IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 16, Issue 7 Ver. IX (July. 2017), PP 93-97
www.iosrjournals.org

In-Vitro Evaluation of Frictional Resistance of three Different Aesthetic Self Ligating Brackets Using two Archwire Alloys

*Ravi Ranjan[1],Devaki Vijaya Lakshmi R[2], Srinivasan B[3], Nagachandran K S[4],Catherine Sunitha[5]
[1,2,3,4,5]*(Department of Orthodontics, Meenakshi University, India)*
*Corresponding author: *Ravi Ranjan*

Abstract: *Aim: To estimate and compare the frictional forces engendered by three types of aestheticself-ligating brackets with two straight wire alloys. Materials: The study comprised of a total of 90 brackets, of which 30 passive (Damon clear 2),30 active(GAC In-Ovation C) and 30 interactive (Empower clear) orthodontic brackets with a slot size of .022X.028 MBT prescription in combination with stainless steel(SS) and Titanium molybdenum alloy(TMA) wires of dimension 0.019X0.025inch.Frictional resistance was evaluated using Instron Universal testing machine and the results were tabulated.Results: passive aesthetic self-ligating brackets had least amount of friction when equated with active and interactive aesthetic self-ligating brackets with the use of either SS and TMA straight wires.Conclusion: The frictional resistance did not remain the same when tested with both the different types of rectangular straight wire alloys.All brackets showed higher frictional resistance when TMA rectangular straight wire alloy was used.*

Keywords: *Aesthetic self-ligating brackets, Frictional resistance,Stainless Steel and TMA alloy wires.*

I. Introduction

Orthodontists have always been fascinated by the concept of friction and have constantly attempted to tame it. Frictional force in orthodontics is multivariate, dependent on mechanical or biological factors. Mechanical factors include bracket/wire alloy material, cross section, surface texture stiffness and methods of ligation. Physical factors include presence of intraoral plaque, calculus, type of saliva and microbial flora[1]. Friction is a force that reduces or resists the relative motion of two surfaces in contact[2,3]. History revealed that Da vinci's frictional concept was remodeled by Amontons and later in 1785, Charles Augustin coulomb developed the concept further.There are two phases of frictional resistance encountered by a body, i.e (i) static, (ii) kinetic friction. In 1883, Morin introduced Static friction. It is a force needed to instigate motion from rest. Later in 1886 Reynolds added kinetic friction which plays its role while a body is experiencing motion[4].

Kusy and Whitley classified friction into three major types; Classical friction which is caused by conventional ligation, Bindingcaused by deformation of the archwire (Frank and Nikolai 1980) and Notchingcaused by excessive deformation of the archwire(Hansen1998) resulting in interlocking of archwire and brackets[5].Max Hain et al concluded that conventional method of ligation leads to high frictional resistance. Self- Ligating Brackets (SLB) came into popularity to sort out the limitations encountered with conventional ligation techniques[6]. In 1935, the first self- ligating bracket named the Russel lock appliance was developed[7]. Self-ligating brackets are categorized as passive, active or interactive depending on the compression level of the spring clip assembly expressed upon the wire[8].

Dwight H Damon developed passive self-ligating bracket which has a movable labial passive slide that creates a hollow tube inside the bracket during closure.Passive self-ligation bracket design lack adequate tip, torque and rotational control which was overcome by development of active self-ligation system [9,10].

In 1975, Hanson developed the active self-ligating bracket namely Speed, which consisted a stainless-steel spring, later upgraded to Niti flexible spring, that exert pressure over the archwire in the slot, allowing a constant activation upon thicker wires. Active appliances have a spring clip that functions as the fourth wall of the bracket slot which makes positive contact with the archwire[11]. Interactive self-ligating brackets are amalgamated version of active and passiveself-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[12]. At final phase of treatment while space closure the posteriors are subjected to be passive for reduced friction where as anteriors are active for adequate torque expression and also anterior brackets have a low-profile design.Recently more adolescents and adults seek orthodontic treatment for improved smile not only at the end of the treatment but also during treatment prefer commercially available aestheticself-ligating bracket systems[13].

