Egyptian
Orthodontic Journal

A STUDY OF FRICTIONAL RESISTANCE GENERATED FROM DIFFERENT LEVELING ARCH WIRES THROUGH SELFLIGATING SPEED BRACKET IN THE DRY STATE

Ahmed E.A. Salama*, Ghada El Mehy**

ABSTRACT

The frictional resistance (FR) of the speed brackets was studied among different types of leveling arch wires of 0.014" gauge including, plane stainless steel (S.S.), S.S. with vertical loop, multistranded and nitinol arch wires. These arch wires were configurated into a simulated U-shaped arch form to be fitted into a dental arch mould carrying a full upper set of the tested bracket under the dry state.

Ten arch wires of each group were tested using the Universal Testing Machine. The statistical analysis showed that there was a statistically significant difference among the tested group. (SS.) with vertical loop arch wire showed the least amount of (FR) followed by Plane (S.S.), then multi stranded arch wire and lastly nitinol arch wire showed the highest (FR).

INTRODUCTION

As a bracket and tooth move along an arch wire, friction opposes such movement. Friction can be a major factor determining the efficiency of an orthodontic appliance. Friction increases the force necessary to move teeth, slows tooth movement and contributes to the loss of anchorage. A number of factors, both physical and biological, affect friction in Orthodontics bracket properties (material, manufacturing process, design), arch wire properties (material and cross section), ligation method, patient factors (bracket-arch wire angulations, dynamic forces of the mouth) and biological films[22, 18].

*Lecturer of Orthodontics, faculty of Dental Medicine, Girls branch, Al- Azhar University.
** Lecturer of Orthodontics, faculty of Dentistry, Tanta University.

The orthodontist seeks an arch wire-bracket combination that has both biocompatibility and low friction. Friction is a common orthodontic problem which tends to resist the movement of the bracket and arch wire in the desired direction. So an important consideration in selecting an arch wire for initial leveling during orthodontic treatment is stiffness ie, the force delivered per unit of deactivation [(19)].

The friction resistance which occurs during sliding mechanics consists of complex interaction between the bracket, arch wire and method of legation [(11)]. The overall resistance to sliding in orthodontic appliance is a combination of classical friction, arch wire-bracket binding and arch wire notching [(10)]. Other important parameters are the bracket to wire positioning in a three-dimentional space, the ligation force and type of ligation, the interbracket distance and lubrication [(24)].

With regard to arch wires, several studies have generally shown that frictional resistance generally increased with an increase in arch wire size and rectangular wires produced more friction than round wire [(1,8,2)].

The design of a self-ligating bracket affects its frictional properties. Whether the arch wire contacts the slide or the clip of the self-ligating bracket (which restrains the archwire in the slot)[(23, 14)] determines the (FR) for the particular archwire-bracket combination.

The speed bracket can readjust itself three-dimensionally until the archwire is fully seated in the slot and any deviation during any kind of tooth movement results in a labial deflection of the spring that reactivate the homing action [(3).]

It was reported that the variables which affect the bracket-archwire friction resistance have been carried out under dry condition, as the effect of salivary lubrication is controversial [(1)].

This current laboratory study was designed to evaluate the frictional resistance of the SPEED brackets using different leveling arch wires, plane S.S., S.S. with a vertical loop, multistranded and nitinol arch wires under the dry condition.

Material and Methods

In this current study the friction resistance was evaluated by sliding four types of leveling archwires of 0.014" including plane S.S., S.S. with a vertical loop mesial to the canine, multistranded (round) and nitinol archwires. The bracket used was the selfligating SPEED brackets in a simulated U-shaped arch form, carrying a full upper set of bracket under the dry state. Ten arch wires from each group has been tested (Fig. 1).

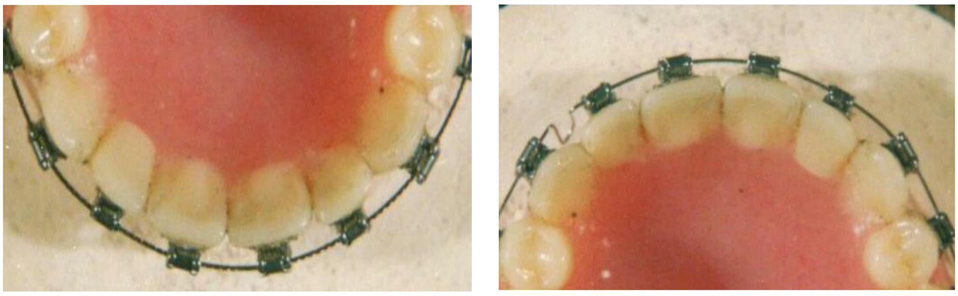

Fig.(1) Showing tested arch wire

The bracket used in this study was made of stainless steel alloy, with slot size of 0.22". The Universal Testing Machine was used to measure the amount of F.R. at the bracket-wire interface to simulate orthodontic sliding mechanics, with small tangential displacement.

