Coated, uncoated stainless steel ligatures versus Self ligation- In the perspective of friction

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Abstract

Introduction: Friction has intrigued Orthodontists for decades. Various appliance and mechanics have been thought to reduce or enhance friction which is the reason for continuous study on the topic. Hence the purpose of this study was to evaluate the effect of Teflon coated arch wires and ligatures on resistance to sliding during simulated canine retraction with conventional and self ligating ceramic brackets with metal slot.

Material and Methods: Total 120 samples were taken and divided into six groups and for each group (20 brackets) twenty readings were taken. Tidy's frictional test design was used to simulate canine retraction. The test was done under dry condition. To visualize the surface morphology of Teflon coated and uncoated arch wires, they were subjected to scanning electron microscopic evaluation, before and after experiment.

Results: Mean values were compared by student's t- test/one way ANOVA appropriately. Multiple range tests by Tukey - HSD (Honesty Significant Difference) analysis were employed to identify the significant groups at 1% level and comparison of least friction groups at 5% level. Teflon coated wires and ligatures produced significantly less resistance to friction than stainless steel wires and ligatures. (p=0.001).

Conclusions: The resistance to friction was less with a combination of conventional ceramic brackets, Teflon coated wires and Teflon coated ligatures when compared with all other groups (p=0.05).

Keywords: Teflon; Ceramic; Resistance

Introduction

When two objects slide over one another with an external load, the resistance that occurs on the surface of the two objects is known as Friction.[1] In order to reduce friction, in orthodontics surface coating of orthodontic arch wires has been proposed. Teflon or polytetrafluoroethylene (PTFE) is one such coating material which is characterized by a completely fluoridated chain and it is a material with low coefficient of friction, can be used to coat over the arch wire to reduce friction.[2] Previous studies[2,3,4] have been conducted with a combination of Teflon coated arch wires, conventional ligatures and brackets. The results of these studies revealed efficiency of Teflon coated arch wires in reducing friction. The aim of the present study is to evaluate frictional characteristics of Teflon coated arch wires and ligatures combined with and without self ligating ceramic brackets with metal slot.

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Materials and Methods

7 cm straight length of 0.019 x0.025 inch stainless steel wires (SSW) (n=60) (Ormco, Orange, CA) and Teflon coated stainless steel wires (TCW) (n=60) (Rabbit force orthodontics, Libral traders, New Delhi, India) were tested against upper right canine brackets (0.022 x 0.025 inch slot). Two types of ceramic brackets were tested, ceramic self ligating brackets with metal slot (CSL) (Damon 3 mx, Ormco, Orange, CA) (n=40) and conventional Ceramic bracket with metal slot (CCB) (Victory series 3M Unitek, Monrovia, California) (n=80). The arch wires were self retained with the self ligating brackets where as they were secured either with stainless steel ligatures (SSL) (Ormco Orange, CA) or Teflon coated ligatures (TCL) (Modern Ortho, Ludhiana, Punjab, India).

120 samples were taken and divided into six groups and for each group (n=20 brackets) twenty readings were taken. Each bracket was tested only once, and each time the canine bracket, arch wire, and ligature wire were changed and replaced with a new one so as to eliminate the influence of wear. The study design and groups evaluated are given in Figure 1.

In this study, Tidy's[5] frictional test design was used to simulate canine retraction. The test was done under dry condition.[6] With the use of a power arm, the retraction force was simulated in such a way that it acted at the center of resistance of the canine. An acrylic jig was prepared (Figure 2). Upper right quadrant brackets and tubes were bonded onto the jig with 8 mm interval except between lateral incisor and 2nd premolar bracket for which a 16 mm space was provided for the movable canine bracket. The same setup was followed for conventional ceramic brackets on one side and self ligating ceramic bracket on the other side of the same jig. The 10 mm distance was chosen according to Burstone and Pryputniewicz[7] findings about location of centre of resistance. The amount of friction was measured using Universal testing machine (Instron 3382). A constant 100 gm load was suspended from power arm. 0.019 x 0.025 inch stainless steel arch wire was chosen because it is the recommended size for sliding mechanics with 0.022 x 0.25 inch slot brackets.[8]

