



## A Comparative Evaluation Of Frictional Resistance Of Coated Wires And Non-Coated Wires In Conventional Stainless Steel Brackets: An In-vitro study.

### Dental Science

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### ABSTRACT

**Objectives:** To evaluate the dynamic frictional resistance of coated stainless steel wires and non coated stainless steel wires in conventional stainless steel bracket system.

**Materials and Methods:** The study was performed using specially designed apparatus that included 10 aligned brackets to compare the frictional resistance generated by conventional stainless steel brackets(0.022" slot) coupled with stainless steel, fully coated stainless steel and labially coated stainless steel archwires of varying dimensions by Universal Testing Machine. (Instron Machine, Model No.4501) Each bracket-archwire combination was tested 13 times. The data obtained were subjected to statistical analysis.

**Results:** Stainless steel archwire (16x22) shows least frictional mean values when compared to the varying dimensions and surface characteristic of archwires. (19X25)Teflon coated (Fully coated) stainless steel archwire shows highest frictional mean values when compared to the varying dimensions and surface characteristic of archwires. Fully coated archwires shows more frictional values than labially coated archwires and conventional stainless steel archwires.

**Conclusions:** Teflon coated (Fully coated) stainless steel archwire shows more friction than Labially coated stainless steel archwires and also more amount of friction than stainless steel archwires. Stainless steel archwire shows least frictional resistance values than Coated stainless steel archwires and also frictional values increased when the size of archwire increased.

### KEYWORDS:

Dynamic frictional resistance, Fully coated Teflon stainless steel archwires, Labially coated Teflon stainless steel archwires, Stainless steel brackets.

### INTRODUCTION:

Friction has been reported in the orthodontic literature as early as 1960's with an emphasis being given to the recognition of the fact that it is one of the commonest causes of appliance inefficiency, especially when sliding mechanics is employed as a method of retraction. When one body slides or tends to slide over another body, the force that acts to oppose the tendency to move is called the force of friction<sup>1</sup>. Friction exists in two forms - Static and Dynamic (kinetic) friction<sup>2</sup>. From an orthodontic perspective the initial force that is generated between the arch wire and the bracket is static in nature. Similarly the force generated by the movement or sliding of the archwire through the bracket slot is dynamic in nature. Numerous studies on friction have been carried out based on a number of parameters<sup>3</sup> such as archwires-varying cross sections, sizes, alloys, bracket composition, inter-bracket distance, bracket width, size of the slot, second order angulations, degree of torsion, ligation techniques, and wet or dry working fields have helped in identifying the patterns of friction.

Many technological innovations and developments in the areas of archwire processing and bracket designs have helped to minimize the phenomenon of friction. These improvements have led to the introduction of an array of archwires with alterations in their surface chemistry like Ion implantation, Teflon coating, etc.

PTTF (polytetrafluoroethylene) is a synthetic fluoropolymer of tetrafluoroethylene. PTFE is most well known by the DuPont brand name Teflon. Teflon (PTFE) was accidentally invented by Roy Plunkett of kinetic chemicals in New Jersey in 1938<sup>4</sup>.

The purpose of this study is to comparatively evaluate the dynamic frictional resistance generated by the stainless steel bracket system with Teflon coated archwires (i.e. labially coated Teflon archwires and fully coated Teflon archwires) and conventional stainless steel archwires of varying sizes.

### MATERIALS & METHODS:

In this study 3 custom fabricated metal jigs were used to house the bracket-archwire assemblies and carried out the frictional resistance study. One conventional stainless steel bracket system were used (0.022 slot Gemini, 3M Unitek). The archwires used were of Stainless steel Alloy (TP Orthodontics, Company), Fully Coated Teflon Stainless Steel archwire (G&H Wire Company), Stainless Steel archwire with Teflon coating on labial surface (DB Orthodontics Company). Archwire samples of the present study has the dimensions of (0.016" X 0.022"), (0.017" X 0.025"), (0.019" X 0.025")

The custom fabricated metal jigs had a dimension of 10cm in length, 3.5 cm in width and 1 cm thickness. The surfaces of each of the metal jigs were equally roughened so as to facilitate optimal bonding of the brackets<sup>5,6</sup>.

The maxillary 2nd bicuspid to 2nd bicuspid brackets (Left to Right) of Conventional 3M Gemini brackets were bonded with a cyanoacrylate adhesive (Quickfix) to the custom fabricated steel bars. The dimensions of the bar being 10cm x 3.5cm x 1cm. A line was drawn parallel to the long axis of each of these metal bars in order to aid in the alignment during drawing of the archwire through the bracket assembly so that friction was not induced by adverse tipping or torsion moments.

The ten brackets of each of the GEMINI Stainless steel bracket systems were engaged onto a 0.021" x 0.025" wire stainless steel so as to fill up the slot while the applied adhesive hardened on the steel bar. This technique enabled the bracket slot to be aligned along the length of the steel bar and parallel to it. Thereby allowing the slot of the bracket to be perpendicular to the surface of the steel bar.

