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Comparison Of Frictional Resistance Between Interactive Self Ligating, Passive Self Ligating And Conventional Orthodontic Brackets - An In Vitro Study

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Abstract: *Aim: to analyze the frictional forces generated by three types of self ligating brackets ; two passive (Damon 3MX and Smartclip) and one interactive (Empower) when compared to conventional orthodontic brackets using two arch wire dimensions 0.016 NiTi wire and 0.019X0.025 inch stainless steel wire. Materials: The study consisted of a total of 60 brackets, 15 each of Damon 3MX, Smartclip, Empower and conventional orthodontic brackets with a slot size of .022X.028. Result: Self ligating brackets had less friction when compared with conventional brackets with both round and rectangular wires.Among the passive self ligating brackets, Damon 3MX shows the least friction when tested both with round and rectangular wires when compared to Smartclip. The frictional resistance does not remain the same when tested both with round and rectangular wires, for the interactive self ligating bracket (Empower). All brackets showed higher frictional forces as the wire size increased.*
Keywords: *conventional stainless steel brackets, fixed appliance therapy, frictional resistance, passive self ligating brackets, self ligating brackets.*

I. Introduction

The speciality of orthodontics has been going through a period of considerable research interest in the role of friction during tooth movement. During the past thirty years, studies have focused on both the contact between the wire and the bracket- or tube-slot as a potential source of frictional resistance during sliding mechanics and the many associated factors that can affect that resistance to tooth movement. Previous experiments have identified variables in the archwire, bracket, ligature and oral environment as contributors to frictional forces.

In the orthodontic literature, friction was discussed as early as 1960 when Stoner[1] warned of the difficulty in determining the amount of force to be applied to a tooth because of the role of frictional resistance. Understanding of friction impairing tooth movement is largely based on long-standing theories, by Leonardo Da Vinci, Guillaume Amontons, and Charles-Augustin Coulomb.

Friction is the resistance to motion that occurs when an object moves tangentially against other.[2] During fixed appliance therapy, the main force that contrasts the tooth movement is the frictional force developed between the interface of the bracket slot and arch wire.[3]

The total contact-force between the objects is expressed as two components when there is attempted or actual relative displacement between surfaces in contact. One component, the normal force, is a pushing force with an orientation perpendicular to the shared contact-surface. The frictional force component impedes the motion between the surfaces and is, therefore, opposite in direction to that of intended or actual motion.[4]

A series of method have been proposed with the aim of limiting friction at the bracket/wire/ligature interface, such as loosely tied stainless steel ligatures, self ligating brackets (SLB), and unconventional ligature systems. The disadvantages of conventional ligating system include high friction, force decay, potential impediment to oral hygeiene and time consuming among others. To overcome these disadvantages self ligating brackets were introduced.

Self ligating brackets (SLB) are ligature-less bracket systems that have a mechanical device built into the bracket to close the edgewise slot. [5] Thus, self-ligating brackets have an inbuilt metal labial face which can be opened or closed.[6] Classification of self ligating brackets includes those that have a spring clip that presses against the archwire (''active'' or ''interactive'' Self ligating brackets) and those in which the self-ligating clip does not press against the archwire (''passive'' self ligating brackets). Passive Self ligating brackets have consistently shown a smaller amount of friction than active self ligating brackets, with the exception of the use of undersized round archwires.[7,8]

Self-ligation was initially described by Stolzenberg in 1935.[9] The first self-ligation bracket was called the Russell-Lock edgewise attachment. Self-ligation lost its popularity until the 1970s when Ormco introduced the Edgelock. It wasn't until the 1980s that self-ligation gained widespread use with the introduction of Forsadent and SPEED in 1980. [9,10]

The newly introduced so called interactive self ligating brackets combine the advantages of passive and active self ligating brackets. They can lock (passive) and seat (active) the arch wires into the base of the slot with low functional friction so as to fully express the prescription.[11,12] During space closure the anteriors can be made active for proper torque control and posteriors are passive to allow for reduced friction. Ease of opening , maximum retention, accurately contoured pads , low profile particularly in anteriors, reduced treatment time , reduced chair side time are some of the other advantages of interactive self ligating brackets . Very little research has been done using these brackets.