The arch wires were secured with 0.010 inch Teflon coated and stainless steel ligatures for the respective groups. The ligatures of the canine brackets were first tightened and unwound by 3 turns to permit free sliding along the arch wire. Loose ligation was checked by rocking the ligature to confirm that there was little play between both spans of ligature and arch wire. The jig with this assembly was mounted on the lower jaw of the Instron machine. The canine bracket was moved upward with the use of a "U" shaped wire from an acrylic block which was mounted to the movable upper jaw of the Instron machine with the cross head speed of 5mm/min (Figure 3).

In each test the brackets were moved a distance of not less than 5mm.The load cell readings were recorded on the digital display. The frictional value was calculated by subtracting the load on the power arm from the load cell reading.

To visualize the surface morphology of Teflon coated and uncoated arch wires before and after experiment, the wires were randomly selected and subjected to scanning electron microscopic (SEM) evaluation.

Results

The results were subjected to statistical analysis. The mean and standard deviations were estimated from the sample for each study group. Mean values were compared using one way ANOVA. (Table I, Figure 4). Multiple range tests by Turkey HSD (Honesty Significant Difference) analysis was employed to identify the significant groups at 1% level (Table II) and comparison of least friction groups at 5% level (Table III).

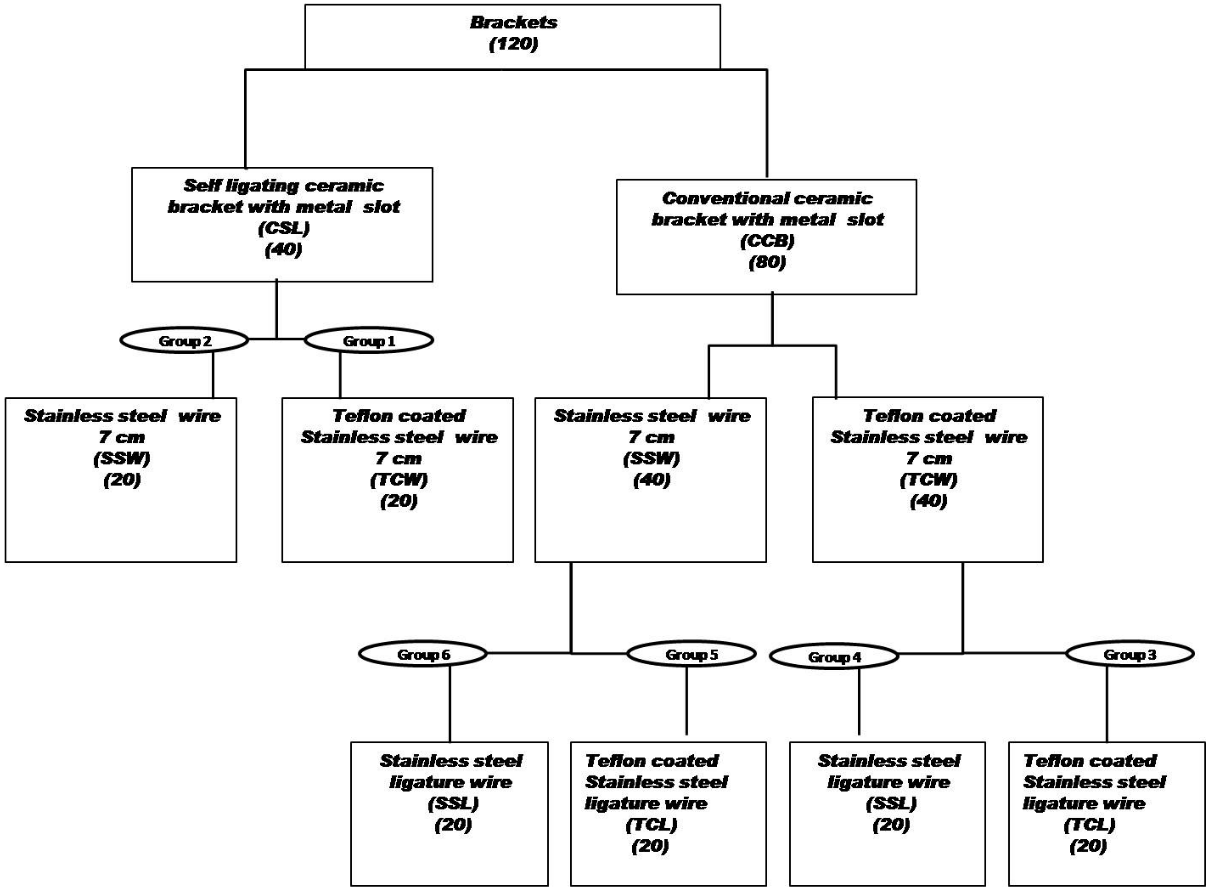

Figure 1

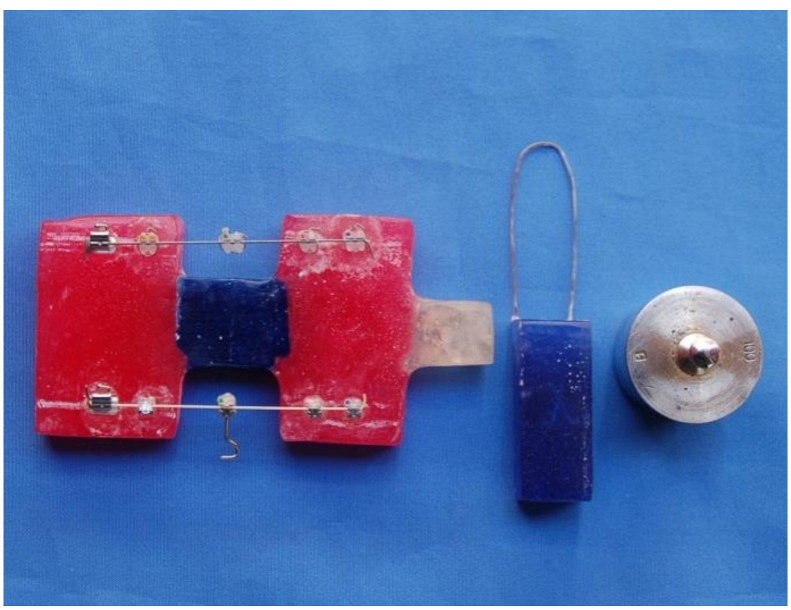

Figure 2

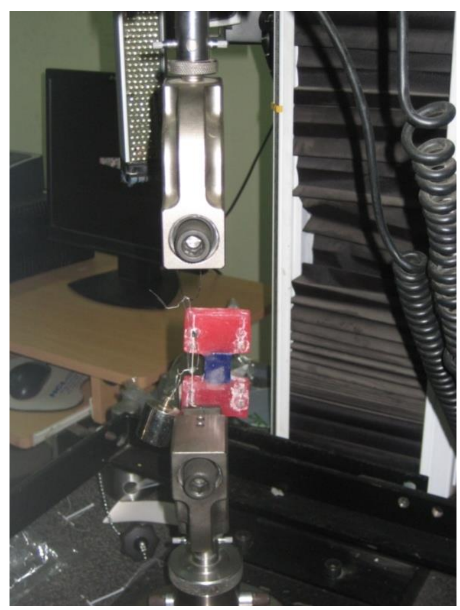

Figure 3

TCW produced significantly less friction when coupled with TCL and CCB with metal slot, than CSL brackets. SSW produced more friction when coupled with TCL and CCB with metal slot, than TCW. SSW produced highest friction when coupled with SSL and CCB with metal slot, than any other system evaluated in this study.

