ORIGINAL RESEARCH PAPER

Volume-8 | Issue-6 | June-2019 | PRINT ISSN No. 2277 - 8179

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

EFFECT OF INTRAORAL ENVIRONMENT ON THE PROPERTIES OF DIFFERENT ALIGNMENT WIRES – IN VIVO STUDY

Dental Science

Dr. Yukti Raj* B.D.S, M.D.S King George's Medical University, Lucknow *Corresponding Author

Dr. Abhay K.Das B.D.S, M.D.S

Dr. Pradeep Tandon B.D.S, M.D.S Professor and Head, King George's Medical University, Lucknow

Dr. Alka Singh B.D.S, M.D.S King George's Medical University, Lucknow

Dr. Gyan P. Singh B.D.S, M.D.S King George's Medical University, Lucknow

Dr. Syed Shafaq Zainab B.D.S, M.D.S

ABSTRACT

This study aims to evaluate and compare the effect of intraoral environment on tensile strength and modulus of elasticity of different alignment wires on Universal Testing Machine.

Materials and methods: 144 wire samples were divided into 4 groups(Group I- IV). **Group I** = 0.014 inch stainless steel wire, **Group II** = 0.014 inch Nickel-Titanium wire, **Group III** = 0.014 inch Thermoelastic Nickel Titanium wire, **Group IV** = 0.016 x 0.022 inch Graded thermodynamic Nickel Titanium wire, keeping 72 wire samples as Unused wire(A) and 72 as Retrieved(B) wire samples .

Results: There was decrease in tensile strength and modulus of elasticity for **Retrieved(B)** wires.The tensile strength of Stainless steel was found to be maximum while Thermoelastic Ni-Ti showed minimal value. Modulus of elasticity of graded thermodynamic Ni-Ti showed minimal value.

Conclusion: Graded thermodynamic Nickel Titanium wires were found to perform better clinically, delivering a constant force over time.

KEYWORDS

Wires, Tensile strength, modulus of elasticity, Graded thermodynamic Ni-Ti.

INTRODUCTION

The evolution of wire started from Gold, Stainless steel, Nitinol[1], TMA[2], super elastic Chinese NiTi[3], Japanese[4] NiTi, Body heat activated NiTi wires[5] to Graded thermodynamic NiTi[6] wire. With time, concept of archwire use has changed from variable cross section orthodontics and variable modulus orthodontics[7] to variable transformation temperature orthodontics. Optimum orthodontic tooth movement is produced by light, continuous force as explained by **Smith** [8] and **Reitan**[9]. Hence, elastic property and mechanical factors both must be considered for alignment to be achieved[10,11]. Many in-vitro studies have been done to evaluate the mechanical properties of different alignment wires[12,13,14,15]. Oral environment being dynamic involve continuous interaction of different stresses, masticatory forces, temperature fluctuations (**Chaturvedi and Upadhayay,2010)**[16]. **Kim et al**[17] showed that both NiTi and Stainless steel were susceptible to pitting and localized corrosion. Archwires when engaged, the reactivity status of wire increases leading to their increased reactivity[18]**.** Wires as they remain in the oral cavity, breaks as reported in clinical studies of **Lin M, Lin S, Lee T, Huang H**[19] and **Matasa**[20]**.**

AIMS AND OBJECTIVES:

1. Evaluate the effect of intraoral environment on tensile strength and modulus of elasticity of different alignment wires after initial alignment.
2. Comparison of tensile strength and modulus of elasticity among different wires.

MATERIALS AND METHODS

On the basis of wire materials, samples were divided into 4 groups**(Group I- IV)** keeping 18 samples in each group as a standard (**Unused wire=A**) and 18 wires as a used (**Retrieved=B**) sample after the initial alignment(3-4months) was complete.

Criteria for selection of subjects were as follows:

Inclusion criteria:

1. Upper and lower fixed orthodontic treatment are required.
2. Had not undergone any fixed orthodontic appliance therapy before.
3. The patient between 12 – 18 years of age group.
4. Moderate crowding of 5.1mm - 8mm**.**

Exclusion criteria:

1. Mild(0-5mm) and severe(more than 8mm) crowding.
2. Severe posterior crossbites like scissor bite.
3. Systemic disease.
4. Periodontal disease or any loss of attachment.

