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RESEARCH ARTICLE

Frictional Characteristics of the Newer Low-friction Elastomeric Ligatures

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ABSTRACT

Aim: The aim of this *in vitro* study was to investigate the efficiency of the new generation of elastomeric ligatures with innovative designs (Slide™ and AlastiK™ Easy-to-Tie) in reducing frictional resistance (FR) during sliding mechanics as compared with conventional ligatures.

Materials and methods: Sixty ligature samples divided into four groups were used for the study. Group A: QuiK-StiK™ (3M Unitek, Monrovia, CA, USA), Group B: AlastiK™ Easy-to-Tie (3M Unitek, Monrovia, CA, USA), Group C: Slide™ (Leone, Firenze, Italy), and Group D: SS ligatures 0.010″ (Libral Traders, New Delhi, India). Universal Testing Machine, Instron was used for measuring FR at the bracket-wire interface.

Results: There was statistically significant difference in FR among all the four groups of ligatures tested ($p < 0.001$). Slide ligatures produced the least amount of FR followed by SS ligatures, Easy-to-Tie, and QuiK-StiK in the increasing order of the FR values registered.

Conclusion: Slide™ ligatures may represent a valid alternative to passive self-ligating brackets when minimal amount of friction is desired. Angulation introduced into the elastomeric ligatures reduces the friction in comparison to conventional elastomeric ligatures.

Keywords: Angulated elastomeric ligatures, Frictional resistance, Low-friction elastomeric ligatures, Slide ligatures.

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INTRODUCTION

Friction is defined as the resistance to motion when one object moves tangentially against another.[1] When sliding mechanics is used in orthodontics, friction occurs at the bracket-wire interface. Some of the applied force is, therefore, dissipated as friction and the remainder is transferred to supporting structures of the tooth to mediate tooth movement. This reduces the effectiveness of the mechanics, decreases tooth movement efficiency, and further complicates anchorage control.[2]

In this context, one of the major goals of the orthodontic manufacturing companies is the search for new products that would generate less friction during sliding mechanics. Over the last two decades, major efforts have been made to develop the so-called low-friction brackets, wires, and ligatures.

Schumacher et al[3] found that friction was determined mostly by the type and force of ligation. Ligation with stainless steel (SS) ties can lead to higher forces, as a range of ligating forces may be used by different operators and ligation forces cannot be precisely controlled.[3] Also, incidents of injury to gingival tissues and to the operator have been reported. Although loose SS ligatures produce less friction compared with elastomeric modules,[4-11] and elastomeric ligatures are subject to permanent deformation with time and they also deteriorate in moist environment as a result of slow hydrolysis, the convenience and speed of application elastomeric rings are likely to ensure their continued popularity among clinicians.

To overcome the disadvantages of the conventional ligation techniques, self-ligating brackets were introduced.[6,12-14] This is a ligature less bracket system with a mechanical device built into the bracket to close off the bracket slot.

Recently, new low-friction ligatures (Slide™, Leone, Firenze, Italy) have been introduced, similar to elastic ligatures, but with an anterior part that is more rigid and similar to the mechanical device of self-ligating brackets. According to the manufacturer, slide is constructed from a special polyurethane mix approved for medical use. Once the ligature is applied on the bracket, it simulates the labial cover of a passive self-ligating bracket, thus transforming the slot into a tube that allows the archwire to slide freely. Elastomeric ligatures designed with a 45° bend (AlastiK™ Easy-to-Tie; 3M Unitek, Monrovia, CA, USA) were also introduced recently. The manufacturer claims that the unique angle shape reduces the range of movement needed for bracket ligation that makes tie-wing hook-up easier and more efficient.

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The aim of this study was to investigate the efficiency of the new generation of elastomeric ligatures with innovative designs (Slide™ and AlastiK™ Easy-to-Tie) in reducing frictional resistance (FR) during sliding mechanics as compared with conventional ligatures.

