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Comparison Of The Fractional Characteristics Of Conventional Vs Self-Ligating Orthodontic Brackets - An invitro Observational Study

Research Article

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Abstract

Background: The fractional characteristics (FC) of orthodontic brackets is an essential factor in determining the choice of available bracketing systems and the same is linked to treatment outcomes. The current study was conducted to evaluate the FC in conventional bracketing systems (CBS) and passive self-ligating bracket system(SLB) in wet and dry conditions.
Material and Methods: An invitro observational study was conducted premolar 022 slot brackets between Group A [(conventional brackets; n=108) sub-divided into A1= Metal brackets / A2= Ceramic brackets, A3= Synergy brackets)with n=36 in each group] and group B [(Self ligating brackets; n=108sub-divided into B1= smart clip; B2= Empower and B3= Damon Q brackets) with n=36 in each group]. A 19x25 SS rectangular straight wire cut into 10mm each fragments were passed through the brackets of all these groups and FC were evaluated on an Instron universal testing machine in both wet and dry conditions. The intergroup values were compared byone-way analysis of variance (ANOVA) followed by post Hoc (Bonferroni) test for multiple group comparison, where $p<0.05$ were taken for significance.
Results: The mean values of frictional characteristics of group groups A1,A2,A3, B1, B2 and B3 in dry medium were 4.99N, 5.83N 4.75N, 4.41N, 3.49N 1.46N and respectively. The mean values of frictional characteristics of groups A1,A2,A3, B1, B2 and B3 in wet condition were 5.83N, 8.24N, 5.82N, 5.16N, 4.24N and 2.34N respectively.
Conclusion: The current study demonstrated that Damon Q brackets to have least frictional characteristics. They were followed by empower self-ligating bracket, Smart clip self-ligating brackets, synergy brackets, metal brackets, ceramic brackets in the same order for both wet and dry conditions.

Keywords: Brackets; Fractional Characteristics Orthodontics; Self-Ligating.

Introduction

The orthodontic therapy lies around achievement of desired 'tooth movement'. The tooth movement essentially occurs when the applied forces adequately overcome the generated friction at the bracket-wire junction.[1] The high levels of frictional force between the bracket slot and the archwire might cause binding between the two components; this in turn result in little or no tooth movement.Frictional resistance is directly associated with the treatment duration as well as the force application. As the frictional force between the bracket slot and the arch-wire increases, the adhesion also increases leading to reduced tooth movement. [1] Likewise , lower the forces, the conserve is the anchorageand minimal is root resorption. Thus, ideal forces which may not be too low or high for desired movement is intended for treatment success. The forces applied and treatment outcomes are also dependant on factors such as the bracket type/ material, wire alloy, wire dimensions, the method used for ligationand torque angulation (at junction of bracket slot – wire).[1] This significant influence of friction in orthodontics had led to increase in research for surface evaluation to determine the frictional characteristics. [2] Several researchers and manufacturers have been introducing newer materials that are of less frictional resistance, but the orthodontist should have a first and knowledge about the frictional

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characteristics of the newer appliances and mechanics as they are directly associated with the treatment and responsible for the treatment outcome.[2]

The self-ligating brackets (SLB) have added advantage of reducing the frictional characteristics and chair side working time.[3, 4] The SLB are either active or passive SLB's by various manufacturers suggesting to be the ideal bracket system.[5] The Damon Q type of SLB system, when introduced, had revolutionised the treatment planning protocol suggesting a non-extraction treatment protocol for most of the cases.[6] There are studies in favour of SLB [7-10] and paradoxically reports [10-14] which are stated they are not significantly useful in reducing fractional forces as CBS. A systematic review had favoured the SLB as opposed to CBS.[15]

Given the advancements in orthodontic brackets, higher friction force, an analysis of three-dimensional tooth positioning and novel four double wings of the smart clip all aided in further understanding of ideal bracketing system. Also, the controversial issues of commercially available bracketing systems existed in current practice periods, influencing the choice of brackets. Thus, the current study was conducted to evaluate the kinetic fictional resistance in CBS and passive SLB system by passing similar 19x25 SS rectangular wire in wet and dry conditions.

Material and Methods

The study was designed to be a invitroobservational studyconducted in the Department of Orthodontics and Dentofacial Orthopaedics, Indira Gandhi Institute of Dental Sciences, SBV University, Pillayarkuppam, Pondicherry.The physical tests were performed at Central Institute of Plastics Engineering and Technology, Chennai, Tamil Nadu, from May 2016 to March 2017.
The study was approved by Institutional Ethical clearance (IEC, Indira Gandhi Institute of Dental Sciences, SBV University, Pillayarkuppam, Pondicherry) prior to the start of the study(Reference number: IGIDSIEC2016NDP07PGASODO, approved on 16/12/2015). A written informed consent was obtained from all the participants, upon fulfilling the inclusion criteria.