Table I: Comparison of all groups using one way ANOVA

Groups	Description	N	Mean	SD	F-value	P-value*
Group-1	CSL with TCW	20	3.4060	0.8021	21.711	0.001
Group-2	CSL with SSW	20	4.6120	0.8009		
Group-3	CCB with TCW & TCL	20	3.0235	0.6547		
Group-4	CCB with SSW & TCL	20	4.4350	0.7290		
Group-5	CCB with TCW & SSL	20	3.9565	0.6806		
Group-6	CCB with SSW & SSL	20	4.9730	0.6142		

(*significantly less frictional value when compared to the other group **p<0.01)

CSL - Ceramic self ligating brackets,
CCB - Conventional ceramic brackets,
TCW - Teflon coated wires,
SSW - Stainless steel wires,
TCL - Teflon coated ligatures,
SSL - Stainless steel ligatures

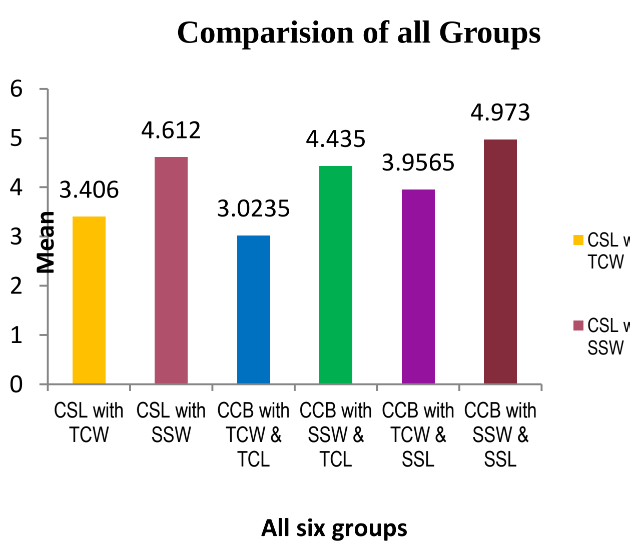

Figure 4

Table II: Turkey's - HSD (Honesty Significant Difference) analysis at 1% level

Comparison	Groups	N	Mean	SD	t-value	P-value**
Group 1Vs. Group 2	CSL with TCW	20	3.4060*	0.8021	4.758	0.001
	CSL with SSW	20	4.6120	0.8009		
Group 3 Vs. Group5	CCB with TCW & TCL	20	3.0235*	0.6547	6.442	0.001
	CCB with SSW & TCL	20	4.4350	0.7290		
Group 3 Vs. Group 4	CCB with TCW & TCL	20	3.0235*	0.6547	4.418	0.001
	CCB with TCW & SSL	20	3.9565	0.6806		
Group 3 Vs. Group 6	CCB with TCW & TCL	20	3.0235*	0.6547	9.712	0.001
	CCB with SSW & SSL	20	4.9730	0.6142		
Group 5 Vs. Group 4	CCB with SSW & TCL	20	4.4350	0.7290	2.146	0.001
	CCB with TCW & SSL	20	3.9565*	0.6806		
Group 5 Vs. Group 6	CCB with SSW & TCL	20	4.4350*	0.7290	2.524	0.016
	CCB with SSW & SSL	20	4.9730	0.6142		
Group 4 Vs. Group 6	CCB with TCW & SSL	20	3.9565*	0.6806	4.959	0.001
	CCB with SSW & SSL	20	4.9730	0.6142		

(*significantly less frictional value when compared to the other group **p<0.01)

CSL – ceramic self ligating brackets, CCB – conventional ceramic brackets, TCW- Teflon coated wires, SSW- stainless steel wires, TCL – Teflon coated ligatures, SSL– stainless steel ligatures