The wires used were**(Fig. 1)**

Group I = 0.014 inch stainless steel wire.
Group II = 0.014 inch NiTi wire.
Group III = 0.014 inch Thermoelastic NiTi wire.
Group IV = 0.016 x 0.022 inch Graded thermodynamic NiTiwire.

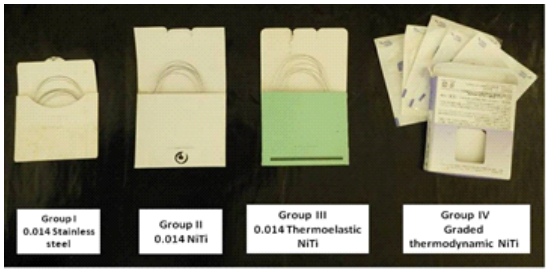

Fig 1: Different Groups of Unused wires.

Group IV wire is a superelastic shape memory NiTi wire with very low hysteresis that provide gradually increasing forces from anterior to posterior segment. Therefore, graded thermodynamic wire will produce significantly lower in small anterior teeth, while it will gradually increase the force moving from the anterior to the posterior segment of the wire(**Kuftinec and StomD,2008**[6]). Removed archwires are shown in **Fig.2.**

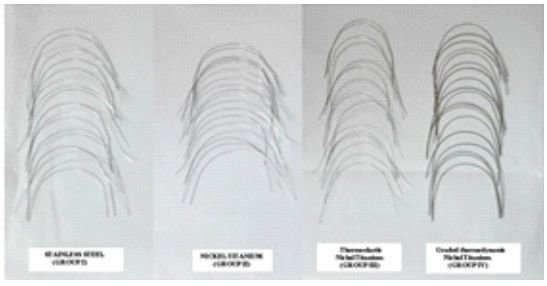

Fig 2: Used wire samples in different Groups

The above mentioned group of wires were tested for tensile strength & modulus of elasticity with a **Universal Testing Machine (Model 3382, Instron, Canton, MA, USA)(Verstrynge, Van Humbeek, and Willems, 2006[12])** with the help of the **BLUEHILLsoftware(Fig.3)**

Fig3: Universal Testing Machine

RESULT

From Table 1, it was found that the mean tensile strength of **Group I** was maximum followed by **Group II, Group IV** and was least for **Group III** samples

Type	Mean ± SD	Min	Max	p-value
Group IA	2076.2 ± 43.4	2020.9	2209.0	<0.001
Group IB	1707.3 ± 178.2	1488.8	1987.6	
Group IIA	1725.8± 96.1	1489.9	1885.2	<0.001
Group IIB	1043.6 ± 144.0	867.5	1287.7	
Group IIIA	1048.5 ± 26.2	1009.4	1098.9	0.002
Group IIIB	954.6 ± 115.1	620.9	1040.8	
Group IVA	1083.4 ± 63.9	1003.0	1199.0	<0.001
Group IVB	1003.3 ± 51.6	870.0	1090.0	

p*>0.05=not significant, p**<0.05=just significant, p***<0.01=significant, p****<0.001=highly significant.

Table 1:Intergroup comparison of mean and SD of Tensile Strength among various Standard(A) and Used(B) wire Groups in MPa units.

From Table 2, the modulus of elasticity was maximum for **Group I** followed by **Group II, Group III** and was least for **Group IV.**

Type	Mean ± SD	Min	Max	p-value
Group IA	126316 ± 4436.2	112423.0	129654.0	<0.001
Group IB	106718.6 ± 2404.8	102890.0	112423.0	
Group IIA	100325.5 ± 5767.0	95648.0	120120.0	<0.001
Group IIB	49861.9 ± 6265.2	35201.0	58643.0	
Group IIIA	23370.8 ± 2262.4	20567.0	29743.0	<0.001
Group IIIB	15595.6 ± 867.0	14521.0	16848.0	
Group IVA	11961.8 ± 1126.0	7977.0	12987.0	<0.001
Group IVB	10802.2 ± 548.5	10067.0	11503.0	

p>0.05=not significant, p<0.05=just significant, p<0.01=significant, p<0.001=highly significant.

