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Evaluation of frictional resistance between Metal bracket and a self ligating bracket using 19 x 25 inch Stainless Steel wire - An In Vitro study

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ABSTRACT

Aims & objectives - The aim of this study was to evaluate and compare the frictional resistance between a metal bracket (MBT 0.022''prescription) and a self ligating bracket.

Materials & methods - A 0.019" x 0.025'' straight length stainless steel archwire (Ortho organizer, USA) was used. All tests were conducted in dry condition on Universal Testing machine. The sample tested in the study were grouped as follows: Group I – Self ligating brackets, smart clip (3M Unitek), Group II – Stainless steel Ligature wire (Dentsply).

Results - Results has revealed that the lowest value of kinetic friction was in group 2 i.e. in the stainless steel ligature wire . The value was 0.094 ± 0.046. The results were compared with student 't' test for pair wise comparison. Mean, standard deviation and error was calculated.

Conclusion - It can be concluded that Stainless steel ligature wire is the best choice when 0.019 x 0.025 inch rectangular wire is used.

Key words – Friction, ligation, self ligating brackets

INTRODUCTION

Friction is defined as "the force tangential to the common boundary of two bodies in contact that resist the motion of one relative to the other." The amount of friction generated is proportional to the force with which the two surfaces are pressed together and upon the nature of the surfaces in contact.[1] The earliest recorded experiments on friction were carried out by the versatile genius Leonardo da vinci approximately 450 years ago. Friction is the biggest energy annihilator of this world, approximately 70% of all energy gets lost due to friction.[2] The subject of friction in orthodontic treatment mechanics has attracted considerable attention in recent years. Appliance manufacturers have battled over which bracket or system has the least friction. Treatment principles & modalities have been developed to account for the effects of friction on tooth movement & biological responses.[3]

In orthodontics, the motive force for moving teeth is generated by the archwire and for proper transmission of the force with the bracket, it is necessary to hold it securely in the bracket slot. Therefore, the method of ligation is an important factor that contributes to the frictional force generated between bracket and the archwire interface.[4]

Stainless Steel (SS) ligatures have been the time-tested method of ligation and are widely used. Loosely tied stainless steel ligatures are thought to produce less friction than standard elastomeric ligatures.[5] The term **self-ligation** in orthodontics implies that the orthodontic bracket has the ability to engage itself to the archwire and is, therefore, assumed to reduce friction by eliminating the ligation force.[6] Shivapuja & Berger[7] found that self ligating brackets generated less friction than conventional brackets. Voudouris et al[8] observed that self-ligating brackets, both with passive and active labial arms, produced less friction than conventional brackets in association with steel ligatures. Readward et al,[9] however, observed that self-ligating brackets has produced less friction only under certain conditions. Therefore, this study will be conducted to compare a frictional resistance between metal bracket with stainless steel ligature wire & a self- ligating bracket.

AIMS & OBJECTIVES

The aim of this study was to evaluate and compare the frictional resistance between a metal bracket (MBT 0.022''prescription) with stainless steel ligature wire and a self ligating bracket (0.022'' slot) using 0.019 x 0.025" inch stainless steel wire in dry condition.

MATERIAL & METHOD

A 0.019" x 0.025'' straight length stainless steel archwires (Ortho organizer, USA) was used. Brackets used were preadjusted edgewise conventional metal bracket (MBT prescription 0.022'' slot, Gemini series, 3M Unitek) and Self ligating bracket (MBT prescription 0.022'' slot, Smart clip, 3M Unitek). The brackets incorporated in the study were taken from a standard company to ensure the quality of tip, torque, good surface and slot texture and good quality of stainless steel grade. The brackets used in the study were of same manufacturer.

TEST GROUPS –

1. Group I – Self ligating brackets, smart clip, 3M Unitek
2. Group II – Stainless steel Ligature wire, Dentsply

PREPARATION OF SAMPLE FOR TESTING

The evaluation of friction between the brackets and the archwire was carried out as per the test protocol described by Tidy[10]. It consisted of a simulated half arch fixed appliance with archwire ligated in position. SS wire (19 x 25'') was engaged in the bracket slot before the brackets were bonded onto a sheet so that no torque will be incorporated into system. Now these Four edgewise brackets having slot dimensions of .022 x .028" with zero torque and zero angulations were bonded onto a rigid Perspex sheet at 8mm intervals. A space of 16mm was left at the center for sliding the canine bracket to simulate canine retraction. Twenty two sets of acrylic Perspex sheet were made. Eleven sheets was used for conventional metal brackets and other eleven was used for self ligating brackets. For stabilizing the bracket on the sheet, commercially available cyanoacrylate adhesive (Fevi Kwik, Pidilite Industrial Ltd, Mumbai, India) was used.

The movable canine bracket was soldered with a 10mm power arm from which weights of 100gm was hung to represent the single equivalent force acting at the centre of resistance of the tooth root. The length of the power arm was chosen to represent the distance from the slot to the center of resistance of the typical canine bracket.