Table III: Comparison of all least friction groups at 5%

Groups	N	Mean	SD	F-value	P-value*
CCB with TCW & TCL	20	3.0235	0.6547	2.21	0.05 significant
CSL with TCW	20	3.4060	0.8021		
CCB with TCW & SSL	20	3.9565	0.6806		
CCB with SSW & TCL	20	4.4350	0.7290		

(*significantly less frictional value when compared to the other group *p<0.05)

CSL – ceramic self ligating brackets, CCB – conventional ceramic brackets, TCW- Teflon coated wires, SSW- stainless steel wires, SSL – stainless steel ligatures, TCL – Teflon coated ligatures)

SEM surface evaluation photomicrographs (before and after experiment) of TCW and SSW are given at 500X magnification level (Figure 5 to Figure 8)

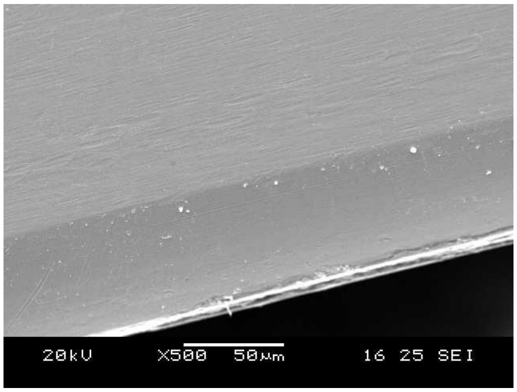

Figure 5: SSW before experiment

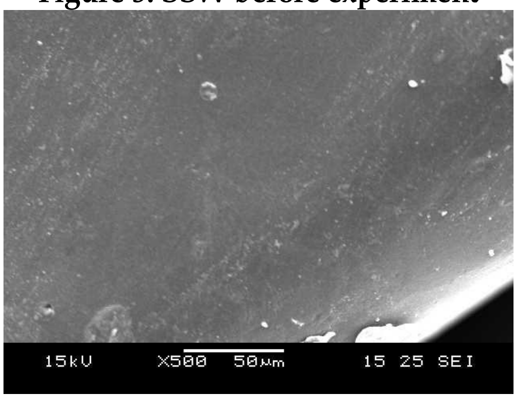

Figure 6: TCW before experiment

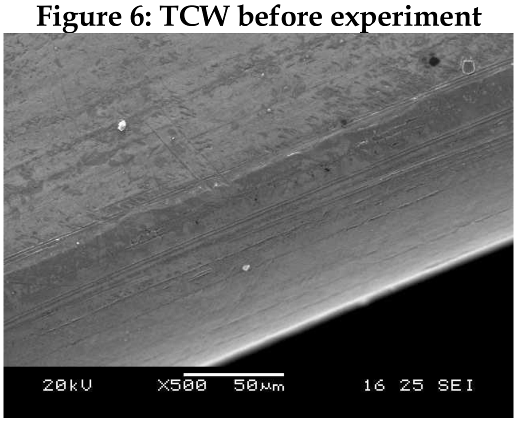

Figure 7: SSW after experiment

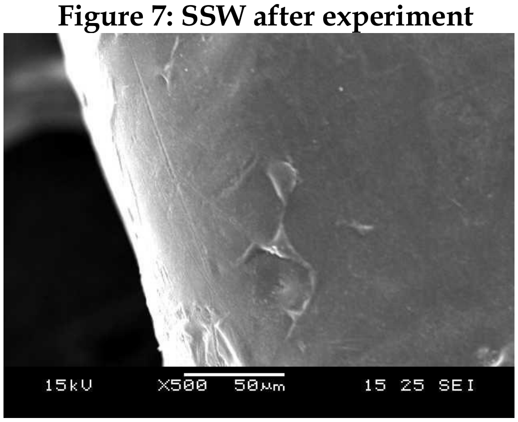

Figure 8: TCW after experiment

Discussion

When sliding mechanics is used during canine retraction or en-mass retraction, friction occurs at the wire bracket interface. Friction between arch wire and bracket is multi-factorial and it depends upon the variables like arch wire, size/shape/material, angulation of bracket to wire, bracket width/material/design, lubrication, surface roughness. In the present study, the effect of variables like method of ligation and surface coating of arch wire and ligatures were studied.

