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ELASTOMERIC LIGATION DESIGNS AND ITS FRICTION DURING ORTHODONTIC TOOTH MOVEMENT

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ABSTRACT:

Objective: The aim of this in-vitro study was to evaluate the friction level of three different elastomerics ligatures vs. Smartclip self-ligating brackets.

Materials & Methods: Three types of different ligations (Conventional elastomeric ligature, Non-conventional elastomeric ligature, Easy-to-tie) were tied to Gemini brackets and the self-ligation of a passive self-ligating bracket. The bracket ligation systems were tested combined with 0.017” x 0.025” straight stainless steel arch-wire.

Results: There was significant difference among all groups ($p< 0.001$). Conventional elastomeric ligature had friction values higher than non-conventional elastomeric ligature, Easy-to-tie & self-ligating bracket. Where it was significantly higher than non-conventional elastomeric ligature & self-ligating bracket ($p<0.001$). The least values of friction were that exerted from self-ligating bracket & non-conventional elastomeric ligature, which were significantly lower than Easy-to-tie & Conventional elastomeric ligature.

Conclusions: conventional elastomeric ligature had the highest friction. Non-conventional elastomeric ligature & Self-ligating bracket exerted almost the same friction. Easy-to-tie showed less friction than conventional elastomeric ligature, although this difference wasn’t significant.

Keywords: Static friction, Elastomeric ligatures, self-ligating brackets.

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INTRODUCTION:

Since the 1960’s it has been a well-known fact that in orthodontics, friction has a great influence about the loss of applied force during sliding [1-3]. Making it a good reason until this day for continuous trials by manufacturers and companies to make new materials with different designs, claiming less friction than that conventionally used. The massive revolution of new materials almost every couple of months made studies evaluating friction in orthodontics never get old.

For a tooth to move, overcoming the friction between bracket & arch-wire interface is required [4-6] which has always been a challenge. Understanding the friction between bracket & arch wire interface is essential to obtain optimal tooth movement & biologic response [4,7] conserving anchorage and preserving the tooth from root resorption [4].

Friction in its classic definition is the force that delays or resists relative motion of objects in contact, when

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surfaces slide against one another several forces arise. One is the frictional force component; the other is the normal force component; which in orthodontics is represented by method of ligation; making it a vital contributing factor in managing friction [8]. Where the frictional force is a tangent to the contacted surfaces, while normal force is perpendicular to the contacted surfaces and the frictional force component.

Extensive researches were devoted to identify causes of friction and how to minimize it. A significant amount of friction appeared to be affected by the appliances physical characteristics and certain biologic variables. The type of ligation used, influence the actual amount of force released by the orthodontic system significantly more than the type of bracket used (stainless steel vs. ceramic) [9]. And so, the quest for efficiency has motivated the progress of numerous materials aimed to reduce friction and provide optimal orthodontic tooth movement.

This study aimed to evaluate the friction released from three different elastomeric ligations with different designs, and comparing it with friction generated from Smartclip self-ligating bracket [SLB].

MATERIALS AND METHODS:

Upper 1st premolar brackets were used for both conventional Gemini brackets [CB] and Smartclip SLB, combined with 0.017” x 0.025” straight stainless steel [SS] arch-wires. CBs were ligated with three different ligatures; Conventional Power ‘O’ tie [CEL], Low friction Non-conventional Slide O-tie [NEL] and Alastik Easy-to-tie [ETT] Table (1).

This *in-vitro* study had four groups (Table 2); Group (1) consisted of CB ligated with CEL (Figure 1), Group (2) was composed of CB with ETT (Figure 2a, 2b), Group (3) had CB combined with NEL (Figure 3a, 3b) and SLB was used in Group (4) (Figure 4).

A custom-made metallic apparatus composed of two parts; a bar to which bracket was attached, and a steel support containing two holes for the wire to pass through and using a simple screw system to fix the wire in place.

An Instron universal testing machine -where the apparatus was attached to- was used to apply the friction test (Figure 5). The test was performed with a crosshead speed of 5 mm/min over a distance of 10 mm. The values of static friction were recorded and then statistically analyzed.

There was a three-minute waiting period after placement of the ligature allowing it to relax before starting each test [4]. Each type of ligation was tested giving a total of 30-readings for each group with new wire and ligature on each trial to minimize the influence of elastic deformation.

Statistical analysis

A non-parametric analysis using Kruskal-Wallis test and Mann-Whitney comparisons was used. The recorded data were statistically analyzed using SPSS, version 20. A *P-value* < 0.05 was considered statistically significant.

RESULTS:

Statistical analysis of the **static coefficient of friction** showed that there were significant differences of friction between all studied groups (Table 3/ Figure 6).

There was significant difference between CEL, ETT, NEL & SLB. Where CEL & ETT were significantly higher than both SLB and NEL. There was an insignificant difference between ETT and CEL. There was insignificant difference between NEL and SLB as well.

DISCUSSION:

Mitchell in 2001 mentioned that the retardation force during sliding mechanics is a result of the dynamic relationship between bracket, wire and ligation types employed into the oral environment [10]. This force level must be kept in consideration in order to obtain the desired tooth movement with preserving the health and vitality of both teeth and supporting periodontal structures [11].

