American Journal of
Oral Medicine and Radiology

ISSN - 2394-7721

www.mcmed.us/journal/ajomr

Research Article

COMPARITIVE STUDY OF FRICTION TESTING OF UNCOATED, POLYMER-DRUG COATED & TEFLON/TOOTH COLOURED ORTHODONTIC ARCHWIRES

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ABSTRACT
Archwire alloys are available in various forms and shapes for multiple tooth movements like intrusion and retraction of teeth during orthodontic treatment. Coating on archwires can be done by various methods to improve its mechanical and surface corrosion properties. Chemical and thermal passivation, laser welding, laser melting, surface ion implantation and cathodic electrophoretic deposition of functional materials has been used as surface modification treatment to improve its thermal and mechanical properties. In this study, we are planning to do an in-vitro comparative assessment of the friction/wear resistance of uncoated, polymer-drug coated and Teflon/tooth coloured orthodontic archwires.

Key words:- Archwire alloys, Orthodontic treatment, Uncoated, Polymer-drug coated and Teflon/tooth.

Access this article online

Home page:
http://www.mcmed.us/journal/ajomr

DOI:
http://dx.doi.org/10.21276/ajomr.2019.6.2.5

Quick Response code

Received:25.09.19	**Revised:**12.10.19	**Accepted:**15.10.19

INTRODUCTION

Archwire alloys are available in various forms and shapes for multiple tooth movements like intrusion and retraction of teeth during orthodontic treatment.

Stainless steel archwires have always been the mainstay for this phase of treatment. Titanium-based archwire is also used for this purpose.

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In Earlier days gold wires were used for orthodontic treatment. Due to the cost factor, it has been replaced by stainless steel wires, which has improved mechanical and physical properties.
More recently, Co -Cr, Ni-Ti, B-TMA and multi stranded stainless archwires have been developed with a good range of physical and mechanical properties.

Nickel titanium (NiTi) archwires are widely used during the alignment phase of orthodontic straight-wire mechanics. These archwires have unique properties of superelasticity and shape memory which are responsible for their growing use among clinicians [1].

Titanium molybdenum alloys: Mechanical properties of these wires are generally assessed by tensile, bending, and torsion tests. Although wire characteristics determined by these tests do not necessarily reflect the behavior of the wires under clinical conditions, they provide a basis for comparison of these wires. .

Friction :

Friction, or resistance to sliding (RS), can be defined as the resistance to motion when a solid object moves tangentially against another RS can be divided into three components: classical friction, elastic binding, and plastic binding or physical notching. In the passive configuration, when the archwire does not contact the mesial and distal edges of the bracket slot, only classic friction contributes to RS.

Friction and wear phenomena in archwire-bracket contacts are crucial for the quality of orthodontic treatment. Indeed, high friction coefficient induces overstressing.

Recent studies show that resistance to friction and wear between the archwire and the bracket are of great importance for the quality of orthodontic treatment.

Nitinol alloy has been extensively studied as an implant material for biomedical applications (orthodontic wires, self-expanding cardiovascular and urological stents, bone implants and tiny surgery tools). Its good corrosion resistance and biocompatibility with the human body can be attributed to a layer comprised mainly of TiO_2, with a small amount of NiO on the outermost surface layer[2].

Polytetrafluoroethylene (PTFE) is a synthetic fluoropolymer of tetrafluoroethylene that has numerous applications. The best known brand name of PTFE-based formulas is Teflon by Chemours. Chemours is a spin-off of DuPont, which originally discovered the compound in 1938.

Coating on archwires can be done by various methods to improve its mechanical and surface corrosion properties. Chemical and thermal passivation, laser welding, laser melting, surface ion implantation and cathodic electrophoretic deposition of functional materials has been used as surface modification treatment to improve its thermal and mechanical properties.

In this study, we are planning to do an in-vitro comparative assessment of the friction/wear resistance of uncoated, polymer-drug coated and Teflon/tooth coloured orthodontic archwires.

MATERIALS AND METHODOLOGY

Nickel titanium wires- Uncoated, Polymer-Nanosilver coated and Teflon/Tooth coloured wires, PTFE, PFA.