Table 2:Intergroup comparison of mean and SD of Modulus of Elasticity among various Standard(A) and Used(B) wire Groups in MPa units.

DISCUSSION

Comparison of the result done through **ANOVA**, **SNV- z** on **SPSS version 21software.**

Table No. 1 shows the evaluation of mean Tensile strength for **Group I, II, III and IV** between subgroup **A(Unused)** and **B(Retrieved)** in MPa units. From the table, it was found that the mean tensile strength of **Group I** was maximum followed by **Group II, Group IV** and was least for **Group III** wires. These were similar to the findings of **Andreasen[1], Burstone[7], Bernabe & Flores[21], Krishnan and Kumar[22], Juvvadi et al[23]** for **Group I.** However some previous studies **(Burstone[7], Kapila and Sachdeva[13], Wilkinson[24])** showed increased values. The values obtained for **Group II** were similar to the study of **Andreasen[1], Bradley et al[25]** while increased values were shown by the studies of **Kapila and Sachdeva[13], Kusy and Whitley[26]** .4For **Group III** wires, these were having tensile strength similar to the study of **Gravina, Brunharo, Canavarro, Ellas and Quintao[27]**. In all these four groups the mean tensile strength was found to be highly significant for **Group I, II, IV** and significant for **Group III**. This was supported by the study of **Liu, Lee and Liu[28]**. **Group III** failed to demonstrate better performance than **Group I** or **Group II** archwires which may be either due to the large variation in individual metabolic response**,** variation in manufacturing process or due to microcavities formed due to pooling of Ni and Ti intraorally **(Gravina et al)[27].** The modulus of elasticity as shown in **Table No.2** was maximum for **Group I** followed by **Group II, Group III** and was least for **Group IV** wires**.** In all these four groups the modulus of elasticity was found to be highly significant for **Group I, II, III and IV**. This gradation was found similar to the in-vitro studies of **Andreasen & Morrow[1], Kusy[29], Kusy & Greenberg[30], Kapila & Sachdeva[13], Kusy[31], Iijima et al[32]** and in-vivo study of **Evans[33]**. According to an in-vitro study of **Gravina et al[34]**, **Group III** demonstrated superior properties than **Group I** and **Group II** archwires as opposite to what found in our study. This may be due to the same reasons discussed above. Values of **subgroup A** were found to be higher than **subgroup B** which clearly explains that the properties were decreased and wire detoriated after their use in the oral cavity, these were similar to the findings of **Bourauel, Scharold, Jager and Eliades[35]**. The mean detoriation were found to be highly significant for all the wire groups. On comparing the combined effect of Retrieved wires**(Table 3)** as a % of Standard among various wire Groups, it was found that the used % of combined effect was maximum for **Group IV** and it was followed by the **Group-I**

Group	Combined Effect (Geometric Mean of Two Effects)				z-value	p-value
	GM of % of Means	GM of SD Ratio	GM of % of Min.	GM of % of Max		
Group Ib	83.4	1.5	82.1	88.3	1.893	0.058
Group IIb	54.8	1.3	46.3	57.7	3.853	<0.001
Group IIIb	77.9	1.3	65.9	73.2	2.260	0.024
Group IVb	91.4	.6	104.6	89.7	1.301	0.193

p>0.05=not significant, p<0.05=just significant, p<0.01=significant, p<0.001=highly significant.

Table 3: Comparison of combined effect of mean Tensile Strength and Modulus of Elasticity among various wire groups, Group Ib, IIb, IIIb and IVb as a percentage of Standard strengths.

