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Measurement of Surface Roughness of Copper Nickel Titanium Arch Wires at Dry and Wet Conditions: An *In vitro* Study

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ABSTRACT

Introduction: The first phase of orthodontic therapy depend on flexible archwires, usually ''Nickel-titanium'' alloy to relate. The substantially load during movement of the tooth. Copper has been additional to nickel-titanium arch wires, subsequent made an alloy with potential clinical benefit. Also, the surface, characteristics, for instance roughness surface, hardness of orthodontic arch wires, and topography are essential determinants of the efficiency of archwire-guided movement of the tooth. They besides affect the potential of corrosion and the aesthetics components of orthodontic.

Aims and objective: This in vitro study was planned to assess the roughness of Copper Nickel Titanium arch wires from altered brands in dry and wet condition (acidic and neutral artificial saliva).

Materials and methods: Three types of CuNiTi orthodontic archwires from different brands were used: CuNiTi (Ormco brand), CuNiTi (IOS brand) and CuNiTi (Orthotechnology brand). They were rectangular (0.018 × 0.025 inch) in cross section and cut into pieces of 25 mm in distance. Thrity pieces from each company were divided into three groups; first one was left in dry condition and the other two groups ten pieces for each group were submerged in artificial saliva ((pH=6.75 ± 0.015)) and ((pH=3.5 ± 0.015)) at 37^{0}C for 2 months. The atomic force microscope was used to assess surface analysis of very samples. Then, the obtained data were analyzed using ANOVA and Tukey's test.

Results: After immersion period, CuNiTi wires from orthotechnology brand exhibited the highest roughness among the study groups. On, the hand, the minimum roughness was CuNiTi wires from Ormco rand when compared to equivalent archwires. However, statistically non-significant different was noticed in surface roughness between groups of archwires from different company at dry condition. On the other hand, a highly significant different was noticed in surface roughness between groups of archwires from different company at wet condition.

Conclusion: The copper nickel titanium archwires from Ormco brand were the greatest and the most suitable alignment orthodontic archwires in term of the minimum roughness firstly and over the sequence of period of this study.

Key words: Copper nickel titanium arch wires, Atomic Force Microscope (AFM), Surface roughness, Artificial saliva

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INTRODUCTION

The Fixed orthodontic appliances normally fixed by brackets and bands on teeth, and have arch wires made of nickel-titanium or stainless steel. The alloys have to be completely biocompatible and, must aggravate an suitable biological response, within the tooth Figure 1 [1].

Archwire is one of the greatest important portions of fixed orthodontic appliance; the impeccable one should have the capacity to move a tooth with a continuous light force practical to it [3]. Nickel titanium- Copper chromium Alloy (CuNiTi): This alloy was advanced by Dr. Rohit Sachdeva and Miyasaki in 1994. It composed of (49.87%) nickel, (5.64%) Copper (42.99%) titanium and (0.5%) chromium [4].

To raise the thermal-reactive assets of the wire and raise the transformation temperature to above that of the oral cavity and to

Figure 1: Fixed orthodontic appliance [2].

recompense for this, the copper added to the alloy, chromium is additional to decrease the transformation temperature. Originally, Copper NiTi was produced with four altered austenitic transformation temperatures covering both thermo elastic archwires and pseudo elastic [5].

The surface characteristics especially roughness played an important role in determining the corrosion, friction, hygiene, color stability (for coated wires) and the efficiency of teeth retraction [6-7]. Researches proved a direct relationship between roughness surface and Corrosion of archwires and release of ions in the oral situation. With aggregate roughness surface of the arch wire, the forces of frictional will be increased so that it will boost the contact area among the bracket and the archwire. This in turn will diminish the force of orthodontic by about 50% or more thus lowering the value of treatment of orthodontic [8-9]. The, purpose of the current study was to survey the roughness surface of copper nickel titanium arch wires at dry condition and neutral, acidic of artificial saliva.

