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Review Article

Frictional Resistance in Orthodontics -A Review

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Abstract: This article reviews the frictional resistance of archwires based on the cross section, microscopic structure and stiffness. Bracket factors like slot width and depth and material influencing friction. Different types of ligation influencing friction. Role of saliva, biofilm and wire bracket combinations on friction. Friction in wire, bracket and ligation combination.

Keywords: Frictional Resistance, Orthodontics, archwires.

INTRODUCTION

Orthodontists use forces that are variable for different types of tooth movement. Oppenheim and Schwarz stated that Optimum force is equivalent to the capillary pressure, which is 20-26 gms/sq.cm of root surface area. If the force applied is greater than the optimal force, the capillaries occlude and rupture forming a hyalinized layer which resists the tooth movement. Therefore, the amount of force to be applied and the friction are the two important parameters that determine the tooth movement.

To deliver optimal forces for efficient and predictable tooth movement, it is necessary to have the knowledge about the force required to overcome friction. Friction is the resistance to motion that occurs when an object moves tangentially against another [1]. When two surfaces in contact slide or tend to slide against each other, two components of total force arise. One of these is the frictional component, which is parallel in direction to the intended or actual sliding motion and opposes the motion (Fig. 1). The other component is perpendicular to or at right angles to one or both contacting surfaces and also to the frictional force component. The magnitude of the frictional force is proportional to the amount of normal force that pushes the two surfaces together [2].

There are 2 types of friction
Static and kinetic

1. Static friction opposes any applied force. Its magnitude is exactly what it must be to prevent motion between 2 surfaces, up to the point at which it is overcome and movement starts. (Fig 2).

2. Kinetic friction, which usually is less than static friction, then opposes the direction of motion of the object [2] (fig-2).

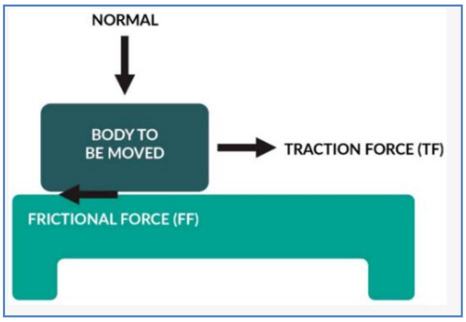

Fig-1

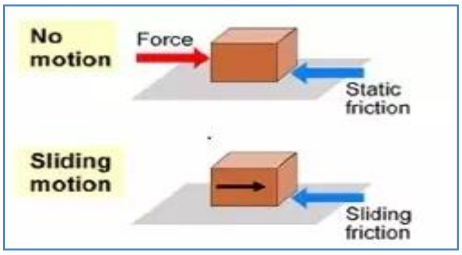

Fig-2

Vaughan *et al*., listed several variables that can directly or indirectly contribute to the friction [3]:

1. Arch wire
a. Material
b. Cross-sectional shape/size
c. Surface texture
d. Stiffness

2. Ligation of arch wire to bracket
a. Ligature wire
b. Elastomerics

3. Bracket
a. Material
b. Slot width and depth
c. First order bends (in-out)
d. Second order bend (angulation)
e. Third order bends (torque).

4. Orthodontic appliance
a. Interbracket distance
b. Level of bracket slots between adjacent teeth
c. Forces applied for retraction

5. Intraoral variable
a. Saliva
b. Plaque
c. Acquired pellicle
d. Corrosion

Archwire

a) Material

Different types of materials are used for the fabrication of archwires. Stainless steel, nickel titanium, Beta titanium, Cobalt chromium nickel alloy arch wires are most commonly used. Stainless steel wires are associated with least amount of friction. And Beta titanium wires produce the most [4]. Vinod Krishnan *et al*., stated frictional resistance is TMA >. TiMolium > stainless steel at static and kinetic friction in vitro at 0.05 and 0.1 N weight [5].