In both of these groups no significant difference was found from the hypothesis assumed after the use of wire. The minimum used % of combined effect was seen in **Group-II** wires which was significantly different from the hypothesis assumed after the use of wire. As many in-vitro(**Andreasen[1], Kapila and Sachdeva[13], Kusy[26,29,30,31,36], Evans[33], Iijima et al[32], Gravina et al[27,34,37]**) studies have been done to evaluate the properties of wire, this study as done in-vivo is benefitted with the amalgamation of different factors(organic and inorganic) which comes to play in the oral environment. The oral temperature(37^{o}c) holds more importance for **Group III** wires, as they are activated in the oral environment at 35^{o}c (Type III variety). Most important in alignment and leveling archwires include the low stiffness of wire which will be able to deliver low forces per unit of deactivation(**Montasser,2017)[38].** Henceforth, in our study **Group IV** wires delivered minimum modulus of elasticity hence can be considered to be best among the four different wire material tested. Also being rectangular, these wires will be able to control root movement and express torque from the initial stages of tooth movement as supported by the study of **Kapila and Sachdeva(1989)[13]**.6The next very important criteria is the tensile strength of the wire ligated to resist any permanent deformation. As **Group I** wires showed the maximum tensile strength, it is justified that lowest diameter archwires are preferable for alignment and leveling when these are used but as there modulus of elasticity also being highest amongst all groups, omit its use as a preferable wire for alignment and leveling. Considering the combination of the two properties(tensile strength and modulus of elasticity), **Group IV** wires were found to be best for the use in initial alignment. Also as these wires had minimal decrease in strength after its retrieval from the oral cavity after initial alignment.

CONCLUSION

The following conclusions were drawn:-

1. On comparing **Unused(A)** and **Retrieved(B)** wires, tensile strength and modulus of elasticity in **Retrieved** wire groups were found to be decreased.
2. **Group III** wires showed least tensile strength which may be due to large variation in individual metabolic response, due to variation in manufacturing process or due to pooling out of ions in the oral cavity. **Group I** were found to have maximum tensile strength amongst all.
3. **Group IV** wires showed least detoriation in tensile strength and modulus of elasticity amongst the four groups of wire while **Group II** showed maximum when retrieved from the oral cavity after initial alignment .
4. Graded thermodynamic NiTi (**Group IV**) wires showed minimal change in modulus of elasticity and tensile strength and hence found to perform better clinically.