The aim of this invitro study was to analyze the frictional forces generated by three types of self ligating brackets ; two passive and one interactive when compared to conventional orthodontic brackets using two arch wire dimensions.

II. Headings

1. INTRODUCTION
2. AIM AND OBJECTIVES
3. MATERIALS AND METHODS
4. RESULTS
5. CONCLUSION
6. ACKNOWLEDGEMENTS
7. BIBLIOGRAPHY

III. Aim And Objectives

To evaluate the frictional resistance of two types of passive self ligating brackets, one type of interactive self ligating bracket and conventional orthodontic brackets.
To compare the frictional resistance between the four groups.

IV. Materials And Method

Four different brackets were used for the study: Conventional orthodontic brackets (American Orthodontics), Empower (American orthodontics), Smart clip (3m), Damon 3MX (Ormco). The two different types of arch wires used for the study were: 0.016 NiTi (American Orthodontics) and 0.019x0.025 SS (American Orthodontics). Sixty arch wire segments, with a .019 x .025 inch stainless steel and 0.016 NiTi were used. 0.016 NiTi wire was used since they are used during alignment stage and 0.019 X 0.025 SS wires were used since they are used during retraction stage Arch wire were ligated to the conventional bracket slot with stainless steel ligatures tightly and then unwound a quarter turn[13,14].

Methodology

A prefabricated commercial 4 inch x 2 inch acrylic plate was used. At one end of the plate a horizontal and vertical line was drawn, the point of intersection of these two lines was taken as a point of bracket placement. The brackets were placed in this point and then stabilized by means of an industrial adhesive.

Instron testing machine was used with 10 kg load cell to determine the frictional force levels. The machine was adjusted in the tensile mode and the force levels were measured in kilograms in a digital read out. The Instron testing machine not only measured the kilogram of tensile force required to pull the wire through fixed bracket but also gave the tracking distance as a digital read out in lengths of millimeter as the cross head travelled superiorly up the wire.

A wire of about 10mm length was taken and placed in the bracket and ligated. The other end of acrylic plate was mounted on to the lower grip of Instron testing machine. The free end of the arch wire was fixed to the upper grip of Instron testing machine which was connected to the load cell. It is cleaned with 95% alcohol and air dried[15] to maintain asepsis and moisture control.

Each wire was pulled through the bracket slot by a distance of 10mm at a speed of 5mm per min[16], the force levels were recorded from the digital marker. The arch wire and bracket were tested such that a new bracket was used for every test and then discarded. This was done in order to eliminate dimensional changes. All the tests were done in dry conditions. Frictional resistance was evaluated in dry states against 0.019 x 0.025 inch rectangular stainless steel arch wire and 0.016 inch round NiTi arch wire and the results were tabulated.

V. Results

Table I

Oneway

DESCRIPTIVES

FRICTIONAL RESISTANCE OF 0.016 NITI WIRE

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Smartclip	15	140.027	2.6604	.6869	138.553	141.500	134.3	144.1
Conventional	15	140.353	2.6373	.6810	138.893	141.814	132.3	142.9
Empower	15	132.020	2.6154	.6753	130.572	133.468	128.5	139.4
Damon 3mx	15	131.800	3.0613	.7904	130.105	133.495	127.6	140.8
Total	60	136.050	4.9625	.6407	134.768	137.332	127.6	144.1

Table I shows mean and standard deviation for 0.016 NiTi wire

Table II

ANOVA

FRICTIONAL RESISTANCE OF 0.016 NiTi WIRE

	Sum of squares	Df	Mean square	F	Sig
Between Groups	1029.539	3	343.180	45.387	.000
Within Groups	423.431	56	7.561		
Total	1452.970	59			