The Gemini series brackets were ligated using 0.010" stainless steel ligature wires. This set up was repeated for each of the three metal bars which were bonded with their respective brackets. (fig.1,2)

The sliding friction is generated is calculated using a UTM (UNIVERSAL TESTING MACHINE) INSTRON. (Model no 4501) This universal testing machine is used for testing a variety of parameters such as friction, surface tension, hardness, elasticity, etc.

Prior to the start of the tests, the bracket-archwire assembly orientations to the holding jaws present at both ends of the testing machine.

For the standardization of the testing, a new archwire was used for each test run of the respective bracket assembly. This was carried out to prevent any distortion of the bracket slot or the archwire. Each archwire and the bracket slot were cleaned with methylated spirit and then dried with compressed air 5 min before the test run.

Once the bracket-archwire assembly was set up on the Universal testing machine, the load cell was calibrated to 1000g and the archwire was pulled through the bracket assembly at a cross head speed of 0.5mm per minute through a distance of 5 cm and the frictional force was noted in Newtons 5,6. Each archwire was drawn through the bracket assemblies and a mean value of the frictional force was taken into consideration.

**RESULTS:**

Mean values of (16X22) stainless steel archwires shows least frictional resistance as compare to the (16X22) Fully coated and Labially coated Teflon Stainless steel archwires.(Table-1)(Graph-1) Mean values of (17X25) stainless steel archwires shows least frictional resistance as compare to the (17X25) Fully coated and Labially coated Teflon Stainless steel archwires.(Table-2)(graph-2) Mean values of (19X25) stainless steel archwires shows least frictional resistance as compare to the (19X25) Fully coated and Labially coated Teflon Stainless steel archwires.(Table-3)(Graph-3). One Way ANOVA revealed that the difference in the frictional values for Stainless steel archwires and Teflon Coated archwires (i.e. Fully coated and Labially coated) were statistically significant.

**DISCUSSION:**

Friction can be described as the function of the relative roughness of two surfaces in contact.7 The wires used in our study were differing in their surface characteristics and sizes. The materials used include Gemini 3M Unitek Stainless Steel Brackets and Stainless steel archwires, Labially coated (Teflon coated) stainless steel archwires, Fully coated (Teflon coated) stainless steel archwires of dimensions (16 X 22), (17 X 25), (19 X 25) of rectangular cross-sections of wires have been used in this study. In our study, W1 (16X22 SS) shows lower levels of frictional resistance when compared to the W2 (16X22 Labially coated SS) and W3 (16X22 Fully coated SS). [Table- 1] In our study, W4 (17X25 SS) shows lower levels of frictional resistance when compared to the W5 (17X25 Labially coated SS) and W6 (17X25 Fully coated SS).[Table-2] In our study, W7 (19X25 SS) shows lower levels of frictional resistance when compared to the W8 (19X25 Labially coated SS) and W9 (19X25 Fully coated SS)[Table-3] This can be attributed to the increased surface roughness of Fully Coated stainless steel archwires when compared with the Labially coated Teflon stainless steel archwires and conventional stainless steel archwires. 8,9,10 In our study, W1 (16X22 SS) shows lower levels of frictional resistance when compared to the W4 (17X25 SS) and W7 (19X25 SS) (Graph-4) and also W2 (16X22 Labially coated SS) shows lower levels of frictional resistance when compared to the W5 (17X25 Labially coated SS) and W8 (19X25 Labially coated SS) (Graph-5) And also present study shows, W3 (16X22 Fully coated SS) shows lower levels of frictional resistance when compared to the W6 (17X25 Fully coated SS) and W9 (19X25 Fully coated SS) (Graph-6) There was an increase in the frictional resistance among all archwires and brackets when the diameter of archwires increased in rectangular archwires in the ascending order. These values are similar to the studies conducted by Susan Thomas et al11, Drescher et al12

Teflon coated wires (i.e. labially coated and fully coated archwires) in the present study tabulated the maximum amount of frictional resistance in comparison to conventional stainless steel archwires. In the present study we observed increased frictional resistance with Teflon coated wires. The increase in frictional resistance can be due to irregularities found on unused Teflon coated wire. Garner et al, R.P.Kusy and J.Q. Whitley13also concluded an increase in surface roughness of archwires leading to increased frictional resistance Teflon coated wire showed the maximum peak value in comparison to

all the other wires. The increase in depth parameter of surface roughness can be due to the fact that Teflon coating peeled off from the surface of the wire after experimentation by Firas Elayyan, Nick Silikas and David Bearn10,14, who showed an increase in depth of surface roughness of retrieved coated arch wires.

The clinical significance of this study implies that stainless steel brackets are associated with higher magnitudes of frictional resistance with Teflon coated archwires. (i.e. Labially coated and fully coated) Therefore greater amount of force is needed to move a tooth with this bracket- wire combination than the stainless steel archwire and stainless steel brackets combination.