Hence, thisin-vitro study was designed to estimate the frictional resistance between Passive, Active, and Interactive aesthetic self-ligating brackets in conjugation with stainless steel (SS) and Titanium Molybdenum Alloy (TMA) straight wire alloys.

Headings

1. Introduction
2. Aims and objectives
3. Materials and methods
4. Results
5. Conclusion
6. Bibliography

I. Aims and Objectives

To estimate and evaluate the frictional resistance of passive, active and interactive aesthetic self-ligating brackets in combination with stainless steel and TMA straight wire alloys.

II. Materials and Methods

A total of 90 aesthetic self-ligating brackets were divided into three groups (Table 1) with 30 samples in each group. Further stainless steel and TMA straight length alloys (Table 2) were used in all the three groups to evaluate the frictional resistance between the bracket-wire combinations (Table 3).

Table 1: Brackets used in the study

Bracket Type	**Material**	**Slot size and**	**Samplesize (Total = 90)**	**Manufacturer**
GROUP I Passive	Poly Crystalline Alumina	0.022”×0.028” MBT	30	Damon clear 2, Ormco
GROUP II Active	Poly crystalline Alumina	0.022”×0.028” MBT	30	GAC In-ovation C, Dentsply
GROUP III Interactive	Poly crystalline Alumina	0.022”×0.028” MBT	30	Empower, American orthodontics

Table 2: Wire alloy sub groups

Subgroups	**Alloy**	Wire dimension	**Samplesize**	**Manufacturer**
Sub group A	Stainless steel	0.019”×0.025”	45	G&H Orthodontics
Sub group B	TMA	0.019”×0.025”	45	Ormco

Table 3: Bracket -wire alloy combination groups

Groups	Sample size	Bracket-wire combination
IA	15	Passive aesthetic SLB with SS straight wire alloys
IB	15	Passive aestheticSLB with TMA straight wire alloys
IIA	15	Active aesthetic SLB with SS straight wire alloys
IIB	15	Active aesthetic SLB with TMA straight wire alloys
IIIA	15	Interactive aesthetic SLB with SS straight wire alloys
IIIB	15	Interactive aesthetic SLB with TMA straight wire alloys

Test Specimen Fabrication: -

The frictional resistance test was conducted according to the protocol given by Tidy[14]. For each bracket type sample, individual rigid rectangular acrylic plastic jig (14cm length by 4cm width by 0.5cm thickness), with a cut out (1.5cm depth by 1.2 cm width)at a span of 2cm from one of the extremities was prepared and used for the friction testing. For each acrylic jig, three maxillary aesthetic self-ligating preadjusted edgewise brackets with 0.022x0.028 inch slot of the same bracket type in each group and a molar buccal tube (0.022x0.028 in) were attached onto the jig with an industrial adhesive. The brackets and buccal tubes were attached with an interbracket distance of 8 mm, with a 16mm gap in the middle for the movable canine bracket. A 5cm long SS or TMA wire segment of 0.019”x0.025” dimension was inserted into the slot of the brackets. It represented a simulated half-arch fixed appliance with the straight wire in vertical position. At One end, anorthodonticwireof1mmdiameterby14mmlengthwasbondedtothemeshbaseof every singleaestheticself-ligatingmovablecaninebracketbaseinallthethreebracketgroupsandontheotherenda100gweightwasbondedtothemeshbase simulating the weight of a tooth was hung at a distance of 10mm from bracket base. A ligature wire of

0.010inch dimension was first fully tightened and then slacked to permit free sliding of the movable canine bracket.

FRICTION TESTINGPROCEDURE:

Friction testing was also carried out under dry condition using a universal testing machine (Model 3382K6819, Instron, Canton, Mass, UK) as per the protocol given by Krishnan et al[15]. The acrylic plastic jig assembly with the bonded self-ligating brackets and wire was clamped to the stable crosshead of the testing machine on one side. A 0.010inch ligature wire tied to the movable load cell of the machine. The crosshead speed was maintained at 5 mm per minute throughout the test. Movable canine brackets had power arm attached to it on to which 100gm weight was suspended. The load required to move the canine self-ligating bracket was recorded. One of the part of it would be frictional resistance, remaining would be the translatory force employed on tooth. Bluehill software (Version 2.0) on a computer was utilized to trace a load-deflection graph during individual test to estimate peak and mean values of friction. where the x-axis denoted the self-ligating bracket movement in milli-meters, and the y-axis documented the force exerted in newtons. The frictional force was calculated as difference between the reading of load-cell and that of the power arm. The static friction was recorded as initial peak of the graph. At fixed intervals, kinetic friction was evaluated on y-axis.