This study agreed with most researchers; as the findings were consistent with Camporesi *et al.* [12], where friction exerted from Slide NEL was significantly lower than that of CEL. This was rationale by the ligation design where NEL's design does not apply force on the wire resembling passive ligation of SLB.

ETT showed lower friction than CEL, although this difference wasn't significant agreeing with Hain *et al.* [13] They also found no significant difference in the friction exerted from CEL and ETT modules, also confirming the results of Natt *et al.* [14] The different design of ETT with the 45° bend & the flat inner cross-section (Figure 7), which believed to drive stresses evenly over the entire inner surface, reducing stress concentration at the inner walls and so reduced friction [15].

Friction generated by both Non-conventional elastomerics and Smartclip self-ligating bracket were insignificantly different, concurring with Franchi *et al.* [9] who concluded that Smartclip self-ligating brackets and Non-conventional elastomerics are valid alternatives for low friction during sliding mechanics. However, Reznikov *et al.* [16] found that in certain clinical situations, a firm passive bracket clip could have a negative effect on the friction, showing that the Slide ligature has superior frictional characteristics compared with Conventional elastomeric & Smartclip.

This in-vitro study proved that the ligation design had a great influence on the frictional resistance. Supporting declarations that friction can be varied by choosing an appropriate ligation type.

CONCLUSION:

- The conventional 'O' tie revealed the highest friction followed by Alastik Easy-to-tie then Slide ligature and self-ligating bracket having the lowest friction.
- Both Slide Non-conventional elastomerics & Smart-clip self-ligating brackets generated almost similar friction, so NELs may represent a valid alternative to passive SLBs.

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TABLES:

Table (1): Elastomeric Ligatures and its manufacturers.

Material	**Company**
Conventional Power ‘O’ tie [CEL]	Ormco, USA
Non-conventional Slide ligature [NEL]	Leone, Italy
Alastik Easy-to-tie [ETT]	3M Unitek, USA
Smartclip self-ligating bracket [SLB]	3M Unitek, USA

Table (2): Groups of this study

Group #	**Details**
1	CB* with CEL**
2	CB with ETT***
3	CB with NEL****
4	Smartclip SLB*****

*__CB:__ Gemini conventional bracket. **__CEL:__ Conventional Elastomeric Ligation; ***__ETT:__ Alastik Easy-to-tie; ****__NEL:__ Non-conventional Elastomeric Ligation; *****__SLB:__ Self-ligating bracket.

Table (3): Comparison of static coefficient of friction between all studied groups.

Static Coefficient of Friction	**Power 'O' tie**	**Easy-to-tie**	**Slide**	**Smart clip SLB**	***P***
Median	2.48	1.96	.275	.17	<0.001*
Minimum	.98	1.12	.08	.04	
Maximum	7.42	6.34	.61	.34	
P1		.159	<0.001*	<0.001*	
P2			.001*	.001*	
P3				.822	

Comparison between all groups was done using Kruskal Wallis test, while comparisons between 2 groups was done using Man Whitney test.

Significant at p < 0.05.

P: comparison between all studied groups.

P1: comparison versus O-tie.

P2: comparison versus Easy-to-tie.

P3: comparison versus Slide Leone.

FIGURES:

Figure (1): Conventional 'O' tie.

Figure (2): Easy-to-tie.

Figure (3): Non-conventional Slide elastomeric **(a)** Frontal view. **(b)** Proximal view.

Figure (4): Smartclip self-ligating bracket.

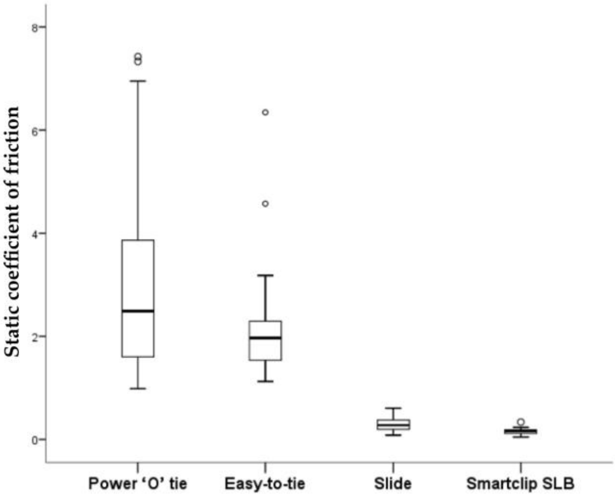

Figure (6): Box plot chart of Static coefficient of friction in all studied groups.

Figure (5): Instron universal testing machine with metallic assembly attached.

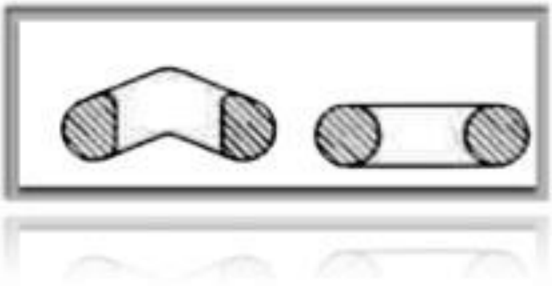

Figure (7): Cross-section of Easy-to-tie vs. CEL.