Table II shows comparison between groups is statistically significant

Table III

Post Hoc Tests Multiple Comparisons

Dependent Variable: FRICTIONAL RESISTANCE OF 0.016 NiTi WIRE Turkey HSD

(I)BRACKETS	(J)BRACKETS	Mean Difference (I-J)	Std . Error	Sig	95% Confidence Interval	
					Lower Bound	Upper Bound
SMARTCLIP	CONVENTIONAL	-.3267	1.0041	.988	-2.985	2.332
	EMPOWER	8.0067*	1.0041	.000	5.348	10.665
	DAMON 3MX	8.2267*	1.0041	.000	5.568	10.885
CONVENTIONAL	SMARTCLIP	.3267	1.0041	.988	-2.332	2.985
	EMPOWER	8.3333*	1.0041	.000	5.675	10.992
	DAMON 3MX	8.3333*	1.0041	.000	5.895	11.212
EMPOWER	SMARTCLIP	-8.0067*	1.0041	.000	-10.665	-5.348
	CONVENTIONAL	-8.3333*	1.0041	.000	-10.992	-5.675
	DAMON 3MX	.2200*	1.0041	.996	-2.439	2.879
DAMON 3MX	SMARTCLIP	-8.2267*	1.0041	.000	-10.885	-5.568
	CONVENTIONAL	-8.5533*	1.0041	.000	-11.212	-5.895
	EMPOWER	-.2200	1.0041	.996	-2.879	2.439

*The mean difference is significant at the .05 level

Table III multiple comparison shows the comparison between Conventional brackets and Smartclip and Empower and Damon 3MX are not statistically significant

Table IV

Oneway Descriptives

FRICTIONAL RESISTANCE OF 0.019 X 0.025 SS WIRE

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Conventional Brackets	15	385.507	3.2890	.8492	383.685	387.328	379.8	391.0
Smartclip	15	372.247	6.1331	1.5836	368.850	375.643	361.1	382.5
Empower	15	383.513	3.4155	.8819	381.622	385.405	376.8	391.4
Damon 3mx	15	319.353	8.3158	2.1471	314.748	323.958	301.8	334.6
Total	60	365.155	27.7089	3.5722	357.997	372.313	301.8	391.4

Table IV shows mean and standard deviation for 0.019 x 0.025 SS wire

Table V
ANOVA
FRICTIONAL RESISTANCE OF 0.019 x 0.025 SS WIRE

	Sum of squares	Df	Mean square	F	Sig
Between Groups	43489.547	3	14496.516	448.630	.000
Within Groups	1809.521	56	32.313		
Total	45299.068	59			

Table V shows comparison between groups is statistically significant

Table VI

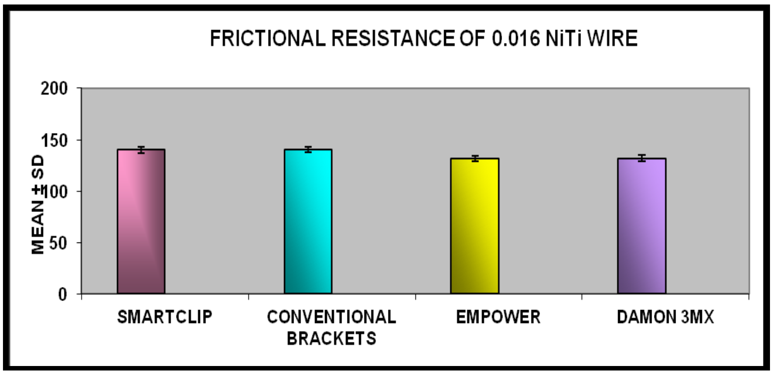
Post Hoc Tests

Multiple Comparisons
Dependent Variable : FRICTIONAL RESISTANCE OF 0.019 X 0.025 SS WIRE
Turkey HSD