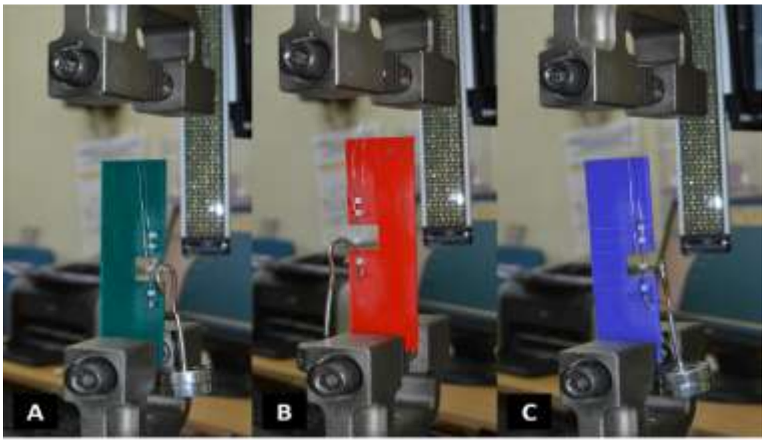


Fig 1 Friction testing for aesthetic self-ligating brackets (A) Passive, (B) Active and (C) Interactive

IV. Results

The mean and standard deviation of kinetic frictional forces of each bracket type with Stainless Steel and TMA wires were determined. The results were then evaluated using SPSS software (version16, IBM corporation). One-way analysis of variance (ANOVA) and the Tukey's post-hoc multiple comparison test was used for each archwire category to test the significance of difference between the mean values of frictional forces. The mean frictional resistance values for all the three bracket groups were shown in Table 4 and the group comparison using ANOVA analysis is shown in Table 5.

Table 4: Frictional resistance values for SS and TMA wires with three types of self-ligating brackets

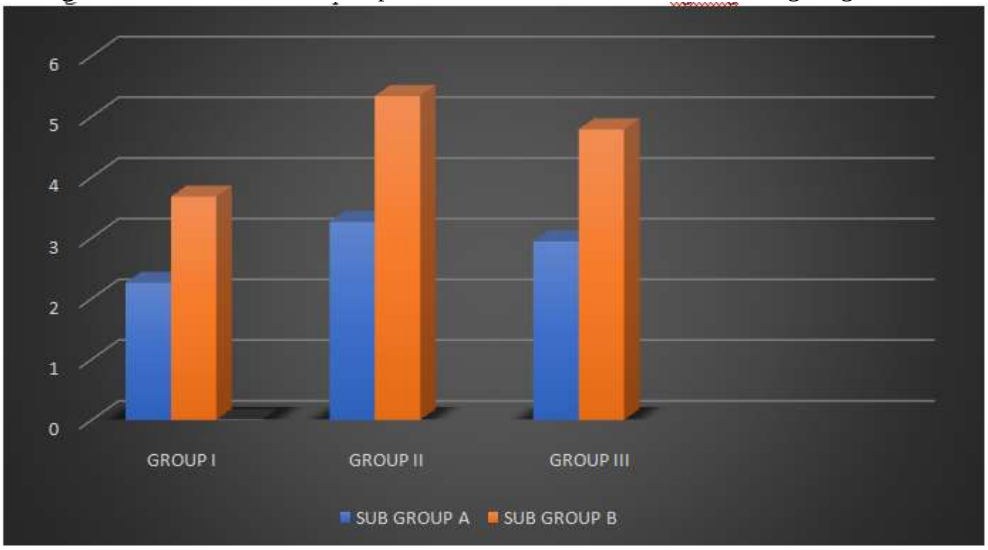
		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	
						Lower Bound	Upper Bound			Sig.
SS WIRE	Damon Clear 2	15	2.2633	.09139	.02360	2.2127	2.3139	2.12	2.43	**.0001**
	EMPOWER	15	2.9440	.16093	.04155	2.8549	3.0331	2.74	3.31	**.0001**
	GAC In Ovation C	15	3.2640	.25201	.06507	3.1244	3.4036	2.76	3.62	**.0001**
	Total	45	2.8238	.45736	.06818	2.6864	2.9612	2.12	3.62	**.0001**
TMA WIRE	Damon Clear 2	15	3.6813	.34992	.09035	3.4876	3.8751	3.23	4.20	**.0001**
	EMPOWER	15	4.7900	.44344	.11450	4.5444	5.0356	4.22	5.82	**.0001**
	GAC In Ovation C	15	5.3393	.20204	.05217	5.2274	5.4512	4.95	5.67	**.0001**
	Total	45	4.6036	.77515	.11555	4.3707	4.8364	3.23	5.82	**.0001**