Nano laboratory materials :

Planar magnetron sputtering unit(Adulon Polymers, Coimbatore) Scanning electron microscope(Mechanical department, Anna university Chennai)

METHOD OF PREPARATION OF NANO SILVER COATED ORTHODONTIC ARCHWIRES

Surface modification of Nickel titanium orthodontic archwires with Ag nanoparticles was carried out by Adulon polymers laboratory, Coimbatore, by a process of **electrodeposition/sputtering**.

Sputtering process remove surface atoms or molecular fragment from a solid cathode (target) by bombarding it with positive ions from an inert gas (argon) discharge, and deposit them on the nearby substrate to form a thin film. Substrates are placed in a vacuum chamber and are pumped down to a prescribed process pressure. Sputtering starts when a negative charge is applied to the target material causing a plasma or glow discharge. Positively charged gas ions generated in the plasma region are attracted to the negatively biased target plate at a very high rate of speed. This collision creates a momentum transfer and ejects atomically sized particles from the target. These particles are deposited as a thin film on to the surface of the substrates.

In this study, sputtering was carried out on Niti orthodontic wires (substrates) using silver(ag) as the target. A plasma generated inside the vacuumised chamber ejected surface atoms from the silver target, which were sputtered on to the stainless steel brackets (substrates). The distance between the substrate and the target was kept constant at 7 cm and sputtering was conducted for a period of 10 minutes. All archwires were sputtered at the same time to achieve a thin and uniform coating of silver[3].

METHODS

This study was done on 100 specimens of orthodontic archwires for each of the tests. The specimens were divided into 2 test groups. Each group consisted of 25 specimens.

STUDY DESIGN

Study was allocated into 2 groups (experimental study)

-25 wires in each control groups (25*2=50)

-25 wires in each experimental group (25*2=50)

MECHANICAL PROPERTIES

Friction testing: It will be done with the use of fixture provided to which the wire will be ligated to the bracket and pulled at a speed of 10mm/min until 20mm. Maximum load obtained during test is considered as the frictional resistance.

Frictional measurements were made with a universal testing machine at a crosshead speed of 10 mm per minute set in standard tensile mode and force levels required to pull the wire through the bracket (022 3 028-

in slot, Gemini maxillary right first premolar bracket, Roth prescription, 3M Unitek, Monrovia, Calif), which was fixed on a metal sheet. The arch wires were ligated by using 0.012-in elastomeric ligatures. The arch wire and bracket were tested so that a new wire and a new bracket with fresh ligation were used for each combination and then discarded to eliminate the influence of wear[4].

The orthodontic wires were mounted on to a specially designed jigs for the friction test. The jig consisted of a flat acrylic platform of dimensions (—x—x—cm). To this platform an orthodontic premolar bracket was fixed a standard length using cyanoacrylate glue and dried. The Orthodontic wire was mounted on to the bracket and was ligated. The assembly was mounted vertically onto the universal testing machine platform and the orthodontic wire was pulled through the bracket at a cross head speed of 10mm/minute until 20mm length. The maximum load during the test was considered as the frictional resistance (n = 5)

FRICTION TEST MEASUREMENTS

Sample A1 denotes polymer-drug coated 0.016 inch round Niti arch wire.

Sample A2 denotes polymer-drug coated 0.016*0.022 inch rectangular Niti arch wire

The mean of A1 is higher than the mean A2 and the standard deviation of A1 is also higher A2. This

	MAX LOAD (N)
SAMPLE A1	
1	6.43
2	11.02
3	2.6
4	1.17
5	2.26
MEAN	4.696
S.D	3.626560905
SAMPLE A2	
1	2.16
2	6.07
3	8.25
4	2.43
5	1.36
MEAN	4.054
S.D	2.651524844
SAMPLE B1	
1	0.76
2	0.39
3	5.18
4	0.91
5	0.48
MEAN	1.544
S.D	1.827617028
SAMPLE B2	
1	1.1
2	7.05
3	0.54
4	0.71
5	0.65
MEAN	2.01
S.D	2.527061535
SAMPLE C1	
1	1.18
2	0.88
3	0.87
4	0.69
5	0.77
MEAN	0.878
S.D	0.166300932
SAMPLE C2	
1	1.31
2	2.94
3	3.37
4	3.44
5	2.08
MEAN	2.628
S.D	0.817885078

statistical analysis shows that the polymer drug coated frictional resistance of round wire is better than the rectangular wire.