SSW produce less friction compared to Niti and TMA wires.[9] Rectangular wires produce more friction compared to round wires. [10, 11] Coated wires like Teflon coated and ion implanted TMA produces less friction. In the present study TCW produced less friction than SSW.

Different type and method of elastomeric module ligation produce different amount of friction.[12] Edwards and Jones[13] proved that figure eight ligation produces more friction than normal ligation. Giampietro Farronato and Rolf Maijer[2], De Franco et al[3] proved that the Teflon material which posses lower coefficient of friction than polyurethane elastomer resulted in a lower friction value. In accordance with this, TCL invariably produced less friction than SSL in the present study.

To decrease the chair side working time and to improve oral hygiene, self ligating brackets were introduced with an added advantage of reduced friction. Passive self ligating brackets may exert less friction than active ones[14,15] when used with round wires in certain clinical situations since when closed, passive brackets form a rigid tube applying no direct force to the wire. Cacciafesta and Maria Francesca Sfondrini[16] stated that stainless steel self ligating brackets generate lower frictional resistances than conventional stainless steel brackets. Contrary to this, in present study among all the bracket arch wire combinations

CCB with metal insert and TCW ligation with TCL ties produced the least frictional value.

It has be proved through many experimental models[9,17-21] that stainless steel brackets exhibit less friction than polycrystalline or single crystal ceramic brackets. For most of the comparisons of the ceramic brackets, single crystal brackets tended to be lower in friction than polycrystalline brackets. This is by virtue of more porosity and coarseness on surface of ceramic brackets than stainless steel brackets. Janahan Rajakulendran and Steven Jones[22] in their study claimed that stainless steel brackets and ceramic brackets with metal slot produce similar amount of friction. Hence in the present study we have not included conventional stainless steel brackets.

Another possible alteration in the slots of ceramic brackets to reduce friction was suggested by Umal H Doshi et al.[23] They used Ceramic with gold-palladium slot bracket coupled with colored TMA arch wire and found this to be a good alternative to stainless steel for space closure with sliding mechanics.

Conclusively, CCB with TCW and TCL showed least amount of friction when compared with all the groups. The reason for this might be Teflon or polytetraflouroethylene (PTFE) being an anti adherent and esthetic material with good mechanical stability and lesser coefficient of friction. To further reduce the friction the bracket slot can also be coated with Teflon. Stannard et al[24] in their study stated that stainless steel wires on Teflon coated brackets consistently exhibited the lowest friction values. However frictional behavior of the combination of Teflon coated brackets, arch wire, ligature wire have yet to be studied.

SEM evaluation at 500x magnification revealed the following,

1. Teflon coating produced a smooth and homogenous layer on the surface of the SSW (Figure 7).
2. SSW after experiment (Figure 6) expressed more irregularities on the surface, when compared with the wire before experiment (Figure 3).
3. TCW showed a distinct pattern that resembled a pealed of surface (Figure 8), when compared with the wire before experiment (Figure 7).

Despite having limitations, it can be concluded from the present study that the combination of Teflon coated wires and ligatures are a better choice in esthetically demanding and low friction situations. However further studies are needed to evaluate this fact in vivo.

Conclusions

1. TCW/TCL/CCB with metal slot exhibited least friction.
2. SSW/SSL/CCB with metal slots exhibited highest frictional resistance.

Surface coating of brackets may further reduce friction; however a combination of surface coating arch wire, ligatures, bracket or using surface coated self ligating brackets and arch wire has yet to be studied in relevance of friction.

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