MATERIALS AND METHODS

Planning of artificial saliva

The mechanisms of artificial saliva (0.7 g NaCl, 1.2 g KCl, 0.26 g Na_2HPO_4, 0.2 g K_2HPO_4, 1.5 g $NaHCO_3$, 0.33 g KSCN, 0.13 g, urea and 1000 ml deionized water). NaOH and Lactic acid were used to alter ''the pH of artificial saliva using the pH-meter'' and kept in, 37°C using incubator using filter paper after filtering to get clear of any unsolvable impurities and salts. The pH of artificial saliva was attuned to 6.75 ± 0.015 and 3.5 ± 0.015 using a pH meter (Jenway, Cyprus and model 3320, equivalent to the pH of human salivary [10-12].

Preparation of the samples

The samples were made of 3 types of rectangular cross-section (0.018 × 0.025 inch) maxillary archwires: CuNiTi archwires (Ormco corp., Glendora, CA, USA), Copper Nickel Titanium archwire (Ortho Technology®, USA, TruFlex™, full form) and copper nickel titanium arch wire (IOS, International Orthodontic Services, Stafford, USA). The straight portions of archwire were cut into parts of 25 mm in length [13]. Total of 90 pieces, 30 pieces from every type of archwires, were divided in the matter that 10 parts from every company keep on in a dry condition'' as a control group'', whereas the other 20 parts were submerged in artificial of saliva for 2 months, ten pieces from each groups were submerged in pH of artificial of saliva 6.75 and pH=3.5.

Afterward, samples was employed in glass containers separated and held from its ends by dental floss in a way that any touching should be avoid the wall. Then, added of artificial saliva so that sample was submerged completely (Figure 2).

After that the samples were saved at 37^0C in an incubator (Fisher scientific) for 2 month. The artificial of saliva was replaced regularly each 7 days with a solution fresh to evade its saturation with the products of the degradation [14,15]. After the two month the samples were washed by distilled water. Then, left in on filter papers to dry and preserved in petri dishes.

Preparation of specimens

It wants to use minor slides as an alternative to regular ones with the purpose of use Aomic force microscope for analysis the sample. The cut of slide into minor sections (2 × 2 cm) by a diamond cutting instrument. Each segment of wire was then attached on a slide (Figure 3).

Washing the samples

Next after two month the samples were submerged in solution of distilled water and one drop of 2% sodium dodecyl sulfate solution, and cleaned ultrasonically for 3 minutes at 20 watt to eliminate the unclean layer formed through handling. Then the samples were rinsed with distilled water then allowable to dry in air and reserved in closed petri dishes to be prepared for assessment. Atomic force microscope used

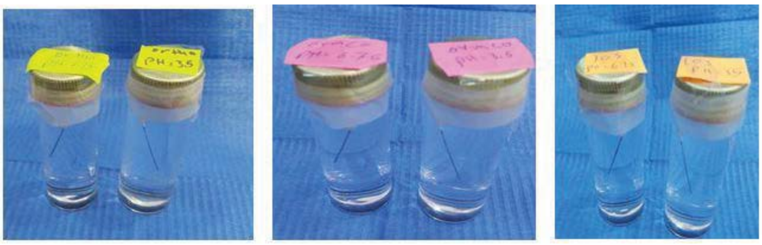

Figure 2: The sample inside the artificial saliva.