The sample of 108 in each group was taken conveniently in and sorted into two groups A and B. The Group A (conventional brackets) was sub-divided into A1= Metal brackets; A2= Ceramic brackets, A3= Synergy brackets). Likewise, the group B (Self ligating brackets) was also sub-divided into B1= smart clip; B2= Empower and B3= Damon Q brackets)]. The subgroups each had sample of 36. A 19x25 SS rectangular straight wire cut into 10mm each fragments were passed through the brackets and frictional characteristics were evaluated on an Instron universal testing machine in both wet and dry conditions. The wet conditioning of the bracketand wire, distilled water was used with respect to previous researchers.[7]

The materials procured for this study were segregated into 2 groups which is group A and group B. Group A consists of conventional bracket systems which is again subdivided as group A1 which has 36 premolar brackets of 022 slot MBT stainless steel metal brackets, group A2 has 36, 022 slot MBT ceramic premolar brackets and group A3has 36 premolar brackets of Synergy manufactured by Rockymountain.inc which is 022 slot and MBT mechanics.

The brackets were fixed to colour coded acrylic sheets of 20x5cm using Cyano acrylic adhesive and the distance between the brackets were maintained at 10 mm as it replicates the average inter bracket distance). A guide line is drawn on the acrylic sheet to help the operator to fix the bracket in a straight line as the sliding mechanics in retraction is done after levelling and aligning to prevent excessive friction, as the wire passes through the bracket ,slot should be placed parallel to prevent un necessary excessive torque values.The 19x25 SS rectangular wire of 10cm straight length was placed in the bracket slot using module ligation was attached to the upper head of Instron machine.[9, 10] Then these acrylic fixtures were attached to the lower head of the universal testing machine. 19x25 SS rectangular wire is attached to the upper arm of the testing machine and a load of 1KN was applied with a cross head speed of 2mm/min. The lubricant of each group was applied to the wire, next to the bracket slot, using a micropipette with a standard volume of 50 ml. This speed was chosen as the standard because other researchers have found no significant difference in friction measurements using speeds from 0.5 to 50mm/ min. Kinetic friction was recorded for every 2mm while 10cm of wire was drawn through the assembly. The readings were recorded in Newtons. In both the dry and wet field, the values were been recorded from the instron machine and the obtained data was subjected to comparisons by statistical analysis.

Statistical analysis

The descriptive data was represented in terms of mean and standard deviation(SD). The intergroup values were compared by one-way analysis of variance (ANOVA) followed by post Hoc analysis (Bonferroni test) for multiple group comparison. The $p<0.05$ value were taken for significance in all instances.

Results

The study was conducted between Group A (conventional brackets; n=108) and group B (Self ligating brackets; n=108) in both wet and dry conditions. The mean± standard deviation values of frictional characteristics of conventional bracket system obtained are 4.9968±0.533, 5.8300±0.466 and 4.7520±0.506 for A1, A2 and A3 in in dry conditions respectively. The same in case of wet conditions showed values of 466±0.078, 0,389±0.065 and 0.468±0.079 for A1, A2 and A3 respectively.

The multiple group comparisons showed highly significant differences ($p=0.0005$) in all combination except for comparisons of A2-A3 ($p=0.113$) in dry conditions and wet conditions ($p=1.00005$). See Table 1

Likewise, the mean± standard deviation values of frictional characteristics of conventional bracket system obtained are 4.415±.0.281, 3.49±0.377 and 1.46±0.331 for A1, A2 and A3 in in dry conditions respectively. The same in case of wet conditions showed values of 5.1625±0.622, 4.246±0.5124 and 2.342±0.3912 for A1, A2 and A3 respectively. The multiple group comparisons showed highly significant differences ($p=0.0005$) in all combination. See Table 2

Figure 1. Armamentarium of the study with brackets mounted on colour coded acrylic sheets (Blue/A2 :ceramic bracket, black/ A3: synergy brackets, Green/ B3: Damon Q brackets, yellow/B1: smark clip brackets, Red/B2: Empower brackets, White /A1: Stainless steel brackets).

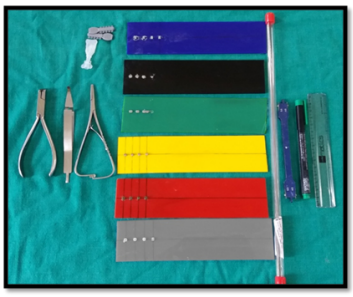

Figure 2. Friction testing using Instron machine.

Table 1: Multiple Comparison of Frictional Characteristics of Conventional Bracket System in Both Wet and Dry Conditions.

