate with its two terminals bended (Figure 1) to prevent slipping of the wire in the brackets slots during the test operation, the arch wire was secured with in the slot by the ligature ties to the fixed brackets.

The measurements of friction between bracket and arch wire were done with the attached apparatus to the universal tensile testing machine.

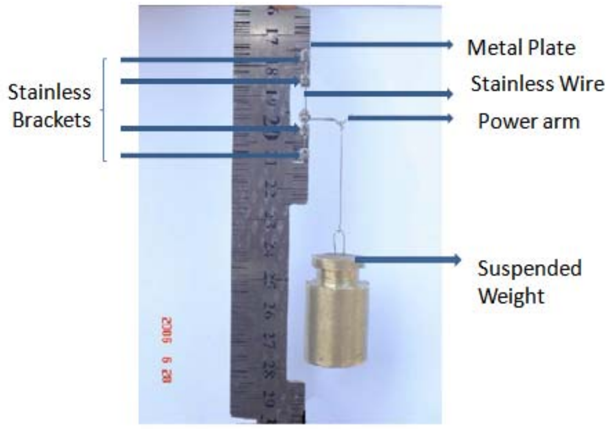

Figure (1): The simulated half arch fixed appliance of metal base plate apparatus.

All tests were conducted under dry conditions at 29° C using a tensile testing machine with the crosshead moving downward at a speed of 0.5 mm/sec.

An equation used by Tidy [6] was applied to calculate the coefficient of friction that include: $\mu = p\,w / 2\,f\,h$ (μ=coefficient of friction, p= friction (load cell readings minus the load suspended from the power arm), w = width of the bracket, f= load suspended from the power arm, and h = length of the power arm (distance from the center of the bracket to the center of resistance of a normal canine tooth root). The statistical analyses included the descriptive (mean, standard deviation, minimum and maximum values), ANOVA and Duncan's Multiple Analysis Range test at $p \leq 0.05$ significant level.

RESULTS

The descriptive statistics (mean, standard deviation, minimum and maximum values) of the static and kinetic frictional coefficients for the groups are demonstrated in Tables (1 and 2).

The analysis of variance (Duncan's test at $p \leq 0.05$ significant level) showed that the frictional coefficient of the combination utilizing the elastomeric ligature was significantly greater ($p \leq 0.05$) as compared with stainless steel and teflon ligature wires for both static and kinetic frictions (Tables: 3 and 4).

Table (1): Descriptive statistics of the coefficient of static friction for the ligature groups.

Bracket	Arch wire	Ligature	Mean	SD	Minimum	Maximum
Stainless Steel	Stainless Steel	Stainless Steel	0.117	0.009	0.105	0.135
		Teflon coated	0.139	0.023	0.097	0.18
		Elastic ligature	0.188	0.014	0.172	0.219

Sample subjects of each group were 10; SD= standard deviation.

Table (2): Duncan's Multiple Analysis Range Test of the static coefficient of friction for the ligature groups.

Bracket	Arch wire	Ligature	Number	Mean	SD	Significance
Stainless Steel	Stainless Steel	Stainless Steel	10	0.117	0.009	A
		Teflon coated	10	0.139	0.023	B
		Elastic ligature	10	0.188	0.014	C

ANOVA test: F=45.912; $p< 0.001$; SD: standard deviation, different letters mean significant difference.

Table (3): Descriptive statistics of the coefficient of kinetic friction for ligature groups.

Bracket	Arch wire	Ligature	Mean	SD	Minimum	Maximum
Stainless Steel	Stainless Steel	Stainless Steel	0.124	0.011	0.111	0.146
		Teflon coated	0.144	0.087	0.033	0.342
		Elastic tie	0.200	0.018	0.18	0.225

Sample subjects of each group were 10; SD= standard deviation.

Table (4): Duncan's Multiple Analysis Range Test for the kinetic coefficient of friction for the ligature groups.

Bracket	Arch wire	Ligature	Number	Mean	SD	Significance
Stainless Steel	Stainless Steel	Stainless Steel	10	0.124	0.011	A
		Teflon coated	10	0.144	0.087	A
		Elastic tie	10	0.200	0.018	B

ANOVA test: F= 5.845; $p< 0.01$; SD: standard deviation; different letters means significant difference.

DISCUSSION

Comparing the effect of the ligature materials on the value of friction with each combinations showed that the elastic ligature demonstrated a significantly greater mean value for both static and kinetic frictional coefficient than that of stainless steel and teflon ligature wires. Concerning elastic ligature, this result has a wide spread agreement in the orthodontic literature discussing the same subject. The majority of the authors agreed that stainless steel ligatures produce less friction than standard elastic ligature[8–11]. The reason behind this controversy is further clarified by that, whether the stainless steel ligature wire is tight or loosely ligature, it will greatly affect frictional resistance. As for loosely tied stainless steel ligature wire, the reasons that make elastic ligatures more friction generator, some of which are: First, is the continuous force exerted on the arch wire by the elastic ligature when stretched over the brackets wings which is very much less for the loosely ligatured stainless steel ligature. Whereas, for tightly ligatured stainless steel ligature wire; the force of ligation will exceed that of the elastic ligature and might reach to complete locking of the arch wire to the bracket; and second is the coefficient of friction between elastic material and stainless steel sliding surfaces is much greater than that between two stainless steel surfaces in contact[10].

The value of the coefficient of both static and kinetic friction generated by teflon coated ligature wire material was found to be the lowest among the three groups of materials used. This result has a reasonable explanation by Von Fraunhofer *et al*.,[12] as they concluded that the low frictions value were the result of the teflon material possessing a lower coefficient of friction than the polyurethane elastomer. Another possible explanation, as they stated, would be that the elastic ligature generates higher force of engagement of the arch wire into the bracket slot, whereas teflon coated ligature wire has the stress relaxing property which made that material.

CONCLUSIONS

It is obvious that elastomeric ligatures have higher sliding resistance (friction) when utilized with stainless steel arch wire and bracket when compared with stainless steel and teflon ligature wires used with stainless steel arch wire and bracket.

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