MATERIALS AND METHODS

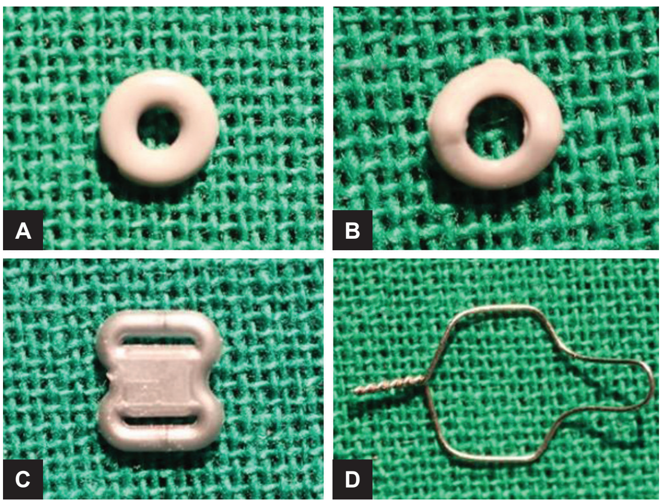
Sixty ligature samples divided into four groups were used for the study (Figs 1A to D). Each group was composed of 15 ligatures as follows:

- Group A (Fig. 1A): QuiK-StiK™ (3M Unitek, Monrovia, CA, USA)
- Group B (Fig. 1B): AlastiK™ Easy-to-Tie (3M Unitek, Monrovia, CA, USA)
- Group C (Fig. 1C): Slide™ (Leone, Firenze, Italy)
- Group D (Fig. 1D): SS ligatures 0.010″ (Libral Traders, New Delhi, India)

Mandibular right central incisor brackets with MBT prescription and 0.022″ slot dimension (Gemini™; 3M Unitek, Monrovia, CA, USA) were used for the study. Straight lengths of 0.019″ × 0.025″ SS wires (Rocky Mountain Orthodontics, Denver, CO, USA) were used for the friction testing. A total of 60 tests were performed. While performing each test new bracket, wire and ligature was used.

Each bracket was mounted on an acrylic block (Fig. 2) using a cyanoacrylate adhesive (Fevi kwik; Pidilite Industries Limited, Mumbai, India). The acrylic blocks were custom made by Matrix Corporation, Govandi, Mumbai. These offered a flat surface onto which brackets could be fixed (Figs 3A to D). Horizontal and vertical laser markings were made on the acrylic blocks to facilitate accurate placement of the brackets.

Universal Testing Machine, Instron (PRAJ Industries, Pune, Maharashtra, India) (Fig. 4) was used for measuring FR at the bracket-wire interface. The Instron consists of two jaws, the upper jaw and the lower jaw. The upper jaw is capable of moving in a vertical direction with the



Figs 1A to D: Ligatures used in the study

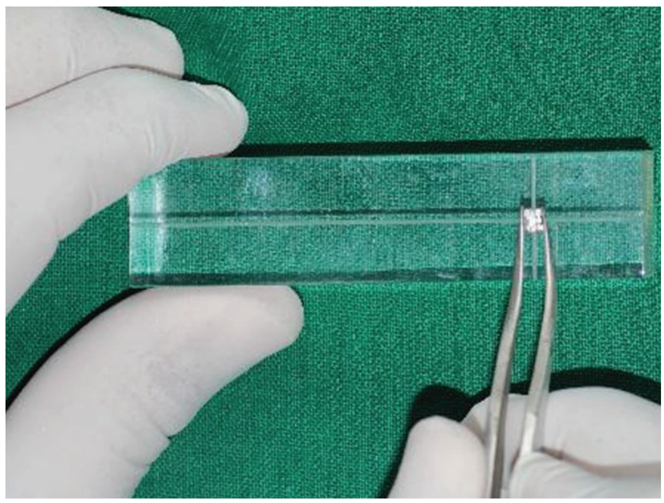
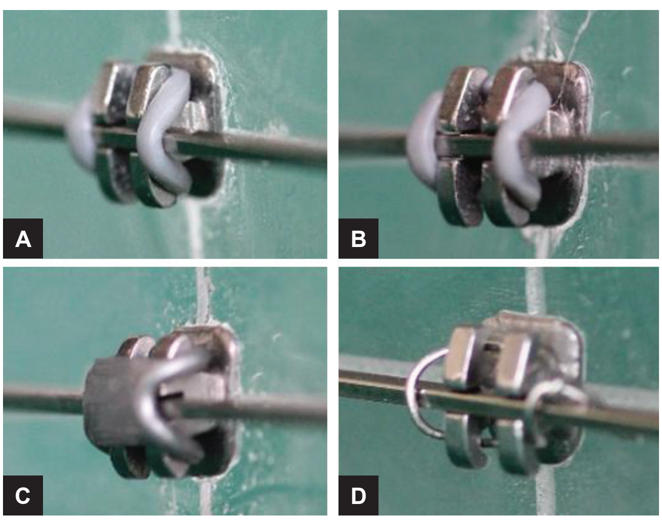