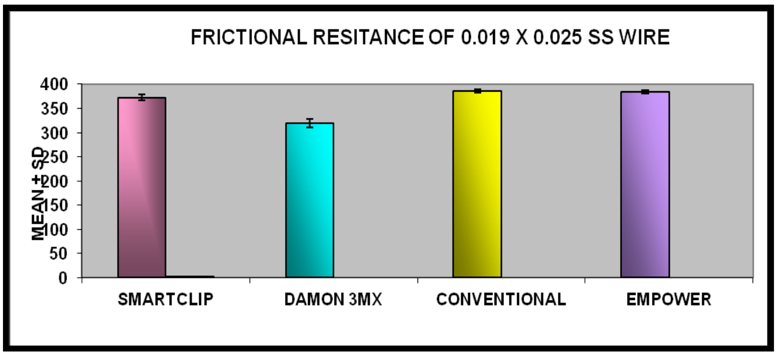
(I)BRACKETS	(J)BRACKETS	Mean Difference (I-J)	Std. Error	Sig	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
SMARTCLIP	DAMON 3MX	52.8933*	2.0757	.000	47.397	58.389
	CONVENTIONAL	-13.2600*	2.0757	.000	-18.756	-7.764
	EMPOWER	-11.2667*	2.0757	.000	- 16.763	-5.771
DAMON 3MX	SMARTCLIP	-52.8933*	2.0757	.000	-58.389	-47.397
	CONVENTIONAL	-66.1533*	2.0757	.000	-71.649	-60.657
	EMPOWER	-64.1600*	2.0757	.000	-69.656	-58.664
CONVENTIONAL	SMARTCLIP	-13.2600*	2.0757	.000	-10.665	18.756
	DAMON 3MX	66.1533*	2.0757	.000	60.657	71.649
	EMPOWER	1.9933*	2.0757	.772	-3.503	7.489
EMPOWER	SMARTCLIP	-11.2667*	2.0757	.000	5.771	16.763
	DAMON 3MX	64.1600*	2.0757	.000	58.664	69.656
	CONVENTIONAL	-1.993	2.0757	.772	-7.489	3.503

*The mean difference is significant at the .05 level

Table VI multiple comparison shows except the comparison between Empower and conventional all other comparisons are statistically significant.



GRAPH-1



GRAPH-2

VI. Conclusion

Friction at the bracket-wire interface prevent the attainment of optimal force levels in the supporting tissues and thereby decrease the tooth movement and increases the anchorage strain. Therefore, a decrease in frictional resistance tends to benefit the hard and soft tissue response. Self ligating brackets are introduced to the dentistry with the advantage of having reduced frictional resistance compared to conventional brackets.

The purpose of this in vitro study was to analyze the frictional forces generated by three types of self ligating brackets ; two passive (Damon 3MX and Smartclip) and one interactive (Empower) when compared to conventional orthodontic brackets using two arch wire dimensions 0.016 NiTi wire and 0.019X0.025 inch stainless steel wire. The study consisted of a total of 60 brackets, 15 each of Damon 3MX, Smartclip, Empower and conventional orthodontic brackets with a slot size of .022X.028.

The frictional resistance of different groups in ascending order with 0.016 NiTi wire was Damon 3MX, Empower, Smartclip and conventional stainless steel brackets and with 0.019 x 0.025 inch SS wire was Damon 3MX, Smartclip, Empower and conventional stainless steel brackets.

The results of our study is as follows that

1) Self ligating brackets had less friction when compared with conventional brackets with both round and rectangular wires.
2) Among the passive self ligating brackets, Damon 3MX shows the least friction when tested both with round and rectangular wires when compared to Smartclip.
3) The frictional resistance does not remain the same when tested both with round and rectangular wires, for the interactive self ligating bracket (Empower).
4) All brackets showed higher frictional forces as the wire size increased.

Data suggest that sliding mechanics are best executed with self ligating brackets than conventional brackets. Moreover these data reveal the usefulness of interactive self ligating brackets when used in anterior teeth during retraction and finishing stages where some amount of friction is desirable.

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