U- shaped acrylic denture simulating the dental arch form was used having orthodontic bands with their tubes on its right & left molar tooth and the brackets were accurately positioned and bonded on its acrylic teeth with an orthodontic adhesive (Relay A. bond).

The tested arch wires were fitted into the brackets. The archwires were pulled through the bracket slot at a standard speed of 10mm./min. as it was reported that, there was no significant difference in frictional value using speeds from 0.5 to 50 mm. / min [15,4].

Each type of arch wire was planed to take the U-shaped arch form except the nitinol arch wires were ready made. For S.S. arch wire with vertical loop of 6mm. length was formed between the lateral and canine acrylic teeth. Each leveling arch was of 0.014" gauge and of 20 cm. length. The brackets and archwires were cleaned with 95% ethanol before testing to avoid any contamination [24].

Data analysis:

The mean and standard deviation were calculated for the (F.R.) generated form SPEED brackets with different types of leveling archs. ANOVA test was also used to evaluate the difference among the tested groups.

RESULTS

Friction resistance was tested for plane S.S., S.S. with vertical loop, multistronded and nitinol leveling arch wires, in simulation of orthodontic sliding mechanics in the patient's mouth.

The apparatus is done under the dry state.

ANOVA test showed that there was a statistically significant difference among the tested group of leveling arch wire (table 1). The arch wires showed the least amount of (FR) among the whole tested groups was (0.43) in the S.S. with vertical loop, then plane S.S. (0.51) then multi stranded arch wire(0.58) and nitinol showed the highest (FR) value (0.73) (Table 1).

Table (1): mean, standard deviation and ANOVA of the tested groups

Variables	Mean	Standard deviation	F-value
Plan S.S.	0.51	$\pm$ 0.39	0.315*
S.S. with vertical loop	0.43	$\pm$ 0.28	0.315*
Multistrand	0.58	$\pm$ 0.41	0.315*
Nitinol	0.73	$\pm$ 0.25	0.315*

n= 10 n= 40 *significant

DISCUSSION

The frictional resistance encountered during sliding mechanics constitutes complex interactions between bracket, archwire and method of ligation. This resistance at bracket-archwire interface has shown to improve tooth movement. Consequently, as the friction at the bracket-arch wire interface increases, the proportion of the applied force transmitted into tooth movement decreases thus, reducing the efficiency of the orthodontic appliance (9,10).

On comparing the frictional resistance of the four tested archwires, it was revealed that the S.S. with vertical loop archwire exhibited the least amount of friction (0.43) as compared to the other types of arch wires, then plane S.S. archwire (0.51). This is in accordance with the work of (1,2,7)

It is known that increasing the length of the wire increases its ductility and flexibility, thus the amount to the friction is suspected to be reduced. This holds true specifically that the results suggested that S.S. wires with vertical loop produced lower friction characteristics than other types of the tested wires.

The influence of the bracket and arch wire properties on the frictional resistance has been well documented by extensive research(10,13). The bracket used in this study was self-ligating SPEED bracket which was considered to produce less amount of friction than that of the ligation system technique this is in accordance with the work of Sims (1993)[20] and Thomas (1998)[21].

Generally, stainless steel wire produces less static and kinetic friction than nitinol wire [11]. The rounded cross section stainless steel wire was associated with the least amount of friction which could be attributed to the absence of edges that reduced the amount of plowing. On the other hand, the multistranded arch wires encountered many irregularities and sharp edges as compared to the stainless steel wire. As proved in the results of this study the frictional resistance of the multitranded archwire recorded was 0.58, this might be due to the interlocking during displacement [12,17,6].

It is worth mentioning that the stiffness is an important consideration in selecting of the archwires , low stiffness wires can be produced by conventional (NiTi) because the modulus of elasticity of NiTi is approximately 20 % that of st. st. archwires .

This results have shown that nitinol archwires expressed the greatest amount of friction (0.73) among the other types tested. The prominent abrasive, wear and increased coefficient of friction of NiTi suggest its relative softness than the st.st.because friction and hardness are inversely related.

Any previous studies reported a comparable frictional properties with both NiTi and S.S. wires where the variation could be related to the difference in methodology. The slight archwire tilting during testing might have resulted in a prominent edge thus increasing the coefficient of friction for this type of wire. Also the use of acrylic teeth differ from that of the natural teeth.

REFERENCES

1- **Angolkdar PV, Kpila S, Duncanson MG, Nanda RS.** Evaluation of friction between ceramic brackets and orthodontic wires of four alloys. Am. J. Orthod. Dentofac. Orthop. 1990; 98: 499 – 506.