Fig. 2: Fixing of bracket on to acrylic block



Figs 3A to D: Ligatures tied on to the bracket-wire combination: (A) QuiK-StiK™, (B) AlastiK™ Easy-to-Tie, (C) Slide™and (D) SS ligatures

Fig. 4: Universal testing machine, Instron

desired speed or force depending on the study design. In the present study, speed was the criterion used and force was measured. The lower jaw was rendered to be stationary.

The acrylic blocks were attached to the fixed lower jaw of the Instron machine (Fig. 4) ensuring that the bracket slot is perpendicular to the base of the machine. Straight lengths of wire were fixed to the moving arm of the testing machine and then tied to the bracket slot using ligature. The rate of movement was prefixed at 3 mm per minute, and each test was carried out for 1.5 minutes. The peak FR registered was recorded as the static frictional force. A drop of carboxy methyl cellulose based artificial saliva (Wet Mouth; ICPA Health Products Limited) was placed on to the bracket-wire-ligature assembly using a salivary applicator 10 minutes prior to the testing to simulate oral environment (Fig. 5). The force levels needed to move the wire through the bracket slot were registered and transmitted to a computer. Sliding movement was recorded in millimeters (mm), time in minutes and FR in grams.

STATISTICAL ANALYSIS

Data collected were analyzed and presented using descriptive statistics, tables, and charts. Further analysis was done with analysis of variance (ANOVA) followed by Tukey's *post hoc* test. The level of significance was set at 5%. All p values less than 0.05 were treated as significant. All statistical computations were performed using Statistical Package for the Social Sciences (SPSS) software version 20.0.

RESULTS

There was statistically significant difference in FR among all the four groups of ligatures tested ($p < 0.001$) (Table 1). Slide ligatures produced the least amount of FR followed by SS ligatures, Easy-to-Tie, and QuiK-StiK in the increasing order of the FR values registered (Graph 1). On further analysis with Tukey's *post hoc* test, statistically significant differences were found between all the four groups except between Easy-to-Tie and SS ligatures (Table 2).

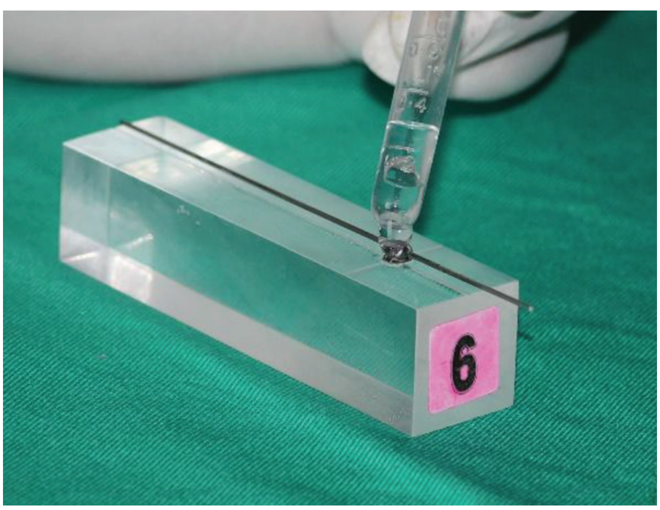
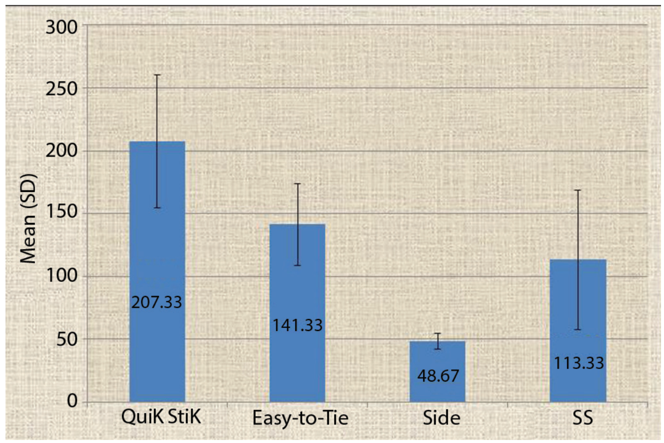