B) Cross section

Based on cross section the wires are classified as round, square, rectangle and multi-stranded. Rectangular wires showed greater friction compared to round. Kusy *et al*., [6] stated as the diameter of wire increases friction increases [7].

b) Surface texture

The microscopic structure of Stainless steel has an optical surface roughness of 0.10 µm(fig 3), NiTi wires, had an optical surface roughness ranged from 0.10 to 1.30 µm (Fig 4), ß-titanium, had an optical surface roughness ranged approximately 0.21 µm.(fig 5) [8]. Stainless steel has smoothest surface compared to NiTi, Co-Cr and TMA [9].

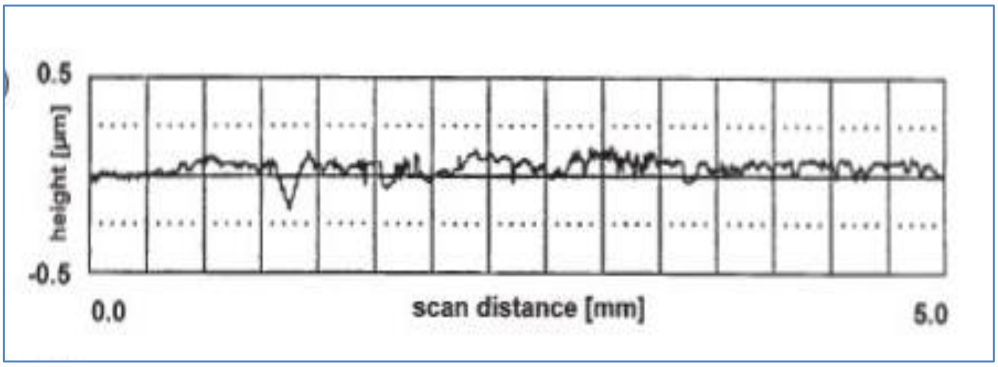

Fig-3

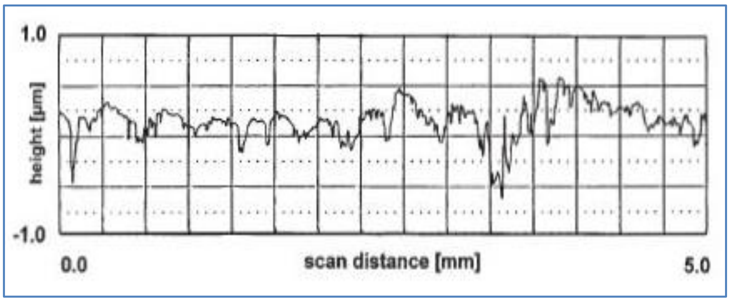

Fig 4

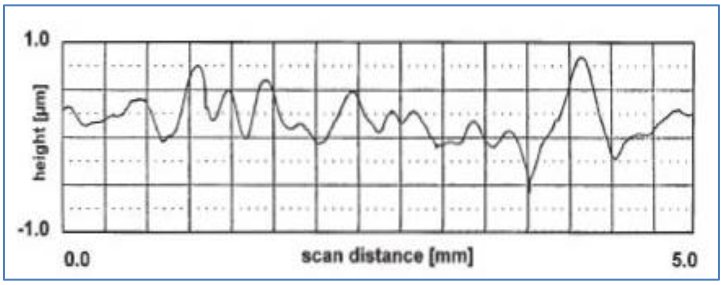

Fig-5

d) Stiffness

The stiffness of 16 x22 SS is 12±2 and beta titanium is 5 ±0.4[10] as the stiffness of wire decreases there is increases friction [2].