Sample B1 denotes uncoated 0.016 inch round wire

Sample B2 denotes uncoated 0.016*0.022 inch rectangular wire

The mean of B2 is higher than the mean B1 and the standard deviation of B2 is also lower than B1. This shows of group of B2is higher than Group B 1. This statistical analysis shows that the uncoated frictional resistance of round wire is better than the rectangular wire.

Sample C1 denotes tooth coloured/Teflon 0.016 inch round wire

Sample C2 denotes tooth coloured/Teflon 0.016*0.022 inch rectangular wire

The mean of C2 is higher than the mean C1.This shows group of C2 is higher than Group C1. This statistical analysis shows that the Teflon coated round wire is better than the rectangular wire in friction resistance.

The results shows that values of A1,A2 is greater than B1,B2 &C1,C2 respectively which shows that polymer-coated round wires are having greater resistance to friction than uncoated and Teflon-coated/tooth coloured sample wires and have greater resistance to friction when compared to rectangular wires of same category as well.

FRICTION TEST MEASUREMENTS

		MAX LOAD (N)	
		Mean	SD
Group	Group A1	4.69600	4.05462
	Group A2	4.05400	2.96449
	Group B1	1.54400	2.04334
	Group B2	2.01000	2.82534
	Group C1	.87800	.18593
	Group C2	2.62800	.91442

The group statistics for the T- Test reveals the mean of the group A1 has higher values than the group A2. The values of C2 is higher than C1, and the B2 is higher than B1 and the values of uncoated rectangular wires are in the lower friction stress category, This shows the round polymer wire has lowest frictional stress than the round Teflon wire.

One way ANOVA
MAX LOAD (N)

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	54.646	5	10.929	1.714	.170
Within Groups	153.027	24	6.376		
Total	207.673	29			

The one way Anova test statistically implies that the F. value is 1.714 and the significant level of 0.170.

T-Test
Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
MAX LOAD (N)	Group A1	5	4.6960000	4.05461835	1.81328045
	Group A2	5	4.0540000	2.96449490	1.32576242

The group statistics for the T-test reveals the mean of the group A1 has higher values than the group A2. This shows the rectangular polymer coated wire has lower frictional stress than the round polymer coated wire.

T-Test
Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
MAX LOAD (N)	Group B1	5	1.5440000	2.04333796	.91380851
	Group B2	5	2.0100000	2.82534069	1.26353077

The group statistics for the T-test reveals the mean of the group B2 has higher values than the group B1. This shows the round uncoated wire has lower frictional stress than the rectangular uncoated wire.

T-Test
Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
MAX LOAD (N)	Group C1	5	.8780000	.18593009	.08315047
	Group C2	5	2.6280000	.91442332	.40894254

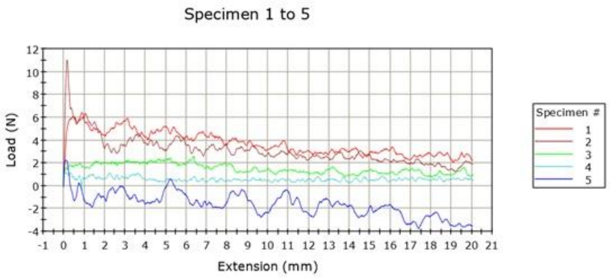
The group statistics for the T-Test reveals the mean of the group C2 has higher values than the group C1. This shows the round Teflon wire has lowest frictional stress than the rectangular Teflon wires.

T-Test
Group Statistics

		MAX LOAD (N)	
		Mean	SD
Group	Group A1	4.69600	4.05462
	Group B1	1.54400	2.04334
	Group C1	.87800	.18593

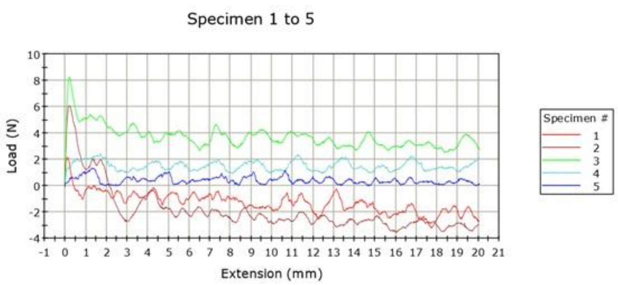
For the frictional test analysis test was done in the groups of A1,B1and C1. The values are tabulated and the research was done under by calculating the mean values.A1 has the higher mean value than B1. The statistical analysis shows that the round polymer coated wires has higher resistance to friction than the uncoated wires. The Teflon-coated wires are capable of withstanding the max load of 2.628 Mpa.