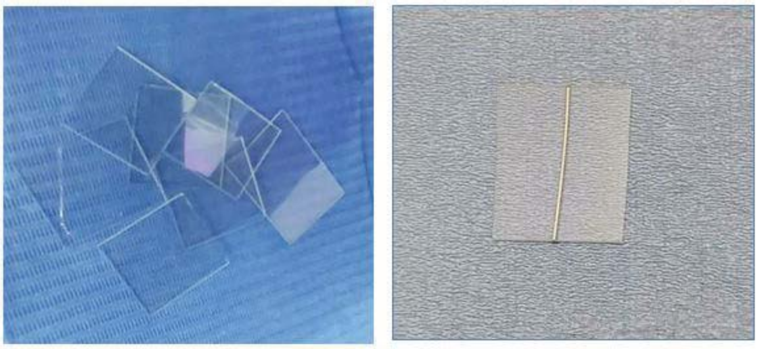

Figure 3: The sample of wire fixed on a slide.

to evaluate the surface roughness of the samples [16,17]. For every specimen 3 areas on archwire have been scanned by a scanning area of 25 × 25 µm: 1 in the center and the others on two mm away. Value of mean was used; values of numerical in nm were resolute in every scan (Ra) to explain its surface roughness [18-20]. (Average Roughness) is the mean of arithmetical of the absolute values of the surface profile scanned [21].

Tapping of mode was used under ambient the conditions [22-23]. The sample was stable to piezo scanner by 3 translatory grades of freedom. Consequently, the 3 dimensional Atomic force microscope view on the monitor of the attached computer representative the surface of specimen. The images were processed by using proprietary software provided with atomic force microscope.

RESULTS

Statistical analysis Data was analyzed using computer software (SPSS-Statistical Package of Social Science-, version 19, Chicago, USA). The following statistics were used:

Descriptive statistics

Including the mean standard deviation (S.D.) median minimum (Min.) and maximum (Max.) values and statistical tables.

Inferential statistics

First Shapiro-Wilks test using to tested normality of Data testing the normality of data was approved by using Shapiro-Wilk test in order to relate the appropriate statistical test. Results showed the p-values were higher than (0.05) for all the subgroups representative that the data normally distributed (Table 1).

In addition, Table 2 displayed One-way (ANOVA) and Table 3 displayed Tukey's test were conceded to see if there were any significant differences amongst the groups and to inspect the cause of these differences.

The probability of p-value less than 0.05 was regarded as significant p-value more or equal 0.001 was considered highly significant, and of more than 0.05 was considered as statistically non-significant (Table 4).

Average Roughness (Ra), ''First'' Shapiro-Wilks test was used; it was found that Ra values were distributed normally. Then, Table 3 displayed roughness surface after two month immersion period, CuNiTi wires from Orthotechnology brand had the peak Ra among archwires. Conversely, the lowermost average roughness found in CuNiTi wires from Ormco brand wire. One-way (ANOVA) established a (HS) highly significant difference in average roughness among the 3 type of wires (p=0.000) in wet condition. The data exposed that non-significant differences in average roughness among 3 type of wires at dry condition while a highly significant difference was found between every pair of wire's types at other wet condition (Table 4).

Table 1: Testing the normality of data distribution.

Co	Media	Shapiro-Wilk test	df	p-value
IOS	Dry	0.942	10	0.575 (NS)
	Saliva pH=3.5	0.866	10	0.090 (NS)
	Saliva pH=6.75	0.941	10	0.562 (NS)
ORMCO	Dry	0.915	10	0.314 (NS)
	Saliva pH=3.5	0.863	10	0.105 (NS)
	Saliva pH=6.75	0.884	10	0.145 (NS)
Orthotechnology	Dry	0.916	10	0.327 (NS)
	Saliva pH=3.5	0.85	10	0.058 (NS)
	Saliva pH=6.75	0.896	10	0.199 (NS)

Table 2: Mean and S.D. values of the (Ra) in nm, of different Cu NiTi arch wire types and ANOVA test.