2- **Bendar JR, Gruendeman GW, Sandrik JL.** Acompariative study of frictional forces between orthodontic brackets and arch wires. Am. J. Orthod. Dentofac. Orthop. 1991; 100 : 513 – 22.

3- **Berger JL.** Self ligation in the year 2000.J. Clin. Orthod. 2000; vol. 34 No 2: 74-81.

4- **Braun S, Bluestein M, Moore BK, Benson G.** Friction in perspective. Am J Orthod Dentofacial Orthop. 1999 Jun;115(6):619-27.

5- **Cacciafesta V, Sfondrini MF, Scribante A, Klersy C, Auricchio F.** Evaluation of friction of conventional and metal-insert ceramic brackets in various bracket-archwire combinations. Am J Orthod Dentofacial Orthop. 2003 Oct;124(4):403-9.

6- **Frank CA, Nikolai RJ.** A comparative study of frictional resistances between orthodontic bracket and arch wire. Am J Orthod. 1980 Dec;78(6): 593-609

7- **Ho KS, West VC.** Friction resistance between edgewise brackets and archwires. Aust Orthod J. 1991 Oct;12(2):95-9

8- **Kapila S, Angolkar PV, Duncanson MDJ, Nanda RS:** Evaluation of friction between edgewise stainless steel bracket and orthodontic wires of four alloys. Am. J. Orthod. Dentofac. Orthop. 1990 ; 98: 117 – 26.

9- **Kusy RP, Whitley JO.:** Friction between different wire-bracket configurations and materials. Seminars in orthodontics 1997; 3 : 166 – 77.

10- **Kusy RP**, **Whitley JQ**, **Prewitt MJ**. Comparison of the frictional coefficients for selected archwire-bracket slot combinations in the dry and wet states. Angle Orthod. 1991 Winter;61(4):293-302

11- **Michelberger DJ, Eadie RL, Faulker MG, Glover KE, parased NG, and Major PW.** The friction and wear patterns of orthodontic brackets and archwires in the dry state. Am. J. Orthod. Dentofac. Orthop. 2000, 118: 662 – 74.

12- **Nicolls J**. Frictional forces in fixed orthodontic appliances. Dent Pract Dent Rec. 1968 Jun;18(10):362-6.

13- **Omana HM**, **Moore RN**, **Bagby MD**. Frictional properties of metal and ceramic brackets. J Clin Orthod. 1992 Jul;26(7):425-32.

14- **Pizzoni L., Ravinholt G., Melsen B.** Frictional forces related to self-ligating brackets. Eur. J. orthod 1998; 20 : 283 – 91

15- **Prososki RP, Bagby MD, Erickson LC**. Static frictional force and surface roughness of nickel titanium arch wires. Am. J. Orthod. Dentofac. Orthop 1991: 100: 341 – 8.

16- **Read-Ward GE, Jones SP, Davies EH.** A comparison of self-ligating and conventional orthodontic bracket systems. Br J Orthod. 1997 Nov;24(4):309-17

17- **Riley JL Garrett SG.** Frictional force of ligated plastic and metal edgewise brackets. J. Dent. Res. 1979;58:A21

18- **Rossouw PE, ed.** Friction in orthodontics. Seminars in orthodontics 2003,9. Quoted from Frictional resistance of ceramic brackets when subjected to variable tipping movement by Bagby MN, Peter Bovenzier.T.orthodontics cyber journal-online journal 2004.

19- **Rucker BK and Kusy RP:** Resistance to sliding of stainless steel wires and comparison with single stranded leveling wires. Am. J. Orthod. Dentofac. Orthop. 2002: 73 – 83.

20- **Sims AP, Waters NE, Birine DJ.** A comparison of the forces required to produce tooth movement in vitro using two self-ligating brackets and a pre-adjusted edgewise bracket. Eur J Orthod. 1993 Oct;15(5):377-85.

21- **Thomas S, Sherriff M, Birnie D.** A comparative in vitro study of the frictional characteristics of two types of self-ligating brackets and two types of pre-adjusted edgewise brackets tied with elastomeric ligatures. Eur J Orthod. 1998 Oct;20(5):589-96.

22- **Tidy DC.** Frictional forces in fixed appliances. Am. J. Orthod. Dentofac. Orthop. 1989;96:249-54.

23- **Voudouris JC. Interactive edgewise mechanisms:** form and function comparison with conventional edgewise brackets. Am. J. Orthod. Dentofac. Orthop. 1997; 111: 119 – 40

24- **Willems G, Colcheret K, Celis JP, Verbeke G, Chatzicharalampous E:** Frictional behavior of stainless steel bracket wire combination subjected to small oscillat-displacement. Am. J. Orthod. Dentof. Orthop. 2001; 120 : 371 – 77.