Bracket

a) Material

The brackets are made of metals, ceramic, plastic and plastic reinforced with metal. Ceramic brackets produce greater friction compared to Stainless stell [11]. The frictional resistance of Ceramic is 7.32 ± 0.10N and Self-ligating brackets is 2.35 ± 0.15N which is least [12]. Self-ligating brackets exhibited superior performance when coupled with smaller wires [13]. Steven *et al.*, studied the frictional characteristics of the Damon3 ™ , Speed ™ , In-Ovation R ™ and

Time 2 ™ self-ligating brackets and stated Damon3 ™ bracket demonstrated the lowest frictional resistance to sliding, while the Speed ™ bracket produced significantly ($P < 0.001$) more frictional resistance [14].

b) Manufracturing or processing

Sintered stainless steel bracket showed less friction compared to cast stainless steel brackets [13].

c) Slot width and depth

Kapila *et al*., stated that narrow brackets are associated with lower friction than wider brackets [2].

d) **First order second order and third order bends**

Ogata *et al.,* stated that frictional resistance increased as the 2nd order deflections increased. In tipping movements frictional resistance of NiTi was low compared to stainless steel. The third order bends or torque using rectangular wires increased friction [15].

Method of ligation

There are different methods of ligation used to secure the archwire with the brackets. According to study conducted by Hain *et al*., round modules produce least resistance to friction compared to rectangular modules and super slick modules [16]. Paola *et al*., stated elastomeric modules showed increased resistance to sliding compared to Stainless steel ligatures [17].

Biological factors

A) Saliva

Baker *et al*., stated saliva reduces friction by acting as a lubricant [18].

Friction in Wire bracket combination

The friction in wire bracket combination is influenced by asperities (fig 6), critical angle (fig-7) and the slip stick phenomenon. The increase in asperities and the decrease in critical angle increase the friction.

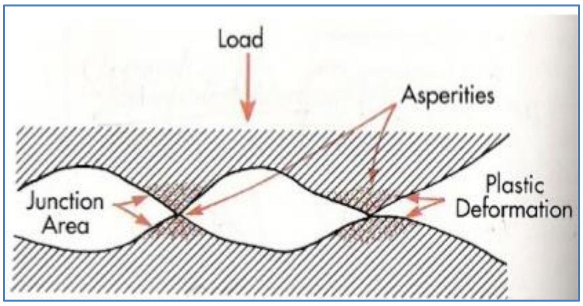

Fig-6

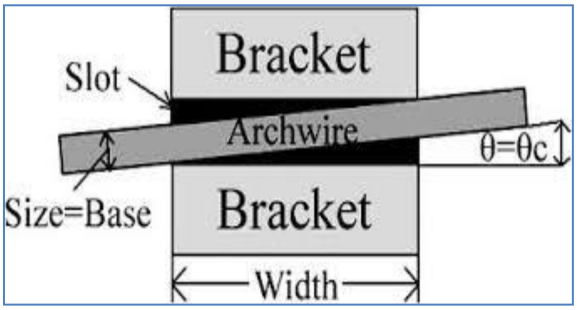

Fig-7

Vaughan *et al*., stated that SS and Co-Cr wires produced significantly less friction than beta -Ti and Ni-Ti wires in sizes 0.016 inch, 0.017 x 0.025 inch, 0.018 inch, and 0.018 x 0.025inch in brackets with 0.022-inch slots.

Frictional forces with 0.022-inch brackets was between 30.1 gm for 0.018-inch SS wire and 168.3 gm for 0.017 x 0.025-inch for Beta-Ti wire [3].

The SS bracket- SSwire combination produced the least amount of frictional resistance. TMA wires combined with SS brackets produced most amont of friction followed by Elgiloy and NiTi wires [6].

Friction in wire bracket and ligature combination

SLB and unconventional elastomeric ligatures on conventional brackets showed lower friction compared to conventional elastomeric ligatures on conventional brackets [17]. Elastic modules tied in figure of 8 showed greatest friction, and there was no significant difference between conventionally tied module and SS ligature. Teflon coated ligatures showed least friction when used with stainless steel bracket and archwire [12].

CONCLUSION

Frictional resistance is least in stainless steel wires, self-ligating brackets and Saliva. Friction increases as the roughness of the wire bracket surface increases. Friction is an imperative phenomenon. The clinician should be aware of the variable characteristics of the orthodontic material combinations contribute to friction during sliding mechanics.

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