*. The mean difference is significant at the 0.05 level

Table 5: One-way analysis (ANOVA) for group comparisons

		Sum of Squares	df	Mean Square	F	**Sig.**
SSWIRE	Between Groups	7.835	2	3.918	120.220	**.0001**
	Within Groups	1.369	42	.033		
	Total	9.204	44			
TMA WIRE	Between Groups	21.399	2	10.700	89.188	**.0001**
	Within Groups	5.039	42	.120		
	Total	26.438	44			

Fig 2: Frictional resistance comparison between three different self -ligating brackets



Multiple comparison using Post–Hoc test revealed that with both Stainless steel and TMA straight wires, Group I self- ligating brackets had statistically low mean frictional values followed by Group III and Group II respectively which is given in Table 6.

Table 6: Post-hoc Tukey's test for multiple group comparisons

Dependent Variable	(I) GROUPS	(J) GROUPS	Mean Difference (I-J)	Std. Error	**Sig.**	95% Confidence Interval	
						Lower Bound	Upper Bound
SSWIRE	Damon Clear 2	EMPOWER	-1.00067*	.06592	**.0001**	-1.1608	-.8405
		GAC In Ovation C	-.68067*	.06592	**.0001**	-.8408	-.5205
	EMPOWER	Damon Clear 2	1.00067*	.06592	**.0001**	.8405	1.1608
		GAC In Ovation C	.32000*	.06592	**.0001**	.1599	.4801
	GAC In Ovation C	Damon Clear 2	.68067*	.06592	**.0001**	.5205	.8408
		EMPOWER	-.32000*	.06592	**.0001**	-.4801	-.1599
TMAWIRE	Damon Clear 2	EMPOWER	-1.10867*	.12647	**.0001**	-1.4159	-.8014
		GAC In Ovation C	-1.65800*	.12647	**.0001**	-1.9653	-1.3507
	EMPOWER	Damon Clear	1.10867*	.12647	**.0001**	.8014	1.4159
		GAC In Ovation C	-.54933*	.12647	**.0001**	-.8566	-.2421
	GAC In Ovation C	Damon Clear 2	1.65800*	.12647	**.0001**	1.3507	1.9653
		EMPOWER	.54933*	.12647	**.0001**	.2421	.8566
*. The mean difference is significant at the 0.05 level.							

V. Conclusion

The purpose of this in vitro study was to analyze the frictional forces generated by three types of aesthetic self-ligating brackets namely passive (Damon clear2), active (In-Ovation C) and Interactive

(Empower) using two 0.019x0.025inch dimension straight wire viz. stainless steel and Titanium molybdenum alloys. The study samples consisted of a total of ninety brackets with a slot size of .022X.028-inch dimension divided into three groups with thirty in each group. The friction testing revealed highest frictional resistance for the active bracket group followed by interactive and was least for the passive aesthetic self-ligating bracket group.