Fig. 5: Application of artificial saliva

Table 1: Comparison of frictional resistance [Mean (SD)] among the groups using one-way ANOVA test

Groups	*No. of samples*	*Frictional resistance Mean (SD)*
QuiK StiK	15	207.33 (53.1)
Easy-to-Tie	15	141.33 (32.5)
Slide	15	48.67 (6.4)
SS	15	113.33 (55.5)
F-value	–	37.096
p-value	–	<0.001**

*p < 0.05: Significant, **p < 0.001: Highly significant



Graph 1: Frictional resistance (gm) registered by the four types of ligatures tested

Table 2: *Post hoc* analysis (multiple comparisons)

Dependent Variable: FR Tukey HSD					*95% confidence interval*	
(I) Group		*Mean difference (I–J)*	*Std. error*	*Sig*	*Lower bound*	*Upper bound*
QuiK StiK	Easy-to-Tie	66.000*	15.273	0.000	25.56	106.44
	Slide	158.667*	15.273	0.000	118.23	199.11
	SS	94.000*	15.273	0.000	53.56	134.44
Easy-to-Tie	QuiK StiK	–66.000*	15.273	0.000	–106.44	–25.56
	Slide	92.667*	15.273	0.000	52.23	133.11
	SS	28.000	15.273	0.269	–12.44	68.44
Slide	QuiK StiK	–158.667*	15.273	0.000	–199.11	–118.23
	Easy-to-Tie	–92.667*	15.273	0.000	–133.11	–52.23
	SS	–64.667*	15.273	0.000	–105.11	–24.23
SS	QuiK StiK	–94.000*	15.273	0.000	–134.44	–53.56
	Easy-to-Tie	–28.000	15.273	0.269	–68.44	12.44
	Slide	64.667*	15.273	0.000	24.23	105.11

*The mean difference is significant at the 0.05 level

DISCUSSION

When sliding mechanics is used, friction occurs at the bracket-wire interface. Some of the applied force is, therefore, dissipated as friction and the remainder is transferred to supporting structures of the tooth to mediate tooth movement. Therefore, maximum biological tissue response occurs only when the applied force is of sufficient magnitude to adequately overcome friction and yet be within the optimal range of force necessary for effecting movement of the tooth.

Thus, the clinical advantage of reduced resistance to sliding should translate to reduction in the amount of time to move teeth.[1] Studies involving comparative assessment of frictional force values generated while using new ligatures elicit important data that link didactic research with clinical applicability within the limits of *in vitro* models. In the present study, carboxy methyl cellulose based artificial saliva was used to simulate oral conditions. Leal et al[15] suggested that mucin and carboxy methyl cellulose based artificial saliva provides a reliable alternative to human natural saliva.

The variations in the experimental methods used in different studies in the literature make it difficult to compare our results with that of other studies of this type. However, some similarities in the findings were observed.

Slide™ ligatures showed levels of friction that were significantly lower than all the other three groups tested. This was in agreement with the findings of Baccetti and Franchi,[16] Tecco et al,[17] and Sivaraj.[18] One of the most favorable features of the Slide™ ligatures is the possibility of turning any type of existing conventional bracket system into a ''low-friction'' bracket system. Furthermore, these innovative ligatures can be applied on specific groups of teeth wherein lower levels of friction are desired.

Pairwise comparison revealed that the 45° angulated AlastiK™ Easy-to-Tie produced lower FR values than conventional elastomeric ligatures (QuiK-StiK™). SS ligatures generated lower FR values than AlastiK™ Easy-to-Tie ligatures. However, the difference was statistically not significant, implying that both SS ligatures and AlastiK™ Easy-to-Tie were equally efficient in reducing FR when compared with conventional elastomeric ligatures. These results concur with the findings of Arun and Vaz.[19]

CONCLUSION

- Among the different types of elastomeric ligatures compared in this study, Slide™ ligatures produced the least friction, followed by 45° angulated AlastiK™ Easy-to-Tie elastomers.
- Due to the special design, Slide™ ligatures may represent a valid alternative to passive self-ligating brackets when minimal amount of friction is desired.
- Angulation introduced into the elastomeric ligatures reduces the friction in comparison to conventional elastomeric ligatures.

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