One of the limitations of the present study was difficult in extrapolating the values for friction determined in-vitro to an in- vivo situation. This was due to difficulty in reproducing oral conditions such as muscular and occlusal forces, role of saliva, malposed teeth and tooth movement through bone,etc. which may affect the binding of archwire to the bracket.

With the advancement in esthetic materials and their manufacturing process, wide varieties of archwires are available for clinical use. Therefore it has become important to understand the frictional characteristic of these materials before they are used.

**CONCLUSION:**

This study was done to comparatively evaluate the dynamic frictional resistance of Teflon coated stainless steel archwires (i.e. Fully coated and Labially coated) and conventional stainless steel archwires of varying sizes with stainless steel bracket system.

**The result of this study revealed the following findings:-**

- The overall dynamic or kinetic frictional resistance of (0.016"x 0.022") stainless steel archwires demonstrated the least level of frictional value when compared to other dimensions of stainless steel archwires.
- The overall dynamic or kinetic frictional resistance of (0.016"x 0.022") Labially coated Teflon stainless steel archwires demonstrated the least level of frictional value when compared to other dimensions of Labially coated Teflon stainless steel archwires.
- The overall dynamic or kinetic frictional resistance of (0.016"x 0.022") Fully coated Teflon stainless steel archwires demonstrated the least level of frictional value when compared to other dimensions of Fully coated Teflon stainless steel archwires.
- Fully coated Teflon stainless steel archwires revealed higher frictional forces than conventional stainless steel archwires. Labially coated Teflon stainless steel archwires produced more friction than stainless steel archwires.
- The frictional values for all tested archwires exhibited increased frictional values as the dimension of archwires are increased with conventional stainless steel bracket system were found.
- Stainless steel archwires can be effectively and efficiently used in conjunction with stainless steel brackets to bring about the desired movement of teeth.

	N	Mean	SD	Min	Max	P- value
<b>W1</b>	13	159.746	1.004	157.789	161.262	<0.05
<b>W2</b>	13	185.793	1.013	183.789	186.8999	<0.05
<b>W3</b>	13	214.953	0.982	212.899	216.691	<0.05

**FIGURES AND LEGENDS:**

**Table- 1 – Comparison of mean values and SD for Archwires W1,W2,W3 in SS Brackets(gms)**

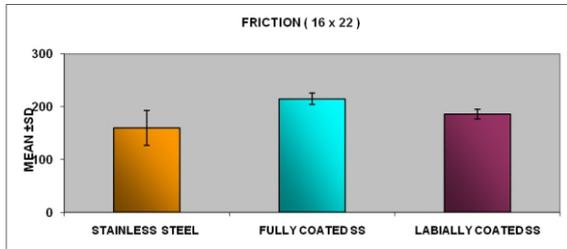
	N	Mean	SD	Min	Max	P- value
<b>W4</b>	13	205.857	0.964	203.789	207.382	<0.05
<b>W5</b>	13	237.746	1.141	235.142	239.801	<0.05
<b>W6</b>	13	261.635	0.993	259.620	263.126	<0.05

**Table- 2 – Comparison of mean values and SD for Archwires W4,W5,W6 in SS Brackets(gms)**

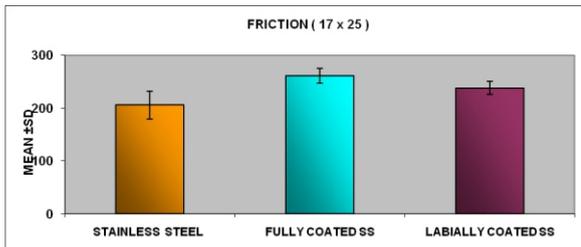
	N	Mean	SD	Min	Max	P- value
<b>W7</b>	13	262.687	1.127	260.091	264.714	<0.05
<b>W8</b>	13	286.635	0.994	284.620	288.126	<0.05
<b>W9</b>	13	318.403	1.026	316.029	320.094	<0.05

**Table- 3 – Comparison of mean values and SD for Archwires W7,W8,W9 in SS Brackets(gms)**

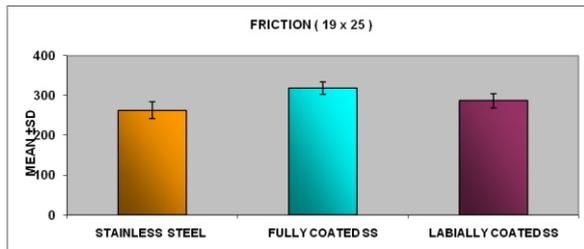
**Graph 1 – Comparison of mean values of frictional force generated between Archwires W1, W2, W3 in SS Brackets (gms)**



**Graph 2 – Comparison of mean values of frictional force generated between Archwires W4,W5,W6 in SS Brackets(gms)**



**Graph 3 – Comparison of mean values of frictional force generated between Archwires W7,W8,W9 in SS Brackets(gms)**



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