Following conclusions were drawn from the above results:
1) With both SS and TMA wire alloys, passive aesthetic self-ligating brackets had least friction.
2) Frictional resistance was higher for TMA wires than compared to SS wires in combination with either passive, active or interactive SLBs.
3) Though self-ligating brackets possess less friction, the present study showed that the Active aesthetic self-ligating brackets had high friction than the interactive and passive types owing to its spring clip design.

Limitations:
1) Within limits this experimental study was performed in the dry condition which is totally diverse from the clinical intraoral scenario where wet environment along with soft plaque and microbial flora which could influence the frictional properties of the bracket-archwire combinations.
2) The present study evaluated the friction between conventional SS and TMA straight wire alloys whereas recent clinical application prefers usage of aesthetic archwires with these aesthetic ceramic self-ligating bracket systems which should be evaluated further in future studies.

Future scope:
i) Laser beams applied on to the bracket slot, could modify the surface characteristics of the bracket slot thereby altering the frictional resistance and future studies are needed.
ii) Further application of vibration to accelerate tooth movement and to reduce the binding and notching of bracket-archwire interface with these passive ceramic self-ligating bracket systems should be evaluated

Bibliography

[1]. Sujeet Kumar,Shamsher Singh, Rani Hamsa P.R, Sameer Ahmed, Evaluation of Friction in Orthodontics Using Various Brackets and Archwire Combinations-An in Vitro Study,J Clin Diagn Res. 2014; 8(5): ZC33–ZC36
[2]. Tselepis M, Brockhurst P,West VC,The dynamic frictional resistance between orthodontic brackets and archwires.Am J Orthod Dentofacial Orthop 1994;106:131-38
[3]. Amit gupta, Ravindra B sable ,The effect of various ligation methods on friction in sliding mechanics, JIndian Orthod Soc, 2013;47(2):83-87
[4]. Brian Armstrong-Helouvry, Control of machines with friction(AH Dordrecht, The Netherlands, Kluwer academic publishers, 1991)
[5]. Robert P. Kusy, John Q Whitley Influence of arch wire and bracket dimensions on sliding mechanics: derivatives and determinations of the critical contact angles for binding, Eur J Orthod 21(1999)199-208
[6]. Max Hain, Ashish Dhopatkar, and Peter Rock,A comparison of different ligation methods on friction, Am J Orthod Dentofacial Orthop 2006;130:666-70
[7]. Nigel Harradine,The History and Development of Self-Ligating Brackets; Sem in Orthod 2008; Vol 14, No 1, 2008: 5-18
[8]. Renata Sathler, Renata Goncalves Silva, Guilherme Janson, Nuria Cabral Castello Branco, Demystifying self-ligating brackets. Dental Press J Orthod 2011;16(2):50.e1-8
[9]. Dwight H Damon: The Damon low friction bracket: Abiologicallycompatible straight wire system. ClinOrthod,1998; 670 - 680.
[10]. David Birnie : - The Damon Passive Self-Ligating Appliance System; Sem in Orthod 2008;14:19-35.
[11]. Herbst Hanson Dr. G. Herbert Hanson on the SPEED brackets, J Clin Orthod 1986;183-189.
[12]. John C. Voudouris, Christos Schismenos; Kresimir Lackovic; Mladen M. Kuftinec: Self-Ligation Aesthetic Brackets with Low Frictional Resistance. Angle Orthod.2010; 80:188–19
[13]. J.S. Russell: Current Products and Practice Aaesthetic Orthodontic Brackets; J Orthod, Vol. 32, 2005, 146–163
[14]. D. C. Tidy,Frictional forces in fixed appliances, Am J Orthod Dentofac Orthop 1989;96:249-54.
[15]. Manu Krishnan,Sukumaran Kalathil,Kurian Mathew Abraham, Comparative evaluation of frictional forces in active and passive self-ligating brackets with various archwire alloys, Am J Orthod Dentofac Orthop 2009;136:675-82

*Ravi Ranjan. "In-Vitro Evaluation of Frictional Resistance of three Different Aesthetic Self Ligating Brackets Using two Archwire Alloys." IOSR Journal of Dental and Medical Sciences (IOSR-JDMS) 16.7 (2017): 93-97.