Dependent Variable	(I) Material	(J) Material	Mean Difference (I-J)	P value.
Dry Medium	A1	A2	0.833	0.001
		A3	1.078	0.001
	A2	A1	-0.833	0.001
		A3	0.245	0.133
	A3	A1	-1.078	0.001
		A2	-0.245	0.133
Wet Medium	A1	A2	2.418	0.001
		A3	2.411	0.001
	A2	A1	-2.418	0.001
		A3	-0.007	1.001
	A3	A1	-2.411	0.001
		A2	0.007	1

P <0.05 is considered significant; test : post Hoc analysis (bonferroni)

Discussion

The self-ligating brackets (SLB) were introduced in 1935 in orthodontics, with purposes of reducing the frictional characteristics and chair side working time. They also had been reported to reduce the overall orthodontic treatment time. [3, 4] As the SLB systems advanced, with introduction of the Damon Q the treatment planning protocol started to favour the non-extraction cases.[6] The fractional characteristics (FC) of orthodontic brackets have effect on the tooth movement and thus, indirectly linked to treatment outcomes. The current study had evaluated the FC in 3 available options in each conventional bracketing systems (CBS) and passive self-ligating bracket system(SLB) in wet and dry conditions by passing similar 19x25 SS rectangular in all cases.

On comparing all the mean values of samples tested for frictional resistance in wet and dry conditions that is these values showed an overall increase of frictional resistance in wet medium for all the groups and the reason which has been explained by authors in different studies. In both wet and dry condition group B1, had shown high frictional resistance but in a similar study done.

There are studies done by hadreported that significantly lower fractional forces were recorded with SLB compared to CBS. A

Table 2. Multiple Comparison of Frictional Characteristics of Self Ligating Bracket System in Both Wet and Dry Conditions.

Dependent Variable	(I) Material	(J) Material	Mean Difference (I-J)	P values
Dry Medium	B1	B2	0.917	0.001
		B3	2.951	0.001
	B2	B1	-0.917	0.001
		B3	2.034	0.001
	B3	B1	-2.951	0.001
		B2	-2.034	0.001
Wet Medium	B1	B2	0.916	0.001
		B3	2.820	0.001
	B2	B1	-0.916	0.001
		B3	1.904	0.001
	B3	B1	-2.820	0.001
		B2	-1.904	0.001

P <0.05 is considered significant; test : post Hoc analysis (bonferroni)

systematic review had favoured the SLB as opposed to CBS. This was reported when coupled with small round arch-wires in the absence of tipping/torque in case of an ideally aligned arch. Also, the review showed that sufficient evidence was not found to claim that with large rectangular wires, in the presence of tipping/torque or in cases with considerable malocclusion, SLBs were no superior to CBS.[15] Paradoxically, a few studies also reported that SLB not significantly useful in reducing fractional forces as CBS or that SLB had similar FC as compared to CBS. [10-14] Crncoli V et alin their study had measured the friction force generated during sliding mechanics with conventionaland Synergy brackets using different arch wire and ligating systems. They had shown that conventional brackets exhibited a frictional force higher than other brackets. They also concluded that the synergy bracket with a silicone ligature placed around the inner tie wing yielded lowest friction values.[16] Fleming et alcompared the effects of a self-ligating bracket system (Smart Clip) and a conventional edgewise bracket (Victory) to align incisors and improve transverse mandibular arch dimension changes over 30 weeks. The authors concluded that there was little difference overall in the pattern of arch alignment and levelling from the 2 appliance systems.[17]

In wet conditions on evaluating the frictional values obtained on multiple comparisons among group B, group B1 showed a higher frictional resistance on comparing with group B2 and group B3. And group B3 exhibited significantly less friction among the group.Thariq et alhad compared frictional resistance between passive self-ligating and conventional orthodontic brackets, and concluded that among passive self-ligating brackets, Damon brackets showed least friction when compared with smart clip. They also found that the resistance doesn't remain for empower brackets. [18] This is in lie with current study.A lower friction is needed for alignment, in last phases, ahigher friction force is deemed to attain a dimensional control of the tooth position.[19, 20]

The current study showed, when compared for frictional characteristics are Damon Q with least frictional characteristics followed by Empower SLB , then Smart clip SLB bracket, and Synergy conventional bracket followed by SS metal brackets and Ceramic conventional bracket with highest frictional values. The frictional values of Synergy (CBS) was close to the values obtained by both the Empower and Smart clip (SLB), making them valuable alternatives for SLB.

The limitation in this study was in vitro nature of study and usage of distilled water instead of saliva. The reason was difficulties in procurement, contamination and storage of natural saliva. The variations in commercially available artificial salivary substitutes also may cause methodological bias, so were avoided. The frictional values found in the present study should be assumed for real comparisons unless validated in invivo settings in large scale populations.

Conclusion

The current study demonstrated that Damon Q brackets to have least frictional characteristics. They were followed by empower self-ligating bracket, Smart clip self-ligating brackets, synergy brackets, metal brackets, ceramic brackets in the same order for both wet and dry conditions. The clinicians may make choices in the type of brackets based on these observations apart from patient factors.

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