FRICTION TEST GRAPHS



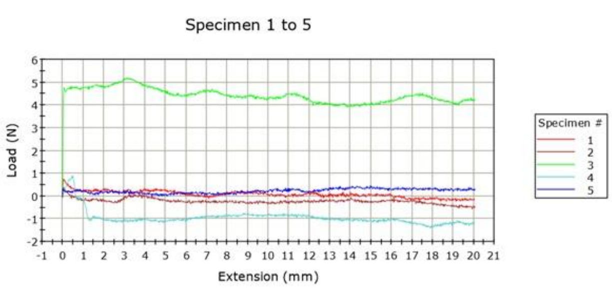
Sample A1

	Maximum Load (N)
1	6.43
2	11.02
3	2.60
4	1.17
5	2.26



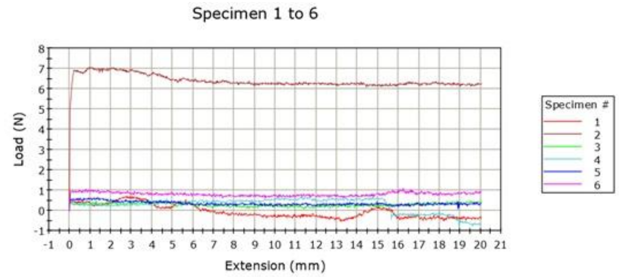
Sample A2

	Maximum Load (N)
1	2.16
2	6.07
3	8.25
4	2.43
5	1.36



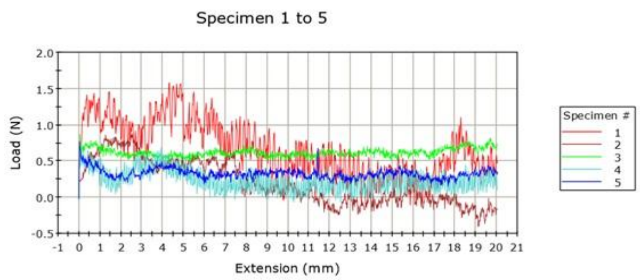
Sample B1

	Maximum Load (N)
1	0.76
2	0.39
3	5.18
4	0.91
5	0.48



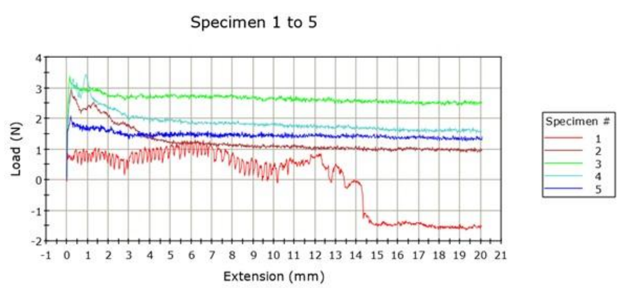
Sample B2

	Maximum Load (N)
1	1.10
2	7.05
3	0.54
4	0.71
5	0.65
6	1.10



Sample C1

	Maximum Load (N)
1	1.58
2	0.88
3	0.87
4	0.69
5	0.77



Sample C2

	Maximum Load (N)
1	1.31
2	2.94
3	3.37
4	3.44
5	2.08

RESULTS

Friction Test Measurements

The mean of A1 is higher than the mean A2 and the standard deviation of A1 is also higher A2. This statistical analysis shows that the polymer-drug coated frictional strength of round wire is better than the rectangular wire.

The mean of B2 is higher than the mean B1 and the standard deviation of B2 is also lower than B1. This shows of group of B2 is higher than Group B 1. This statistical analysis shows that the uncoated frictional strength of round wire is better than the rectangular wire.

The mean of C2 is higher than the mean C1.This shows of group of C2 is higher than Group C1. This statistical analysis shows that the Teflon coated compressive strength of round wire is better than the rectangular wire[5].

CONCLUSION

The results shows that values of A1,A2 is greater than B1,B2 &C1,C2 respectively which shows that polymer-coated round wires are having greater resistance to friction than uncoated and Teflon-coated/tooth coloured sample wires and have greater resistance to friction when compared to rectangular wires of same category as well.

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