Media	Co	N	Descriptive statistic (in nm)				ANOVA test	
			Mean	SD	Min	Max	F-test	p-value
Dry	IOS	10	24.857	7.13	13.27	35.48	0.309	0.000 (NS)
	ORMCO	10	23.194	6.127	13.86	31.44		
	Orthotechnology	10	25.688	8.264	14.57	37.44		
Saliva pH=3.5	IOS	10	135.089	10.225	118.76	145.52	242.759	0.000 (HS)
	ORMCO	10	107.384	11.135	96.11	120.16		
	Orthotechnology	10	211.265	11.361	195.65	224.98		
Saliva pH=6.75	IOS	10	133.971	10.241	119.29	149.18	305.833	0.000 (HS)
	ORMCO	10	102.085	2.207	99.79	106.24		
	Orthotechnology	10	190.641	9.359	177.9	201.8		
*NS=Non-Significant different (non any different between group)								
* HS= Highly Significant different (there is different between groups)								

Table 3: Differences in average roughness of different types of CuNiTi wires after immersion period.

Media	Co		Mean Difference	p-value
Saliva pH=3.5	IOS	ORMCO	27.705	0.000 (HS)
		Orthotechnology	-76.176	0.000 (HS)
	ORMCO	Orthotechnology	-103.881	0.000 (HS)
Saliva pH=6.75	IOS	ORMCO	31.886	0.000 (HS)
		Orthotechnology	-56.67	0.000 (HS)
	ORMCO	Orthotechnology	-88.556	0.000 (HS)

Table 4: Significant values.

Non-significant (NS)	p>0.05
Significant (S)	0.05 ≥ p>0.01
Highly significant (HS)	p ≤ 0.01

DISCUSSION

The data obtained from the current study showed a significant increase roughness in media with low pH valve compared to neutral and dry condition (control). This was probably due to that the acidic media may reduce the resistance of alloys to corrosion as proposed by many researchers [24-28].

Acidic condition provides a strong reducing medium because it contains high concentration of Hydrogen ions which exert a reducing effect that tries to pull oxygen from oxide layer (the passive layer) [29,30]. At dry condition, CuNiTi arch wire from Orthotechnology brand were higher significant mean value of roughness surface (Ra) when compared to analogous archwires, CuNiTi archwires from Ormco brand were least significant mean value of surface roughness (Ra) when compared to analogous archwires; this was probably because of the manufacturing process. At wet condition in the artificial saliva neutral and acidity, CuNiTi arch wires from Orthotechnology brand were high significant mean value of surface roughness (Ra) after compared to analogous arch wires and less roughness was CuNiTi from Ormco brand. Mostly, the disparities in roughness surface amongst the 3 types of archwires might be recognized to the type of manufacturer, surface material, and manufacturing technique. Also, possible factors influencing the surface integrity in artificial saliva might be related to the original roughness surface deposition method (fabrication process and synthesis) used surface material-substrate adhesion strength and material stability. All that is coming in agreement with [31-34]. The low pH intensified the cathodic reaction to corrosion. The postulated mechanism is that the passive protective layer of titanium oxides formed on the archwire surfaces is dissolved by the action of protons in an acid ph, leading to release of metal ions [35,36]. There is non-significant different in roughness (Ra) between archwires from different brands at dry condition, and in both solution the CuNiTi archwires from IOS and orthotechnology brands presented significantly higher mean values of roughness, that because The artificial saliva based solutions have corrosive result because of the presence of chloride ions. If the environment comprises certain amounts of chloride ions then they lead to the formation of pitting corrosion. Pitting corrosion produced by the existence of chloride ions in the saliva solutions. There are numerous voids formed as a consequence of corrosion. These corrosion products formed on the surface as several oxides.

The formation of voids is inevitable because of chemical interaction among the metal and the solution, which results in dissolution of matrix in the course of corrosion. In artificial saliva, Titanium ions are released from metal surface because of the lower, affinity of nickel to oxygen and the Titanium-based oxide might appear in the crystalline form as result of corrosion. The oxide, formations on surface,commonly appear in the crystalline form because of the nucleation [37-41].

CONCLUSION

It can concluded from this study that roughness surface of CuNiTi arch wires submerged in artificial saliva has a material specific pattern. CuNiTi archwires for Ormco brand had lowest roughness And CuNiTi archwires for Orthotechnology brand had highest roughness.

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