REFERENCES

1. Andreasen and Morrow. Laboratory and clinical analyses of nitinol wire. Am J Orthod Dentofacial Orthop; 1978; 73;2:142-51.
2. Burstone and Goldberg, Beta titanium : A new Orthodontic alloy . Am J Orthod Dentofacial Orthop; volume 1980 Feb (121-132).
3. Burstone, Qin and Morton , Chinese Niti wire – A new orthodontic alloy. Am J Orthod Dentofacial Orthop; volume 1985 June (445-452).
4. Miura, Mogi,Ohura and Hamanaka: Super elastic property of Japanese NiTi along wire for use in Orthodontics. Am J Orthod Dentofacial Orthop; 1986 August (1-10).
5. Sachdeva R. Sure-Smile: Technology-driven solution for orthodontics. Tex Dent J. 2002;119 (7) :608-15.
6. Dr. Mladen M. Kuftinec, StomD. Making a Good Use of a Good Material: BioForce® Arch Wires. ©2008GACInternational.
7. Burstone CJ. Variable-modulus orthodontics. Am J Orthod Dentofacial Orthop;1981;80:1-16.
8. Smith R,Storey E:The Importance of force in Orthodontics. Aust Dent J;56:291-304,1952.
9. K.Reitan. Some factors determining the evaluation of forces in orthodontics. Am J Orthod Dentofacial Orthop; 1957;32-45.
10. Proffit William R., Fields Henry W and Sarver.D.M : Contemporary orthodontics, fifth Editions.
11. Skinner and Philips: Science of Dental materials, Eleventh edition.
12. Verstrynge. A , Humbeeck.Jan V & Williams.G . In-vitro evaluation of the material characteristics of stainless steel and beta titanium orthodontic wire ; Am J Orthod Dentofacial Orthop; October 2006 ; 130:4: 460-470.
13. Kapila.S and Sachdeva.R. Mechanical properties and clinical applications of orthodontic wires ; Am J Orthod Dentofacial Orthop; August 1989; 96:2: 100-108.
14. Eliades.T and Bourauel.C. Intraoral ageing of orthodontic materials:The picture we miss and its clinical relevance; Am J Orthod Dentofacial Orthop; April 2005; 127:4: 403-412.
15. West Alan E. , Jones Melcolm L. and Newcombe Robert G. Multiflex versus superelastic: A randomized clinical trial of the tooth alignment ability of initial arch wires ; Am J Orthod Dentofacial Orthop; November 1995 ; 108 :5: 464 – 471.
16. Chaturvedi T P, Upadhayay S N. An overview of orthodontic material degradation in oral cavity. Indian J Dent Res 2010;21:275-84.
17. Kim H, Johnson JW. Corrosion of stainless steel, nickel-titanium, coated nickel-titanium, and titanium orthodontic wires. Angle Orthod 1999;69:39-44.
18. Eliades T, Athanasiou AE. In vivo aging of orthodontic alloys: Implications for corrosion potential, nickel release, and biocompatibility. Angle Orthod 2002;72:222-37.
19. Lin M, Lin S, Lee T, Huang H. Surface analysis and corrosion resistance of different stainless steel orthodontic brackets in artificial saliva. Angle Orthod 2006;76:23-7.
20. Matasa CG. Microbial attack of orthodontic adhesives. Am J Orthod Dentofac Orthop 1995;108:132-41.
21. Bernabe , Flores-Mir. Dental Morphology and Crowding: A Multivariate Approach. Angle Orthod 2006;76:20–25.
22. Krishnan and Kumar. Mechanical Properties and Surface Characteristics of Three Archwire Alloys. Angle Orthod 2004;74:825–831.
23. Juvvadi et al.Physical, mechanical, and flexural properties of 3 orthodontic wires: An in-vitro study. American Journal of Orthodontics and Dentofacial Orthopedics 2010; 138: 623-30.
24. Wilkinson. Metallurgical aspects of stainless steel. Am J Orthod Dentofacial Orthop;1962; 48:3: 192-206.
25. T. G. Bradley et al. An investigation into the mechanical and aesthetic properties of new generation coated nickel-titanium wires in the as-received state and after clinical use. European Journal of Orthodontics 2013;1-7.
26. Kusy and Whitley. Thermal and mechanical characteristics of Stainless steel, titanium-molybdenum and nickel-titanium archwires. American Journal of Orthodontics and Dentofacial Orthopedics 2007; 131:229-37.
27. Gravina et al. Mechanical properties of NiTi and CuNiTi wires used in orthodontic treatment. Part 2: Microscopic surface appraisal and metallurgical characteristics. Dental Press J Orthod. 2014:69-76.
28. Liu, Lee, and Liu. Effect of loading force on the dissolution behaviour and surface properties of nickel-titanium orthodontic archwires in artificial saliva. American Journal of Orthodontics and Dentofacial Orthopedics 2011;Vol 140;Issue 2:166-76.
29. Kusy. Comparison of nickel-titanium and beta titanium wire sizes to conventional orthodontic arch wire materials. Am J Orthod Dentofacial Orthop; 1981 ; 79 :6: 625-629.
30. Kusy and Greenberg: Comparison of elastic properties of Nickel titanium and Beta titanium arch wires. Am J Orthod Dentofacial Orthop; Vol 1982; Sept:199 –205.
31. Kusy Robert P. A review of contemporary arch wires: Their properties and characteristics. Angle orthodontic ;1997 :3:197-207.
32. Iijima, Muguruma, Brantley, Choe, Nakagaki, Alapati, Mizoguchi. Effect of coating on properties of esthetic orthodontic nickel-titanium wires. Angle Orthod. 2012;82:319–325.
33. Evans.W, Jones.L and Newcombe.R. Clinical comparison and performance perspective of three aligning arch wires; Am J Orthod Dentofacial Orthop; July 1998; 114 :1:32-39.
34. Gravina et al. Mechanical properties of NiTi and CuNiTi shape-memory wires used in orthodontic treatment. Part 1: Stress-strain tests. Dental Press J Orthod. 2013;18(4):35-4.
35. C.Bourauel, W.Scharold, A.Jager, T.Eliades. Fatigue failure of as-received and retrieved NiTi orthodontic archwires. Dental Materials; 24;2008: 1095-1101.
36. Kusy. Use of nomograms to determine elastic property ratios of orthodontic arch wires. volume 1983; May: 374-381.
37. Gravina et al. Clinical evaluation of dental alignment and leveling with three different types of orthodontic wires. Dental Press J Orthod. 2013;18(6):31-7.
38. Montasser, Keilig, and Bourauel. Archwire diameter effect on tooth alignment with different bracket-archwire combinations.