TESTING OF SAMPLES

All tests were conducted in dry condition on Universal Testing machine (UTM) (Tinius Olsen) whose capacity is 5kgN with an accuracy of ±1% (Fig.1). The movable bracket was suspended from the load cell of the testing machine while the Perspex sheet was mounted on the cross head below. The full-scale load was set at 100gm with a crosshead speed of 5mm/minute to a distance of not less than 2.5mm. The computer connected to the testing machine displayed a graph showing peak force variation. All measurements were performed under dry conditions at room temperature of 20° ± 2°C. After placing Stainless steel ligature (0.010 inch) at the bracket tie wings, they were pulled tightly and twisted to the point at which the pigtail began to double back on itself. Consequently the pigtail was cut & bent under the archwire.[11]

11 test readings were taken at each group of ligature ties immediately after placement. The readings were recorded from the monitor of the testing machine. The load cell reading represented the clinical force of retraction that would be applied to the tooth, part of which would be lost in friction, while the remainder would be transmitted to the tooth root. All readings were recorded in Newton's and then converted into grams (1 N = 101.9gm)

Fig: 1- Jig's placement in UTM

Thus, the difference between the load cell reading and the load power arm (100gm) represented friction (P). The coefficient of friction of the archwire – bracket interface can be calculated by the formula:

$$P = \frac{2Fh\mu}{W}$$

Where,
P = Frictional resistance
F = Equivalent force acting at a distance i.e. 100gm
W = Bracket slot width
h= 10mm
μ = Coefficient of friction

RESULTS

Results has revealed that the lowest value of kinetic friction was in group 2 i.e. in the stainless steel ligature wire (0.094± 0.046). Self ligating brackets shows more frictional resistance (0.121± 0.046) compared to stainless steel ligature wire (Table 1). However there is no statistically significant difference between the frictional resistance of these two groups as $p > 0.05$ (Table 2).

TABLE 1:- Calculation of mean, standard deviation, standard error for each group

Type of Ligature	N	Mean	Std. Deviation	Median	Std. Error	95% Confidence Interval for Mean	
						Lower Bound	**Upper Bound**
Self Ligating bracket/ Group 1	11	0.121	0.046	0.118	0.009	0.120	0.158
Ligature wire/ Group 2	11	0.094	0.046	0.078	0.008	0.223	0.257

TABLE-: 2 Comparison of self ligating brackets and SS ligature wire using student t-test

*unpaired 'T' test

Types of ligature	N	Mean	Std. Deviation	t	Df	'p' value*
Self Ligating Bracket	11	0.121	0.046	1.392	20	0.179
SS Ligature Wire	11	0.094	0.046			

DISCUSSION

From a clinical perspective, the aim is to keep the frictional forces as low as possible and ideally to eliminate them altogether. Frictional resistance is one of the critical factors that determine the efficiency of orthodontic tooth movement, especially when sliding mechanics are adopted. In sliding mechanics, an archwire that is slightly smaller than the slot width is inserted into the bracket slot. All the applied retraction force will contribute to the tooth movement if no friction exists. However, this situation does not occur in clinical application because some force by the ligation will hinder the movement of the archwire. [12]

Space closure is usually undertaken on Stainless steel and possibly Titanium molybdenum alloy (TMA) wire. It is generally accepted that space should not be closed on NiTi wire, as it has low stiffness and hence this wire type was not included in this investigation.[12] The 19 X 25- in stainless steel archwire was chosen in conjuction with a 0.022" metal bracket slot because this gives good overbite and torque control while allowing free sliding in the buccal segment.[13]

Self ligating brackets – The findings of the present investigation are contrary to the perception that stainless steel self ligating brackets generate lower frictional resistance than conventional Stainless steel brackets (Sims et al) [14] . In this study self ligating brackets showed no significant difference with conventional ligature wire; however ligature wire

showed least frictional resistance when using 19 x 25'' stainless steel wire. The 19 x 25'' stainless steel wire with slot of 0.022'' produced an increased friction even in self ligating brackets, as the bracket slot is filled, the difference between self ligating and conventional brackets are minimized. This is related to less tipping allowed before teeth are straightened back by the wire resilience. This cycle occurs at a faster rate with more slot play.[6] It is not proved that with large rectangular wires, in the presence of tipping and /or torque and in arches with considerable malocclusion, self ligating brackets produce lower friction compared with conventional brackets. This study corroborates the study by Ehsani et al[6] that friction of both self-ligating and conventional brackets increased as the archwire size increased. Similar result have been obtained by Tecco et al.[15]

Stainless steel ligature wire – Results of this study suggests that the lowest amount of friction is seen when using stainless steel ligature wire in conjuction with metal bracket and rectangular stainless steel archwire. Khambay et al [12] investigated the archwire seating force of different ligation methods and concluded that stainless steel ligature wire produced the lowest mean frictional forces. Thus, the self-ligating brackets did not appear to have any advantages when larger rectangular archwires were used.[15]

CONCLUSIONS

From the results of the present study following conclusions can be drawn:

1. The lowest amount of coefficient of kinetic friction was seen in SS ligature wire using 19 x 25'' SS wire.
2. There was statistically no significant difference found between the coefficient of kinetic friction of self ligating brackets and SS ligature wire.

It can be concluded that Stainless steel ligature wire is the best choice when larger size of rectangular wires is used.

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